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Research Article / Araştırma Makalesi

Impact of acha, pigeon pea, and oyster mushroom flour blends on amino acid profiles: Economic and health benefit

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Ogodo Nwankwegu & Mbaeyi-Nwaoha; Impact of acha, pigeon pea, and oyster mushroom flour blends on amino acid profiles: Economic and health benefit

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Abstract

Most Africans, especially the people of Nigeria, are diagnosed for reduced muscles mass, slow metabolism, and low immunity due to consumption of poor-quality proteins. In this research, an investigation on the possibilities of improving the amino acid contents, the protein value of composites flours of different blends of acha, pigeon pea and oyster mushroom was done. Four formulations were evaluated: sample A1P0M0 contained only acha, while samples A75P20M5 contained 75% acha, 20% pigeon peas, and 5% mushroom; sample A70P20M10 contained 70% acha, 20% pigeon peas, and 10% oyster mushroom, and sample A65P20M15 contained 65% acha, 20% pigeon peas and 15% oyster mushroom. For amino acids profile, Leucine levels increased from 9.40 % (A75P20M5) to 10.01 % (A65P20M15). Concentration of essential amino acid, amino acid score based on whole chicken egg amino acid and essential amino acid score increased as pigeon pea and oyster mushroom were increased with threonine ranging from 0.99 % (A1P0M0) to 1.13 % (A65P20M15). Protein quality improved, ranging from 3.53 % (sample A1P0M0) to 3.83 % (sample A65P20M15) for protein efficiency ratio. This study suggests best flour blends to optimize nutritional quality, economic and health benefit.

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INTRODUCTION

Acha (*Digitaria exilis*), commonly referred to as fonio, is a small-grain considered to have been cultivated in West Africa for thousands of years (1). It is enjoyed and valued for its nutritional benefits, including large quantities of essential and non-essential amino acids also micronutrients (2). Acha has some limitations in lysine content; lysine is an essential amino acid and is frequently low in cereals (3).

Pigeon pea (*Cajanus cajan*) is a perennial crop belonging to the family Leguminosae and is cultivated mainly in the tropical and subtropical parts worldwide (4). It is well endowed with proteins and essential amino acids, particularly lysine, which makes it a good complement to cereals such as acha. Introducing pigeon pea in food blends can increase protein quality only to a great degree, by addressing nutritional gaps, particularly in amino acid profiles. Pigeon pea is rich in essential amino acids such as lysine, which is often limited in cereals like acha. When combined, these foods complement each other's nutritional deficiencies, leading to a balanced amino acid profile (5).

The use of mushrooms, especially the oyster mushroom (*Pleurotus ostreatus*), is discovered to have nutritional value and be a cure for most diseases. It contains protein, vitamins, minerals, and bioactive compounds that are vital for our body. Oyster mushrooms are also rich in total sulfur-rich amino acids such as methionine and cysteine, which are normally low both in cereals, and pulses (6).

The principle of complementation has an impact on the amino acid profile score of the flour blend by combining ingredients with varying amino acid compositions to balance nutritional deficiencies. For example, blending acha that is limited in lysine with pigeon pea, which is lysine-rich, creates a more complete protein profile. Similarly, oyster mushrooms add sulfur amino acids like methionine and cysteine, which are often deficient in both cereals and legumes. This complementary effect enhances the overall protein quality and nutritional value of the blend (5).

Essential amino acids are rich in acha, lysine content is rich in pigeon peas, and sulfur amino acids are rich in oyster mushrooms (7). Uzodinma et al. (8) reported that pigeon pea blends significantly enhanced protein utilization can be attributed to the improved bio-accessibility of essential amino acids because pigeon peas are rich in lysine, an amino acid often deficient in cereals like acha, that supports weight and muscle mass maintenance. Similarly, Babarinde et al. (7) highlighted the benefits of such blends in enhancing essential amino acid profiles, crucial for dietary fortification.

Furthermore, the amino acid profiles of these blends have been shown to surpass those of their individual components in several key areas. For instance, the inclusion of pigeon peas and oyster mushrooms can address the lysine deficiency in acha and boost the overall nutritional quality of the flour. This makes such blends particularly valuable in regions where protein-energy malnutrition is prevalent and where dietary diversity is limited.

In conclusion, the combination of acha, pigeon pea, and mushroom in flour blends offers a viable approach for enhancing nutritional content of foods. This approach not only improves the amino acid profile but also contributes to better overall health outcomes. The study's goals focused on to determine the amino acid profile of flour blends composed of acha, pigeon pea, and oyster mushroom.

MATERIALS AND METHODS

Materials

Procurement of raw resources

Production of acha flour

The procedure outlined by Ubbor et al. (11) was adapted with minor adjustments to prepare the acha flour. Two kilograms of acha grains were sorted to remove stones, dirt, chaff and other extraneous matters before washing in pure tap water and drained in a plastic sieve. Acha grains were gently placed in a hot air oven at a temperature of 50 °C (6 h; Gallenkemp 300 Plus, England) in order to minimize microbial growth

and for proper milling. After drying, the dried samples were ground with a Fritsch hammer mill (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder and passed through a 500 μm mesh sieve. The flour was sealed in an airtight polyethylene bag and was displayed at a room temperature of 23 °C for other analysis.

Production of pigeon peas flour

Procedure of Arukwe at al. (12) was followed for the preparation of pigeon peas flour with slight changes. The pigeon peas (2 kg) were sorted; dirt, stones, and other foreign materials were removed, then washed in clean tap water and drained through a plastic perforated container, and blanched at 100°C for 10 minutes. It was then dehulled and toasted for 15 minutes at 150°C. The toasted grain was oven-dried (Gallenkemp, 300 Plus, England) at 60 °C for 8 h to reduce moisture content, enable efficient milling and suitable storage for minimizing microbial spoilage. The dried samples were milled (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder and sieved (500 μm mesh) to fine flour. The flour was sealed in an airtight polyethylene bag and kept at room temperature (23 °C) for future use.

Production of oyster mushroom flour

Slightly altered version Owheruo et al. (13) were used to prepare the oyster mushroom flour. The fresh oyster mushroom (1 kg) sample was sorted to remove dirt and debris then washed (in clean tap water), clean sharp knives was used to cut the oyster mushrooms into uniform pieces for even drying using oven (Gallenkemp, 300 Plus, England) at 60 °C for 6 min for faster drying, ground with a Fritsch hammer mill (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder, and sieved (500 μm mesh) to fine flour. The blended flour mixtures were thoroughly combined to ensure uniform distribution of ingredients and stored in a zip lock bag, at room temperature (23°C) until needed.

Preparation of composite flour:

Sample codes A1P0M0, A75P20M5, A70P20M10, and A65P20M15 represent different blends of flour with varying proportions of acha, pigeon pea, and oyster mushroom. Specifically:

- A1P0M0: 100% acha flour (control).
- A75P20M5: 75% acha, 20% pigeon pea, 5% oyster mushroom flour.
- A70P20M10: 70% acha, 20% pigeon pea, 10% oyster mushroom flour.
- A65P20M15: 65% acha, 20% pigeon pea, 15% oyster mushroom flour.

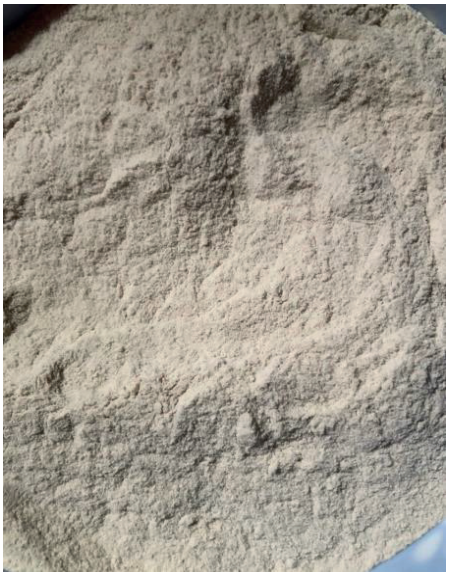

Plate 1. Acha flour

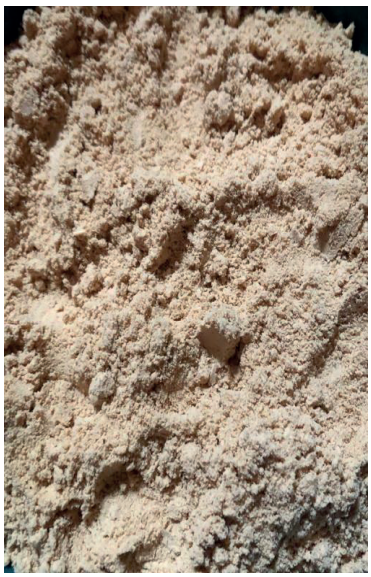

Plate 2. Oyster mushroom flour

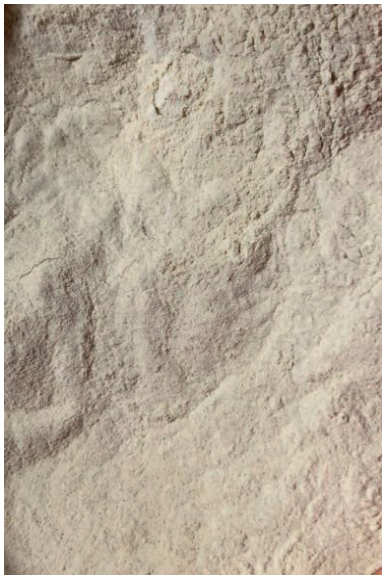

Plate 3. Pigeon pea flour

The flour blends were thoroughly blended using a Kenwood KW-3006 350W electric mixer (Kenwood Appliances, Uk). and stored in a zip-lock bag as are detailed in Table 1.

Methods

Protein quality determination

Amino acid profile

The determination of amino acid profile was done following (15), a defatted 20 mg sample was placed in a glass ampoule, 7 mL of 6 hydrochloric acid, were added into the ampoule and nitrogen passing through the solution was used to remove oxygen. The glass ampoule, flamed with a Bunsen burner and was then placed in an oven already set at 105±5°C for 22 h. The ampoule was cooled (23°C) and then cut open carefully at the top using a glass cutter. The contents were filtered using Whatman No. 1 filter paper to remove particulates and ensure a clear solution for analysis. Identification of amino acids was identified using technique of ion exchange chromatography on a multiple-sample amino acid analyzer in sequence analyser Technician (Technician Instruments Corporation, New York, USA). Tryptophan was excluded from this analysis, L-Norleucine (Sigma-Aldrich, USA) was used as the internal reference standard. The amino acid analyzer was calibrated with Norleucine at a known concentration of 5 μmol/mL, ensuring precision and consistency in quantifying the amino acids in the sample. This method allows for accurate determination of amino acid concentrations, expressed as a percentage of total protein content. The determination of the amino acid profile was conducted following established protocols. A defatted 20 mg sample was placed in a glass ampoule, and 7 mL of 6 N hydrochloric acid (HCl) was added. Oxygen was removed by passing nitrogen gas through the solution. The ampoule was sealed using a Bunsen burner flame and placed in an oven at 105 ± 5°C for 22 hours for hydrolysis.

After cooling, the ampoule was opened, and its contents were filtered. Amino acid identification was performed using ion exchange chromatography on a Technician Instruments Corporation amino acid analyzer (New York, USA). Norleucine served as the internal reference standard, and the amino acid content was quantified based on peak areas provided by the integrator. Results were expressed as a percentage of the total protein. Note: Tryptophan was excluded due to degradation in the acidic environment.

Nutritional parameters were determined on the basis of the amino acid profiles.

Amino acid score determination

Three different methods were used to calculate the amino acid scores

1. The scores are based on amino acid values when compared to those of a whole chicken egg (16)

2. The essential amino acid scoring pattern established by (10) is used to calculate the scores as reported by (9)

Essential amino acid index (EAAI)

Equation proposed by (17) was used to calculate the essential acid index.

Table 1. Proportions of acha, pigeon pea, and oyster mushroom flour blends

Sample code	Acha (%)	Pigeon pea (%)	Mushroom (%)
A1P0M0	100	0	0
A75P20M5	75	20	5
A70P20M10	70	20	10
A65P20M15	65	20	15

Key: A1P0M0= 100% acha flour (Control); A75P20M5=75% acha, 20% pigeon peas, 5% oyster mushroom flour; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom flour; A65P20M15=65% acha, 20% pigeon peas, 15% oyster mushroom flour.

$$EAAI = \sqrt[9]{\frac{(\text{Phenylal x Vali x Threo x Isoleu x Meth x Histi x Lys x Leu x Tryp})a}{(\text{Phenylal x Vali x Threo x Isoleu x Meth x Histi x Lys x Leu x Tryp})b}}$$

Where, (Phenyl x Vali x …….) a is test sample; and (Phenyl x Vali x …….) b content of the sample amino acid is standard protein (%; casein), respectively…Equation 1

Determination of predicted protein efficiency (P-PER)

This was estimated as described by (18) in the equation:

P-PER ……..…...…...Equation 2

Determination of predicted biological value (BV)

This was calculated according to method described by (19) in the equation:BV……. Equation 3

Analysis of data

A completely randomized design (CRD) was used with triplicate replicates for this analysis and was subjected to statistical analysis through IBM SPSS Statistics 24.0 (Statistical Product for service solution) and Expert Software Version 11. The significant difference between means were determined using (ANOVA) and means separated using the Duncan Multiple Range test and significance was accepted at $p < 0.05$ as described by (20).

RESULTS AND DISCUSSIONS

Table 2 presents the amino acid composition of flour samples composed of various blends of acha, pigeon pea, and oyster mushroom. Each amino acid's concentration (%) is provided for four samples (A1P0M0 to A70P20M10) with different ingredient proportions, with means ±

Table 2. Amino acids profile (%) of flour blend samples

Amino acid (%)	A1P0M0	A75P20M5	A70P20M10	A65P20M15
Leucine	9.600±0.005 ^{b}	9.400±0.005 ^{a}	9.813±0.005 ^{c}	10.016±0.005 ^{d}
Lysine	3.870±0.005 ^{b}	3.450±0.005 ^{a}	4.310±0.005 ^{c}	4.610±0.005 ^{d}
Isoleucine	4.526±0.005 ^{c}	4.190±0.005 ^{a}	4.323±0.005 ^{b}	4.610±0.005 ^{d}
Phenylamine	5.070±0.005 ^{b}	4.170±0.005 ^{a}	5.230±0.005 ^{c}	5.590±0.005 ^{d}
Valine	5.780±0.005 ^{b}	5.610±0.005 ^{b}	4.976±0.005 ^{a}	5.170±0.005 ^{b}
Methionine	2.350±0.005 ^{b}	2.460±0.005 ^{c}	2.190±0.005 ^{a}	2.573±0.005 ^{d}
Proline	6.410±0.005 ^{b}	5.986±0.005 ^{a}	5.983±0.005 ^{a}	6.270±0.005 ^{ab}
Arginine	5.160±0.005 ^{c}	4.830±0.005 ^{b}	4.810±0.005 ^{a}	5.593±0.005 ^{d}
Tyrosine	3.440±0.005 ^{b}	3.110±0.005 ^{a}	3.110±0.005 ^{a}	3.790±0.005 ^{c}
Histidine	2.420±0.005 ^{a}	2.310±0.005 ^{a}	2.693±0.005 ^{a}	2.750±0.005 ^{a}
Cystine	2.256±0.005 ^{c}	2.060±0.005 ^{b}	1.950±0.005 ^{a}	2.480±0.005 ^{d}
Alanine	7.510±0.005 ^{d}	7.090±0.005 ^{b}	7.020±0.005 ^{a}	7.360±0.005 ^{c}
Glutamic acid	18.620±0.005 ^{d}	17.490±0.005 ^{a}	17.640±0.005 ^{b}	17.950±0.005 ^{c}
Glycine	3.713±0.005 ^{c}	3.400±0.005 ^{a}	3.520±0.005 ^{b}	3.870±0.005 ^{d}
Threonine	3.970±0.005 ^{a}	4.003±0.005 ^{b}	4.360±0.005 ^{c}	4.500±0.005 ^{d}
Serine	3.970±0.005 ^{a}	4.240±0.005 ^{b}	4.460±0.005 ^{c}	4.236±0.005 ^{d}
Aspartic acid	4.510±0.005 ^{a}	7.380±0.005 ^{b}	7.570±0.005 ^{c}	7.970±0.005 ^{d}
Tryptophan	2.050±0.005 ^{b}	1.940±0.005 ^{a}	2.210±0.005 ^{c}	2.370±0.005 ^{d}

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: A1P0M0= 100% acha; A75P20M5=75% acha 20% pigeon peas5% oyster mushroom; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom; A70P20M10=65% acha, 20% pigeon peas, 15% oyster mushroom.

standard deviation and significant differences indicated by different superscripts.

Leucine levels increased with higher oyster mushroom content, from 9.60 % (A1P0M0) to 10.02 % (A70P20M10). This trend demonstrates the nutritional benefit of adding pigeon pea and oyster mushroom, consistent with findings by Benitez (19), which highlight the enhancement of essential amino acids in blended cereal products. Lysine levels varied between 3.40 % (A75P20M5) to 4.31 % (A70P20M10), with significant differences ($p < 0.05$) between all samples. Increase in lysine is particularly beneficial, as lysine is often a deficient amino acid in grains. Krawecka et al. (21) made similar observations of increased lysine content as the legumes combined with cereals boosted the 'protein digestibility corrected amino acid score. Isoleucine showed significant difference ($p < 0.05$), with values increasing from 4.19 % (A75P20M5) to 4.61 % (A70P20M10) as evidenced by previous research emphasizing the complementary amino acid profiles of such blends (22). Phenylalanine content rose from 4.17 % (A75P20M5) to 5.59 % (A70P20M10). The increased levels of phenylalanine and other essential amino acids in the blends are consistent with findings by Benitez (19), which showed that combining grains with legumes and oyster mushrooms improves the amino acid profile significantly.

Valine concentrations increased from 5.61 % (A75P20M5) to 5.17 % (A70P20M10). Methionine levels increased slightly from 2.46 % (A75P20M5) to 2.57 % (A70P20M10). Methionine is another essential amino acid often lacking in plant-based diets, and its increase in these blends supports the nutritional adequacy of the product (23). Proline content showed a significant rise from 5.99 % (A75P20M5) to 6.27 % (A70P20M10). The inclusion of pigeon pea and oyster mushroom significantly enhances the proline content, which is beneficial for maintaining healthy skin and connective tissues. Arginine levels also increased, from 4.83 % (A75P20M5) to 5.59 % (A70P20M10). Arginine is essential for immune function and cardiovascular health, and its increase in these cereal blends aligns with research by Millward (9) on the benefits of legume and oyster mushroom fortification in cereals.

Tyrosine content rose from 3.11 % (A75P20M5) to 3.79 % (A70P20M10), further indicating the enhanced nutritional profile of the cereal blends. This improvement is consistent with findings by Sa et al. (24). Histidine increased from 2.31 % (A75P20M5) to 2.75 % (A65P20M15). Cystine levels rose from 2.06 % (A75P20M5) to 2.48 % (A65P20M15), enhancing the nutritional value of the cereals by providing a source of sulfur-containing amino acids, important for protein synthesis and metabolic functions (19).

Alanine content increased from 7.09 % (A75P20M5) to 7.36 % (A70P20M10). Glutamic acid showed the highest concentration among all amino acids, with values ranging from 17.49 % (A75P20M5) to 17.95 % (A1P0M0). Significant levels of glutamic acid are crucial for metabolic functions and neurotransmitter activity (24). Glycine, Threonine, Serine, Aspartic acid, and Tryptophan also showed increased concentrations across the samples, with the highest values generally observed (A70P20M10). These amino acids are essential for various bodily functions, including protein synthesis, immune response, and neurotransmission (23; 25).

Table 3 presents the mean concentrations of various amino acids in flour samples composed of different blends of acha, pigeon pea, and oyster mushroom. Each sample (A1P0M0 to A70P20M10) represents varying proportions with means ± standard deviation and significant differences indicated by distinct superscripts. Incorporating pigeon pea and oyster mushroom into acha-based cereals significantly improves their amino acid content and overall nutritional value. Total Amino Acids (TAA) range from 93.09 % (A75P20M5) to 102.17 % (A70P20M10), with significant differences among samples ($p < 0.05$). Total Non-Essential Amino Acids (TNEAA) vary from 55.57 % (A75P20M5) to 59.82 % (A70P20M10), showing significant differences ($p < 0.05$). The higher TNEAA levels highlight the positive impact of these ingredients (19).

Total Essential Amino Acids with Histidine (TEAA with His) range from 37.52 % (A75P20M5) to 42.35 % (A70P20M10), with

significant different ($p < 0.05$), demonstrating improved nutritional quality. Total Essential Amino Acids without Histidine (TEAA without His) range from 35.22 % to 39.60 %, also showing significant differences ($p < 0.05$) and confirming the beneficial impact on protein quality (25). Percentage of Total Non-Essential Amino Acids (% TNEAA) ranges from 59.69 % (A75P20M5) to 58.55 % (A75P20M5), with significant differences ($p < 0.05$), indicating a balanced nutritional composition. Percentage of Total Essential Amino Acids with Histidine (% TEAA with His) ranges from 40.31 % (A70P20M10) to 41.45 % (A75P20M5), showing significant differences ($p < 0.05$).

Total Neutral Amino Acids (TNAA) range from 56.02 % (A75P20M5) to 59.82 % (A65P20M15), with significant differences ($p < 0.05$). This indicates improved protein content and potential health benefits (18). Total Acidic Amino Acids (TAAA) range from 24.87 % (A75P20M5) to 24.78 % (A1P0M0), with significant differences ($p < 0.05$), highlighting improved metabolic and nutritional functions (25). Total Basic Amino Acids (TBAA) range from 10.57 % (A75P20M5) to 12.58 % (A70P20M10), with significant differences ($p < 0.05$). Total Sulphur Amino Acids (TSAA) range from 4.52 % (A75P20M5) to 5.05 % (A70P20M10), with significant differences ($p < 0.05$). Total Aromatic Amino Acids range from 7.27 % (A75P20M5) to 9.38 % (A70P20M10), with significant differences ($p < 0.05$), reflecting improved health benefits (19).

Table 4 presents the amino acid scores for flour samples composed of various blends of acha, pigeon pea, and oyster mushroom flours, compared against the amino acid profile of whole chicken egg. The scores are expressed as mean values with standard deviations, and significant differences are indicated by different superscripts. Different superscripts (a, b, c, d) reveal that the values are significantly different from each other at $p < 0.05$, while the same superscript indicates no significant difference.

Leucine content increases progressively with the

Table 3. Concentration of essential amino acid of flour blend samples

Amino acid	A1P0M0	A75P20M5	A70P20M10	A65P20M15
TAA	94.720±0.1.95 ^{b}	93.090±0.005 ^{a}	95.806±0.003 ^{c}	102.170±0.005 ^{d}
TNEAA	55.560±0.005 ^{a}	55.570±0.005 ^{a}	56.060±0.005 ^{b}	59.820±0.005 ^{c}
TEAA with His	39.363±0.005 ^{b}	37.520±0.005 ^{a}	39.740±0.005 ^{c}	42.350±0.005 ^{d}
TEAA without His	36.940±0.005 ^{b}	35.220±0.005 ^{a}	37.390±0.000 ^{c}	39.600±0.005 ^{d}
% TNEAA	58.530±0.005 ^{b}	59.686±0.005 ^{d}	58.510±0.005 ^{a}	58.550±0.005 ^{c}
% TEAA with His	41.670±0.005 ^{d}	40.310±0.005 ^{a}	41.480±0.005 ^{c}	41.450±0.005 ^{b}
% TEAA without His	38.910±0.005 ^{c}	37.830±0.005 ^{a}	39.760±0.005 ^{d}	38.630±0.005 ^{b}
TNAA	56.886±0.003 ^{c}	56.020±0.005 ^{a}	59.020±0.005 ^{b}	59.820±0.005 ^{d}
TAAA	23.130±0.005 ^{a}	24.870±0.005 ^{b}	25.210±0.005 ^{c}	24.780±0.005 ^{b}
% TAAA	24.370±0.005 ^{a}	26.710±0.005 ^{d}	26.310±0.005 ^{c}	25.373±0.005 ^{b}
TBAA	11.460±0.005 ^{b}	10.570±0.005 ^{a}	11.480±0.005 ^{c}	12.580±0.005 ^{d}
% TBAA	17.610±0.005 ^{d}	13.750±0.005 ^{a}	14.040±0.005 ^{b}	16.370±0.005 ^{c}
TSAA	4.586±0.005 ^{c}	4.520±0.005 ^{b}	4.130±0.005 ^{a}	5.050±0.005 ^{d}
% (TSAA)	4.840±0.005 ^{c}	4.863±0.003 ^{c}	4.310±0.005 ^{b}	4.190±0.005 ^{a}
% Cystine in TSAA	48.580±0.005 ^{c}	45.580±0.005 ^{a}	46.970±0.005 ^{b}	49.134±0.005 ^{d}
TarAA	8.500±0.005 ^{c}	7.270±0.005 ^{a}	8.330±0.005 ^{b}	9.380±0.005 ^{d}
% TarAA	8.960±0.005 ^{c}	7.810±0.005 ^{a}	8.686±0.003 ^{b}	9.810±0.005 ^{d}

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: A1P0M0= 100% acha; A75P20M5=75% acha 20% pigeon peas5% oyster mushroom; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom; A70P20M10=65% acha, 20% pigeon peas, 15% oyster mushroom. TAA = Total Amino acid; TNEAA = Total non-essential amino acid; TEAA = Total essential Amino acid with Histidine; TNAA = Total neutral amino acid; TBAA = Total basic Amino; TSAA = Total Sulphur Amino acid. TArAA = Total aromatic amino acid.

addition of pigeon pea and oyster mushroom. This significant increase ($p < 0.05$) highlights the effectiveness of blending acha with pigeon pea and oyster mushroom to enhance leucine levels, aligning with findings from recent studies on the amino acid enhancement properties of legumes and oyster mushrooms (18). Lysine content shows variability, with the highest value observed in A65P20M15 (0.69 %). The values range from 0.56 % (A75P20M5) to 0.700 % (A70P20M10), reflecting significant improvement in lysine content with increasing oyster mushroom content ($p < 0.05$).

Isoleucine scores range from 0.75 % (A75P20M5) to 0.84 % (A70P20M10), with a clear trend of enhancement as the proportion of pigeon pea and mushroom increases. This finding supports Songs et al. (19), who documented the high isoleucine content in mushroom and legume combinations. Phenylalanine content shows a significant increase ($p < 0.05$) from 0.82 % (A75P20M5) to 1.10 % (A70P20M10). Valine content ranges from 0.74 % (A75P20M5) to 0.75 % (A65P20M15), while methionine ranges from 0.77 % (A75P20M5) to 0.80 % (A65P20M15). Both amino acids show significant improvements ($p < 0.05$) with higher oyster mushroom content, corroborating findings from recent studies on nutritional enhancements through food blending (26).

Proline, arginine, and histidine scores show notable increases, with proline ranging from 0.05 % in Sample A75P20M5 to 1.72 % (A65P20M15), arginine from 0.79 % (A75P20M5) to 0.92 % (A65P20M15), and histidine from 0.96 % (A75P20M5) to 1.15 % (A70P20M10). Cystine and alanine scores are significantly higher in Sample A65P20M15 (1.32 %) for cystine and 1.40 mg/L for alanine), indicating effective sulfur amino acid enhancement through the blend (19). Glutamic acid, glycine, and threonine contents increase significantly with the addition of pigeon pea and oyster mushroom. Glutamic acid ranges from 0.86 % (A75P20M5) to 1.07 % (A70P20M10), glycine from 0.90 % (A75P20M5) to 1.07 % (A70P20M10), and threonine from 0.78

Table 4. Amino acid score from blends of acha, pigeon pea and oyster mushroom flours based on whole chicken egg amino acid.

Amino acid (%)	A1P0M0	A75P20M5	A70P20M10	A65P20M15
Leucine	1.150±0.005 [a]	1.200±0.005 [a]	1.136±0.141 [a]	1.200±0.005 [a]
Lysine	0.640±0.005 [b]	0.560±0.005 [a]	0.650±0.005 [b]	0.690±0.005 [c]
Isoleucine	0.800±0.005 [c]	0.7500±0.005 [a]	0.770±0.005 [b]	0.8400±0.005 [d]
Phenylamine	0.990±0.000 [b]	0.816±0.005 [a]	1.030±0.008 [c]	1.100±0.005 [d]
Valine	0.740±0.005 [b]	0.740±0.005 [b]	0.660±0.005 [a]	0.750±0.005 [b]
Methionine	0.730±0.005 [b]	0.770±0.005 [c]	0.690±0.005 [a]	0.800±0.005 [d]
Proline	1.650±0.005 [a]	0.050±0.005 [a]	3.060±0.005 [d]	1.720±0.005 [c]
Arginine	0.850±0.005 [c]	0.790±0.005 [a]	0.820±0.005 [b]	0.920±0.005 [d]
Histidine	1.020±0.005 [c]	0.960±0.005 [a]	0.980±0.005 [b]	1.150±0.005 [d]
Cystine	1.250±0.005 [c]	1.153±0.008 [b]	1.070±0.005 [a]	1.320±0.005 [d]
Alanine	1.400±0.005 [b]	1.320±0.005 [a]	1.300±0.005 [a]	1.403±0.028 [b]
Glutamic acid	1.190±0.005 [d]	0.860±0.005 [a]	1.120±0.005 [c]	1.070±0.005 [b]
Glycine	1.240±0.005 [d]	0.900±0.005 [b]	1.080±0.005 [c]	0.320±0.005 [b]
Threonine	0.776±0.008 [a]	0.780±0.005 [a]	0.850±0.005 [b]	0.880±0.005 [c]
Serine	0.570±0.005 [b]	0.540±0.005 [b]	0.570±0.005 [b]	0.600±0.005 [a]
Aspartic acid	0.730±0.005 [a]	0.690±0.005 [b]	0.766±0.061 [a]	0.743±0.003 [a]
Tyrosine	0.870±0.005 [c]	0.780±0.005 [b]	0.780±0.005 [b]	0.720±0.005 [a]

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: A1P0M0= 100% acha; A75P20M5=75% acha 20% pigeon peas5% oyster mushroom; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom; A70P20M10=65% acha, 20% pigeon peas, 15% oyster mushroom.

% (A75P20M5) to 0.880 % (A70P20M10). Serine, aspartic acid, and tyrosine scores increase with higher oyster mushroom content.

Table 5 presents the essential amino acid scores for flour samples produced from blends of acha, pigeon pea, and oyster mushroom flours, based on the Ubbor et al. (11) standard. The values are given in % and include the means and standard deviations for each blend. Different superscripts (a, b, c, d) indicate that the values are significantly different from each other at $p < 0.05$, while the same superscript indicates no significant difference. Threonine content varies significantly among the samples, from 0.720 % (A75P20M5) to 0.13 % (A65P20M15). The increase in threonine with higher oyster mushroom content is significant ($p < 0.05$). Isoleucine scores range from 1.05 % (A75P20M5) to 1.16 % (A70P20M10). The mean isoleucine content increases with higher oyster mushroom content, reflecting the findings of previous researcher (19)

Leucine content also shows a significant increase across the samples, from 1.34 % (A75P20M5) to 1.43 % in Sample A70P20M10. This enhancement is consistent with studies that report the benefits of pigeon pea and oyster mushroom supplementation in improving the leucine content in food blends (24). Lysine scores range from 0.63 % in Sample A75P20M5 to 0.77 % in Sample A70P20M10. The observed increases are significant and suggest that pigeon pea, known for its high lysine content, effectively boosts lysine levels when included in the blend (21). Sulphur amino acids (Methionine + Cystine) content ranges from 1.29 % (A75P20M5) to 1.44 % (A70P20M10). There is significant increase in these amino acids, especially in Sample A65P20M15.

Total aromatic amino acids (Phenylalanine + Tyrosine + Tryptophan) show significant variability, from 1.78 % (A75P20M5) to 1.76 % (A70P20M10), with a notable decrease (A65P20M15) to 1.96 %. Tryptophan content increases significantly, from 1.94 % in Sample A75P20M5 to 2.37 % (A70P20M10). This significant enhancement underscores the potential of combining cereals and legumes with oyster mushrooms to boost tryptophan levels, which are critical for serotonin synthesis (27).

Valine content ranges from 1.12 % (A75P20M5) to 1.14 % (A70P20M10). The observed increases are consistent with studies of (25).

Table 6 reveals the protein quality of flour samples composed of different blends of acha, pigeon pea, and oyster mushroom. Values are in %, including means and standard deviations for each blend. P.E.R values vary from 3.47 (A75P20M5) to 3.83 (A70P20M10). The highest P.E.R (A70P20M10) indicates that the blend

Table 5. Essential amino acid score from blends of acha, pigeon pea and oyster mushroom flours based on FAO/WHO (1973) standard

Amino acid (%)	A1P0M0	A75P20M5	A70P20M10	A65P20M15
Threonine	0.986±0.003 ^{b}	0.720±0.005 ^{a}	1.090±0.005 ^{c}	1.130±0.005 ^{d}
Isoleucine	1.110±0.005 ^{b}	1.050±0.005 ^{a}	1.800±0.005 ^{d}	1.160±0.005 ^{c}
Leucine	1.370±0.005 ^{b}	1.340±0.005 ^{a}	1.400±0.005 ^{c}	1.430±0.005 ^{d}
Lysine	0.766±0.005 ^{b}	0.630±0.005 ^{a}	0.730±0.005 ^{ab}	0.770±0.005 ^{b}
Sulphur amino acid (Met + Cystine)	1.310±0.005 ^{c}	1.290±0.005 ^{b}	1.180±0.005 ^{a}	1.440±0.005 ^{d}
Total Aromatic amino acid (Pheny + Tyr + Try)	1.850±0.005 ^{c}	1.780±0.005 ^{b}	1.760±0.005 ^{a}	1.960±0.005 ^{d}
Tryptophan	2.050±0.005 ^{b}	1.940±0.005 ^{a}	2.210±0.005 ^{c}	2.370±0.005 ^{d}
Valine	1.120±0.005 ^{a}	1.120±0.005 ^{a}	4.970±0.005 ^{c}	1.140±0.005 ^{c}

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: A1P0M0= 100% acha; A75P20M5=75% acha 20% pigeon peas5% oyster mushroom; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom; A70P20M10=65% acha, 20% pigeon peas, 15% oyster mushroom.

with the highest proportion of oyster mushroom (15 %) facilitates the most efficient protein utilization. The Biological Value (B.V) of the flour blends ranges from 95.12 (A75P20M5) to 110.30 (A70P20M10). The B.V measures the proportions of absorbed protein incorporated into the body. The significantly higher B.V (A70P20M10), which includes the highest percentage of oyster mushroom, suggests enhanced protein quality. This finding concurs with previous studies where it was established that the addition of mushrooms enhances nutritional value of proteins (10).

The EAAI values range from 0.98 (A75P20M5) to 1.12 (A70P20M10). EAAI assesses protein quality based on the presence of essential amino acids. Highest EAAI in Sample A70P20M10 confirms superior amino acid profile of the cereal blend with the highest oyster mushroom content. This is backed up by research that shows that fortification of oyster mushroom improves the nutritional value of food stuffs (19). % EAAI mirrors the trend seen in EAAI, ranging from 98.00 % (A75P20M5) to 112.00 % (A70P20M10). This percentage provides a relative measure of the protein's adequacy in meeting human dietary needs. The highest % EAAI (A70P20M10) corroborates the enhanced nutritional value provided by higher oyster mushroom content (24)

The data indicate that increasing the proportion of oyster mushroom in the cereal blend significantly enhances the protein quality, as evidenced by improvements in P.E.R, B.V, EAAI, and % EAAI. These findings are supported by recent literature, which highlights the beneficial effects of oyster mushroom supplementation in boosting the nutritional quality of food products.

CONCLUSIONS

Incorporation of blends obtained from acha, pigeon pea, and oyster mushroom in different proportions into flour significantly increased their amino acid profile and protein quality hence it improves dietary value particularly in places where protein malnutrition is prevalent. These blends provide more balanced intake of amino acids necessary for growth, maintenance of muscles as well as overall health. Different cereal grains blended with protein sources such as mushrooms and pigeon peas increase consumption options other than relying on one food source reducing vulnerability to food deficits or poor diet diversity in areas affected by inadequate food supply. According to results of this research, most of the parameters improved significantly, especially in the sample A65P20M15. It shows that blending is potentially sustainable and provide healthy dietary alternatives.

These findings strongly suggest that these blends can be developed into functional foods or dietary supplements from catering to targeted populations such as sportspersons, the elderly, potentially sustainable and healthy dietary alternatives for people with specific nutritional needs. This would also generate economically viable options for local farmers and communities. The crops can also be included in sustainable agricultural systems for local economic improvement and maintenance of biodiversity. Improved protein quality and amino acid profiles can play a role in solving public health problems

Table 6. Protein quality of flour bends of acha, pigeon and oyster mushroom

Parameters	A1P0M0	A75P20M5	A70P20M10	A65P20M15
P.E.R	3.530±0.005 ^{b}	3.470±0.005 ^{a}	3.660±0.005 ^{c}	3.830±0.005 ^{d}
B.V	107.110±0.005 ^{c}	95.120±0.005 ^{a}	100.52±0.005 ^{b}	110.300±0.005 ^{d}
EEAI	1.090±0.005 ^{c}	0.980±0.005 ^{a}	1.030±0.005 ^{b}	1.120±0.005 ^{d}
% EEAI	109.003±0.000 ^{c}	98.003±0.005 ^{a}	103.000±0.008 ^{b}	112.003±0.003 ^{d}

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly ($p > 0.05$) different ($p > 0.05$). Key: A1P0M0= 100% acha; A75P20M5=75% acha 20% pigeon peas5% oyster mushroom; A70P20M10= 70% acha, 20% pigeon peas, 10% oyster mushroom; A70P20M10=65% acha, 20% pigeon peas, 15% oyster mushroom. P.E.R = Protein efficiency ratio, B.V = Biological Value, EEAI = Essential amino acid index

related with protein-energy malnutrition and solve the widespread problem of micronutrient deficiency, especially in developing countries.

Conflict of Interest

There was no conflict of interest between authors.

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Research Article / Araştırma Makalesi

Enhancing protein quality in breakfast cereals with blends of acha, pigeon pea, and oyster mushrooms

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Abstract

This study focuses on enhancing the protein quality in breakfast cereal with acha (*Digitaria exilis*), pigeon pea (*Cajanus cajan),* and oyster mushroom (*Pleurotus ostreatus*). Protein quality, concentration of essential amino acids, amino acid score with reference to whole chicken egg, and FAO/WHO standard were determined. A completely randomized design (CRD) was used for this analysis; the significant difference between means was determined (ANOVA) and separated using the Duncan multiple range test; the significance was accepted at $p < 0.05$. Four sample formulations were used: 100% acha (control) sample 101, blends of acha, pigeon pea, and oyster mushroom at different proportions of 75:20:5 (sample 102), 70:20:10 (sample 103), and 65:20:15 (sample 104). Protein efficiency ratio (P.E.R.), biological value (B.V.), essential amino acid index (EAAI), and percentage of EAAI (% EAAI) were determined for protein quality. (P.E.R.) values ranged between 2.93 (101), 2.82 % (102), 3.18 % (103) and 3.29 % (104). Essential, non-essential, acidic, neutral, sulfuric, aromatic, and their percentages were determined. For amino acid score, leucine levels showed values from 8.35% (101), 7.910% (102), 8.90 (103), and 9.31% (104) and sample 104 with the highest value and significantly difference ($p< 0.05$). These findings strongly suggest the potential of these blends to serve as sustainable, healthy dietary alternatives for diabetic people, as they substitute animal proteins, including providing nutrient-dense options such as improved amino acid balance.

INTRODUCTION

Protein quality is critical in diabetes type management to support muscle repair and maintain glucose levels, as well as enhance metabolic activities (1). Diabetes mellitus is a chronic disease characterized by elevated blood glucose levels, leading to damage in the heart, blood vessels, eyes, kidneys, and nerves. Over half a billion people worldwide, mostly of working age, are affected by this condition (2). Managing diabetes is expensive with complications and severe health impacts (3). High blood sugar causes oxidative stress, damaging pancreatic beta cells and disrupting insulin secretion (4). Foods that can help manage high blood sugar and oxidative stress are highly important. Low/moderate glycemic index functional foods most often consumed by diabetic patients, with high antioxidants and rich in dietary fibre, aid glucose control and protect the beta cells of the pancreas (5, 6). Such foods are recommended, specifically for diabetes treatment (2). Some foods assist in controlling blood glucose levels, weight, and boosting the brain exercises when consumed in breakfast (7).

Breakfast prevents diseases attributed to blood sugars and maintains the body fit (8). Combined with pigeon pea, acha (fonio) improves the content of essential amino acids, which helps introduce nutritional density into cereals for diabetes by helping muscles and regulating blood sugar levels (7). Cereal products made from acha and pigeon pea can be encouraged; nevertheless, it is vital to know that not all gluten-free cereals are characterized by low GI values. Low-GI diet refers to the rate at which glucose is ingested into the body's system and its circulatory system and is thus an important aspect of diabetes (9). The inclusion in cereals of low GI as well as good amino acid profiles: low GI cereals like acha and pigeon pea blends would ensure adequate intakes of the vital amino acids and a good glycemic index. Also, inclusion of oyster mushrooms enhances the nutritive quality specifically in amino acids, hence being appropriate for diabetics (10, 11).

Lysine, leucine, and threonine, which are important for protein synthesis, are highly present in pigeon pea. Acha contains methionine and cysteine and is comparatively high in fiber, which makes it low-glycemic. Both collectively help in the preservation of muscles and metabolic benefits (12, 13). Flavour and nutritive value are also boosted through the addition of oyster mushrooms; proteins as well as other substances such as antioxidants and polysaccharides are found in oyster mushrooms. It also raises the levels of glutamic acid, alanine, and aspartic acid, which enhance taste and immune function—a key factor for diabetics (10, 11). Enhancing the protein quality of breakfast cereals could aid in diabetes management by supporting muscle mass preservation and improving metabolic health. Bioactive compounds in pigeon pea and oyster mushroom offer additional health benefits (13). This research might lead to new functional foods that meet the nutritional needs of diabetic patients, providing a practical dietary solution.

Furthermore, the amino acid profiles of these blends have been shown to surpass those of their individual components in several key areas. For instance, the inclusion of pigeon peas and oyster mushrooms can address the lysine deficiency in acha and boost the overall nutritional quality of the flour. This makes such blends particularly valuable in regions where protein-energy malnutrition is prevalent and where dietary diversity is limited. A different criterion for determining amino acid scoring patterns was shown and obtained from the 14 standard reports. The objectives of the study were producing breakfast cereals from composite blends with acha, pigeon pea, and oyster mushroom and determining the amino acid profile.

MATERIALS AND METHODS

Materials

Source of Raw Materials

White acha grains (*Digitaria exilis*), white Pigeon pea (*Cajanus cajan*) was purchased from the international market in Abakaliki, Ebonyi State, while oyster mushroom (*Pleurotus ostreatus*) was gotten from the National Biotechnology Development Agency, South East Centre, government house, Ebonyi state. The chemicals for the analysis were of laboratory-grade quality, procured from Sigma-Aldrich, London,

United Kingdom.

Production of Acha Flour

A modified version of the method described by (13) was applied to prepare the acha flour. Two kilograms of acha grains were sorted to remove stones, dirt, chaff, and other foreign materials. The cleaned grains were then washed with fresh tap water and drained using a perforated plastic container. The grains were dried in a hot air oven (Gallenkemp, 300 Plus, England) at 50°C for 6 hours to reduce moisture content, enable efficient milling, and suitable storage, minimizing microbial spoilage. After drying, the dried samples were milled (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder and sieved (500 µm mesh).

The flour was sealed in an airtight polyethylene bag and kept at room temperature (23°C) for future use, as shown in Figure 4.

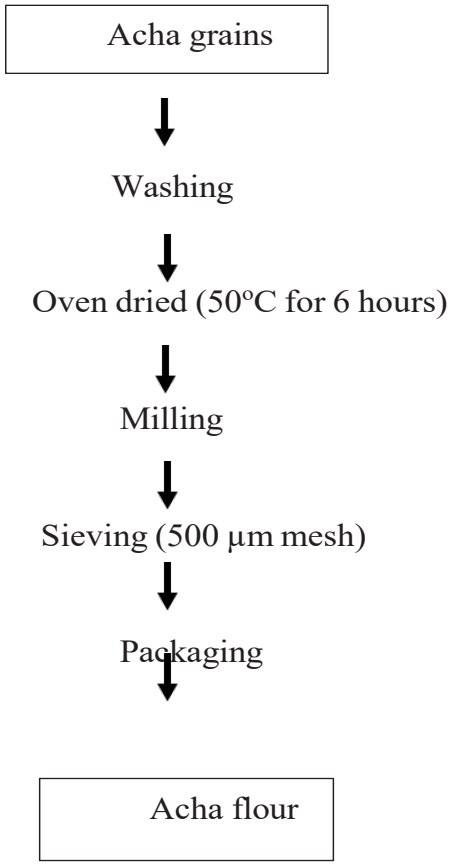

Figure 4. Flow chart for Acha flour production (13).

Production of Pigeon Peas Flour

Procedures of (15) were adopted for the production of pigeon pea flour with modifications. The pigeon peas (2 kg) were sorted; dirt, stones, and other foreign materials were removed, then washed in clean tap water and drained through a plastic perforated container, and blanched at 100°C for 10 minutes. It was then dehulled and toasted for 15 minutes at 150°C. The toasted

Figure 1

Plate 1. Acha grains

Figure 2

Plate 2. Fresh oyster mushroom

Figure 3

Plate 3. Pigeon pea grains

grain was oven-dried (Gallenkemp, 300 Plus, England) at 60°C for 8 hours to reduce moisture content, enable efficient milling, and suitable storage, minimizing microbial spoilage. The dried samples were milled (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder and sieved (500 µm mesh) to fine flour. The flour was sealed in an airtight polyethylene bag and kept at room temperature (23°C) for future use, as shown in Figure 5.

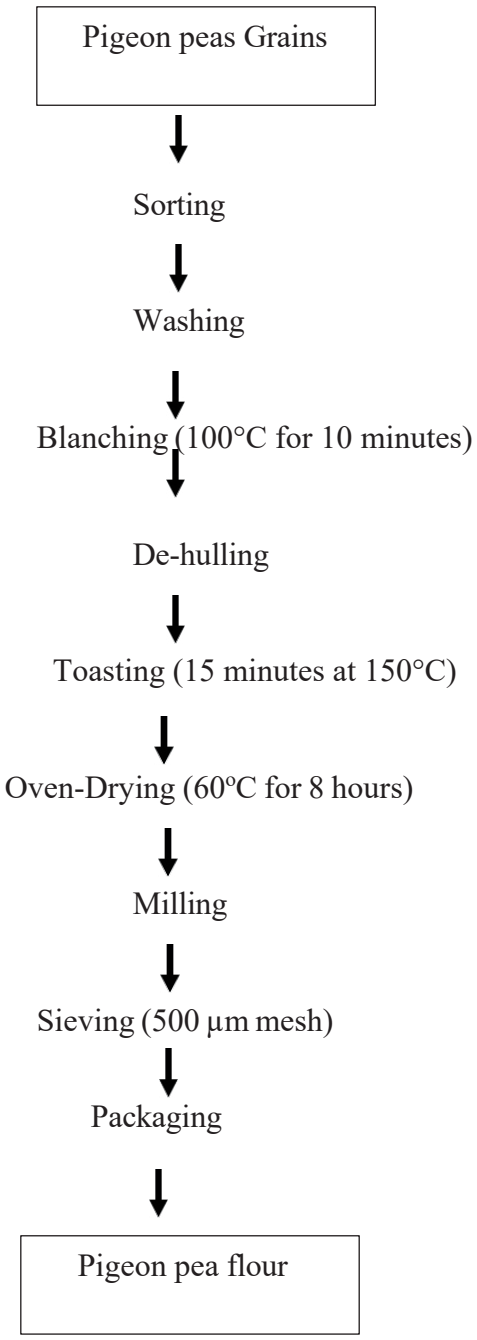

Figure 5. Flow chart for Pigeon pea flour production (15).

Preparation of Oyster Mushroom Flour

The approach of (16) with minor adjustments was used to prepare the oyster mushroom flour. The fresh oyster mushroom (8 kg) sample was sorted to remove dirt and debris, then washed (in clean tap water). Clean, sharp knives were used to cut the mushrooms into uniform pieces for even drying using an oven (Gallenkemp, 300 Plus, England) at 60°C for 8 hours for faster drying, then milled (Fritsch Pulverisette 19 Mill, Fritsch GmbH, Germany) into a fine powder and sieved (500 µm mesh) to fine flour. The flour was sealed in an airtight polyethylene bag and kept at room temperature (23°C) for future use, as shown in Figure 6.

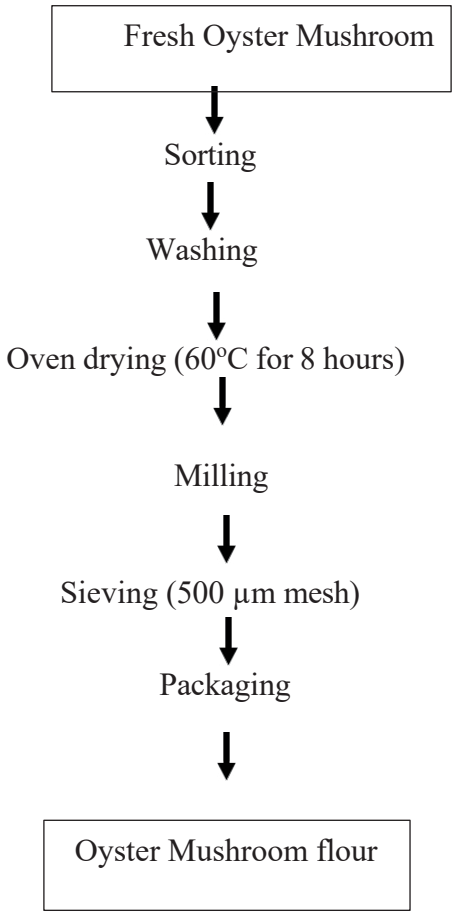

Figure 6. Flow chart for Oyster Mushroom flour production (16).

Pigeon Pea, and Oyster Mushroom Flour Blends

Sample codes 101, 102, 103, and 104 represent different blends of flour with varying proportions of acha, pigeon pea, and oyster mushroom. Specifically:

- 101: 100% acha flour (control).
- 102: 75% acha, 20% pigeon pea, 5% oyster mushroom flour.
- 103: 70% acha, 20% pigeon pea, 10% oyster mushroom flour.
- 104: 65% acha, 20% pigeon pea, 15% oyster mushroom flour.

The flour blends were thoroughly mixed using a Kenwood KW-3006 350W electric mixer (Kenwood Appliances, Uk). and stored in a zip-lock bag. The composite flour mixtures were chosen based on the results from previous research (17) and are detailed in Table 1.

Processing of Breakfast Cereal From Blends of Acha, Pigeon Pea and Oyster Mushroom

Breakfast cereals were produced from the flour blends, formulated as depicted in Figure 4, and prepared according to the method described by (18), with some modifications. Each blend consisted of 200 g of flour, which was hand-mixed in a stainless-steel bowl for about 3 minutes to ensure uniformity. 160 ml of water was added slowly, and the entire dough was mixed thoroughly for about 2 minutes to obtain uniform dough. The dough was shaped into flakes using a manual extruder and they were placed on a baking tray. The flakes were then toasted in an oven at 150°C for 35 minutes. After cooling to room temperature, the flaked breakfast cereals were removed from the pan, packaged in rigid plastic containers, and stored at ambient temperature for further analysis, as shown in Figure 7.

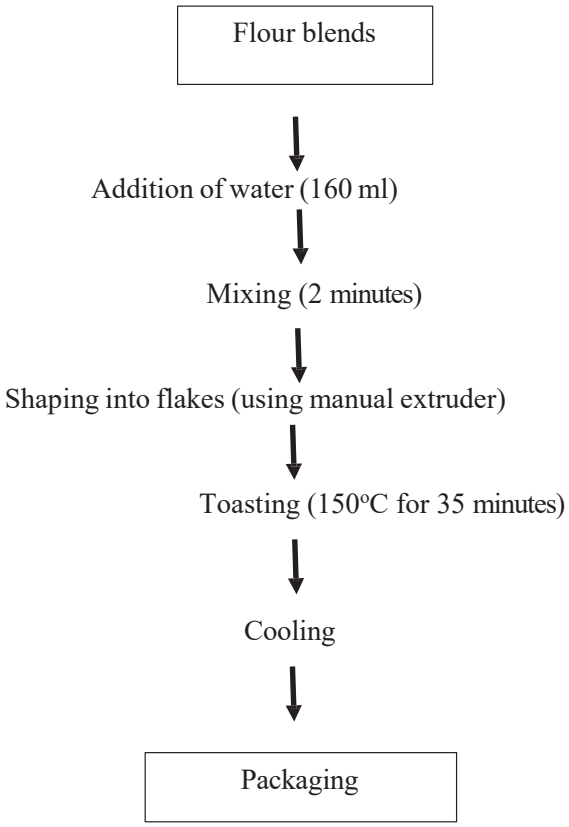

Fig. 7. Flow chart for the production of breakfast cereal (18) with slight modification.

METHODS

Protein Quality Determination

Amino acid analysis

The amino acid profile was assessed using the procedure outlined by (19). A defatted 20 mg sample was placed in a glass ampoule, and 7 ml of 6 normal hydrochloric acid were added. Nitrogen gas was used to purge the ampoule of

Table 1. Proportional composition of flour blends from acha, pigeon pea, and oyster mushroom

Sample Code	Acha (%)	Pigeon pea (%)	Oyster Mushroom (%)
101	100	0	0
102	75	20	5
103	70	20	10
104	65	20	15

Key: Sample Code 101= 100% acha flour (Control); 102=75% acha, 20% pigeon peas, 5% mushroom flour; 103= 70% acha, 20% pigeon peas, 10% mushroom flour; 104=65% acha, 20% pigeon peas, 15% mushroom flour.

oxygen. The ampoule was then sealed using a Bunsen burner flame and heated in an oven at 105±5°C for 22 hours. After cooling, the ampoule was carefully opened, and the contents were filtered. Amino acid analysis was conducted using ion-exchange chromatography with a Technician Sequential multi-sample amino acid analyzer (Technician Instruments Corporation, New York, USA). Tryptophan was not included in this analysis, and norleucine was used as the internal standard. The amino acid composition was determined from the standard area obtained from the integrator and expressed as percentages of the total protein. The determination of nutritional parameters was carried out by analyzing the amino acid profiles.

- Total Amino acid (TAA) = Add all amino acid

  Leu + Lys + Isoleu + Phen + Val + Meth + Pro + Arg +……+ Tryt …….... Equation 1
- Total non-essential amino acid (TNEAA) = Add all non-essential amino acid

  Alanine + Asparagine + Aspartic + Glu + Ser + Gly + Pro…….....Equation 2
- Total essential amino acid (TEAA) = Add all essential amino acid

  Histi + Isoleu + Leu + Lys +Meth + Pheny + Threo + Try + Val …….……..... Equation 3
- % TNEAA $= \frac{\text{Total non−essential amino acid}}{\text{Total Amino acid}} X \frac{100}{1}$…….…..... Equation 4
- % TEAA with Histidine $= \frac{\text{Total essential amino acid with histidine}}{\text{Total non−essential amino acid}} X \frac{100}{1}$…….…..... Equation 5
- % TEAA without Histidine

  $= \frac{\text{Total essential amino acid without histidine}}{\text{Total non−essential amino acid}} X \frac{100}{1}$…….... Equation 6
- Total neutral amino acid (TNAA) = Add all neutral amino acid

  Ala + Gly + Val + Leu + Iso + Phe + Try + Meth + Pro + Ser + Thre + Cyst…Equation 7
- Total acidic amino acid (TAAA) = Aspartic Acid + Glutamic acid...….....Equation 8
- % Total acidic amino acid

  (TAAA) $= \frac{\text{Aspartic Acid + Glutamic acid}}{\text{Total amino acid}} X \frac{100}{1}$…….....Equation 9
- Total Sulphur amino acid

  (TSAA) = Methionine + Cystine……...Equation 10
- % Total Sulphur amino acid

  (TSAA) = $\frac{\text{Methionine + Cystine}}{\text{Total amino acid}} X \frac{100}{1}$……...……..Equation 11
- Total basic Amino acid

  (TBAA) = Histidine + Lysine + Arginine……..… ...…Equation 12
- % TBAA $= \frac{\text{Histidine + Lysine + Arginine}}{\text{Total amino acid}} X \frac{100}{1}$…….…… Equation 13
- % Cystine in TSAA $= \frac{\text{Cystine}}{\text{Total Sulphuric acid}} X \frac{100}{1}$……..… ….....….…....Equation 14
- Total aromatic amino acid (TArAA) = Phenylalanine + Tyrosine……..… ..Equation 15
- % TArAA $= \frac{\text{Phenylalanine + Tyrosine}}{\text{Total amino acid}} X \frac{100}{1}$…….…….. .Equation 16

Table 2. Provisional amino acid scoring pattern reference pattern for whole chicken egg

Amino acid	Whole chicken egg (g/100g)
Lysine	6.2
Histidine	2.4
Arginine	6.1
Threonine	10.7
Serine	5.1
Glutamic acid	7.9
Proline	12.0
Glycine	3.8
Alanine	5.4
Cystine	1.8
Valine	7.5
Methionine	3.2
Isoleucine	5.6
Leucine	8.3
Tyrosine	4.0
Phenylalanine	5.1

(20)

- Amino acid score $= \frac{\text{mg of amino acid in 1g of test protein}}{\text{mg of amino acid in reference pattern}}$…… Equation 17

Table 3. Provisional amino acid scoring pattern reference pattern

Amino acid	mg per g of protein
Isoleucine	40
Leucine	70
Methionine + Cystine	55
Phenylalanine + Tyrosine	60
Threonine	40
Tryptophan	10
Valine	50
Total	360

(14)

Amino acid score $= \frac{\text{mg of amino acid in 1g of test protein}}{\text{mg of amino acid in reference pattern}} X \frac{100}{1}$…….. Equation 18

Determination of predicted protein efficiency (P-PER)

- This was estimated as described by (22) in the equation:

$$\text{P-PER} = 0.468 + 0.454 + \text{Leu} - 0.105 \times \text{Tyr} \quad \text{Equation 19}$$

Determination of predicted biological value

- This was calculated according to method described by (23) in the equation:

$$\text{BV} = 1.09 \times \text{EAAI} - 11.7 \quad \text{Equation 20}$$

Essential amino acid index (EAAI)

- Method of (24) was used to calculate the essential amino acid index by using the ratio of test protein to the reference protein for each nine essential amino acids. The reference protein for essential amino acids used was set by (25), as shown in table 4.

Table 4. Amino acid composition of casein

Phenylalanine	4.0
Isoleucine	4.3
Leucine	8.9
Lysine	6.5
Methionine	2.6
Threonine	4.3
Tryptophan	1.2
Valine	6.2
Arginine	2.5
Histidine	2.1
Cysteine	0.4
Tyrosine	4.2
Alanine	4.3
Glycine	3.4
Proline	13.4
Serine	6.8
Asparagine or Aspartic Acid (unspecified)	(6.2) 6.6
Aspartic Acid	2.8
Asparagine	(3.4)
Glutamine or Glutamic Acid (unspecified)	(18.6) 18.2
Glutamic Acid	(9.9)
Glutamine	(8.7)

$$EAAI = \sqrt[9]{\frac{(\text{Phenyl x Valine x Threo x Isoleu x Meth x Histi x Lys x Leu x Tryp})a}{(\text{Phenyl x Valine x Threo x Isoleu x Meth x Histi x Lys x Leu x Tryp})b}}$$

where, (Phenyl x Valine x …….) a is test sample; (Phenyl x Valine x.....) b is standard protein casein (%), respectively……...……..... Equation 21

Casein is used as a reference protein due to the fact that it is a ‘‘complete’’ protein containing all of the nine essential amino acids in the appropriate proportions (26).

Concentration of essential compounds

This was estimated as described by (19) in the equation:

Amino acid score determination

These distinct methodologies were used to calculate the amino acid scores

1. The reference pattern for essential amino acid values when compared to those of a whole chicken egg was set by (20). Whole chicken egg is used because the protein is ideal and known to contain a biological value closely approaching 100% (13). Certain proteins may give an apparent score greater than 100%, but it is admitted that such a value cannot be used to alter the dietary protein requirement since intakes of N (nitrogen) should be less than required to meet the N requirements (21). The reference pattern for essential amino acid value is shown in Table 2.

2. The reference pattern for essential amino acids was set by (14) and used to determine the essential amino acid score of the breakfast cereal produced from blends of acha, pigeon pea, and

Table 5. Amino acid composition for breakfast cereals from blends of acha, pigeon pea and oyster mushroom

Amino acid	101 (%)	102 (%)	103 (%)	104 (%)
Leucine	8.350^{b}±0.005	7.910^{a}±0.005	8.900^{c}±0.005	9.310^{d}±0.005
Lysine	3.450^{b}±0.005	3.230^{a}±0.005	3.740^{c}±0.005	4.370^{d}±0.005
Isoleucine	4.260^{b}±0.005	3.310^{a}±0.005	4.520^{c}±0.005	5.140^{d}±0.005
Phenylanine	4.610^{b}±0.005	3.720^{a}±0.005	4.520^{c}±0.005	5.140^{d}±0.005
Valine	3.860^{b}±0.005	3.360^{a}±0.005	4.240^{c}±0.005	4.740^{d}±0.005
Methionine	1.350^{b}±0.005	1.260^{a}±0.005	1.390^{c}±0.005	1.470^{d}±0.005
Proline	5.180^{b}±0.005	4.160^{a}±0.005	5.623^{c}±0.005	6.090^{d}±0.005
Arginine	4.823^{b}±0.005	3.530^{a}±0.005	4.990^{c}±0.005	5.850^{d}±0.005
Tyrosine	3.780^{b}±0.005	2.920^{a}±0.005	3.780^{c}±0.005	4.470^{d}±0.005
Histidine	2.620^{b}±0.005	1.920^{a}±0.005	2.910^{c}±0.005	3.350^{d}±0.005
Cystine	1.210^{b}±0.005	0.850^{a}±0.005	1.330^{c}±0.005	1.390^{d}±0.005
Alanine	4.130^{b}±0.005	3.603^{a}±0.005	4.360^{c}±0.005	4.550^{d}±0.005
Glutamic acid	14.310^{d}±0.005	10.290^{a}±0.005	13.470^{c}±0.005	12.890^{b}±0.005
Glycine	3.560^{c}±0.005	2.520^{a}±0.005	3.210^{b}±0.005	3.870^{d}±0.005
Threonine	3.220^{b}±0.005	2.860^{a}±0.005	3.500^{c}±0.005	3.750^{d}±0.005
Serine	3.700^{b}±0.005	3.003^{a}±0.005	3.810^{c}±0.005	4.160^{d}±0.005
Aspartic acid	6.820^{b}±0.005	5.640^{a}±0.005	7.320^{c}±0.005	8.003^{d}±0.005
Tryptophan	0.920^{b}±0.005	0.786^{a}±0.005	1.050^{c}±0.005	1.230^{d}±0.005

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: 101= 100% acha; 102=75% acha 20% pigeon peas5% mushroom; 103= 70% acha, 20% pigeon peas, 10% mushroom; 104=65% acha, 20% pigeon peas, 15% mushroom.

oyster mushroom, shown in Table 3.

Analysis of Data

A completely randomized design (CRD) was used with three replicates for this analysis and results were subjected to statistical analysis using Statistical Product for service solution (IBM SPSS Statistics 24.0) and Expert Software Version 11. The significant difference between means were determined using (ANOVA). The means were separated using the Duncan Multiple Range test and significance was accepted at $p < 0.05$ as described by (27).

RESULTS AND DISCUSSION

Table 5 presents the amino acid composition of breakfast cereals made from various blends of acha, pigeon pea, and oyster mushroom. Each amino acid's concentration (%) is provided for four samples (101 to 104) at different proportions, the means ± standard deviation and significant differences with same superscript indicates no significant ($p > 0.05$) difference, respectively.

Leucine levels showed values from 8.35% (sample 101), 7.910% (sample 102), 8.90 (sample 103), 9.31% (sample 104) and sample 104 with the highest value, showing the nutritional benefit of adding pigeon pea and oyster mushroom, as supported by (23). Lysine concentrations ranged from 3.23% in sample 102 to 4.37% in sample 104, with all samples showing significant ($p < 0.05$) differences. This increase is particularly beneficial since lysine is often limited in cereals, aligning with findings by (5). Isoleucine levels improved significantly, rising from 3.31% in sample 102 to 5.14% in sample 104, supporting the findings of (28). Phenylalanine content increased between 3.72% (sample 102), 4.52% (sample 103) and 5.14% in sample 104, with the blend improvements is consistent with (23). Valine concentrations rose from 3.36% in sample 102, 4.24% in sample 103 and 4.74% in sample 104. Methionine levels showed a slight increase from 1.26% in sample 102 to 1.47% in sample 104, an essential amino acid often lacking in plant-based diets, as highlighted by (29). Proline content significantly rose from 4.16% in sample 102 to 6.09% in sample 104.

Arginine levels increased from 3.53% in sample 102 to 5.85% in sample 104. Tyrosine content increased from 2.92% in sample 102 to 4.47% in sample 104, further enhancing the nutritional profile of the blends (23). Histidine increased from 1.92% in sample 102 to 3.35% in sample 104, important for growth and tissue repair (30). Cystine levels rose from 0.85% in sample 102 to 1.39% in sample 104, enhancing the nutritional value by providing sulfur-containing amino acids. Alanine content increased from 3.60% in sample 102 to 4.55% in sample 104, supporting overall amino acid profile improvement (28). Glutamic acid showed the highest concentration among all amino acids, with values ranging from 10.29% in sample 102 to 14.31% in sample 101, essential for metabolic functions and neurotransmitter activity (29). Other amino acids such as Glycine, Threonine, Serine, Aspartic acid, and Tryptophan also showed increased concentrations, with the highest values generally in sample 104, crucial for various bodily functions (31).

Table 6 summarizes the various concentrations of essential compounds of breakfast cereal produced from blends of pigeon pea, acha, and oyster mushroom parameters (essential, non-essential, acidic, neutral, sulfuric, aromatic, and their percentages). Each sample (101 to 104) represents different proportions, with means ± standard deviation; the same superscript (a, b, c, d) indicates no significant difference ($p > 0.05$), respectively. Total amino acids (TAA) ranged from 64.640% (sample 102) to 89.590% (sample 104), showing substantial increases (23, 16). Total non-essential amino acids (TNEAA) range from 36.330% to 51.670%, indicating a positive impact of these ingredients (28).

Total essential amino acids with histidine (TEAA with His) increase from 28.360% in (102) to 38.320% in (104), enhancing the nutritional quality. Similarly, total essential amino acids without histidine (TEAA without His) show significant improvement, ranging from 26.440% to 34.970% (31). Percentage of total non-essential amino acids (% TNEAA) varies from 56.160% (102) to 59.290% (101), while percentage of total essential amino acids with histidine (% TEAA with His) ranges from 40.710% to 45.870%. Total neutral amino acids (TNAA) increase significantly, from 37.340% to 50.660%, indicating improved protein content according to (30).

Total acidic amino acids (TAAA) range from

15.930% (102) to 21.130% (101), highlighting enhanced metabolic functions. Total basic amino acids (TBAA) increase from 8.500% (102) to 13.570% (104), indicating enhanced nutritional profiles. Total sulfur amino acids (TSAA) range from 2.110% to 2.860%, and total aromatic amino acids range from 6.640% to 9.703%, both showing significant differences and reflecting improved health benefits (31).

Table 7 presents the amino acid composition of cereal blends from acha, pigeon pea, and oyster mushroom with reference to whole egg standards. This demonstrates their potential as plant-based protein sources; in sample 104, leucine (1.11%), lysine (0.70%), and isoleucine (0.92%) were enhanced. Leucine, thereby addressing protein synthesis and muscle maintenance, supports the research work of (31). Immunity function is built up with the addition of legumes, which

Table 6. Concentration of essential compounds of breakfast cereal produced from blends of pigeon pea, acha and oyster mushroom

Amino acid	101 (%)	102 (%)	103 (%)	104 (%)
Total Amino acid (TAA)	80.150^{b}±0.005	64.640^{a}±0.005	82.586^{c}±0.003	89.59^{d}±0.005
Total non-essential amino acid (TNEAA)	47.520^{b}±0.005	36.330^{a}±0.005	47.850^{c}±0.005	51.670^{d}±0.005
Total essential amino acid with Histidine (TEAA)	32.630^{b}±0.005	28.360^{a}±0.005	35.040^{c}±0.005	38.320^{d}±0.005
TEAA without Histidine	30.010^{b}±0.000	26.440^{a}±0.005	32.130^{c}±0.008	34.970^{d}±0.005
% TNEAA	59.290^{d}±0.005	56.160^{a}±0.005	57.730^{c}±0.005	57.712^{b}±0.005
% TEAA with Histidine	40.710^{a}±0.005	45.870^{d}±0.000	42.270^{b}±0.005	42.770^{c}±0.005
% TEAA without Histidine	37.440^{a}±0.005	42.760^{d}±0.005	38.760^{b}±0.005	39.030^{c}±0.005
Total neutral amino acid (TNAA)	44.350^{b}±0.005	37.340^{a}±0.005	46.680^{c}±0.005	50.660^{d}±0.005
Total acidic amino acid (TAAA)	21.130^{d}±0.005	15.930^{a}±0.005	20.790^{b}±0.005	20.890^{c}±0.005
% TAAA	26.360^{d}±0.005	24.760^{b}±0.008	25.080^{c}±0.005	23.320^{a}±0.005
Total basic Amino (TBAA)	10.890^{b}±0.005	8.500^{a}±0.005	11.400^{c}±0.005	13.570^{d}±0.005
% TBAA	17.610^{b}±0.005	13.750^{a}±0.005	14.040^{c}±0.005	16.370^{d}±0.005
Total Sulphur Amino acid (TSAA)	2.550^{b}±0.005	2.110^{a}±0.005	2.720^{c}±0.005	2.860^{d}±0.005
% (TSAA)	3.180^{a}±0.005	3.410^{c}±0.005	3.280^{b}±0.005	3.190^{a}±0.005
% Cystine in TSAA	47.436^{b}±0.018	40.280^{a}±0.005	48.900^{d}±0.005	48.600^{c}±0.005
Total aromatic amino acid	6.723^{a}±1.666	6.640^{a}±0.005	8.570^{b}±0.003	9.703^{b}±0.005
% TArAA	10.470^{c}±0.005	10.260^{a}±0.005	10.310^{b}±0.005	10.830^{d}±0.005

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: 101= 100% acha; 102=75% acha 20% pigeon peas5% mushroom; 103= 70% acha, 20% pigeon peas, 10% mushroom; 104=65% acha, 20% pigeon peas, 15% mushroom.

are associated with lysine, thus supporting (32) and arginine (0.96%), having a role in insulin sensitivity in diabetic patients, as reported by (34). Essential sulfur amino acids such as methionine at 0.46% and cystine at 0.78% agree with (33) that help combat oxidative stress.

Despite this, these blends contain protein values below those seen in whole eggs; however, the blends have the correct amino acid composition, leading to a better-quality dietary protein. Consuming pulse-based proteins aids glycemic control of diabetes and muscle maintenance as they substitute animal proteins, including providing nutrient-dense options such as improved amino acid balance, enhanced digestibility, sustained nitrogen retention, and complementary proteins, which are in line with the dietary restrictions and health needs of diabetic patients (35). Plant proteins generally have lower saturated fat, supporting cardiovascular health, which is crucial for diabetics (36).

Table 8 presents the essential amino acid score of the breakfast cereal produced from blends of acha, pigeon pea, and oyster mushroom with reference to the (13) standard. The highest values for threonine (0.94%), isoleucine (1.29%), and leucine (1.33%) were recorded in sample 104, respectively, attributing to the inclusion of pigeon pea and oyster mushroom, which are rich in essential amino acids. These findings support the research by (37), that stated, cereal-legumes interactions for balanced amino acid profiling of foods.

Compared to the (13) reference standards, these

Table 7. Amino acid composition of cereal blends from acha, pigeon pea, and oyster mushroom with reference to whole egg standards

Amino acid	1O1 (%)	102 (%)	103 (%)	104 (%)
Leucine	$0.100^{a}\pm0.005$	$0.950^{b}\pm0.005$	$1.060^{c}\pm0.005$	$1.110^{d}\pm0.005$
Lysine	$0.560^{b}\pm0.005$	$0.530^{a}\pm0.005$	$0.600^{c}\pm0.005$	$0.700^{c}\pm0.005$
Isoleucine	$0.760^{b}\pm0.005$	$0.590^{a}\pm0.005$	$0.810^{c}\pm0.005$	$0.920^{d}\pm0.005$
Phenylamine	$0.900^{b}\pm0.000$	$0.730^{a}\pm0.005$	$0.940^{c}\pm0.008$	$1.030^{d}\pm0.005$
Valine	$0.520^{b}\pm0.005$	$0.450^{a}\pm0.005$	$0.570^{c}\pm0.005$	$0.630^{d}\pm0.005$
Methionine	$0.420^{b}\pm0.005$	$0.390^{a}\pm0.000$	$0.430^{a}\pm0.005$	$0.460^{c}\pm0.005$
Proline	$1.360^{b}\pm0.005$	$1.100^{a}\pm0.005$	$1.470^{c}\pm0.005$	$1.610^{d}\pm0.005$
Arginine	$0.790^{b}\pm0.005$	$0.580^{a}\pm0.005$	$0.820^{c}\pm0.005$	$0.960^{d}\pm0.005$
Histidine	$1.090^{b}\pm0.005$	$0.800^{a}\pm0.005$	$1.210^{c}\pm0.005$	$1.400^{d}\pm0.005$
Cystine	$0.680^{b}\pm0.005$	$0.470^{a}\pm0.008$	$0.740^{c}\pm0.005$	$0.780^{d}\pm0.005$
Alanine	$0.770^{b}\pm0.005$	$0.670^{a}\pm0.005$	$0.810^{c}\pm0.005$	$0.850^{d}\pm0.028$
Glutamic acid	$1.190^{b}\pm0.005$	$0.860^{a}\pm0.005$	$1.120^{c}\pm0.005$	$1.07^{d}\pm0.005$
Glycine	$1.190^{c}\pm0.005$	$0.840^{a}\pm0.005$	$1.070^{b}\pm0.005$	$1.290^{d}\pm0.005$
Threonine	$0.630^{b}\pm0.008$	$0.556^{a}\pm0.005$	$0.690^{c}\pm0.005$	$0.740^{d}\pm0.005$
Serine	$0.470^{b}\pm0.005$	$0.380^{a}\pm0.005$	$0.480^{b}\pm0.005$	$0.496^{b}\pm0.005$
Aspartic acid	$0.630^{b}\pm0.005$	$0.520^{a}\pm0.005$	$0.680^{c}\pm0.061$	$0.740^{d}\pm0.003$
Tyrosine	$0.950^{b}\pm0.005$	$0.730^{a}\pm0.005$	$0.950^{b}\pm0.005$	$1.120^{c}\pm0.005$

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: 101= 100% acha; 102=75% acha 20% pigeon peas5% mushroom; 103= 70% acha, 20% pigeon peas, 10% mushroom; 104=65% acha, 20% pigeon peas, 15% mushroom.

blends have lower values, but they have certain advantages for diabetic patients. Leucine is important for muscle protein synthesis and glucose metabolism, which are important for diabetics who are at risk of muscle protein loss (31). Lysine (0.80% in sample 104), aids immune function and enhances collagen formation, critical for wound healing in diabetic individuals. This agrees with findings by (38), that highlighted lysine's importance in improving immune response and tissue repair. Tryptophan (1.23% in sample 104) is crucial in diabetic aiding metabolic regulation, as reported by (39). Therefore, the present results show that cereal blends are functional, sustainable, and healthful substitutes for diabetic dietary control and dietary management.

Table 9 illustrates the protein quality of breakfast cereals made from various blends of acha,

Table 8. Essential amino acid score of the breakfast cereal produced from blends of acha, pigeon pea and oyster mushroom with reference to FAO/WHO (1973) standard

Amino acid	1O1 (%)	102 (%)	103 (%)	104 (%)
Threonine	0.810^{b}±0.005	0.720^{a}±0.005	0.880^{c}±0.005	0.940^{d}±0.005
Isoleucine	1.070^{b}±0.005	0.830^{a}±0.005	1.130^{c}±0.005	1.290^{d}±0.005
Leucine	1.190^{b}±0.000	1.130^{a}±0.005	1.270^{c}±0.008	1.330^{d}±0.005
Lysine	0.630^{b}±0.005	0.593^{a}±0.005	0.680^{c}±0.005	0.800^{d}±0.005
Sulphur Amino Acid (Met + Cystine)	0.730^{b}±0.005	0.6000^{a}±0.000	0.780^{c}±0.005	0.820^{d}±0.005
Total Aromatic amino acid (Pheny + Tyr +Try)	1.550^{c}±0.005	1.180^{b}±0.005	1.600^{c}±0.005	0.780^{a}±0.005
Tryptophane	0.920^{b}±0.005	0.790^{a}±0.005	1.050^{c}±0.005	1.230^{d}±0.005
Valine	0.780^{b}±0.005	0.670^{a}±0.005	0.850^{c}±0.005	0.900^{d}±0.005

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: 101= 100% acha; 102=75% acha 20% pigeon peas5% mushroom; 103= 70% acha, 20% pigeon peas, 10% mushroom; 104=65% acha, 20% pigeon peas, 15% mushroom.

Table 9. Protein quality of breakfast cereal produced from blends of acha, pigeon and oyster mushroom

Parameters	101 (%)	102 (%)	103 (%)	104 (%)
Predicted protein efficiency (P-PER)	2.930^{b}±0.005	2.820^{a}±0.005	3.180^{c}±0.005	3.290^{d}±0.005
Biological Value (B.V)	75.500^{b}±0.005	63.510^{a}±0.005	82.040^{c}±0.005	92.940^{d}±0.005
EEAI	0.800^{b}±0.005	0.690^{a}±0.005	0.860^{c}±0.005	0.960^{d}±0.005
% EEAI	80.000^{b}±0.000	69.000^{a}±0.005	86.000^{c}±0.008	96.000^{d}±0.005

Values are means ± standard deviation of triplicate determinations. Means with same superscripts in a row were not significantly different ($p > 0.05$). Key: 101= 100% acha; 102=75% acha 20% pigeon peas5% mushroom; 103= 70% acha, 20% pigeon peas, 10% mushroom; 104=65% acha, 20% pigeon peas, 15% mushroom.

pigeon pea, and oyster mushroom, which were evaluated using protein efficiency ratio (P.E.R.), biological value (B.V.), essential amino acid index (EAAI), and percentage of EAAI (% EAAI). The means with the same superscripts in a row were not significantly different ($p > 0.05$), while different superscripts (a, b, c, d) indicate that the values are significantly different. Protein efficiency ratio (P.E.R.) values range between 2.93 (101), 2.82 % (102), 3.18 % (103) and 3.29 % (104). The highest P.E.R. in sample 104 indicates the most efficient protein utilization, aligning with studies showing mushrooms' positive effects on protein efficiency due to their high-quality protein and balanced amino acid profile (16). The B.V. of the cereal blend ranged from 63.51% (102) to 92.94% (104). The higher B.V. (104), with the most oyster mushrooms, suggests enhanced quality (24). EAAI values range from 0.69% (102) to 0.96% (104). The highest EAAI in sample 104 confirms the superior amino acid profile of the blend with the highest oyster mushroom content. This supported findings that oyster mushroom fortification enhances food nutritional quality. The % EAAI ranges from 69.0% in sample 102 to 96.00% (104). This measure reflects the protein's adequacy for human dietary needs, with the highest % EAAI (104) corroborating the enhanced nutritional value provided by higher oyster mushroom content (16).

CONCLUSION

The amino acid composition analysis of breakfast cereals was made from blends of acha, pigeon pea, and oyster mushroom blend. According to results of this research, most of the parameters improved significantly, especially the sample 104, which contains the highest levels of leucine (9.31%), lysine (4.37%), and isoleucine (5.14%). These amino acids are vital for protein synthesis, muscle repair, and metabolic regulation and particularly beneficial for diabetic patients.

The blends also showed enhancements in arginine (5.85%) for insulin sensitivity and cystine (1.39%) for antioxidant defenses. Such compositions make these cereal blends promising functional foods for managing diabetes, supporting muscle maintenance, and promoting overall health. The addition of pigeon pea and oyster mushroom complements amino acid deficiencies in acha, offering a plant-based alternative with enhanced nutritional value. These findings strongly suggest that these blends are potentially sustainable and healthy dietary alternatives for diabetic people.

Conflict of Interest

There was no conflict of interest between the authors during the course of research work.

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Research Article / Araştırma Makalesi

Gaziantep ve Hatay ili yöresel yemeklerinin besin ögesi örüntü profillerinin farklı yöntemlerle değerlendirilmesi

Evaluation of nutrient profiling systems of local dishes of Gaziantep and Hatay provinces by different methods

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Özet

Bu çalışma, geleneksel Gaziantep ve Hatay mutfaklarındaki yöresel tariflerin beş farklı besin ögesi örüntü profiliyle objektif olarak değerlendirilmesi amacıyla yapılmıştır. Çalışmada NRF 9.3 modeli, FSA-Ofcom-WXY modeli, SAIN-LIM sistemi, NUTRI-SCORE ve Choices Program (Uluslararası Sağlıklı Seçimler Modeli) uygulanmıştır. Yedi yemek grubu başlığında Hatay mutfağından 48, Gaziantep mutfağından 46 tarif değerlendirilmiştir. NRF 9.3'e göre, Gaziantep iline ait yemek gruplarında en yüksek puanı mezeler-salatalar-piyazlar, en düşük puanı tatlılar - reçeller ve Hatay iline ait yemek gruplarında ise en yüksek puanı sebze yemekleri, en düşük puanı tatlılar-reçeller almıştır. FSA-Ofcom-WXY'e göre, tariflerin Gaziantep ili için %69,6'sı, Hatay ili için ise %77,1'i daha sağlıklı olarak tanımlanmıştır. SAIN-LIM'e göre; Gaziantep ili tariflerinin %36,9'u tercih edilebilir olarak tanımlanırken, bu oran Hatay ili tariflerinde %54,2'dir. NUTRI-SCORE'a göre; Gaziantep ve Hatay illerine ait farklı yemek tariflerinin sırasıyla %36,9 ve %54,2'si A, %19,6 ve %12,5'i B, %32,6 ve %18,7'si C, %10,9 ve %14,6'sı D kategorilerinde sınıflandırılmış, E kategorisinde tarif saptanmamıştır. Uluslararası Sağlıklı Seçimler modeline göre, Gaziantep ili et yemeklerinin %6,25'i, bulgurlu, pirinçli yemeklerin %37,5'i, meze, salata ve piyazların %66,7'si kriterlere uygun bulunmuş;

sebze yemekleri, çorbalar, tatlı-reçeller ve hamur işleri uygun bulunmamıştır. Hatay ili sebze yemeklerinin %80'i, bulgurlu, pirinçli yemeklerin %40'ı, meze, salata ve piyazların %8,3'ü, çorbaların %33,3'ü Uluslararası Sağlıklı Seçimler modelinin kriterlerine uygun olarak değerlendirilmiştir. Ancak et yemekleri, tatlı-reçeller ve hamur işleri kriterlere uygun değildir. Sonuç olarak; besin ögesi örüntü profilleri yemek tariflerinin değerlendirilmesi için bilimsel temelli araçlardır. Gaziantep ve Hatay illerine ait yöresel tarifler özellikle eklenmiş yağ, şeker, tuz, posa içeriği ve porsiyon büyüklüğü açısından ele alınmalı, tariflerde düzenlemeler yapılmalıdır.

Abstract

Introduction and Aim:

The globalizing world, developments in the field of science and technology, and an intense work tempo, particularly a lack of time dedicated to nutrition, collectively contribute to a societal shift towards a "fast food" style of nutrition. These types of foods are energy-dense, low in nutritional value, high in salt and saturated fat, and made by using unhealthy cooking methods. With the consumption of more energy-dense, ready-made products that replace the natural foods found in traditional cuisines, the incidence of chronic diseases such as obesity, diabetes, heart disease, hypertension, and cancer has been increased in society (1). It is widely acknowledged that nutrition-related non-communicable chronic diseases represent the most significant causes of mortality and morbidity worldwide. Nutrition-related chronic diseases account for approximately 60% of all deaths worldwide. It has been stated by the World Health Organization (WHO) that nutrients such as fat, saturated fatty acids, trans fatty acids, sugar, and salt/sodium consumed in excessive amounts from the diet are potential risk factors for development of chronic diseases (2). National and international strategies have been developed to reduce potential risk factors that are previously mentioned. The common objective of these strategies is to facilitate the selection of healthy foods in society, to direct society towards healthy food choices, and to raise consumer awareness in order to promote healthy food choices. In this regard, nutrient pattern plans or profiles are created to enable consumers to make healthy food choices and to clarify the term quality food. Nutrient patterning is the science of classifying or ranking foods according to their nutritional composition for the prevention of disease and promotion of health (3). Nutrient pattern profiles have been developed to assist consumers in food selection, to define the suitability of health claims of products, to ensure better and clearer nutritional labeling, and to evaluate nutritional quality (4). When local cuisines are considered in terms of nutrition and health, they are generally evaluated subjectively in line with healthy nutrition principles. The advent of various nutrient pattern profiles in recent years has facilitated objective evaluation of the nutritional value of foods and beverages. Therefore, this study aimed to objectively evaluate local dishes in Gaziantep and Hatay cuisine using five different nutritional element pattern profiles.

Material and Method:

It is acknowledged that the local dishes that comprise the Gaziantep and Hatay cuisine are not subjected to scientific evaluation in accordance with the principles of healthy nutrition. Instead, they are assessed solely from a gastronomic perspective, with consideration given to their nutritional and health implications. This study was conducted to objectively evaluate the local recipes in traditional Gaziantep and Hatay cuisines with five different nutritional element pattern profiles. In the study, the NRF 9.3 model (Nutrient Rich Foods), FSA-Ofcom-WXY model (Food Standards Agency-FSA), SAIN-LIM system (Two-score nutrient profiling system: score of nutritional adequacy of individual foods-SAIN); score of nutrients to be limited-LIM system), NUTRI-SCORE and Choices Program (International Healthy Choices Model, International Choices Programme) were applied. Under the heading of seven food groups, 48 recipes from Hatay cuisine and 46 recipes from Gaziantep cuisine were evaluated.

Distribution of local tariffs of Gaziantep and Hatay provinces according to their categories

Food Groups	Number of Dishes Included from Hatay Region	Number of Dishes Included from Gaziantep Region
Meat Foods	5	16
Vegetable Food	5	4
Dishes with Bulgur and Rice	5	8
Soaps	3	4
Appetizers and Salads	12	3
Pastries	9	5
Desserts and Jams	9	6
Total	**48**	**46**

The ingredients in each of the recipes of both cuisines were first converted into one serving. For this purpose, the amount included in one serving was calculated by dividing the total number of servings in the recipes. Using the amount of food in a portion, the macro and micronutrient contents of each recipe were calculated with the Nutrition Information Systems Package Program 7.2 (BEBİS 7.2) program. In order to calculate the amount of energy and nutrients content in a portion of the recipes from both cuisines, the parameters commonly used in all models were selected and the amount of salt not included in the standard recipe was calculated as 0.5 g per portion, based on the Turkey Nutrition and Health Survey (TBSA) 2017 (5). The nutritional values of the recipes were calculated using five different nutrient pattern profile models. These models are NRF 9.3, FSA-Ofcom-WXY, SAIN-LIM, NUTRI-SCORE, and International Healthy Choices Model (Choices Programme).

Results:

In accordance with the findings presented in the NRF 9.3 research report, the food groups within the Gaziantep province demonstrated a notable distinction in preference, with appetisers, salads, and spreads receiving the highest scores and desserts and jams receiving the lowest scores. Similarly, within the Hatay province, a clear contrast emerged, with vegetable dishes receiving the highest scores and desserts and jams receiving the lowest scores. The FSA-Ofcom-WXY model indicates that 69.6% of local recipes in Gaziantep and 77.1% in Hatay were classified as healthier. According to the SAIN-LIM model, while 36.9% of local tariffs in Gaziantep were defined as preferable, this rises to 54.2% in Hatay province's local tariffs. A comparative analysis of the various meal tariffs in the Gaziantep and Hatay provinces revealed that 36.9% and 54.2% were classified as A, respectively, while the corresponding figures for category B were 19.6% and 12.5%. Additionally, 32.6% and 18.7% were assigned to category C, and only 10.9% and 14.6% were identified in categories D and E, respectively. According to the International Healthy Choices model, 6.25% of meat dishes, 37.5% of bulgur and rice dishes, and 66.7% of appetizers, salads, and blarneys in Gaziantep were found to meet the criteria. However, vegetable dishes, soups, desserts, jams, and pastries were not suitable. In Hatay province, 80% of vegetable dishes, 40% of bulgur and rice dishes, 8.3% of appetizers, salads, and blarneys, and 33.3% of soups were evaluated in accordance with the criteria of the International Healthy Choices model. However, meat dishes, desserts, jams, and pastries did not meet the criteria.

Discussion and Conclusion:

Local cuisines have been measured and evaluated based on their unique structures, taste, and diversity, as well as their contribution to the nutrition of societies. The cuisines of Gaziantep and Hatay are two traditional cuisines that occupy a significant position within the local culinary landscape, shaped by the distinctive cultural heritage of their respective regions. They have been recognised by the UNESCO Creative Cities Network list for their cultural significance and contribution to global gastronomy (6). Nutrient pattern profiles are scientifically based tools for evaluating food recipes. When the local recipes of Gaziantep and Hatay provinces are evaluated with their nutritional element pattern profiles, the rate of recipes that can be considered healthy choices are high in the groups of vegetable dishes, appetizers-salads-piyazes, soups, and dishes with bulgur and rice. It was found that the rate of recipes that can be considered healthy choices was low in the meat dishes, pastries, and desserts-jams groups. The main reasons are thought to be the high content of saturated fatty acids due to the amount of salt and animal food used in the recipes of the specified groups, as well as the fact that even one portion value is high in quantity. While the local recipes from both provinces were found to be adequate in terms of the five-nutrient profile used in this study and the content of the recommended nutrients, it was also highlighted that there were instances where these recommended nutrients were present in excess. In order to make the contents of the local recipes of Gaziantep and Hatay provinces healthier in the light of scientific recommendations, it is thought that it would be appropriate to re-evaluate the recipes in terms of the sources and portion sizes of the nutrients recommended to be restricted.

GİRİŞ VE AMAÇ

Küreselleşen dünya ile birlikte bilim ve teknoloji alanındaki gelişmeler, yoğun çalışma temposu özellikle beslenmeye ayrılan zamanı kısıtlayarak toplumu "fastfood (hazır yemek)" tarzı beslenmeye yönlendirmektedir. Bu tarz yiyecekler genellikle enerjisi yoğun, besleyici değeri düşük, tuz ve şeker oranı yüksek ve sağlıksız pişirme yöntemlerinin kullanıldığı yiyeceklerdir. Geleneksel mutfaklarda bulunan doğal besinlerin yerini alan daha yüksek enerjili,

hazır ürünlerin tüketimiyle toplumda obezite, diyabet, kalp hastalıkları, hipertansiyon ve kanser gibi kronik hastalıkların görülme oranı artmıştır. Özellikle sebze ve meyve tüketimine dayalı beslenme şekli olan Akdeniz mutfağı kültürünün yerine batı toplumlarının etkilerinin görülmeye başlandığı Türk mutfağında doymuş yağ tüketiminin artması bu hastalıkların görülme sıklığını arttırmıştır. Değişen hayat şartlarına rağmen öğün düzeni ve besin tercihleri konusunda sağlıklı seçimlerin yapılması hem sağlık durumunu iyileştirmede hem de hastalıklara yakalanma riskinin azaltılmasında anahtar rol oynamaktadır (1).

Beslenmeye bağlı bulaşıcı olmayan kronik hastalıkların dünya genelinde en önemli mortalite (dünya genelinde meydana gelen ölümlerin ortalama %60'ı) ve morbidite nedeni olduğu bilinmektedir. Beslenme kaynaklı fazla miktarlarda tüketilen yağ, trans yağ asitleri, doymuş yağ asitleri, tuz/sodyum, şeker gibi besin ögelerinin kronik hastalıkların oluşumunda ve gelişiminde potansiyel risk faktörü olduğu Dünya Sağlık Örgütü (WHO) tarafından belirtilmiştir (2). Kronik hastalıkların gelişimindeki potansiyel risk etmenlerini azaltmak için geliştirilmiş olan ulusal ve uluslararası stratejiler bulunmaktadır. Bu stratejilerdeki ortak amaç; toplumu sağlıklı besin seçimine yönlendirmek, toplumda sağlıklı besin seçimini kolaylaştırmak ve sağlıklı besin seçiminin teşviki için tüketicinin bilinçlenmesini sağlamaktır. Bu doğrultuda tüketicilerin sağlıklı besin seçimi yapabilmelerini sağlamak ve kaliteli besin terimini netleştirmek için besin ögesi örüntü planları ya da profilleri oluşturulmaktadır (3).

Besin ögesi örüntüsü, hastalıkların önlenmesi ve sağlığın geliştirilmesi için besinlerin besin ögeleri bileşimine göre sınıflanma veya derecelendirme bilimidir (3). Besin ögesi örüntü profili, çocuklara besinlerin pazarlanması, sağlık ve beslenme beyanlarının yapılması, ürünleri sembol veya logo ile etiketlenmesi, bireylerin sağlıklı beslenme ile ilgili bilgilendirilmesi ve eğitilmesi, tüketicilerin sağlıklı ve amaca uygun besin seçimine rehberlik edilmesi, sağlıklı bir diyetin nasıl olabileceğinin tanımlanması, tüketilen yemeğin besin ögesi örüntüsünün belirlenmesi, menülerin değerlendirilmesi, yeni ürün geliştirilmesi ve eski ürünün revize edilmesi, kamu kuruluşlarına besin tedarik edilmesi ve besin tüketiminin yönlendirilmesinde ekonomik araçların kullanılması dahil birçok uygulamada ve ulusal otoriteler tarafından toplum sağlığı beslenme hedeflerinin geliştirilmesi amacıyla kullanılabilmektedir (4).

Yöresel mutfaklar beslenme ve sağlık açısından ele alındıklarında genellikle sağlıklı beslenme ilkeleri doğrultusunda subjektif olarak değerlendirilmiştir. Son yıllarda geliştirilen çeşitli besin ögesi örüntü profilleri, yiyecek ve içeceklerin besin değerlerinin objektif olarak değerlendirilmesine olanak sağlamaktadır. Bu nedenle, bu çalışmada Gaziantep ve Hatay mutfağında yer alan yöresel yemeklerin beş farklı besin ögesi örüntü profili kullanılarak objektif olarak değerlendirilmesi amaçlanmıştır.

MATERYAL VE METOT

Araştırma Yeri, Zamanı ve Örneklem Seçimi

Bu çalışmanın örneklemini Hatay mutfağı ve Gaziantep mutfaklarına ait standart tarifler oluşturmaktadır. Veri toplama işlemi Ekim 2019 – Ağustos 2020, verilerin değerlendirilmesi Ekim 2020 – Ağustos 2021 tarihleri arasında gerçekleştirilmiştir. Çalışmanın evrenini Gaziantep ve Hatay ili yöresel yemek tarifleri oluşturmuştur. Bu çalışmada yöresel olarak yapılan ve menşei Gaziantep ve Hatay'a ait olan toplam 94 yöresel yemeğe yer verilmiştir. Hatay mutfağına ait tarifler T.C. Hatay Valiliği Yayını olan "Hatay Mutfak Kültürü ve Yemekleri" (6), Hatay Keşif Yayınları yayını olan ''Çok Kültürlü Bir Geleneğin Mutfağı Antakya Yemekleri'' (7) ve ''Antakya Mutfağı'' (8) kitaplarından alınmış olup; toplam 48 tariftir. Gaziantep mutfağına ait tarifler Yapı Kredi Yayını olan *"Güneşin ve Ateşin Tadı: Gaziantep Mutfağı*" (9) ve YCM Yayınları yayını olan *''Dört Mevsim Gaziantep Yemekleri''* (10) kitaplarından alınmış olup; toplam 46 tariftir. Menşei Gaziantep veya Hatay olmayan, özellikle civar şehirlerden etkilenerek bu iki ilin mutfağında yer almış yemekler kapsama dâhil edilmemiştir.

Hatay mutfağında ve Gaziantep mutfağında yer alan yemeklerin kategorilerine göre dağılımları Tablo 1.'de verilmiştir.

Araştırmanın Genel Planı

Tablo 1.'de yemek türlerine göre dağılımları verilen toplam 94 adet yemeğe ait tarif üzerinden bir porsiyon miktarları hesaplanarak veri toplama ve analiz işlemleri yapılmıştır. Bir porsiyona giren miktar hesaplamaları tariflerde yer alan toplam porsiyon sayısına bölünerek hesaplanmıştır. Bir porsiyona giren yiyecek miktarları kullanılarak her tarifin makro ve mikro besin ögesi içerikleri Beslenme Bilgi Sistemleri Paket Programı 7.2 (BEBİS 7.2) programı ile hesaplanmıştır.

Her iki mutfağa ait tariflerde bir porsiyona giren miktar hesaplamaları yapılırken; analizi yapılacak parametreler tüm modellerde kullanılan enerji ve besin ögelerini kapsayacak şekilde seçilmiş ve standart tarifte yer verilmemiş tuz miktarları için Türkiye Beslenme ve Sağlık Araştırması (TBSA) 2017 baz alınarak porsiyon başına 0.5 g olarak hesaplanmıştır (11). Tariflerin besin değerleri, beş farklı besin ögesi örüntü profili modeli kullanılarak hesaplanmıştır. Bu modeller NRF 9.3, FSA-Ofcom-WXY, SAIN-LIM, NUTRI-SCORE ve Uluslararası Sağlıklı Seçimler Modeli (Choices Programme)'dir. Kıyaslama yapılan besin ögesi örüntü profili için miktarı analiz edilen parametreler Tablo 2.'de verilmiştir.

NRF 9.3 Besin öğesi örüntü plan/profili modelinin değerlendirilmesi (Besin Ögesi İçeriği Zengin Besin- Nutrient Rich Food, NRF)

NRF 9.3 algoritması, tüketilmesi istenilen 9 besin ögesi (protein, posa, C vitamini, E vitamini, A vitamini, demir, kalsiyum, potasyum ve magnezyum) ile sınırlandırılması önerilen 3 besin ögesi (doymuş yağ, eklenmiş şeker ve sodyum) temel alınarak oluşturulmuştur (18). Değerlendirmede bilim adamları tarafından geliştirilen, sürekli fonksiyon içeren algoritma kullanılmaktadır. Bu algoritmada pozitif alt skordan (tüketilmesi istenilen besin ögeleri), negatif alt skor (sınırlandırılması önerilen besin ögeleri) çıkarılmaktadır. Elde edilen yüksek NRF 9.3 puanı daha sağlıklı içerik anlamına gelirken, düşük NRF 9.3 skoru sınırlandırılması önerilen besin ögelerinin fazlalığına işaret eder ve daha az sağlıklı içerik anlamına gelmektedir. Bu modelin hesaplamasında besinler 100 kkal ve porsiyon miktarı başına besin ögesi içeriklerine göre değerlendirilmiştir (19).

FSA-Ofcom-WXY Besin ögesi örüntü planı/ profili modelinin değerlendirilmesi (İngiltere Besin Standartları Ajansı- Food Standards Agency, FSA)

FSA-Ofcom-WXY modeli basit bir skorlama sistemine sahiptir. Bu model belirlenen her bir besin ögesi eşik değeri içeriğine göre her bir besine skor verir. Sonrasında elde edilen skorlar birbirinden çıkarılarak en son skor elde edilir. Bu hesaplama için kullanılan enerji değeri birimi "kJ"dur. Bu modelde yiyecek ve içeceklerin besin ögesi içeriğine 100 g miktarları üzerinden puan verilmektedir. Yiyecek ve içeceklerin alacağı toplam puan sırasıyla A puanı, C puanı ve toplam puan olmak üzere 3 aşamada hesaplanmaktadır (20). Sonuçta; bir besin "toplam puan" olarak 4 veya daha fazla puan aldıysa ve bir içecek 1 puan veya daha fazla puan aldıysa daha az sağlıklı kabul edilmektedir (21).

Tablo 1. Gaziantep ve Hatay illerine ait yöresel tariflerin kategorilerine göre dağılımları

Yemek Grupları	Hatay Yöresinden Dâhil Edilen Yemek Sayısı	Gaziantep Yöresinden Dâhil Edilen Yemek Sayısı
Et Yemekleri	5	16
Sebze Yemekleri	5	4
Bulgurlu, Pirinçli Yemekler	5	8
Çorbalar	3	4
Mezeler, Salatalar ve Piyazlar	12	3
Hamur İşleri	9	5
Tatlı ve Reçeller	9	6
Toplam	**48**	**46**

SAIN-LIM Besin öğesi örüntü plan/profili modelinin değerlendirilmesi (Fransız Besin Standartları Ajansı - AFSSA)

SAIN skoru 5 pozitif besin ögesi (protein, posa, askorbik asit, kalsiyum ve demir) için ağırlıklı aritmetik ortalamanın eşitliğinin yüzdesi olarak hesaplanmaktadır. Bir opsiyonel besin ögesi (D vitamini, alfa linolenik asit veya E vitamini) de bu denkleme eklenebilmektedir. Skor tabanı besinlerin 100 kkal'lik değerleri için hesaplanmaktadır (15). LIM skoru ise sağlıklı bir diyette alımları sınırlandırılması gerekli olan üç besin ögesi (sodyum, eklenmiş şeker ve doymuş yağ asitleri) için maksimum önerilen 100 g'lık değerlerin ortalamalarının yüzdesidir (22).

SAIN-LIM hesaplaması sonucu ortaya çıkan SAIN skoru *(besinlerin beslenme yeterliliği skoru-score of nutritional adequacy of individual foods)* ve LIM *(sınırlandırılması gereken besin ögeleri skoru-score of nutrients to be limited)* skorlarına göre dört ayrı sınıf oluşmak2tadır.

- Sınıf 1 (en çok uygun – tercih edilebilir profil): Yüksek SAIN ve düşük LIM (SAIN ≥5 ve LIM<7,5),
- Sınıf 2: Düşük SAIN, düşük LIM (SAIN <5 ve LIM <7,5),
- Sınıf 3: Yüksek SAIN, yüksek LIM (SAIN ≥5 ve LIM ≥7,5),
- Sınıf 4 (en az uygun profil): Düşük SAIN, Yüksek LIM (SAIN<5 ve LIM>7,5) ifade etmektedir.

Sınıf 1 ve Sınıf 2 grupta yer alan besin grupları tüketilmesi önerilen besin gruplarını ifade ederken, Sınıf 3 ve Sınıf 4 grupta yer alan besin grupları sınırlı tüketilmesi gereken besin gruplarını ifade etmektedir (23).

Tablo 2. Besin ögesi örüntü profilleri ve özellikleri

NRF 9.3 (12,13)	**FSA-Ofcom-WXY (14)**	**SAIN-LIM (15)**	**NUTRI-SCORE (16)**	**Choices Programme (17)**
-	Enerji (kJ)	-	Enerji (kJ)	Enerji (kJ)
Protein (g)	Protein (g)	Protein (g)	Protein (g)	-
Posa (g)	NSP* posa (g) veya AOAC** posa (g)	Posa (g)	Lifler (g)	Posa (g)
Doymuş yağ (g)	Doymuş yağ (g)	Doymuş yağ (g)	Doymuş yağ (g)	Doymuş yağ (g)
-	-	-	-	Trans yağ (g)
-	-	α-linolenik asit	-	-
Sodyum (mg)	Sodyum (mg)	Sodyum (mg)	Sodyum (mg)	Sodyum (mg)
Eklenmiş şeker (g)	Toplam şeker (g)	Eklenmiş şeker (g)	Toplam şeker (g)	Eklenmiş şeker (g)
A vitamini (IU)	-	-	-	-
C vitamini (mg)	-	C vitamini (mg)	-	-
E vitamini (IU, mg)	-	E vitamini (IU)	-	-
		D vitamini (IU)	-	-
Demir (mg)	-	Demir (mg)	-	-
Kalsiyum (mg)	-	Kalsiyum (mg)	-	-
Potasyum (mg)	-	-		
Magnezyum (mg)	-	-	-	-
-	Meyve-sebze-kuruyemiş (%)		Meyve-sebze-kurubaklagil-sert kabuklu yemişler (%)	

**NSP: Nişasta Olmayan Polisakkarit*

***AOAC: Sindirilemeyen Polisakkarit (American Association of Analytical Chemists)*

NUTRI-SCORE modelinin değerlendirilmesi (French National Institute for Health and Medical Research -INSERM)

Besin Standartları Acentesi besin profili sistemi (FSAm-NPS), 100 g besin (ya da 100 mL içecek) için nütrisyonel bileşim temelinde, enerji (kJ), toplam şekerler (g), SFA (g) ve sodyum'un (mg) dâhil olduğu kısıtlanması gereken elemanlardaki miktara her biri için 0 ile 10 arasında olmak üzere pozitif puanlar vermektedir. Daha sonra, meyveler, sebzeler, baklagiller ve sert kabuklu yemişler (%), lifler (g) ve proteinin (g) dâhil olduğu artırılması gereken elemanlardaki miktarlara, her biri için 0 ile 5 arasında olmak üzere negatif puanlar vermektedir. Negatif puanlar pozitif puanlara eklenerek -15'ten (yüksek nutrisyonel kaliteye sahip ürünler için)

Tablo 3. Choices Program-Uluslararası Sağlıklı Seçimler Modeli Eşik Değerleri (24)

Temel Ürün Grupları İçin Kriterler		
Ürün Grubu	**Kriterler**	**Tanımlar**
Meyve ve Sebzeler		
İşlenmiş ve kurutulmuş meyveler ve sebzeler	SAFA: ≤1,1 g/100 g TFA: ≤0,1 g/100 g Sodyum: ≤100 mg/100 g Eklenmiş şeker: - (eklenmez) Toplam şeker: ≤10,0 g/100 g (sebzeler) veya Toplam şeker: ≤17,0 g/100 g (meyve) Posa: ≥1,0 g/100 g*	Meyve ve sebze suları ile dondurulmuş veya önceden dilimlenmiş meyve ve sebzeler hariç olmak üzere, ileri işleme tabi tutulmuş her türlü işlenmiş meyve ve sebze
Ana Yemekler		
Ana yemekler***	SAFA: ≤2,0 g/100 g TFA: ≤0,15 g/100 g Sodyum: ≤240 mg/100 g Eklenmiş şeker: ≤3,0 g/100 g Toplam şeker: ≤5,0 g/100 g Posa ≥1,2 g/100 g Enerji: ≤600 kkal/porsiyon	Her biri ürünün %70'inden fazlasını oluşturmayan iki veya daha fazla bileşenden oluşan kahvaltı, öğle veya akşam yemeklerinde tüketilen tüm yemekler.
Çorbalar* **	SAFA: ≤1,1 g/100 g TFA: ≤0,1 g/100 g Sodyum: ≤250 mg/100 g Eklenmiş şeker: ≤1,5 g/100 g Toplam şeker: ≤4,0 g/100 g Enerji: ≤100 kkal/100 g	Bir yemek, başlangıç veya atıştırmalık olarak kullanılmak üzere tüm müstahzarlarda özellikle temel olarak et, balık veya sebze suyu içeren ve genellikle katı gıda parçaları içeren sıvı bir gıda: yemeye hazır, soğutulmuş, konserve, dondurulmuş, toz haline getirilmiş (hazırlandığı gibi değerlendirilir).
Yardımcı (Temel Olmayan) Gıda Grupları İçin Kriterler		
Tatlı atıştırmalıklar	SAFA: ≤6,0 g/100 g TFA: ≤0,4 g/100 g Sodyum: ≤200 mg/100 g Eklenmiş şeker: ≤20 g/100 g Toplam şeker: ≤20 g/100 g Enerji: ≤110 kkal/porsiyon	Öğünler arasında veya bir öğünün küçük bir bileşeni olarak tüketilen tatlı bir tada sahip bir ürün.
Diğer tüm ürünler	SAFA: ≤1,1 g/100 g veya ≤%10 enerji TFA: ≤0,1 g/100 g veya ≤%1,0 enerji Sodyum: ≤100 mg/100 g Eklenmiş şeker: ≤2,5 g/100 g veya ≤%10 enerji	Kategorize edilmiş ürün gruplarından herhangi birine girmeyen her türlü gıda ürünü

+40 puana (düşük nutrisyonel kaliteye sahip ürünler için) değişen ayrı bir toplam puan elde edilmektedir.

En sonunda; her bir besinin Nutri-Score hesaplanması için;

- "A" – 1 puan altı (koyu yeşil),
- "B" 0 - 2 puan (açık yeşil),
- "C" 3 - 10 puan arası (sarı),
- "D" 11 - 18 puan arası (açık turuncu) ve
- "E" 19 puan veya daha yüksek (koyu turuncu) olacak şekilde eşikler uygulanmaktadır.

İçecekler için ise eşikler;

- "A" yalnızca su için geçerli (koyu yeşil),
- "B" 1 puana kadar (açık yeşil),
- "C" 2 - 5 puan arası (sarı),
- "D" 6 - 9 puan arası (açık turuncu) ve
- "E" 10 puan üzeri (koyu turuncu) şeklindedir (11).

Choices Program-Uluslararası Sağlıklı Seçimler Modelinin Değerlendirilmesi (Choices Programme - Choices International Foundation)

Uluslararası Sağlıklı Seçimler Modeli kategorilere özgü eşik değerine göre hesaplama yapılan bir besin ögesi örüntü modelidir. Bu model belirlenmiş besin kategorileri için enerji, doymuş yağ, trans yağ, posa, eklenmiş şeker ve sodyum değerleri için eşik değerler sunmaktadır. Tablo 3.'te makale konusu ile ilintili ürün grupları ve eşik değerleri seçilerek verilmiştir (Tablo 3). Uluslararası Sağlıklı Seçimler örüntü profilinde hesaplamalar besinin 100 g değeri üzerinden yapılmaktadır (24).

Verilerin Değerlendirilmesi

Tariflerin enerji ve besin ögesi içerikleri Beslenme Bilgi Sistemleri Paket Programı 7.2 (BEBİS 7.2) analiz edilip, algoritmalar ile gerekli hesaplamalar yapıldıktan sonra elde edilen veriler SPSS (Statical Package for Social Sciences) for Windows 21.0 programı ile analiz edilmiştir.

Veriler parametrik dağılım gösterdiğinde ortalama-standart sapma şeklinde; parametrik dağılım göstermediğinde ise ortanca (minimum-maksimum) olarak verilmiş ve/veya grafik şeklinde sunulmuştur. Değerler parametrik hipotez testi kriterlerini karşılıyor ise iki ortalama arasındaki farkın anlamlılık testi, karşılamıyorsa Mann Whitney U testi ile değerlendirilmiştir. Bu test aşaması sırasında 0.05 yanılma düzeyi ile güven aralığı %95 olarak belirlenmiştir.

Çalışma kapsamında Gaziantep ve Hatay illerine ait yöresel tariflerin Uluslararası Sağlıklı Seçimler Modeline (Choices Programme) göre değerlendirilmesi yapılırken; et yemekleri, sebze yemekleri, bulgurlu, pirinçli yemekler grupları ana yemekler (main meals) kategorisine; çorbalar grubu çorbalar (soups) kategorisine; mezeler, salatalar ve piyazlar grubu işlenmiş ve/veya kurutulmuş meyveler ve sebzeler (processed and dried fruits and vegetables) kategorisine; tatlı ve reçeller grubu tatlı atıştımalıklar (sweet snacks) kategorisine; hamur işleri grubu diğer tüm ürünler (all other foods) kategorisine dâhil edilerek değerlendirilmiştir (24). Her iki ile ait yöresel tariflerin içerikleri, analiz için kullanılan programda standart tarifler içerisinde yer almadığı ve manuel olarak içerik tanımlaması yapıldığı için bu tariflerin değerlendirmesinde trans yağ asidi değerleri hesaba katılmamıştır.

BULGULAR

Gaziantep iline ait yöresel tariflerin NRF 9.3 besin ögesi örüntü profili hesaplamalarında en düşük NRF 9.3 puanını bastık (-14,14) alırken; en yüksek NRF 9.3 puanını Antep salatası (39,28) almıştır. Hatay iline ait yöresel tariflerin NRF 9.3 besin ögesi örüntü profili hesaplamalarında en düşük NRF 9.3 puanını patlıcan reçeli (-15,01) alırken; en yüksek NRF 9.3 puanını ıspanak boraniye (13,55) almıştır (Tablo 4).

Gaziantep iline ait yöresel tariflerin FSA-Ofcom-WXY besin ögesi örüntü profili hesaplamalarında en düşük FSA-Ofcom-WXY puanını maş çorbası ve maş piyazı (-9,00) alırken; en yüksek FSA-Ofcom-WXY puanını lebeniye çorbası ve bastık (14,00) almıştır. Hatay iline ait yöresel tariflerin FSA-Ofcom-WXY besin ögesi örüntü profili hesaplamalarında en düşük

FSA-Ofcom-WXY puanını öcce (mücver) (-10,00) alırken; en yüksek FSA-Ofcom-WXY puanını ceviz reçeli (13,00) almıştır. Gaziantep ve Hatay illerine ait farklı yemek gruplarında yer alan yöresel tariflerin FSA Ofcom-WXY modeline sağlıklı olma durumu değerlendirilmiş, aldıkları puanlarla 'daha az sağlıklı' ve 'daha sağlıklı' olarak sınıflandırılmıştır. Değerlendirmeye alınan 46 Gaziantep ili yöresel tarifin %69,6'sı daha sağlıklı olarak değerlendirilirken, %30,4'ü daha az sağlıklı olarak; değerlendirmeye alınan 48 Hatay ili yöresel tarifin %77,1'i daha sağlıklı olarak değerlendirilirken, %22,9'u daha az sağlıklı olarak sınıflandırılmıştır (Tablo 5).

Tablo 4. Gaziantep ve Hatay illerine ait yöresel tariflerin bir porsiyonlarına ait NRF 9.3. besin ögesi örüntü profili puanları

Gaziantep İline Ait Yöresel Tarifler	**NRF 9,3 Puanı**	**Hatay İline Ait Yöresel Tarifler**	**NRF 9,3 Puanı**
Et Yemekleri		**Et Yemekleri**	
Akıtmalı Ufak Köfte	2,14	Antakya Usulü Döner	-1,91
Alenazik (Alinazik)	-6,32	Aşur (Aşir)	1,30
Ayvalı Ekşili Taraklık Tavası	-3,21	Belen Tavası	2,44
Beyran	-1,39	Kâğıt Kebabı	1,53
Cacıklı Arap Köfte	1,40	Tepsi Kebabı	2,78
Ciğer (Cağırtlak) Kebabı	10,56		
Ekşili Ufak Köfte	2,14		
İçli Köfte (Oruk)	0,97		
Lahmacun	6,54		
Malhıtalı Köfte	-0,02		
Omaç	0,09		
Patlıcan Kebabı	6,04		
Simit Kebabı	-2,52		
Soğan Kebabı	-6,59		
Yağlı Köfte	-0,15		
Yenidünya Kebabı	-2,21		
Sebze Yemekleri		**Sebze Yemekleri**	
Borani	12,66	Ispanak Boraniye	13,55
Erik Tavası	-5,61	Kabak Boraniye	6,84
Öcce (Mücver)	3,89	Öcce (Mücver)	12,41
Pirpirim Aşı	8,14	Şıh Mualle	5,28
		Şıh-ıl Mıhşi	8,25
Bulgurlu, Pirinçli Yemekler		**Bulgurlu, Pirinçli Yemekler**	
Çağla Aşı	-0,95	Firikli Aş	-3,03
Firik Pilavı	0,11	Mütebli	2,03
Firikli Acur Dolması	2,01	Oruk (İçli Köfte)	-0,48
Karışık Dolma	3,84	Sıraysil	1,89
Şiveydiz	3,17	Tepsi Oruğu	2,82
Yoğurtlu Dövme Çorbası	-10,28		
Yoğurtlu Patates	-2,38		

Yuvarlama	-2,68		
Çorbalar		**Çorbalar**	
Börek Çorbası	-3,23	Kumbursiye	3,66
Lebeniye Çorbası	-7,05	Toğga Çorbası	9,02
Maş Çorbası	7,92	Tuzlu Yoğurt Çorbası	-2,72
Öz Çorbası	-4,18		
Mezeler, Salatalar, Piyazlar		**Mezeler, Salatalar, Piyazlar**	
Antep Salatası	39,28	Abugannuş	10,27
Maş Piyazı	13,04	Alenazik (Alinazik)	-8,97
Muhammara	-0,57	Bakla Ezmesi	5,11
		Cevizli Biber	7,43
		Humus	2,14
		Patlıcan Yoğurtlama	-2,70
		Tahinli Tarator	2,72
		Taze Çökelek Salatası	5,45
		Taze Sürk Salatası	5,79
		Zahter Salatası	4,59
		Zengin	0,78
		Zeytin Öfelemesi	-3,36
Hamur İşleri		**Hamur İşleri**	
Antep Kahkesi	-2,77	Biberli Ekmek	-2,02
Nohut Dürüm	3,46	Ispanaklı Börek	5,30
Pirinçli Börek	-2,48	Katıklı Ekmek	-0,37
Şekerli Peynir Böreği	-6,33	Kaytaz Böreği	1,13
Zeytin Böreği	-3,56	Kerebiç	-1,15
		Kete	-2,36
		Kömbe	-4,73
		Külçe	0,65
		Semirsek	1,32
Tatlılar, Reçeller		**Tatlılar, Reçeller**	
Astarlı Sütlaç	-5,86	Ceviz Reçeli	-12,59
Aşure (Aşir)	-5,76	Cevizli Taş Kadayıf	-8,05
Baklava	-7,17	Haytalı	-8,26
Bastık	-14,14	Kabak Tatlısı	-14,68
Katmer	-5,95	Kebbet Reçeli	-14,98
Zerde	-7,11	Künefe	-8,75
		Patlıcan Reçeli	-15,01
		Peynirli İrmik Helvası	-9,76

Gaziantep ve Hatay illerine ait yöresel tarifler SAIN-LIM modeline göre değerlendirildiğinde Gaziantep iline ait 46 yöresel tarifin %36,9'u Sınıf 1, %34,8'i Sınıf 3, %28,3'ü Sınıf 4 olarak değerlendirilmiştir. Gaziantep iline ait yöresel tarifler içerisinde Sınıf 2 grubuna ait tarif bulunmamaktadır. Hatay iline ait 48 yöresel tarifin ise %43,8'i Sınıf 1, %10,4'ü Sınıf 2, %8,3'ü Sınıf 3 ve %37,5'i Sınıf 4 olarak değerlendirilmiştir (Tablo 6).

SAIN-LIM modeline göre Gaziantep iline ait yöresel tariflerden akıtmalı ufak köfte, ekşili ufak köfte, içli köfte (oruk), omaç, patlıcan kebabı, yenidünya kebabı, borani, çağla aşı, firik pilavı, firikli acur dolması, karışık dolma, şiveydiz, maş çorbası, öz çorbası, Antep salatası, maş piyazı ve nohut dürüm tüketilmesi önerilen tarifler (Sınıf 1 ve Sınıf 2) olarak tanımlanırken; alenazik (alinazik), ayvalı ekşili taraklık tavası, beyran, cacıklı arap köfte, ciğer (cağırtlak kebabı), lahmacun, malhıtalı köfte, simit kebabı, soğan kebabı, yağlı köfte, erik tavası, öcce (mücver), pirpirim aşı, yoğurtlu dövme çorbası, yoğurtlu patates, yuvarlama, börek çorbası, lebeniye çorbası, muhammara, Antep kahkesi, pirinçli börek, şekerli peynir böreği, zeytin böreği, astarlı sütlaç, aşure (aşir), baklava, bastık, katmer ve zerde sınırlı tüketilmesi gereken tarifler (Sınıf 3 ve Sınıf 4) olarak tanımlanmıştır.

Hatay iline ait yöresel tarifler ise SAIN-LIM modeline göre aşur (aşir), tepsi kebabı, ıspanak boraniye, kabak boraniye, öcce (mücver), şıh mualle, şıh-ıl mıhşi, mütebli, siraysil, tepsi oruğu, kumbursiye, toğga çorbası, abugannuş, bakla ezmesi, cevizli biber, humus, patlıcan yoğurtlama, tahinli tarator, taze çökelek salatası, taze sürk salatası, zahter salatası, zengin, ıspanaklı börek, kaytaz böreği, külçe ve semirsek tüketilmesi önerilen tarifler (Sınıf 1 ve Sınıf 2) olarak tanımlanırken; Antakya usulü döner, belen tavası, kağıt kebabı, firikli aş, oruk (içli köfte), tuzlu yoğurt çorbası, alenazik (alinazik), zeytin öfelemesi, biberli ekmek, katıklı ekmek, kerebiç, kete, kömbe, ceviz reçeli, cevizli taş kadayıf, haytalı, kabak tatlısı, kebbet reçeli, künefe, patlıcan reçeli, peynirli irmik helvası ve şam tatlısı sınırlı tüketilmesi gereken tarifler (Sınıf 3 ve Sınıf 4) olarak tanımlanmıştır.

Tablo 5. Gaziantep ve Hatay illerine ait farklı yemek gruplarında yer alan yöresel tariflerin FSA-Ofcom-WXY modeline göre sağlıklı olma durumları

		Gaziantep Yöresel Yemekleri		Hatay Yöresel Yemekleri	
Yemek Grubu		**Daha sağlıklı**	**Daha az sağlıklı**	**Daha sağlıklı**	**Daha az sağlıklı**
Et yemekleri	**n**	12	4	5	0
	%	75	25	100	0
Sebze Yemekleri	**n**	4	0	5	0
	%	100	0	100	0
Bulgurlu, Pirinçli Yemekler	**n**	7	1	5	0
	%	87,5	12,5	100	0
Çorbalar	**n**	3	1	3	0
	%	75	25	100	0
Mezeler, Salatalar, Piyazlar	**n**	3	0	11	1
	%	100	0	91,7	8,3
Hamur İşleri	**n**	2	3	7	2
	%	40	60	77,8	22,2
Tatlılar ve Reçeller	**n**	1	5	1	8
	%	16,7	83,3	11,1	88,9
Toplam	**n**	**32**	**14**	**37**	**11**
	%	**69,6**	**30,4**	**77,1**	**22,9**

Tablo 6. Gaziantep ve Hatay illerine ait farklı yemek gruplarında yer alan yöresel tariflerin SAIN-LIM modeli sınıflandırmasına göre değerlendirilmesi

Yemek Grubu		Gaziantep İli Yöresel Tarifleri				Hatay İli Yöresel Tarifleri			
		Tercih edilebilir		Tercih edilmemeli		Tercih edilebilir		Tercih edilmemeli	
		Sınıf 1	Sınıf 2	Sınıf 3	Sınıf 4	Sınıf 1	Sınıf 2	Sınıf 3	Sınıf 4
Et Yemekleri	**n**	6	0	9	1	2	0	2	1
	%	37,5	0	56,25	6,25	40	0	40	20
Sebze Yemekleri	**n**	1	0	3	0	5	0	0	0
	%	25	0	75	0	100	0	0	0
Bulgurlu, Pirinçli Yemekler	**n**	5	0	3	0	3	0	1	1
	%	62,5	0	37,5	0	60	0	20	20
Çorbalar	**n**	2	0	1	1	1	1	0	1
	%	50	0	25	25	33,3	33,3	0	33,3
Mezeler, Salatalar, Piyazlar	**n**	2	0	0	1	9	1	1	1
	%	66,7	0	0	33,3	75	8,33	8,33	8,33
Hamur İşleri	**n**	1	0	0	4	1	3	0	5
	%	20	0	0	80	11,1	33,3	0	55,6
Tatlılar ve Reçeller	**n**	0	0	0	6	0	0	0	9
	%	0	0	0	100	0	0	0	100
Toplam	**n**	**17**	**0**	**16**	**13**	**21**	**5**	**4**	**18**
	%	**36,9**	**0**	**34,8**	**28,3**	**43,8**	**10,4**	**8,3**	**37,5**

Tablo 7. Gaziantep ve Hatay illerine ait farklı yemek gruplarında yer alan yöresel tariflerin NUTRI-SCORE puanına göre kategori dağılımları

		Gaziantep Yöresel Yemekleri					Hatay Yöresel Yemekleri				
		Nutri-Score Puanına Göre Kategoriler					Nutri-Score Puanına Göre Kategoriler				
Yemek Grubu		**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Et Yemekleri	**n**	4	5	6	1	0	2	2	1	0	0
	%	25	31,25	37,5	6,25	-	40	40	20	-	-
Sebze Yemekleri	**n**	4	0	0	0	0	5	0	0	0	0
	%	100	-	-	-	-	100	-	-	-	-
Bulgurlu, Pirinçli Yemekler	**n**	5	1	2	0	0	3	1	1	0	0
	%	62,5	12,5	25	-	-	60	20	20	-	-
Çorbalar	**n**	1	2	0	1	0	2	0	1	0	0
	%	25	50	-	25	-	66,7	-	33,3	-	-
Mezeler, Salatalar, Piyazlar	**n**	2	0	1	0	0	10	1	1	0	0
	%	66,7	-	33,3	-	-	83,4	8,3	8,3	-	-
Hamur işleri	**n**	1	1	3	0	0	4	1	4	0	0
	%	20	20	60	-	-	44,4	11,2	44,4	-	-
Tatlılar ve Reçeller	**n**	0	0	3	3	0	0	1	1	7	0
	%	-	-	50	50	-	-	11,1	11,1	77,8	-
Toplam	**n**	**17**	**9**	**15**	**5**	**0**	**26**	**6**	**9**	**7**	**0**
	%	**36,9**	**19,6**	**32,6**	**10,9**	**0**	**54,2**	**12,5**	**18,7**	**14,6**	**0**

Gaziantep ve Hatay illerine ait yöresel tarifler NUTRI-SCORE modeline göre değerlendirildiğinde Gaziantep iline ait farklı yemek gruplarında yer alan yöresel tariflerin %36,9'u A kategorisinde, %19,6'sı B kategorisinde, %32,6'sı C kategorisinde, %10,9'u D kategorisinde sınıflandırılmıştır. Hatay iline ait farklı yemek gruplarında yer alan yöresel tariflerin ise; %54,2'si A kategorisinde, %12,5'i B kategorisinde, %18,7'si C kategorisinde, %14,6'sı D kategorisinde sınıflandırılmıştır. Gaziantep ve Hatay illerine ait E kategorisinde yer alan yöresel tarif bulunmamıştır (Tablo 7).

NUTRI-SCORE modeline göre Gaziantep iline ait yöresel tariflerden akıtmalı ufak köfte, ekşili ufak köfte, içli köfte (oruk), patlıcan kebabı, borani, erik tavası, öcce (mücver), pirpirim aşı, çağla aşı, firik pilavı, firikli acur dolması, karışık dolma, şiveydiz, maş çorbası, Antep salatası, maş piyazı ve nohut dürüm A skoru; ayvalı ekşili taraklık tavası, cacıklı arap köfte, lahmacun, omaç, yenidünya kebabı, yoğurtlu patates, börek çorbası, öz çorbası ve şekerli peynir böreği B skoru; alenazik (alinazik), beyran, malhıtalı köfte, simit kebabı, soğan kebabı, yağlı köfte, yoğurtlu dövme çorbası, yuvarlama, muhammara, Antep kahkesi, pirinçli börek, zeytin böreği, astarlı sütlaç, aşure (aşir) ve zerde C skoru alırken; ciğer (cağırtlak) kebabı, lebeniye çorbası, baklava, bastık ve katmer D skoru almıştır.

Hatay iline ait yöresel tariflerden ise aşur (aşir), tepsi kebabı, ıspanak boraniye, kabak boraniye, öcce (mücver), şıh mualle, şıh-ıl mıhşi, mütebli, sıraysil, tepsi oruğu, kumbursiye, toğga çorbası, abugannuş, bakla ezmesi, cevizli biber, humus, patlıcan yoğurtlama, tahinli tarator, taze çökelek salatası, taze sürk salatası, zahter salatası, zengin, ıspanaklı börek, kaytaz böreği, külçe ve semirsek A skoru; belen tavası, kağıt kebabı, oruk (içli köfte), alenazik (alinazik), kete ve haytalı B skoru; Antakya usulü döner, firikli aş, tuzlu yoğurt çorbası, zeytin öfelemesi, biberli ekmek, katıklı ekmek, kerebiç, kömbe ve şam tatlısı C skoru alırken; ceviz reçeli, cevizli taş kadayıf, kabak tatlısı, kebbet reçeli, künefe, patlıcan reçeli ve peynirli irmik helvası D skoru almıştır.

Gaziantep ve Hatay illerine ait yöresel tarifler Uluslararası Sağlıklı Seçimler Modeline (Choices Programme) göre değerlendirildiğinde; Gaziantep iline ait tariflerde et yemekleri grubundan patlıcan kebabı; bulgurlu, pirinçli yemekler grubundan firikli acur dolması, karışık dolma, şiveydiz; mezeler, salatalar, piyazlar grubundan Antep salatası Uluslararası Sağlıklı Seçimler modelinin kriterlerine uygun olarak değerlendirilmiştir. Gaziantep iline ait sebze yemekleri, çorbalar, tatlı ve reçeller ile hamur işleri gruplarından Uluslararası Sağlıklı Seçimler modelinin kriterlerine uygun tarif bulunmamaktadır. Hatay iline ait tariflerde ise; sebze yemekleri grubundan kabak boraniye, öcce (mücver), şıh mualle, şıh-ıl mıhşi; bulgurlu, pirinçli yemekler grubundan mütebli, sıraysil; çorbalar grubundan toğga çorbası; mezeler, salatalar, piyazlar grubundan taze çökelek salatası Uluslararası Sağlıklı Seçimler modelinin kriterlerine uygun olarak değerlendirilmiştir. Hatay iline ait et yemekleri, tatlı ve reçeller ile hamur işleri gruplarından Uluslararası Sağlıklı Seçimler modelinin kriterlerine uygun tarif bulunmamaktadır.

TARTIŞMA VE SONUÇ

Yöresel mutfaklar özgün yapıları, lezzet ve çeşitliliğin yanı sıra toplumların beslenmesine verdiği katkı payı ile ölçülür ve değerlendirilir olmuştur. Gaziantep ve Hatay mutfakları kendilerine özgü kültürleri ile yöresel mutfaklar arasında önemli yerlere sahip, UNESCO Yaratıcı Şehirler Ağı listesinde yer almış iki geleneksel mutfaktır (25,26). Bu çalışma Gaziantep ve Hatay iline ait yöresel tariflerin yer aldığı yedi yemek grubunun derlenmesi, bu gruplardaki tariflerin besin ögesi içeriklerinin hesaplanıp beş farklı besin ögesi örüntü profili ile objektif olarak değerlendirilmesi amacıyla yapılmıştır.

WHO "Bulaşıcı Olmayan Hastalıkların Kontrolü ve Önlenmesi Küresel Eylem Planı 2013-2020''de kardiyovasküler hastalıklar, kanserler, kronik solunum yolu hastalıkları ve diyabet gibi bulaşıcı olmayan hastalıkların dünyada büyük önem taşıdığı vurgulanmaktadır. Bu doğrultuda bulaşıcı hastalıkların yükünün azaltılıp hastalıkların, engelliliğin ve ölümlerin önlenmesi amacı ile küresel özellikli 9 hedef vurgulanmaktadır. Bu hedefler; kardiyovasküler hastalıklar, kanser, diyabet veya kronik solunum

yolu hastalıklarına bağlı prematür ölümlerde %25 azalma; zararlı alkol kullanımında %10 azalma; yetersiz fiziksel aktivite prevalansında %10 azalma; toplumun diyetle tuz/sodyum alımında %30 azalma; ≥15 yaş tütün kullanım prevalansında %30 azalma; yüksek kan basıncı prevalansında %25 azalma; obezite ve diyabette artışı durdurma; kalp krizi ve felçleri önlemek için ilaç tedavisi ve danışmanlık (glisemik kontrol dâhil) sağlamayı %50 karşılama; bulaşıcı olmayan hastalıkların tedavisinde temel teknoloji ve ilaç gereksinimlerini %80 karşılamadır (27). Bu amaçlar doğrultusunda, besin ögesi örüntü profillerinin geliştirilmesinde; son dönemde özellikle obezite ve ilişkili hastalıkların görülme sıklıklarının ciddi oranda artması ve bireylerin sağlıklı besin tercihi yapmalarına yardımcı olacak araçların geliştirilmesine duyulan ihtiyaç etkili olmuştur (13).

NRF 9.3. besin ögesi örüntü profili modeli halk sağlığı açısından önemli bir modeldir. Çünkü kısıtlanması gereken besin ögelerini belirttiği gibi tüketilmesi önerilen besin ögelerini de belirtmekte ve hesaba katmaktadır (28). Çalışmamızda her iki ile ait yöresel tariflerde tüketimi sınırlanması istenen besin ögeleri içeriklerinin yüksek olması düşük NRF 9.3. puanına neden olmuştur. Özellikle her iki ile ait yöresel tatlı ve reçellerde eklenmiş şeker miktarının yüksekliğine bağlı olarak NRF 9.3. puanlarının beklenildiği gibi azaldığı görülmüştür. Tüketilmesi istenen besin ögelerinden protein ve posanın içeriklerinin yüksek oluşu bazı tariflerin puanını oldukça yükseltirken bazı tariflerde kısıtlanması önerilen besin ögesi içeriğinin fazla oluşu nedeniyle istenen puan artışını sağlayamamıştır.

FSA-Ofcom-WXY skorlama yöntemi protein içeriği yüksek olan besinleri daha sağlıklı gibi göstermektedir. Bu durum bu modelin bir dezavantajı olarak öngörülmekte ve modele yönelik eleştiri yapılmasına sebebiyet vermiştir. Çünkü protein içeriği yüksek olan besinler açısından yanıltıcı sonuçlar verebilmektedir (29). Bu eleştiriye paralel olarak bu çalışmanın sonuçlarında da FSA-Ofcom-WXY modeline göre iki ile ait yöresel et yemekleri tariflerinin çoğu protein içerikleri nedeniyle daha sağlıklı kategorisinde yer almıştır. Bu modele yönelik dikkat çekilen bir diğer husus ise modelin enerji, doymuş yağ ve şeker içeriklerini temel alması nedeniyle besinlerin enerji yoğunluklarıyla yüksek oranda ilişkide olmasıdır. Bu ilişki FSA-Ofcom-WXY modelinin tüm yüksek enerjili besinleri daha az sağlıklı kategorisinde değerlendirmesine neden olmaktadır (30). Bu çalışmanın sonuçlarında ise yüksek enerjili tariflerin çoğunun bu görüş ile paralellik göstermediği dikkat çekmektedir. Bu durum FSA-Ofcom-WXY modelinin yöresel tariflerin değerlendirilmesinde diğer modellere göre daha yetersiz olduğunu düşündürmektedir.

SAIN-LIM modeline göre, Gaziantep ili yöresel tariflerin %36,9'u "tercih edilebilir" olarak tanımlanırken, bu oran Hatay ili yöresel tariflerinde %54,2 olarak saptanmıştır. Hatay iline ait yöresel tarifler SAIN-LIM modeline göre daha yüksek oranda tercih edilebilir olarak değerlendirilmiştir ancak her iki ile ait yöresel tariflerdeki kısıtlanması önerilen besin ögeleri miktarlarının WHO standartlarına göre yeniden düzenlenmesi ile pozitif skor almalarının sağlanabileceği düşünülmektedir.

NUTRI-SCORE modeli Besin Standartları Acentesi besin profilleme sistemine dayalı, renk kodlu, beş harfli dereceli bir ölçektir. Renk kodlu olma özelliği modelin sonuçlarının grafik format üzerinde görsel olarak ifade edilebilmesini sağlamaktadır (16). NUTRI-SCORE modelinin bu görsel etkinliğinin çeşitli boyutlarını değerlendirmek amacıyla yapılan iki çalışmanın sonucunda da benzer şekilde NUTRİ-SCORE' un tüketiciler tarafından besinlerin beslenme kalitesini karşılaştırmak için net bir şekilde algılandığı ve sonuçlarının iyi anlaşıldığı gösterilmiştir (31,32). Bu model ile ilgili yapılmış başka bir simülasyon çalışmasına göre de bu modelin değerlendirme sonuçlarının tüketicileri daha sağlıklı besin seçimlerine teşvik ettiği ve alışveriş sepetlerinin besin kalitesini iyileştirdiği (33), son olarak daha sağlıklı diyet alımları yoluyla beslenmeyle ilişkili kronik hastalıklara bağlı ölüm oranını potansiyel olarak azalttığı gösterilmiştir (34).

NUTRI-SCORE modelinin değerlendirme kriterlerinde WHO önerilerine uygun olarak kısıtlanması gereken ve tüketilmesi önerilen

besin ögelerinin belirlenmiş olması, araştırmacı açısından diğer modellere göre pratik bir algoritmaya sahip olması ayrıca modelin değerlendirme sonuçlarının tüketici açısından anlaşılır olması ve doğru mesajlar vermesi sebebiyle (35) yöresel tariflerin değerlendirilmesi için uygun olduğu düşünülmektedir.

Uluslararası Sağlıklı Seçimler modelinin kriterleri bilim adamları tarafından WHO, 2003 uluslararası günlük besin ögesi alım hedefleri ve WHO önerilerine göre titizlikle belirlenmesine rağmen kategoriye özgü bir model olması hesaplama yaparken bazı besinlerin hangi kategoride yer alması gerektiğine karar vermek açısından bir sorun oluşturmaktadır. Modelin zorluklarından bir diğeri değerlendirmesi yapılan yiyecek ya da içeceğin "Choices" logosunu alabilmesi için gerekli görülen kriterlerdir. Uluslararası Sağlıklı Seçimler modelinde besinin "Choices" logosunu alabilmesi için model kapsamında tanımlanan her bir besin ögesinin eşik değeri kriterlerini sağlaması ve toplamda tanımlanan besin ögeleri arasından en az %20'sinin kriterlerinin karşılanması gerekmektedir. Bu durum Uluslararası Sağlıklı Seçimler Modeli'nin değerlendirme kriterlerini diğer modellere göre daha belirleyici kılmaktadır. Bu özelliğinden dolayı Uluslararası Sağlıklı Seçimler Modeli'nin yöresel tariflerin değerlendirilmesi için uygun olduğu düşünülmektedir.

Sonuç olarak; Gaziantep ve Hatay illerine ait yöresel tarifler genel olarak değerlendirildiğinde sebze yemekleri, mezeler-salatalar-piyazlar, çorbalar ve bulgurlu, pirinçli yemekler gruplarında sağlıklı seçim olarak değerlendirilebilecek tarif oranının yüksek; et yemekleri, hamur işleri ve tatlılar-reçeller gruplarında ise sağlıklı seçim olarak değerlendirilebilecek tarif oranının düşük olduğu bulunmuştur. Bunun temel nedenlerinin belirtilen gruplara ait tariflerde kullanılan tuz ve hayvansal besin içeren malzeme çokluğuna bağlı olarak doymuş yağ asidi içeriğinin yüksek olmasının yanı sıra bir porsiyon değerlerinin dahi miktar olarak fazla olması olarak düşünülmektedir. Bu çalışmada kullanılan beş besin ögesi örüntü profili ile tüketilmesi önerilen besin ögeleri içerikleri açısından her iki ile ait yöresel tarifler yeterli bulunmasına rağmen, kısıtlanması önerilen besin ögeleri bakımından yüksek içeriğe sahip tariflerin varlığına vurgu yapılmıştır. Gaziantep ve Hatay illerine ait yöresel tariflerin içeriklerinin bilimsel öneriler ışığında daha sağlıklı hale getirilebilmesi için, tariflerin kısıtlanması önerilen besin ögelerinin kaynakları ve porsiyon büyüklükleri açısından yeniden değerlendirilmesinin uygun olacağı düşünülmektedir. Sonuç olarak, yöresel tarifeler özellikle eklenmiş yağ, şeker, tuz içeriği ve porsiyon büyüklüğü açısından ele alınmalı ve halk eğitimleri ile olumlu yaklaşımlar irdelenmelidir. Ayrıca yöresel yemek kitapları ve otoriteler de bu yaklaşımları dikkate almalıdır.

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Research Article / Araştırma Makalesi

Sustainable culinary tourism in Osogbo integrating ecotourism, nutrition, and gastronomy for holistic destination experiences

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Abstract

Sustainable culinary tourism offers a unique opportunity to merge nutrition, local gastronomy, and ecotourism for holistic tourism experiences. This study explores the potential of Osogbo's traditional dishes to enhance sustainable tourism through nutritional awareness, cultural heritage, and environmental conservation. Key objectives include assessing the nutritional profiles of local cuisines, evaluating their impact on tourist satisfaction, and formulating strategies for sustainable culinary tourism. The study hypothesizes that nutritional awareness significantly influences tourist satisfaction and contributes to sustainable tourism development.

A mixed-methods approach was employed, incorporating in-depth interviews with chefs, nutritionists, and cultural custodians, alongside surveys of 322 participants. Nutritional analyses of traditional dishes complemented data on tourists' perceptions of gastronomy's role in their experiences. Statistical tools, including chi-square and regression analysis, were used to test hypotheses, revealing that 93.4% of respondents

valued the nutritional quality of local food, with a strong positive correlation ($\beta = 0.45$, $p = 0.003$) between nutrition and tourist satisfaction.

Findings highlight the potential of Osogbo's culinary offerings in driving sustainable tourism. Traditional dishes, characterized by their nutritional richness and cultural significance, not only enhance visitor experiences but also promote wellness and sustainability. Environmental conservation efforts, such as using local and seasonal ingredients, resonated strongly, with 80% of tourists willing to pay a premium for eco-friendly options.

In conclusion, integrating nutrition into Osogbo's culinary tourism strategies can elevate the region as a model for sustainable tourism. Recommendations include developing nutritional profiling programs, promoting farm-to-table initiatives, and establishing sustainable gastronomy certifications to foster a vibrant and eco-conscious culinary tourism sector

INTRODUCTION

Culinary tourism, an evolving aspect of the broader tourism industry, connects travelers with the cultural heritage of a destination through its food. This experience often goes beyond taste and aesthetics, allowing visitors to engage with the traditional practices and ingredients that shape the identity of a region. In recent years, the role of nutrition in this intersection between food and tourism has gained increasing attention, particularly as health-conscious travel continues to grow (1). With more tourists prioritizing wellness, there is a rising demand for culinary experiences that not only provide cultural insight but also offer nutritional benefits. This emerging trend suggests that promoting the healthful properties of local dishes could significantly enhance tourist satisfaction and open new avenues for sustainable tourism development (2).

Nutrition plays a central role in human health, and its integration into culinary tourism offers the potential for destinations to stand out in an increasingly competitive tourism market. As travelers become more aware of the importance of healthy eating, they are seeking out food experiences that align with their personal health goals. Traditional cuisines, often rooted in the use of fresh, locally sourced ingredients, hold immense potential to meet this demand. These foods, typically rich in essential nutrients such as vitamins, minerals, fiber, and antioxidants, provide not only a sensory experience but also support well-being (3). Promoting these health benefits as part of a destination's culinary tourism strategy could foster a more comprehensive and holistic tourist experience, appealing to both culturally inclined and health-conscious travelers. The nutritional value of traditional diets has long been recognized for its benefits to local populations. Many traditional dishes are based on time-honored agricultural practices that prioritize seasonality and sustainability, yielding nutrient-dense foods that contribute to a balanced diet (4). However, despite the rich nutritional content of these foods, their health benefits are often underrepresented in the tourism industry, where the focus tends to be on their cultural or exotic appeal (5). This oversight presents a missed opportunity to align with the growing global movement toward wellness tourism, in which travelers seek food experiences that contribute positively to their physical health and overall wellness. Highlighting the nutritional aspects of local cuisines could not only elevate tourist satisfaction but also encourage longer stays, repeated visits, and positive word-of-mouth promotion (6). Moreover, the integration of nutrition into culinary tourism has broader implications for public health. As tourists become more health-conscious, destinations that can offer nutritionally balanced meals may support wider public health objectives, particularly in regions where non-communicable diseases such as obesity, diabetes, and heart disease are on the rise. Traditional diets, which are often plant-based and high in dietary fiber, antioxidants, and micronutrients, provide a natural defense against many of these health conditions (4). By promoting local foods that are aligned with global nutritional guidelines, destinations can create unique experiences that serve both tourism and public health goals.

Despite the clear benefits, the role of nutrition

in enhancing culinary tourism remains to be studied more. Current studies have shown that tourist satisfaction is increasingly linked to the quality of the food they consume, with an emphasis on fresh, healthy, and authentic meals (3). In response to this trend, destinations that prioritize the health benefits of their local cuisine in tourism marketing can obtain significant benefits. By providing nutritional information alongside cultural and historical context, these destinations can attract wider audience that includes not only food enthusiasts but also those seeking a health-focused travel experience (1, 9). In addition to boosting tourist satisfaction, emphasizing the nutritional value of traditional foods aligns with the principles of sustainable tourism. Sustainable culinary tourism promotes the use of locally sourced ingredients, supports local economies, and minimizes the environmental impact associated with food production and transportation (7). Traditional foods are often produced using environmentally sustainable practices, which further strengthens the appeal of such dishes to eco-conscious and health-oriented travelers. By integrating nutrition into their culinary tourism offerings, destinations can simultaneously promote environmental conservation, cultural heritage, and public health, creating a holistic tourism approach that meets the evolving needs of the global tourist market (8).

The global trend towards health-conscious tourism offers an opportunity to reposition traditional diets as both culturally significant and nutritionally beneficial. As travelers become more informed about the link between diet and health, they are likely to seek out food experiences that contribute to their well-being. For destinations that are rich in traditional culinary heritage, this shift presents a valuable opportunity to incorporate nutrition into their tourism offerings. In doing so, they can offer a tourism experience that is not only authentic and enriching but also aligned with the health and wellness goals of their visitors (2). This study seeks to contribute to the growing discourse on nutrition-focused culinary tourism by exploring the ways in which traditional diets, rich in local ingredients and nutritional value, can be leveraged to enhance tourist pleasure and promote sustainable tourism development. By emphasizing the nutritional richness of traditional foods and offering a framework for integrating nutrition into the broader context of culinary tourism, this research aims to bridge the gap between culture, health, and sustainability.

Conceptual Framework and Literature Review

This study on sustainable culinary tourism in Osogbo, Osun State, Nigeria, integrates concepts from culinary tourism, sustainability, nutrition, and ecotourism. The framework guiding this research emphasizes the interconnections between local culinary traditions, tourist satisfaction, and sustainable tourism development. The framework includes several key concepts:

Culinary Tourism

Culinary tourism connects food experiences with cultural heritage and is recognized as an essential component of destination marketing (10). This concept is increasingly popular as travelers seek authentic food experiences that reflect the destination's identity (9). The integration of local gastronomy with ecotourism is seen as an avenue for sustainable tourism development and alternative way to preserve both cultural heritage and the local economy (13).

Sustainable Tourism

Sustainable tourism aims to minimize negative environmental, cultural, and economic impacts while maximizing benefits to local communities (7). It emphasizes the importance of using local resources responsibly, such as promoting local foods and eco-friendly agricultural practices (18). In this study, sustainable culinary tourism is framed as a model that supports both environmental conservation and local economy.

Nutrition in Culinary Tourism

With a growing global interest in wellness tourism, there is increasing recognition of the health benefits of traditional diets (3). Incorporating nutritional value into culinary tourism enhances tourist satisfaction and appeals to health-conscious travelers (19). This

study examines how the nutritional value of local dishes in Osogbo can enhance the culinary tourism experience and contribute to public health objectives (4).

Ecotourism Integration

Ecotourism focuses on nature-based tourism that promotes environmental conservation and supports local communities. The integration of ecotourism with culinary tourism can amplify sustainability efforts by highlighting the environmental benefits of locally sourced, seasonal foods (5). This integration not only supports the local economy but also fosters a deeper connection between tourists and the destination's natural heritage (8).

Literature Review

The existing literature shows that culinary tourism, with local food experiences enhancing the appeal of a destination, has a significant impact on tourism satisfaction (2009). Additionally, the sustainability of food systems in tourism is increasingly linked to the environmental and economic benefits of local food practices (14). Studies by (6) and Hall &Gössling (2016) emphasize the need for sustainable food practices within tourism, which align with both public health goals and ecotourism principles.

Recent research highlights the importance of integrating nutrition into culinary tourism as a means to attract health-conscious travelers and support wellness tourism (9). This is especially relevant in destinations like Osogbo, where traditional dishes are not only culturally significant but also nutritionally rich (10). The combination of nutritional and cultural significance can enhance tourist experiences while promoting sustainable practices.

MATERIALS AND METHODS

Methodology

The study employs a mixed-methods approach, combining qualitative and quantitative research. Qualitative data were collected through in-depth interviews with local nutritionists, chefs, and cultural custodians, along with focus group discussions with tourists and residents. These interviews explored the nutritional and cultural significance of local dishes. Thematic analysis was used to identify key patterns and themes in the qualitative data, providing deep insights into the relationship between food, culture, and sustainability in Osogbo (Everett &Aitchison, 2008).

For the quantitative component, a survey was implemented to 322 respondents, focusing on their perceptions of the nutritional value, cultural significance, and sustainability of local cuisine. Descriptive statistics were applied to summarize demographic characteristics and responses. Chi-square tests were used to examine associations between categorical variables, such as familiarity with local culinary traditions and perceptions of sustainability (12). Finally, regression analysis was conducted to assess the impact of nutritional value and cultural significance on tourist satisfaction that support sustainable tourism practices (7). This combination of qualitative and quantitative methods provides a robust understanding of the factors influencing sustainable culinary tourism in Osogbo.

Study Area and Research Design

The study was conducted in Osogbo, the capital of Osun State, Nigeria, a city renowned for its cultural heritage and culinary traditions. Given the focus on nutrition, the research design incorporates both qualitative and quantitative approaches. The qualitative component involved in-depth interviews with local nutritionists, chefs, and cultural custodians to explore the nutritional value and cultural significance of Osogbo's culinary offerings. The quantitative component involved surveys applied to tourists and residents, assessing their perceptions of the nutritional quality of local foods and their impact on the overall tourist experience.

Reconnaissance Survey

A preliminary reconnaissance survey was conducted to gather initial data on local food sources, identify key stakeholders in the culinary and nutrition sectors, and refine the research instruments. This survey also involved visits to local farms and food markets to understand the availability of nutritional ingredients and

the traditional methods of food preparation, ensuring the study's alignment with real-world practices.

Population of the Study

The study population included tourists visiting Osogbo, local residents, tourism operators, food vendors, and nutrition experts. The focus on nutrition required the inclusion of local dietitians and health professionals in the study population to provide insights into the nutritional aspects of the culinary offerings. The population was estimated using records from tourism sites, local health departments, and food markets.

Sample Size Determination

A sample size of 322 respondents was determined using Cochran's formula, with adjustments made for a finite population and the expected response rate. The formula used was:

$$n = \frac{Z^2.p.(1-p)}{e^2}$$

Where:

N = Sample size

Z = Z- value (1.96 for a 95% confidence level)

P = estimated proportion of the population with awareness or interest in nutrition (assumed to be 0.5 for maximum variability).

e = margin of error (0.05).

The initial calculation suggested a sample size of 384, which was adjusted to 322 to account for practical considerations in data collection.

Sampling Technique and Procedure

A multi-stage sampling technique was utilized: Stage 1: Stratification - The study population was stratified into five groups: tourists, local residents, tourism operators, food vendors, and nutrition experts. Stage 2: Random Sampling - Random sampling was employed within each stratum to ensure representative samples. Stage 3: Purposive Sampling - Key informants, including local nutritionists and chefs known for their expertise in traditional and health-conscious cooking, were purposively selected to provide detailed insights into the nutritional dimensions of local cuisine.

Data Collection

Data collection involved structured questionnaires, in-depth interviews, and focus group discussions. The questionnaires captured demographic information, perceptions of local cuisine's nutritional value, and the role of nutrition in enhancing the tourist experience. Interviews with nutritionists and local chefs focused on the nutritional content of traditional dishes, the sourcing of ingredients, and the methods used to prepare meals that are both healthy and culturally significant. Focus group discussions with tourists and residents explored the acceptance and awareness of these nutritional aspects in local culinary practices.

Scale Information

The study used several scales to measure perceptions of sustainable culinary tourism, the nutritional value of local foods, cultural significance, and environmental conservation:

Familiarity with Local Culinary Traditions

Items: Very familiar, somewhat familiar, not familiar

Reliability: Cronbach's alpha = 0.85

Contribution to Sustainable Tourism

Items: High, moderate, low, no contribution

Reliability: Cronbach's alpha = 0.82

Nutritional Value and Cultural Significance

Items: Very important, important, somewhat important, not important

Reliability: Cronbach's alpha = 0.78

Support for Sustainable Culinary Tourism

Items: Very likely, likely, unlikely, very unlikely

Reliability: Cronbach's alpha = 0.80

Willingness to Pay for Sustainable Culinary Options

Items: Very willing, willing, neutral, unwilling

Reliability: Cronbach's alpha = 0.84

These scales were adapted from previous studies and validated by experts, ensuring their relevance and reliability for the study context.

Table 1. Exploration of local culinary traditions' contribution to sustainable tourism by enhancing economic opportunities and cultural understanding within ecotourism practices.

Familiarity Level	**Frequency (n)**	**Percentage (%)**
Very Familiar	120	40
Somewhat Familiar	150	50
Not Familiar	30	10
Total	**300**	100
Contribution Level		
High Contribution	130	43.3
Moderate Contribution	100	33.3
Low Contribution	50	16.7
No Contribution	20	6.7
Total	**300**	**100**
Perception Level		
Strong Impact	140	46.7
Moderate Impact	100	33.3
Minimal Impact	50	16.7
No Impact	10	3.3
Total	**300**	**100**

Table 2. The interconnected dimensions of gastronomy through the lens of nutritional significance, cultural importance, and the frequency of engaging with local culinary experiences

Importance Level	**Frequency (n)**	**Percentage (%)**
Very Important	140	46.7
Important	110	36.7
Somewhat Important	30	10
Not Important	20	6.6
Total	**300**	**100**
Agreement Level		
Strongly Agree	150	50
Agree	100	33.3
Neutral	30	10
Disagree	20	6.7
Strongly Disagree	0	0
Total	**300**	**100**
Frequency Level		
Always	120	40
Often	100	33.3
Sometimes	60	20
Rarely	20	6.7
Never	0	0
Total	**300**	**100**

Data Analysis

Quantitative data were analyzed using descriptive statistics, chi-square tests, and regression analysis to test the hypotheses related to nutrition and tourism satisfaction. Qualitative data were subjected to thematic analysis, identifying patterns and themes concerning the nutritional significance of local foods and their integration into the tourism experience. The analysis also explored how nutritional information influences tourists' food choices and perceptions of sustainability.

RESULTS

It is shown in Table 1 that the majority of respondents are familiar with Osogbo's cuisine, perceiving it as a significant contributor to sustainable tourism, particularly through cultural preservation and economic growth.

It is emphasized in Table 2 that the interconnected dimensions of gastronomy, with respondents, who are valuing the nutritional significance and cultural importance of local cuisine, are frequently engaged with it. These findings demonstrate the strong connection between local food and the tourism experience.

Table 3. Evaluating sustainable culinary tourism through the lens of environmental conservation, economic support, and consumer willingness to invest in locally-sourced, eco-friendly gastronomic experiences.

Likelihood Level	**Frequency (n)**	**Percentage (%)**
Very Likely	130	43.3
Likely	100	33.3
Neutral	50	16.7
Unlikely	20	6.7
Very Unlikely	0	0
Total	**300**	**100**
Contribution Level		
High Contribution	120	40
Moderate Contribution	110	36.7
Low Contribution	50	16.6
No Contribution	20	6.7
Total	**300**	**100**
Willingness Level		
Very Willing	110	36.7
Willing	130	43.3
Neutral	40	13.3
Unwilling	20	6.7
Very Unwilling	0	0
Total	**300**	**100**

Table 4. Chi-square Analyses

Variable	**Chi-Square Value**	**p-value**
$H_0$1: There is no significant relationship between familiarity with local culinary traditions and their perceived contribution to sustainable culinary tourism in Osogbo.	10.45	0.015
$H_0$2: The nutritional value of local gastronomy does not significantly influence its cultural significance in Osogbo.	8.22	0.041
$H_0$3: The likelihood of supporting sustainable culinary tourism is not significantly related to its contribution to environmental conservation	12.33	0.005

It is evaluated in Table 3 that sustainable culinary tourism, showing that respondents recognize its contribution to environmental conservation and economic support, with a majority willing to pay a premium for eco-friendly, locally sourced gastronomic experiences.

It is presented in Table 4 that significant relationships between variables, including familiarity with local cuisine and its contribution to sustainable tourism, the link between nutritional value and cultural significance, and the association between support for sustainable culinary tourism and environmental conservation. These relationships underline the multidimensional benefits of gastronomy in tourism.

It is shown in Table 5 that regression analyses, indicating that integrating culinary traditions and promoting their nutritional and cultural value significantly enhance tourist satisfaction. Sustainable practices and environmental conservation are also shown to drive economic growth.

It is revealed in Table 6 that thematic insights, highlighting key themes such as cultural preservation, economic growth, enhanced tourist experiences, health and wellness, authenticity, and environmental conservation. These themes underscore the holistic benefits of culinary tourism in fostering sustainability.

DISCUSSION AND CONCLUSION

Discussion

Exploration of local culinary traditions' contribution to sustainable tourism by enhancing economic opportunities and cultural understanding within ecotourism practices.

It is examined in Table 1 that respondents' perceptions of the contribution of local culinary traditions to sustainable tourism in Osogbo, considering three dimensions: familiarity level, contribution level, and perception level. These findings are consistent with recent research that highlights the role of gastronomy in enhancing tourism experiences and fostering economic and cultural sustainability (10; 28).For the familiarity level, 90% of respondents report familiarity with

Table 5. Regression analysis of culinary tradition integration on sustainable tourism

Variable	Beta Coefficient	Standard Error	p-value
Culinary Tradition Integration	0.52	0.07	0.001
Constant	2.10	0.45	0.000
Nutritional Value	0.45	0.08	0.003
Cultural Significance	0.30	0.07	0.012
Constant	3.25	0.55	0.000
Sustainable Practices	0.60	0.09	0.000
Environmental Conservation	0.48	0.07	0.002
Constant	2.75	0.45	0.000

Table 6. Thematic analyses

Theme	Frequency of Mention
Cultural Preservation	50
Economic Growth	35
Enhanced Tourist Experience	40
Health and Wellness	45
Authenticity and Tradition	50
Tourist Satisfaction	60
Economic Growth	55
Environmental Conservation	50
Policy Support	45

local culinary traditions, with 40% being "very familiar" and 50% "somewhat familiar," leaving only 10% "not familiar." This high familiarity underscores the embeddedness of local food within the community and its potential for tourism marketing. Familiarity with local cuisine is a critical factor in developing culinary tourism, as it enhances cultural identity and fosters stronger connections between visitors and the destination (28).

Regarding the contribution level, 43.3% of respondents believe local culinary traditions contribute "highly" to sustainable tourism, and 33.3% see their contribution as "moderate." In contrast, 16.7% perceive the contribution as "low," and 6.7% see no contribution. These perceptions align with studies demonstrating that local gastronomy promotes economic development by supporting local producers, creating jobs, and preserving cultural heritage (6). Recent trends in sustainable tourism also emphasize the value of gastronomy in creating authentic, place-based experiences (10;7).

For the perception level, 46.7% of respondents feel local culinary traditions have a "strong impact" on the economy, while 33.3% rate the impact as "moderate." A smaller share, 16.7%, views the impact as "minimal," and 3.3% perceive "no impact." This data reflects the growing recognition of local cuisine as a driver of economic activity, particularly in developing regions where gastronomy can serve as a bridge between tourism and community development (26). Additionally, the integration of local food into tourism strategies has been shown to enhance destination competitiveness and sustainability (22).

In summary, it is highlighted in Table 1 that the significant role of local culinary traditions in Osogbo's tourism landscape. The findings suggest that local food is highly familiar, widely perceived as a valuable contributor to sustainable tourism and recognized for its economic impact. These insights align with contemporary research emphasizing the importance of integrating local gastronomy into tourism strategies to support economic growth, cultural preservation and sustainable development (26; 7).

The interconnected dimensions of gastronomy through the lens of nutritional significance, cultural importance, and the frequency of engaging with local culinary experiences

It is examined in Table 2 that the interconnected dimensions of gastronomy in Osogbo, focusing on nutritional significance, cultural importance, and frequency of engaging with local culinary experiences. The findings reflect global trends emphasizing the role of local food in enriching tourism experiences and promoting health-conscious travel (28; 7).For nutritional significance, 93.4% of respondents rate the nutritional value of local cuisine as important, with 46.7% considering it "very important" and 36.7% "important." Only 10% see it as "somewhat important," and 6.6% deem it "not important." This highlights the growing demand for food tourism that is connected with wellness goals, as travelers increasingly prioritize nutritious, locally sourced meals (26). Such preferences are related with the rise of wellness tourism, where gastronomy plays a dual role by offering health benefits and authentic experiences (19).

Regarding cultural importance, 83.3% of respondents either "strongly agree" (50%) or "agree" (33.3%) that local cuisine is culturally significant, while only 16.7% remain neutral or disagree. This strong agreement underscores the centrality of food in preserving and promoting Osogbo's cultural heritage. Recent studies emphasize that local cuisine serves as a cultural marker and offers tourists deeper insights into a destination's traditions and identity (21; 9).

For frequency of engaging with local culinary experiences, 73.3% of respondents report regular participation, with 40% engaging "always" and 33.3% "often." Only 20% participate "sometimes," and 6.7% "rarely," while none report "never." These findings suggest that local cuisine is deeply embedded in the daily lives of both residents and visitors. The frequent engagement highlights its potential as a tourism asset, capable of attracting food enthusiasts and creating memorable experiences (7).

In summary, it is demonstrated in Table 2 that the significant importance of gastronomy

in Osogbo's tourism context. Respondents recognize the nutritional value and cultural significance of local food, with frequent engagement further reinforcing its role in enhancing the tourism experience. These insights align with contemporary research advocating for the integration of gastronomy into tourism strategies to promote health-consciousness, culturally immersive, and sustainable travel (26; 19).

Evaluation of sustainable culinary tourism through the lens of environmental conservation, economic support, and consumer willingness to invest in locally-sourced, eco-friendly gastronomic experiences.

It is evaluated in Table 3 that sustainable culinary tourism through the lenses of environmental conservation, economic support, and consumer willingness to invest in locally-sourced, eco-friendly gastronomic experiences. The results comply with recent studies emphasizing the importance of sustainable food systems in promoting tourism that is lucrative to both local communities and the environment (23; 7). For environmental conservation, 40% of respondents believe sustainable culinary tourism contributes "highly" to conservation efforts, and 36.7% view its contribution as "moderate." A smaller percentage, 16.6%, see the contribution as "low," and 6.7% perceive no contribution. These findings underscore the growing recognition of eco-friendly practices, such as using locally sourced ingredients and reducing food waste, as critical for minimizing the environmental footprint of tourism. Such approaches are consistent with global sustainable tourism goals and are increasingly supported by tourists seeking greener travel options (26).

Regarding economic support, 43.3% of respondents are "very likely" and 33.3% "likely" to support sustainable culinary tourism initiatives. Only 16.7% are "neutral," and 6.7% are "unlikely" to support such initiatives. This strong willingness reflects the understanding that sustainable culinary tourism directly benefits local economies by supporting farmers, chefs, and small businesses. Recent research highlights that gastronomic tourism can significantly stimulate local economies by creating jobs and promoting regional products (28; 22).

For consumer willingness to invest in eco-friendly gastronomic experiences, 80% of respondents are willing to pay a premium, with 36.7% "very willing" and 43.3% "willing." Only 13.3% are "neutral," and 6.7% are "unwilling." This strong willingness indicates a growing market for sustainable food tourism, as travelers are increasingly willing to pay more for experiences that align with their environmental and ethical values (19; 7).

In summary, it is highlighted in Table 3 that respondents recognize sustainable culinary tourism as a significant contributor to environmental conservation, economic growth, and consumer satisfaction. These findings underscore the potential for Osogbo to position itself as a leader in sustainable gastronomy, leveraging eco-friendly practices to enhance its tourism appeal while supporting both the local economy and environmental goals (26; 6).

Chi-square Analyses

It is presented in Table 4 that the results of chi-square tests analyzing key relationships between variables in the study. These tests evaluate associations between familiarity with local culinary traditions and their perceived contribution to sustainable tourism, the nutritional value of local gastronomy and its cultural significance, and the likelihood of supporting sustainable culinary tourism and its contribution to environmental conservation. The findings emphasize the interconnectedness of gastronomy, sustainability, and cultural identity, consistent with contemporary research on food tourism (10; 7).

The first test examines the relationship between familiarity with local culinary traditions and their perceived contribution to sustainable tourism, yielding a chi-square value of 10.45 and a p-value of 0.015, indicating statistical significance. This finding suggests that respondents who are more familiar with local cuisine are more likely to perceive it as an important contributor to sustainable tourism. Familiarity fosters an appreciation of the cultural, economic, and

environmental value of local food, aligning with studies that highlight the importance of culinary knowledge in shaping perceptions of its broader impacts (28). Destinations which promote awareness of local gastronomy through education and marketing are better positioned to leverage culinary traditions as drivers of sustainable tourism (26).

The second test evaluates the connection between the nutritional value of local gastronomy and its cultural significance, with a chi-square value of 8.22 and a p-value of 0.041 that is also statistically significant. This result reflects the intertwined nature of nutrition and cultural identity in food tourism. Respondents who value the nutritional benefits of local cuisine are more likely to see it as culturally significant, suggesting that traditional diets are perceived as both health-promoting and symbol of local heritage. Recent studies emphasize that traditional foods often embody cultural wisdom and practices, combining health benefits with a deep connection to local history and identity (8; 10, 2020). Integrating nutrition-focused narratives into tourism can enhance the appeal of local food by connecting it to wellness and cultural authenticity.

The third test assesses the relationship between support for sustainable culinary tourism and its perceived contribution to environmental conservation, with a chi-square value of 12.33 and a p-value of 0.005, demonstrating a significant relationship. This finding suggests that individuals who are likely to support sustainable culinary initiatives also believe these initiatives play an essential role in environmental conservation. Eco-friendly food practices, such as farm-to-table models and the use of organic ingredients, are aligned with global goals of reducing tourism's environmental impact (7; 26). The strong collaboration indicates that respondents view gastronomy as a powerful tool for promoting sustainability by reducing food miles, supporting biodiversity and minimizing waste.

Overall, Table 4 underscores the importance of promoting familiarity, nutritional awareness, and sustainability in culinary tourism. The significant relationships revealed by the chi-square tests highlight how these factors interact to enhance perceptions of local gastronomy's role in sustainable tourism development. These insights align with broader trends emphasizing the integration of gastronomy into tourism strategies to foster cultural preservation, environmental stewardship, and economic resilience (9; 22). By fostering awareness of these interconnections, destinations like Osogbo can position themselves as leaders in sustainable culinary tourism.

Regression analysis of culinary tradition integration on sustainable tourism

It is presented in Table 5 that the results of regression analyses examining the impact of key variables culinary tradition integration, nutritional value, cultural significance, sustainable practices, and environmental conservation on sustainable tourism outcomes in Osogbo. These findings provide valuable insights into the multidimensional role of gastronomy in promoting sustainable tourism. The first regression analysis investigates the relationship between culinary tradition integration and sustainable tourism development. The results reveal a strong positive relationship, with a beta coefficient of 0.52 and a p-value of 0.001. This indicates that incorporating local culinary traditions into tourism significantly enhances sustainability outcomes. Culinary traditions, when effectively integrated, create authentic tourism experiences that promote cultural identity, economic opportunities, and environmental consciousness (24). This aligns with global recommendations emphasizing the strategic use of gastronomy in destination branding and development (26).

The second analysis focuses on the influence of nutritional value and cultural significance on tourist satisfaction. Both variables show statistically significant effects, with beta coefficients of 0.45 ($p = 0.003$) for nutritional value and 0.30 ($p = 0.012$) for cultural significance. These findings suggest that tourists value both the health benefits and the cultural authenticity of local cuisine. The stronger impact of nutritional value reflects the rising demand for wellness-oriented tourism experiences,

where food choices align with personal health goals (19). Meanwhile, the cultural significance of cuisine adds depth and meaning to the travel experience, fostering a stronger connection between tourists and the destination (28).

The third regression analysis examines the impact of sustainable practices and environmental conservation on economic growth. Both variables demonstrate strong positive relationships, with beta coefficients of 0.60 ($p = 0.000$) for sustainable practices and 0.48 ($p = 0.002$) for environmental conservation. These results underscore the dual benefits of sustainable culinary tourism, which not only supports environmental objectives but also drives economic growth. By promoting sustainable practices, such as locally sourced ingredients and reduced food waste, destinations can create value for both tourists and local communities (10). The significant contribution of environmental conservation further highlights the role of eco-conscious tourism practices in ensuring long-term sustainability.

In summary, Table 5 underscores the multifaceted contributions of local culinary traditions, nutritional value, cultural significance, and sustainable practices to sustainable tourism in Osogbo. These findings highlight the potential for culinary tourism to enhance tourist satisfaction, support economic growth, and promote environmental sustainability. The regression results align with recent literature advocating for the integration of gastronomy into tourism strategies as a means to achieve holistic sustainability goals (9; 26). By leveraging these insights, destinations like Osogbo can position themselves as models for sustainable culinary tourism.

Thematic analyses Impact of integrating local culinary traditions with ecotourism practices on sustainable tourism development in Osogbo.

It is presented in Table 6 that the results of thematic analysis, highlighting key themes identified from qualitative data on the role of local culinary traditions in sustainable tourism. The themes cultural preservation, economic growth, enhanced tourist experience, health and wellness, authenticity and tradition, tourist satisfaction, environmental conservation, and policy support provide insights into how gastronomy contributes to sustainable tourism in Osogbo.

The theme of cultural preservation (50 mentions) underscores the role of local food in maintaining and promoting Osogbo's cultural identity. Traditional culinary practices are deeply linked to the region's heritage, serving as a medium for storytelling and cultural education. This aligns with recent research emphasizing the significance of food as a cultural artifact that is capable of enriching tourism experiences while preserving traditions (9).

Economic growth (55 mentions) was the most frequently discussed theme, reflecting the perception that local culinary traditions drive economic benefits. Respondents highlighted the potential of food tourism to create jobs, support local producers, and attract tourists, all of which contribute to economic resilience. This is consistent with studies showing that gastronomy is a powerful economic driver when integrated with tourism strategies (26).

The theme of enhanced tourist experience (40 mentions) indicates the ability of local cuisine to create memorable and engaging experiences for tourists. Culinary tourism is increasingly valued for its capacity to provide authentic, multisensory experiences that foster deeper connections between visitors and destinations (8).

Health and wellness (45 mentions) reflects the growing demand for nutritious, health-conscious food experiences among tourists. Respondents recognized the nutritional value of traditional Osogbo cuisine, aligning with the trend of wellness tourism, which promotes well-being through healthy food choices and active lifestyles (19).

The themes of authenticity and tradition (50 mentions) and tourist satisfaction (60 mentions) emphasize the value of local cuisine in creating authentic travel experiences. Tourists increasingly seek destinations that offer genuine cultural heritage sites, and local food serves as a gateway to understanding the community's

traditions and way of life (28).

Environmental conservation (50 mentions) highlights the importance of eco-friendly practices in culinary tourism, such as using local, seasonal ingredients and reducing food waste. These practices contribute to sustainability while enhancing the appeal of the destination for environmentally conscious tourists (22).

Finally, policy support (45 mentions) reflects the need for institutional backing to promote and sustain culinary tourism. Respondents emphasized the importance of creating policies that encourage sustainable practices, protecting cultural heritage, and providing economic incentives for local producers and tourism operators (26).

In summary, it is shown in Table 6 that the multidimensional benefits of integrating local culinary traditions into sustainable tourism. The themes highlight the interconnected roles of culture, economy, health, and environment in shaping a robust tourism framework. These findings align with recent literature advocating gastronomy as a tool for promoting cultural preservation, economic growth, and sustainability (10; 7). By addressing these themes, Osogbo has the opportunity to position itself as a model for sustainable culinary tourism, creating a balance between cultural heritage, economic development, and environmental conservation.

CONCLUSION

The study highlights the pivotal role of integrating nutrition, local gastronomy, and ecotourism for promoting sustainable culinary tourism in Osogbo. Key findings indicate that local culinary traditions, when integrated into tourism, significantly contribute to cultural preservation, economic growth, and environmental sustainability. The nutritional value of local foods strongly influences tourist satisfaction, as evidenced by the significant relationship between nutritional awareness and the cultural appeal of gastronomy. The thematic analysis further underscores the multidimensional benefits of culinary tourism, including cultural preservation, health promotion, and enhanced tourist experiences. Moreover, the study reveals a growing willingness among tourists to invest in eco-friendly gastronomic experiences, supporting both the local economy and environmental conservation. These findings suggest that leveraging the health and cultural significance of local cuisine can position Osogbo as a model for sustainable tourism.

By addressing gaps in nutritional profiling, sustainable practices, and policy support, Osogbo can effectively integrate its culinary heritage into a holistic tourism strategy. This approach can align with global trends that prioritize wellness, sustainability, and cultural authenticity in tourism development.

Recommendations

➢Develop Nutritional Profiling Programs: Conduct detailed nutritional assessments of Osogbo's traditional dishes and promote these findings through tourism campaigns and educational materials.

➢Introduce Sustainable Gastronomy Certification: Establish certification for restaurants and food producers adhering to sustainable practices, including usage of locally sourced ingredients and eco-friendly production methods.

➢Enhance Cultural Documentation: Archive and promote traditional recipes and cooking techniques to preserve culinary heritage and highlight their nutritional value.

➢Promote Farm-to-Table Initiatives: Collaborate with local farmers and producers to create authentic dining experiences, displaying fresh, sustainable ingredients and traditional cooking methods.

➢Seasonal Menu Planning: Encourage restaurants to adopt seasonal menus that maximize the use of fresh, locally available ingredients, reducing food miles and supporting sustainability.

➢Offer Culinary Workshops and Events: Organize cooking classes and food festivals focused on traditional Osogbo cuisine, integrating education in nutrition and sustainability.

➢Create Eco-Friendly Dining Guidelines: Establish and disseminate best practices for reducing food waste, sourcing ingredients sustainably, and adopting energy-efficient cooking techniques.

➢Develop Digital Engagement Platforms: Launch mobile apps or websites that provide tourists with nutritional information, sustainability ratings, and the cultural significance of local dishes and dining venues.

➢Encourage Policy and Community Support: Work with local authorities to implement policies that incentivize sustainable culinary tourism practices and provide training for food vendors and tourism operators.

➢Expand Wellness Tourism Integration: Market Osogbo as a wellness destination by emphasizing the health benefits of its cuisine alongside its cultural and ecological attractions.

➢These recommendations aim to position Osogbo as a leader in sustainable culinary tourism, benefiting both local communities and the broader tourism industry while preserving cultural heritage and promoting environmental sustainability.

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Research Article / Araştırma Makalesi

Investigation of the effect of kefir culture use on some microbiological and sensory properties in gluten-free bread production

Glutensiz ekmek üretiminde kefir kültürü kullanımının bazı mikrobiyolojik ve duyusal özelliklere etkisinin incelenmesi

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Abstract

This study was carried out to examine the effect of using kefir culture as baker's yeast on some sensory quality parameters of gluten-free bread and to offer a more consumable gluten-free bread option to individuals with celiac disease and gluten intolerance. *Lactococcus* sp. count, Total Bacteria Count and mold-yeast enumeration were made in gluten-free bread dough containing kefir culture (test bread) and control bread. The pH value of the the sample was measured with a pH meter. Sensory analyzes were performed on the test and control breads by 11 nutritionist panelists. The results were evaluated with the SPSS 23.0 program. As a result of the sensory analysis, the test bread scored significantly higher than the control bread in terms of volume, shape symmetry, texture, mouthfeel, odor, aroma, taste, general control and preferability ($p<0.001$). The *Lactococcus* sp. count was 3.3 log cfu/g, the total bacteria count was 4.25 log cfu/g, the mold-yeast count was 4.37 log cfu/g and the pH value was determined as 4.62 in the test bread. The use of kefir culture has made significant contributions to the sensory properties of gluten-free bread and has turned gluten-free bread into a more consumable and preferable form.

Özet

Bu çalışma, pişirme mayası olarak kefir kültürü kullanımının glutensiz ekmeğin bazı duyusal kalite parametrelerine etkisini incelemek ve çölyak hastaları ile gluten intoleransı bulunan bireylere daha tüketilebilir formda glutensiz ekmek seçeneği sunmak amacıyla yürütülmüştür. Kefir kültürü içeren glutensiz ekmek (çalışma ekmeği) hamurunda ve kontrol ekmeğinde *Lactococcus* sp., Toplam Aerobik Bakteri ve küf-maya tayini yapılmıştır. Çalışma ekmeğinin pH metre ile pH değeri belirlenmiştir. Çalışma ve kontrol ekmeklerine beslenme uzmanlarından oluşan 11 kişilik panelist tarafından duyusal analizler yapılmıştır. Sonuçlar SPSS 23.0 programı ile değerlendirilmiştir. Yapılan duyusal analizler sonucu çalışma ekmeği hacim, şekil simetrisi, tekstür, ağızda hissedilen yumuşaklık, koku, tat, aroma, satın alınabilirlik ve genel kontrol açısından kontrol ekmeğinden anlamlı derecede daha yüksek puan almıştır ($p<0,001$). Çalışma ekmeğinde laktokok sayısı 3,3 log kob/g, toplam bakteri sayısı 4,25 log kob/g, küf-maya sayısı ise 4,37 log kob/g olarak bulunmuştur. Ayrıca pH değeri 4,62 olarak saptanmıştır. Kefir mayası kullanımı glutensiz ekmeğin duyusal özelliklerine önemli katkılar sağlayarak glutensiz ekmeği daha tüketilebilir ve tercih edilebilir bir forma dönüştürmüştür.

INTRODUCTION

Celiac disease is defined as a chronic inflammatory disease of the small intestine that occurs with the consumption of foods containing gluten (1, 2). The primary treatment for celiac disease, which stems from gluten intolerance, is adherence to a strict gluten-free diet (3, 4). One of the most important challenges for celiac patients in adopting to a gluten-free diet is the quality and accessibility of gluten-free food. Especially in our country, the grain-based diet and the limited production and variety of gluten-free products restrict patients' diet options, and since most gluten-free products are imported, they are more expensive than gluten-containing foods (1). Gluten-free foods are required for celiac patients, as well as those with gluten sensitivity and individuals who avoid gluten due to lifestyle, to follow a gluten-free diet (5).

Gluten is a basic structural protein that provides viscoelasticity and good gas retention ability to the dough, which is an important factor in the bread making process, and is effective in the sensory properties and quality of bread (6-8). Additionally, gluten has a protective effect on starch particles and slows down the staling rate of food by absorbing excess water (9). The absence of gluten in the dough results in a paler color, lower volume and more liquid consistency. It prevents the cooked product from reaching the desired quality and cause it to stale quickly (10, 11).

In recent years, many studies have been conducted on the positive effects of sourdough on bakery products and the addition of sourdough; a significant consensus has been reached that it positively affects breadcrumb structure and volume, nutritional value, taste and shelf life. In addition, it is thought that the quality characteristics of gluten-free bread leavened with sourdough will change positively (12, 13).

According to the Turkish Food Codex, kefir is defined as a fermented milk product in which kefir grains as a mixture of lactose-fermenting and non-lactose-fermenting yeast and bacteria that are responsible from fermentation, especially *Lactobacillus kefiri*, various strains of the *Leuconostoc*, *Lactococcus* and *Acetobacter* genera (14). Alcoholic and lactic fermentations are very important in the production of kefir, which is known for its functional and probiotic properties. Lactic acid, CO2, ethanol and other products resulting from fermentation are the components that directly affect the formation of aroma and taste (15). Kefir has many nutritional benefits due to its ease of digestion, regulation of stomach and intestinal flora, beneficial microorganisms, as well as its vitamin, mineral and protein content (16). This study aimed to investigate the effect of fermenting gluten-free bread with kefir culture on the use of kefir culture in gluten-free bread formulation and the sensory properties of bread and to investigate the presence of Lactococcus sp., a type of lactic acid bacteria, in kefir.

MATERIALS AND METHODS

Materials

In this study, gluten-free flour (contains corn starch and rice flour), salt, kefir culture (a well-known brand and has similar strain contents as in the study of Kok-Tas et al.) (17), sunflower oil and water were used to produce gluten-free bread. The salt, kefir culture and oil used in the study were obtained from markets in Istanbul. Gluten-free bread containing baker's yeast (control bread) was purchased in packaged form from a company in Istanbul. Gluten-free flour from the same company was used in the test bread.

Method

Production of Test Bread (Kefir Culture Containing Bread)

In the production of the test bread; 250 grams of gluten-free flour, 3 grams of salt, 2% kefir culture (5 grams) based on the weight of flour used, 15 grams of vegetable oil, 200 grams of warm water were placed in a mixing bowl and mixed until the dough became smooth. The dough was transferred to a pre-greased mold and flattened with a spatula. The mold with the dough was covered with a cloth and left to ferment in a closed cabinet at 24°C for 20 hours. It was then placed in the oven and left for final fermentation at 40°C for 1 hour. The oven temperature was set to 200°C and baked for 30 minutes (18).

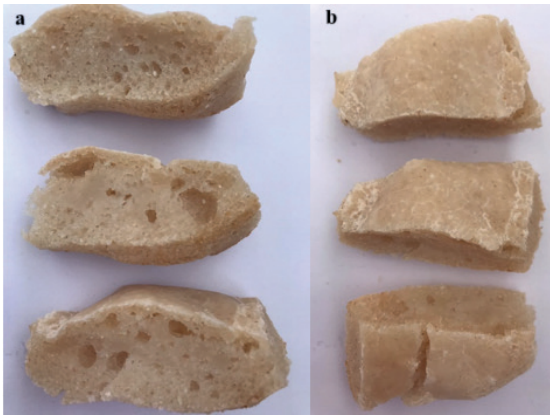

Figure 1a. Internal structure of test bread

Figure 1b. Crust appearance of test bread

Analyses

Microbiological analysis was conducted under aseptic sterile conditions. 10 grams from each of the purchased ready-to-eat bread (control bread) and gluten-free bread (test bread) samples were weighed, placed in a sterile stomacher bag and 90 mL of peptone water (Peptone water; Oxoid CM0009, ThermoFischer, UK) was added to dilute the sample 1/10. After homogenizing the samples, upper dilutions of ten were prepared with peptone water.

In order to count the *Lactococcus* sp. from the lactic acid bacteria in the gluten-free bread sample and gluten-free bread dough containing kefir culture, based on the method of Wang et al., tenfold serial dilution was prepared and inoculated on M17 (Merck Millipore, 63016, Germany) medium by the spread plate method (19). The cultured media were incubated at 37°C for 48 hours under anaerobic conditions (Anaerocult System, Merck 116275). At the end of the incubation, the colonies in the petri dishes were counted and examined with a microscope by gram staining.

In order to determine the Total Bacterial Count in gluten-free bread samples and gluten-free bread dough containing kefir culture, pre-homogenized samples were diluted to 10^{-3} and inoculated on PCA (Plate Count Agar, LabM LAB 149, UK) medium by the spread plate method. The cultured media were incubated at 37°C for 48 hours under aerobic conditions for total bacterial count after the study of Omurtag et al. (20). At the end of the incubation, the results were calculated by counting the petri dishes.

In order to perform mold-yeast counts on gluten-free bread samples and gluten-free bread dough containing kefir culture, the samples, which were previously homogenized and diluted to 10^{-2}, were plated on DRBC (Dichloran Rose-Bengal Chloramphenicol; Oxoid CM1148, ThermoFischer, UK) agar medium and incubated at 25°C, aerobically for 5 days according to the method in Da Silva et al. (21). At the end of the incubation, mold and yeast samples from the petri dishes were enumerated and the results were converted to log cfu/g.

The pH value of gluten-free bread dough fermented with kefir culture was determined by pH-meter (MILWAUKEE MW 102, United States). For this purpose, the pH meter probe was directly immersed in the dough and the reading was taken after the value was fixed.

Sensory Evaluation

Sensory evaluation of bread samples was carried out by a group of 11 nutritionists (9 women and 2 men) who did not smoke or have any food allergies. Then these panelists were trained and informed about the sensory evaluation. The breads were divided into equal pieces and coded with numbers on the production day. The taste and smell of the control and test bread were first examined with their eyes closed, then their eyes were opened and the external appearance characteristics of breads such as crust color and symmetry were evaluated. According to the sensory evaluation form which were prepared according to the protocol (22) panelists evaluated the breads in terms of volume, shape symmetry, crust color, crumb color, texture, mouthfeel, odor, aroma, taste, general control and preferability. A 5-point Likert scale (1, "dislike a lot," to 5, "like a lot") was applied.

Statistical Analysis

Statistical evaluation was made with SPSS (Statistical Package for the Social Sciences) 23.0 program to determine the differences for the results of sensory parameters. Comparative analyzes were made according to groups and Student-t tests were used to analyze the data, and the results were evaluated at the $p<0.05$ significance level within the 95% confidence interval. Microbiological analyzes were calculated using the Microsoft Excel program in accordance with the following formula (23):

Number/mL = (Number of colonies x Dilution factor) / Volume transferred from the dilution tube to the petri dish (mL)

Dilution factor = 1 / Dilution ratio

RESULTS AND DISCUSSION

The evaluation scores of the panelists according to the characteristics of the breads are given in Table 1. According to the table, a significant difference was found between the control bread and the test bread in the evaluations of the bread samples in terms of volume, shape symmetry, crust color, crumb color, texture, mouthfeel, smell, aroma, taste, general control and preferability ($p <0.001$).

Gluten-free breads were evaluated in terms of volume, shape symmetry, crust color, crumb color, texture, mouthfeel, odor, aroma,

Table 1. Sensory properties of test and control breads

	Test Bread Mean±SD	Control Bread Mean±SD	p
Volume	4.09±0.94	3.27±1.10	**<0.001**
Shape Symmetry	4.00±1.00	3.00±1.09	**<0.001**
Crust Color	3.09±1.04	4.45±0.52	**<0.001**
Crumb Color	3.72±1.00	4.45±0.68	**<0.001**
Texture	3.63±1.28	3.00±1.34	**<0.001**
Mouthfeel	4.09±0.94	3.45±1.03	**<0.001**
Odor	3.81±0.98	3.45±0.93	**<0.001**
Aroma	3.90±0.83	3.09±0.70	**<0.001**
Taste	4.45±0.68	3.00±1.09	**<0.001**
General Control	3.90±0.70	2.45±0.82	**<0.001**
Preferability	3.81±0.75	2.54±1.21	**<0.001**

taste, general control and preferability; it was observed that the test bread scored statistically significantly higher than the control bread in all parameters except crust color and crumb color. Accordingly, the kefir culture used in our study created significant sensory differences and it was observed that the bread was at an acceptable level in terms of all evaluated properties. In addition, it is thought that having the panelists make sensory evaluation of gluten-free bread sold in the market together with the test bread was effective in understanding the effect of kefir culture used in the test bread on sensory quality parameters.

In a study, it was found that the bread baked with 3% kefir had better flavor, and consumers showed a preference for kefir-leavened bread in sensory evaluations (24). In another study, the bread produced using sourdough with kefir had higher scores in sensory evaluations (25). Filipčev et al. (2007) stated that adding kefir grains to bread dough contributed to the bread's milder taste, better aroma, increased shelf life, better crumb elasticity, and structure. Furthermore, panelists preferred the kefir-based sourdough breads than others (26). However, in a different study using kefir in sourdough, it was reported that there was no significant difference between the samples in terms of odor and structure, while an increase in bread volume was observed (18). In addition to these studies in the literature, as a result of sensory evaluations, test bread in our study was liked more than control bread. Chawla and Nagal reported low nutritional value, crumbling, short shelf life, lack of flavor, unpleasant mouthfeel and low bread volume as the main defects seen in gluten-free breads (20). In this context, it is thought that the gluten-free bread we produced using kefir culture is both better and acceptable in terms of sensory parameters and better quality.

Lactococcus sp., total bacteria and mold-yeast count results of test and control breads are given in Table 2.

Ataç et al. determined lactic acid bacteria count as 8.49 log cfu/g and yeast count as 6.23 log cfu/g in a gluten-free bread sample obtained with kefir yeast (27). In another study, lactic acid bacteria count of a produced sourdough was 7.96 ± 0.08 log cfu/g and yeast count were 5.32 ± 0.25 log cfu/g (28). Meroth et al. found the number of lactic acid bacteria between 1.2-1.6 x 109 cfu/g and the number of yeasts between 2.7-5.0 x 107 cfu/g in naturally developed perennial rice sourdough, while the number of lactic acid bacteria between 1.2-8.2 x 108 cfu/g and the number of yeasts between 1.7 x 105-5.4 x 107 cfu/g in rice sourdough developed using commercial starter culture (29). As a result of our study, the number of *Lactococcus* in gluten-free bread leavened with kefir culture was found to be 3.3 log cfu/g, the total number of bacteria was 4.25 log cfu/g, and the mold-yeast count was 4.37 log cfu/g. It has been reported that the number of alive *Lactococcus* should be 8-9 log cfu/g and the number of yeasts should be 6-7 log cfu/g to obtain a good bakery product (12, 30). Accordingly, it is seen that the number of *Lactococcus*, as a sort of lactic acid bacteria, and mold-yeast contained in the dough we used in the study is low. As a result of this situation, it is thought that the contribution of sourdough to bread quality can be investigated more extensively by conducting additional microbiological analyses.

In this study, the pH of gluten-free bread dough fermented with kefir culture was measured as 4.62. Dagnas reported that pH is an important factor for mold growth in bakery products. Low pH reduces the activity of microorganisms and affects the product stability positively (31). It is also reported that pH is an important factor in phytic acid degradation and directly affects the

Table 2. Results of microbiological analysis of test and control breads

	Test Bread		Control Bread	
Type of Microorganisms	**n**	**log cfu/g**	**n**	**log cfu/g**
***Lactococcus* sp.**	22	3.3	3	2.47
Total Bacteria	180	4.25	4	2.59
Mold-Yeast	240	4.37	–	–

quality. Increasing the amount of sourdough decreases the amount of phytic acid (32). Özülkü reported that the pH value of sourdough obtained from durum wheat decreased from 6.24 to 3.28 as a result of fermentation (28), while Ataç et al. measured the pH value as 4.87 (27). Even if the leavening technique applied in the studies remains the same, pH changes according to the number of cultures used and the suitable environment for leavening. The use of pH meter and the waiting time of the pH meter in the dough are also important parameters. Although such studies have been carried out, there is no clear range for pH because there are not enough studies, but some studies suggest that it should be around 4.50 to 6.0 (33-36).

CONCLUSION

In this study, kefir culture was shown to be able to ferment gluten-free dough and to provide leavening activity without the need for an additional baker's yeast for gluten-free bread production. The most important contribution of kefir culture to the quality of gluten-free bread was to improve the sensory properties of the bread and to transform gluten-free bread into a more consumable and preferable form. As a result of usage of kefir culture, *Lactococcus* was higher in test bread, which can be further analyzed regard to their biochemical content like bacteriocin like beneficiary substances.

Author Contributions

Study design: AHİ, BİOK, Data obtaining: BİOK, HB, HY, Data analyze: AHİ, BİOK, Drafting the manuscript: AHİ, HB, HY, Critical review: AHİ, BİOK, Final approval: AHİ, BİOK, HB, HY.

Conflict of Interest

All authors declared that they have no conflict of interest.

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Research Article / Araştırma Makalesi

Çöven Otu (Gypsophila Bicolor) kökünün suyu ve farklı bitkisel sütler kullanılarak vegan dondurma geliştirilmesi

Development of vegan ice cream using Coven (Gypsophila Bicolor) root juice and different plant-based milks

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Özet

Giriş ve Amaç: Çöven bitkisi yüzey aktif özelliğe sahip saponin glikoziti içermektedir. Çöven suyu, lokum ve helva üreticileri tarafından çöven köklerinin geleneksel olarak kaynayan suda ekstrakte edilmesiyle üretilmektedir. Çalışmada kullanılan bitkisel sütler, peynir altı suyu ve kazein proteini içermedikleri için alerjiye ve intoleransa yol açmadığından hayvansal sütlere alternatif oluşturmaktadır. Hindistan cevizi, badem, fındık gibi besinler yapısında bulundurdukları vitaminler, esansiyel yağ asitleri, proteinler, polifenoller ve mineraller nedeniyle bitkisel süt eldesinde tercih edilmektedir. Bu çalışmanın amacı, geleneksel yöntemlerle kaynatılan çöven otu kökünün suyu ve bitkisel sütler kullanılarak elde edilen vegan dondurmalar ile çöven kullanılmadan elde edilen vegan dondurma ve piyasada satılan vegan dondurmanın duyusal özelliklerinin karşılaştırılmasıdır.

Yöntem: Çöven köpüğü, salep ve organik elma suyu konsantresi ile badem sütlü dondurma, soya sütlü dondurma, fındık sütlü dondurma, yulaf sütlü dondurma ve Hindistan cevizi sütlü dondurma hazırlanmıştır. Ayrıca çöven köpüğü eklenmeden salep ve organik elma suyu konsantresi ile fındık sütlü

dondurma hazırlanmıştır. Piyasadan satın alınan vegan dondurma ile birlikte 7 farklı dondurmanın duyusal değerlendirilmesi yaptırılmıştır. Elde edilen veriler SPSS 22 paket programı ile değerlendirilmiştir.

Bulgular: Panelistlerin %85'i hazır vegan dondurmayı renk açısından çok iyi olarak değerlendirirken diğer bitkisel sütlerden yapılan dondurmaları ise katılımcıların %52'si iyi olarak değerlendirmiştir. Ağızda erime, sakızımsılık, koku, tat ve görünüş açısından hazır vegan dondurmadan sonra en sık çok iyi olarak değerlendirilen dondurma Hindistan cevizi sütlü dondurma olmuştur.

Sonuç: Dondurma yapımında hacim artışı için yağsız kuru madde yerine çöven köpüğünün kullanılabileceği, geliştirilen tarifelerde farklı miktarlarda çöven köpüğü kullanılabileceği düşünülmüştür.

Extended abstract

Introduction and Aim: Caryophyllaceae (Carnations) is one of the 5 families abundant in terms of species in the Turkish flora, and coven, one of 559 species, 230 of which are endemic, grows in the Central and Eastern Anatolia regions of Türkiye (1). Coven juice, traditionally extracted in boiling water, is used as an additive in the production of halva and Turkish delight, improving the color, volume and structure of the products (2).

Coven plant contains saponin glycoside with surface active properties. Coven juice is obtained traditionally by extracting coven roots in boiling water by Turkish delight and halva producers. The plant-based milks used in the study are alternatives to animal milks because they do not contain whey and casein protein and do not cause allergies and intolerances. Foods such as coconut, almond, and hazelnut are preferred in obtaining plant-based milk due to the vitamins, essential fatty acids, proteins, polyphenols, and minerals they contain. Ice cream is a frequently consumed dairy product obtained by adding air bubbles to the mixture formed by adding milk, sugar, fat, stabilizer, emulsifier, and color and flavor substances and freezing it (3). For high quality ice cream, the mixture must be balanced and processed effectively in terms of physical openers and contain the appropriate amount of stabilizer and emulsifier. Gelatin, carob bean gum, guar gum, carrageenan, agar, gum arabic, sodium carboxymethyl cellulose, and methyl cellulose are the main stabilizers used in ice cream (4). The aim of this study is to compare the sensory properties of vegan ice creams obtained using traditionally boiled coven root juice and herbal milks, vegan ice cream obtained without coven, and vegan ice cream sold in the market.

Method: Almond milk ice cream, soymilk ice cream, hazelnut milk ice cream, oat milk ice cream, and coconut milk ice cream were prepared with coven foam, salep, and organic apple juice concentrate. In addition, hazelnut milk ice cream was prepared with salep and organic apple juice concentrate without adding coven foam. Samples were prepared in the Nutrition Principles Laboratory of the Department of Nutrition and Dietetics, Faculty of Health Sciences, Marmara University. The recipes used for the preparation of the samples were developed by the researchers after reviewing the literature (5,6). Ice creams were prepared by using five different herbal milks, almond, coconut, oat, soy, and hazelnut, with the juice of the coven root obtained. In addition, ice cream was prepared without using hazelnut milk, salep and coven root. This ice cream was prepared to see the effect of coven root juice on the volume increase of ice cream.

Sensory analysis of the samples was carried out at Marmara University Nutrition Principles Laboratory with 15 panelists between the ages of 20-55. In the sensory analysis, 7 samples were evaluated, including almond milk, soy milk, hazelnut milk, oat milk, ice cream obtained using coconut milk, ice cream obtained without hazelnut milk and coven, and purchased vegan ice cream. Sensory evaluation of 7 different ice creams was carried out together with the vegan ice cream purchased from the market. The obtained data were evaluated with SPSS 22 package program. Significant differences between the applications were statistically evaluated with one-way analysis of variance. Kruskal-Wallis test was used in the comparisons between groups of parameters that did not show normal distribution for more than two groups. All statistical calculations were evaluated at a 95% confidence interval and a significance level of $p<0.05$.

Results: The average age of the fifteen panelists was 30.67±6.32 years. 93% of the panelists did not have chronic disease and 87% did not use any medication regularly. None of the ice creams prepared with plant milk were found to be very bad by the panelists in terms of color and odor. No one found hazelnut milk ice cream very bad in terms of color, appearance, texture, consistency, odor and melting in the mouth. In terms of icy texture and melting in the mouth, 33% of the panelists had no decision. Hazelnut milk ice cream was found to be better in appearance than almond milk ice cream, hazelnut milk ice cream without coven and oat milk ice cream. When the sensory properties of hazelnut milk ice cream without coven were evaluated, 67% of the panelists found it good in terms of color. 53% found it bad in terms of texture and melting in the mouth. In addition, it was found to be better than other ice creams except ready-made

vegan ice cream in terms of color. When the sensory properties of oat milk ice cream were evaluated, 67% of the panelists evaluated it good in terms of color. 67% evaluated it bad in terms of icy structure. In addition, the ice cream evaluated as very good most frequently after ready-made vegan ice cream in terms of melting in the mouth, gumminess, smell, taste, structure, appearance and color, was coconut milk ice cream. This situation showed that only coconut milk ice cream, among the ice creams developed, was similar to other vegan ice creams purchased from the market in terms of taste and appearance. The superiority of coconut milk ice cream in terms of taste and appearance can be explained by the fact that the fat content, which is a determining factor in the formation of structure, consistency, flavor and color, is higher than ice creams obtained with other plant milks (5,7). When looking at oat milk ice cream and hazelnut milk ice cream without added coven, the frequency of very bad evaluation is higher than the others. It was thought that this situation could be explained by the fact that hazelnut milk ice cream without added coven does not contain coven foam and as a result, there is no increase in volume and its fat content is low (8).

Conclusion: As a result, among the herbal milk ice creams made using coven root, the one that is most similar to the vegan ice cream sold in the market in 9 different sensory aspects is the ice cream made with coconut milk. Two types of ice cream samples were prepared, one by adding coven foam to hazelnut milk and other without coven foam. According to the results of this study, it can be recommended to use coven foam instead of non-fat dry matter as an additive for volume increase in ice creams. According to the results of the studies, more ice cream recipes obtained with herbal milks and coven foam should be developed. Newly developed recipes can be prepared by using a professional ice cream machine and adding different amounts of coven foam.

GİRİŞ

Caryophyllaceae (Karanfilgiller), Türkiye florasında tür sayısı bakımından en zengin 5 familyadan birisi olup 230'u endemik olan 559 türden biri olan çöven otu Türkiye'de İç Anadolu ve Doğu Anadolu bölgelerinde yetişmektedir (1). Geleneksel olarak kaynayan suda ekstrakte edilen çöven suyu, helva ve lokum üretiminde katkı maddesi olarak kullanılmakta, ürünlerin rengini, hacmini ve yapısını geliştirmektedir (2). Çöven kökünden elde edilen ekstrakt ayrıca kerebiç tatlısı (Mersin), ağda tatlısı (Bartın), otlu peynir, quark peynir, çöven ekmeği (Bartın) ve Görele dondurması yapımında da kullanılmaktadır. Çöven ekstraktı ürünlerin rengini ağartmak, emülgatör görevi görmek, tekstürü ayarlamak, hacmi arttırmak ve böylece ürüne karakteristik özelliklerini kazandırmak amacıyla kullanılmaktadır (8).

Dondurma; süt, şeker, yağ, stabilizatör, emülgatör ve renk ve aroma maddelerinin ilavesiyle oluşturulan karışıma hava kabarcıklarının dahil edilmesi ve dondurulması ile elde edilen ve sık tüketilen bir süt ürünüdür (3). Kaliteli dondurma için, fiziksel açıcıdan karışımın dengede olması ve etkin bir şekilde işlenmesi, uygun oranda stabilizatör ve emülgatör içermesi gerekmektedir. Jelatin, keçiboynuzu sakızı, guar sakızı, karragenan, agar, arap sakızı, sodyum karboksimetil selüloz ve metil selüloz dondurmada kullanılan başlıca stabilizatörlerdir (4).

Gıda katkı maddeleri koruyucu özelliklerinden dolayı besin sanayinde kullanılmasına rağmen sağlık açısından risk taşımakta; alerji, egzama, hiperaktivite, astım, kusma, migren ve depresyon gibi sorunlara yol açabilmektedir (9). Sağlık, yaşam biçimi ve çevreyle ilgili kaygılar nedenleriyle son yıllarda süt tüketimi azalmaya başlamış, alternatif olarak bitkisel bazlı içeceklere olan talep artış göstermiştir (10). Bitkisel kaynaklı sütler, alerjiye neden olabilen peynir altı suyu ve kazein proteini, kolesterol ve laktoz içermediğinden hayvansal sütlere alternatif oluşturmaktadır (11,12).

Yapılan literatür taramasında; çöven otunun vegan dondurma yapımında kullanılmasıyla ilgili çalışmaya rastlanmamıştır. Çöven otu kökünün suyu köpürtülerek elde edilen yapı dondurmalarda hacim artışı sağlayabilmekte, bu da vegan dondurma yapımında kullanılarak hacim artışı ile daha az katkı maddesi kullanılmasını sağlamaktadır. Çöven otu kullanılarak elde edilen dondurmaların piyasadaki vegan ürünlere alternatif olacağı düşünülmektedir. Bu kapsamda çalışmanın

amacı geleneksel yöntemlerle kaynatılan çöven otu kökünün suyu ve bitkisel sütler kullanılarak elde edilen vegan dondurmalar ile piyasadan satın alınan vegan dondurmanın duyusal özelliklerinin karşılaştırılmasıdır.

Yöntem

Çalışmamız geleneksel Kahramanmaraş dondurmasından ve kerebiç tatlısında kullanılan çöven otu kökünün suyundan yola çıkarak planlanmıştır. Çöven otunun köpüksü yapısı ve hacim artışı sağlaması özelliği sayesinde dondurma yapımında kullanılabileceği düşünülmüştür. Daha sonra yapılan literatür taramasında çöven otlu dondurmalarda hayvansal süt kullanıldığı bilgisine erişilmiştir. Hayvansal süt yerine bitkisel süt kullanımı tercih edilen bu çalışma, araştırmacılar tarafından geliştirilerek literatüre katkı sunulması planlanmıştır.

Malzemelerin Temin Edilmesi

Piyasadan temin edilen çöven otu kökü, 30 dakika kaynatılarak suyu elde edilmiştir. Organik elma suyu konsantresi ve bitkisel sütler (badem sütü, yulaf sütü, Hindistan cevizi sütü, soya sütü ve fındık sütü) ve salep de piyasadan satın alınmıştır. Bitkisel sütlere ait içerik bilgisi Tablo 1'de yer almaktadır.

Numunelerin Hazırlanması

Numuneler Marmara Üniversitesi Sağlık Bilimleri Fakültesi Beslenme ve Diyetetik Bölümü Beslenme İlkeleri laboratuvarında hazırlanmıştır. Numunelerin hazırlanması için kullanılan tarifeler, araştırmacılar tarafından literatür taranarak geliştirilmiştir (5,6). Elde edilen çöven otu kökünün suyu ile badem, Hindistan cevizi, yulaf, soya ve fındık olmak üzere beş farklı bitkisel süt ile dondurmalar hazırlanmıştır. Ayrıca fındık sütü ve salep ile çöven otu kökü kullanılmadan dondurma hazırlanmıştır. Bu dondurma ise çöven otu kökünün suyunun dondurmanın hacim artışındaki etkisini görmek amacıyla hazırlanmıştır (Şekil 1).

Bitkisel süt, çöven otu kökü ve salep kullanılarak geliştirilen dondurmanın hazırlanması

Bitkisel süt (1000 ml) 15 dakika kaynatılmıştır. Kaynatıldıktan sonra içine 12 g salep tozu eklenerek 15 dakika daha kaynatılıp kıvamı koyulaştırılmıştır. Karışım ocaktan alındıktan sonra 30 dakika soğutulmuştur. Çöven kökü suyu 30 dakika kaynatmanın ardından çırpıcı ile köpük haline getirilmiştir. Haznesi önceden soğutulmuş olan dondurma makinesinde soğutularak döndürme işlemi başlatılmıştır. İşlem başlatıldıktan 5 dakika sonra içine 300 ml çöven kökü suyu köpüğü eklenmiştir. Hemen ardında 90 ml organik elma suyu konsantresi eklenmiştir. Karışım toplam 30 dakika dondurma makinesinde döndürüldükten sonra buzlukta donmaya bırakılmıştır. Üç gün buzlukta bekleyen dondurmalar duyusal analiz ile değerlendirilmiştir.

Çöven otu içermeyen hazır vegan dondurma içeriği

Çöven otu içermeyen piyasada satılan hazır vegan dondurma, bitkisel proteinler (bezelye proteini, patates proteini), Hindistan cevizi yağı, ayçiçek yağı, stabilizatör (E1422), bitkisel aroma, sofra tuzu, koruyucu (E 202) içermektedir (13).

Duyusal Analiz

Numunelerin duyusal analizi Marmara Üniversitesi Beslenme İlkeleri Laboratuvarında 20 – 55 yaş aralığındaki 15 panelist ile gerçekleştirilmiştir. Duyusal analizde badem sütü, soya sütü, fındık sütü, yulaf sütü, Hindistan

Tablo 1. Piyasadan temin edilen bitkisel sütlerin içeriği

Bitkisel süt (100 ml için)	Enerji	Karbonhidrat	Protein	Yağ
Badem sütü	22 kcal	2,4 g	0,4 g	1,1 g
Yulaf sütü	44 kcal	7,2 g	0,4 g	1,4 g
Hindistan cevizi sütü	14 kcal	0 g	0,1 g	1,2 g
Soya sütü	39 kcal	2,5 g	3,0 g	1,8 g
Fındık sütü	29 kcal	3,2 g	0,4 g	1,6 g

cevizi sütü kullanılarak elde edilen dondurma, fındık sütü ve çöven kullanılmadan elde edilen dondurma ve satın alınan vegan dondurma olmak üzere 7 adet numune değerlendirilmiştir.

Değerlendirme sırasında numunelere rastgele kodlar verilerek panelistlere sunulmuş ve panelistler numunelerin tadımını yaparak duyusal analiz formunda puanlama yapmıştır. Dondurmalar görünüş, kıvam, tat, koku, buzlu yapı, ağızda erime ve sakızımsılık açısından 5 (çok iyi), 4 (iyi), 3 (kararsız), 2 (kötü), 1 (çok kötü) olarak değerlendirilmiştir. Her özelliğe ait puanın aritmetik ortalaması alınarak genel beğeni puanı hesaplanmıştır (14,15).

İstatistiksel Analiz

Elde edilen verilerin SPSS 22 paket programı ile istatistiksel olarak değerlendirilmiştir. Tüm analizler için ortalama ve standart sapma değerleri kullanılmıştır. Uygulamalar arasındaki önemli farklılıklar tek yönlü varyans analizi ile istatistiksel olarak değerlendirilmiştir. İkiden fazla gruplar için normal dağılım göstermeyen parametrelerin gruplar arası karşılaştırmalarda Kruskal-Wallis testi kullanılmıştır. Tüm istatistiksel hesaplamalar %95 güven aralığında, $p<0,05$ anlamlılık düzeyinde değerlendirilmiştir.

Araştırmanın Etik Yönü

Araştırmanın yürütülmesi için Marmara Üniversitesi Sağlık Bilimleri Fakültesi Beslenme ve Diyetetik Bölüm Başkanlığı'ndan izin alınmıştır. Marmara Üniversitesi Sağlık Bilimleri Fakültesi Etik Kurul'undan onay alınmıştır (29.12.2022/176). Çalışmaya katılan bireylere çalışma öncesi 'Bilgilendirilmiş Gönüllü Olur/ Onam Formu' imzalatılmıştır.

BULGULAR

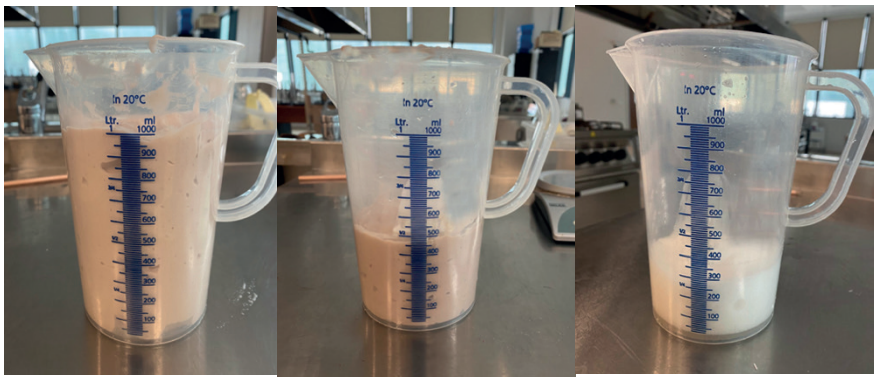
On beş panelistin yaş ortalaması 30,67±6,32 yıldır. Panelistlerin %93'ünün kronik hastalığı ve %87'sinin sürekli kullandığı bir ilaç bulunmamaktadır.

Tablo 1'te bitkisel sütler ile hazırlanmış dondurmalar ve piyasadan alınan vegan dondurmaların görünüş, kıvam, tat, koku, buzlu yapı, ağızda erime ve sakızımsılık açısından değerlendirilmesi yer almaktadır. Bitkisel süt ile hazırlanan dondurmalardan herhangi biri panelistler tarafından renk ve koku açısından çok kötü bulunmamıştır.

Çöven eklenmemiş fındık sütlü dondurmanın fındık sütlü dondurmaya göre görünüş, kıvam, buzlu yapı, ağızda erime ve sakızımsılık açısından çok kötü olarak değerlendirilme sıklığı daha yüksek çıkmıştır. Badem sütlü dondurmanın duyusal özellikleri dikkate alındığında panelistlerin %60'ı renk olarak, %53'ü ise ağızda erime olarak iyi bulmuştur. Panelistlerin %60'ı, fındık sütlü dondurmanın renk ve görünüş açısından iyi olduğunu belirtmiştir.

Görünüş, kıvam, koku ve ağızda erime açısında fındık sütlü dondurmayı çok kötü bulan olmamıştır. Buzlu yapı ve ağızda erime açısından ise panelistlerin %33'ü kararsız kalmıştır. Fındık sütlü dondurma görünüş olarak badem sütlü dondurma, çöven eklenmemiş fındık sütlü dondurma ve yulaf sütlü dondurmadan daha iyi bulunmuştur.

Şekil 1. Sırasıyla çöven köpüğü; bitkisel süt, salep ve elma suyu konsantresi; bitkisel süt, salep, elma suyu konsantresi, çöven köpüğü karışımı.

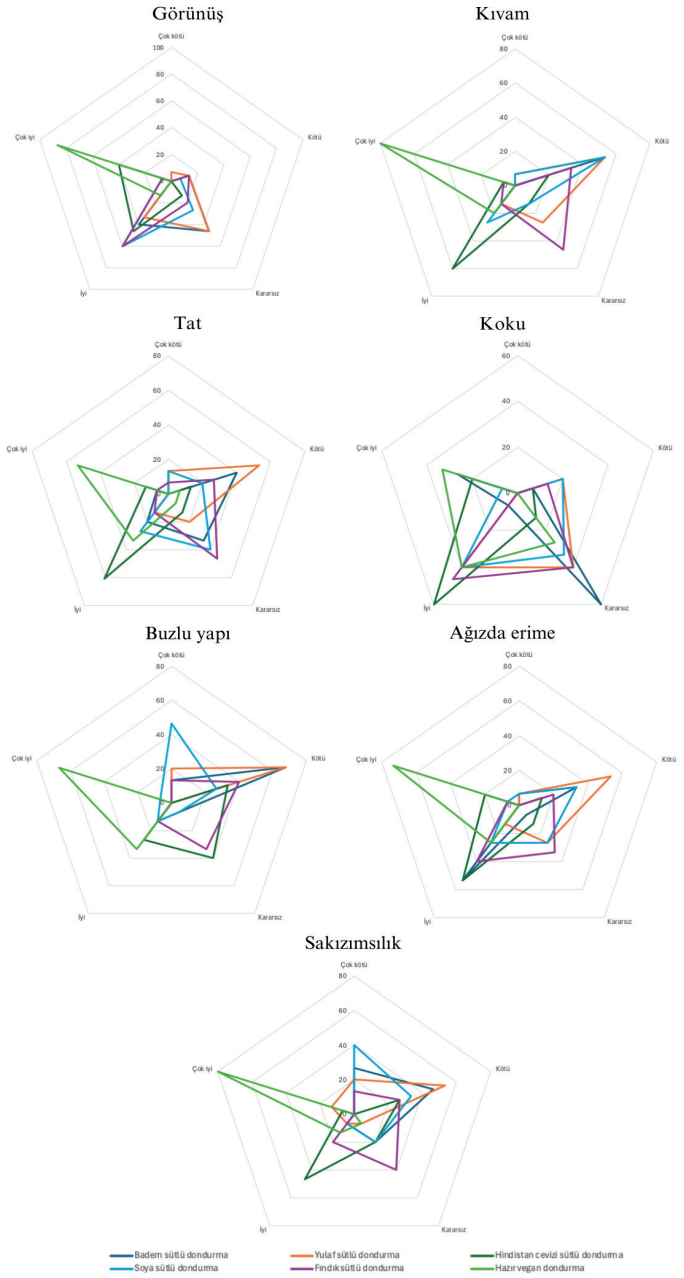


Panelistlerin %67'si, çöven eklenmemiş fındık sütlü dondurmanın duyusal özelliklerini renk olarak iyi; %53'ü ise ağızda erime olarak kötü bulmuştur. Görünüş, kıvam, tat, ağızda erime ve sakızımsılık açısından çöven eklenmemiş fındık sütlü dondurmayı çok iyi bulan olmamıştır.

Panelistlerin çoğunluğu Hindistan cevizi sütlü dondurmanın kıvam, tat ve koku ile ilgili duyusal özelliklerini iyi bulmuştur. %53'ü ise ağızda erime olarak iyi bulmuştur. Hiçbir duyusal özellik açısından Hindistan cevizi sütlü dondurmayı çok kötü bulan olmamıştır. Ayrıca renk olarak hazır vegan dondurma hariç diğer dondurmalardan daha iyi bulunmuştur.

Yulaf sütlü dondurmanın duyusal özellikleri değerlendirildiğinde panelistlerin %67'si renk olarak iyi değerlendirilmiştir. %53'ü kıvam, tat, ağızda erime ve sakızımsılık olarak kötü değerlendirilmiştir. %67'si buzlu yapı olarak kötü değerlendirilmiştir. Kıvam, tat, buzlu yapı, ağızda erime olarak panelistlerin %20'si yulaf sütlü dondurmayı iyi olarak değerlendirmiştir.

Şekil 2. Duyusal analiz değerlendirme sonuçları



Tablo 2'de tat açısından bitkisel sütlü dondurmaların ve piyasada satılan vegan dondurmanın duyusal analiz puanlarının karşılaştırılması verilmiştir. Panelist değerlendirmesine göre yulaf sütlü dondurma ile fındık sütlü dondurma, badem sütlü dondurma, soya sütlü dondurma ve çöven eklenmemiş sütlü dondurma arasında tat açısından istatistiksel olarak anlamlı fark bulunamamıştır.

Öte yandan yulaf sütlü dondurma, soya sütlü dondurma, çöven eklenmiş fındık sütlü dondurma, çöven eklenmemiş fındık sütlü dondurma, badem sütlü dondurma ile Hindistan cevizi sütlü dondurma ve vegan dondurma arasında tat puanında anlamlı fark bulunmuştur ($p<0,001$).

Hindistan cevizi sütlü dondurma ve vegan dondurmanın tat açısından beğenilme oranı diğer bitkisel sütlü dondurmalardan daha yüksek bulunmuştur. Öte yandan Hindistan cevizi sütlü dondurma ile vegan dondurma arasında tat açısından istatistiksel olarak anlamlı fark yoktur.

TARTIŞMA

Lokum ve helva üretiminde katkı maddesi olarak kullanılmakta olan çöven suyu ve bu ürünlerin hacmini, rengini ve yapısını geliştirmektedir. Çöven uzun yıllardır lokum ve helva üreticileri tarafından çöven otunun köklerinin geleneksel usullerle kaynayan suda uzun süre ekstrakte edilmesi ile üretilmektedir (2). Bu çalışmada çöven köpüğünün özellikle hacim ve yapı geliştirici özelliğini dondurmaya uyarlanmıştır. Gıda katkı maddeleri koruyucu özelliklerinden dolayı önemli olmasına rağmen sağlık açısından olan zararları çok sayıda çalışmayla ile doğrulanmıştır. Çocuklarda alerji, egzama, hiperaktivite, astım, kusma, kaşıntı, baş ağrısı, davranış bozuklukları, migren zehirlenme, sindirim sistemi bozuklukları ve depresyon gibi birçok rahatsızlığa sebep olabilmektedir (9).

Bu çalışma için kullanılan hazır vegan dondurma Hindistan cevizi sütü içermektedir. Vegan ürünlerin içerisinde, tatlandırıcı olarak; glikoz şurubu, glikoz-fruktoz şurubu; stabilizatör olarak; keçiboynuzu gamı, karragenan, jelatin nişasta; emülgatör olarak; ayçiçek lesitin, hacim artışı için de yağsız kuru madde bulunmaktadır (13). Bu çalışmada hacim artışı için sağlığa zararları olan katkı maddeleri yerine sağlığa zararı olmayan hatta faydaları olan çöven köpüğü kullanılmıştır.

Duyusal analiz sonuçlarına göre hazır vegan dondurma diğer tüm dondurmalara oranla özellikle rengi ve görünüşü açısından belirgin derecede daha iyi bulunmuştur. Öte yandan hazır vegan dondurma ile Hindistan cevizi sütlü dondurma arasında tat ve görünüş açısından anlamlı fark bulunamamıştır. Ayrıca ağızda erime, sakızımsılık, koku, tat ve görünüş açısından hazır vegan dondurmadan sonra en sık çok iyi olarak değerlendirilen dondurma Hindistan cevizi sütlü dondurma olmuştur. Bu durum bizim geliştirdiğimiz dondurmalardan sadece Hindistan cevizi sütlü dondurmanın tat

Tablo 2. Vegan dondurmaların tat açısından duyusal değerlendirilmesi

Tat	Ortanca	Alt değer – Üst değer	Sıra Ortalaması	p
Badem Sütlü Dondurma[B]	3,0	2,00-5,00	47,33	<0,001
Soya Sütlü Dondurma[B]	3,0	1,00-4,00	45,37	
Fındık Sütlü Dondurma[B]	3,0	1,00-5,00	46,10	
Çöven Eklenmemiş Fındık Sütlü Dondurma[B]	3,0	1,00-4,00	46,63	
Hindistan Cevizi Sütlü Dondurma[A]	4,0	2,00-5,00	69,53	
Yulaf Sütlü Dondurma[B]	2,0	1,00-4,00	32,23	
Hazır Vegan Dondurma[A]	5,0	2,00-5,00	83,80	

Tabloda farklı harflerle gösterilen ortalamalar arasındaki fark anlamlıdır (Kruskal Wallis).

ve görünüş açısından piyasadan satın alınan diğer vegan dondurmaya benzer olduğunu göstermiştir. Hindistan cevizi sütlü dondurmanın tat ve görünüş açısından daha üstün olması; kıvam ve lezzet oluşumunda belirleyici olan yağ oranının diğer bitkisel sütlerle elde edilen dondurmalara göre daha yüksek (5,7) olmasıyla açıklanabilmektedir.

Yulaf sütlü dondurma ve çöven eklenmemiş fındık sütlü dondurma görünüş açısından bakıldığında çok kötü olarak değerlendirilme sıklığı diğerlerinden daha yüksektir. Bu durum; yulaf sütü için yağ içeriğinin düşük olması ile (7), çöven eklenmemiş fındık sütlü dondurma için ise içerisinde çöven köpüğü bulundurmaması ve bunun sonucunda hacimsel olarak artış yakalanmaması ile açıklanabilir. Ayrıca çöven eklenmemiş fındık sütlü dondurmanın çöven eklenmiş fındık sütlü dondurmaya göre görünüş, kıvam, buzlu yapı, ağızda erime ve sakızımsılık açısından çok kötü olarak değerlendirilme sıklığı daha yüksektir. Bu durum çöven köpüğünün dondurma tekstürünü istenen düzeye getirmek amacıyla kullanılabileceğini göstermektedir (8).

Bu çalışmada geliştirilen tüm dondurmalar buzlu yapı açısından vegan dondurmaya göre daha kötü olarak değerlendirilmiştir. Ev tipi dondurma makinesinin kullanılması ve dondurma karışımlarının soğuma sürecindeyken buzluğa atıldıktan sonra tekrar karıştırılmamış olması buzlu yapının kötü olarak değerlendirilmesine sebep olmuş olabilir.

SONUÇ

Sonuç olarak çöven kökü kullanılarak yapılan bitkisel sütlü dondurmalar arasında piyasada satılan vegan dondurmaya 9 farklı duyusal açıdan en benzer olan dondurma Hindistan cevizi sütüyle yapılan dondurma olduğu bulunmuştur. Fındık sütüne çöven köpüğü eklenerek ve çöven köpüğü eklenmeyerek iki çeşit dondurma numunesi hazırlanmıştır.

Bu çalışmanın sonuçlarına göre dondurmalarda hacim artışı için katkı maddesi olarak yağsız kuru madde yerine çöven köpüğünün kullanılması önerilebilir. Ayrıca doymuş yağ içeriği yüksek olan Hindistan cevizi sütünün tercih edilmesinin genel beğenilirliğinin artırabileceği düşünülmüştür. Yapılan çalışmaların sonucuna göre bitkisel sütler ve çöven köpüğüyle elde edilen daha çok dondurma tarifeleri geliştirilmelidir. Bu çalışmada ev tipi dondurma kullanıldığı ve sınırlı sayıda deneme yapıldığı için bu konuda daha fazla çalışmaya ihtiyaç vardır. Yeni geliştirilen tarifeler profesyonel dondurma makinesi kullanılarak ve farklı miktarlarda çöven köpüğü eklenerek hazırlanabilir.

Yazarlık Katkısı

Yazarların çalışmadaki katkı oranları eşittir.

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Research Article / Araştırma Makalesi

Influence of dietary habits and service quality on nutritional satisfaction in urban Ibadan's hospitality sector

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Abstract

This study investigates the influence of dietary habits and service quality on nutritional satisfaction in urban Ibadan's hospitality sector. A cross-sectional survey design was employed, with data collected from 384 respondents across five urban Local Government Areas in Ibadan. The study revealed high satisfaction levels with food flavor (65%) and portion size (55%), but identified concerns regarding special diet options (55% unsatisfied) and service speed during peak hours (45% unsatisfied). Chi-square analysis showed significant associations between customer satisfaction and nutritional value, service speed, cleanliness, and affordability ($p < 0.05$). Regression analysis indicated that frequency of use, nutritional value; service speed, cleanliness, and affordability significantly predict overall satisfaction ($p < 0.01$). While hospitality services positively impact family well-being, affordability remains a significant barrier. The findings underscore the need for hospitality providers to improve nutritional offerings, enhance service efficiency, and balance quality with affordability to meet the diverse dietary needs of urban residents and promote better public health outcomes.

INTRODUCTION

Urbanization is a profound global phenomenon, significantly transforming dietary habits and food consumption patterns (1). In Nigeria, rapid urbanization has notably impacted cities like Ibadan, where residents' lifestyles and food preferences have evolved in response to increased incomes, busier schedules, and shifting tastes (2). As urbanization accelerates, there is a noticeable shift from traditional, nutrient-rich Nigerian meals to fast, processed foods often characterized by high calorie, fat, and sugar content while lacking essential nutrients. This dietary shift poses significant public health risks, including increased prevalence of obesity, diabetes, hypertension, and other diet-related non-communicable diseases (1, 3).

In urban Ibadan, the hospitality sector plays a crucial role in shaping residents' diets. However, there is a growing concern that many hospitality establishments prioritize taste, convenience, and cost over nutritional balance (4). This oversight may undermine the health of urban residents who frequently dine out, potentially reducing the nutritional quality of their diets (4). Service quality in hospitality, encompassing aspects such as staff behavior, the physical environment, and food quality, significantly influences customer satisfaction (5, 6, 7). For example, tangibility, empathy, responsiveness, and assurance dimensions of service quality have been shown to impact customer satisfaction in fast-food settings in Ibadan (8). Similarly, in hotels, food quality, employee behavior, and room amenities significantly affect satisfaction levels (7).

Despite this, the relationship between dietary habits, service quality, and nutritional satisfaction remains underexplored in the context of Ibadan's hospitality sector. The diverse dietary preferences of urban consumers—such as those adhering to vegan, low-carb, or high-protein diets underscore the need for hospitality providers to accommodate varying nutritional expectations (7). Moreover, service quality factors like speed, cleanliness, and staff professionalism directly impact customer satisfaction and, by extension, their perception of nutritional value (6).

Urban consumers are increasingly health-conscious and expect their meals to be nutritionally balanced, but many hospitality providers in Ibadan may not fully meet these expectations. The disconnect between customer dietary habits and the nutritional offerings of hospitality services could potentially affect customer satisfaction and the overall reputation of these establishments (7). The evolving dietary patterns and service expectations in urban Ibadan necessitate an investigation into how these factors influence nutritional satisfaction.

Urbanization in Ibadan has led to significant changes in dietary habits, with many residents relying on the hospitality sector for their daily meals. This shift towards convenience and affordability often overshadows the importance of nutritional quality, leading to a potential mismatch between consumers' dietary preferences and the nutritional offerings provided by hospitality services. As urban residents become more health-conscious, there is a growing expectation for balanced and nutritious meals. However, the hospitality sector may fall short in addressing these needs due to a focus on cost and convenience or insufficient awareness of the nutritional aspects crucial to customer satisfaction. Additionally, the impact of service quality elements such as speed, cleanliness, and overall dining experience—on nutritional satisfaction is not well understood in the context of urban Ibadan.

This research aims to address these gaps by exploring the relationship between dietary habits, service quality, and nutritional satisfaction in Ibadan's hospitality sector. By examining these factors, the study seeks to provide insights for improving hospitality services to better meet customer nutritional needs and to inform policymakers about promoting better nutritional standards in urban areas.

Null Hypotheses

H01: There is no significant relationship between satisfaction with nutritional value and customer satisfaction in urban hospitality establishments.

H02: There is no significant relationship between satisfaction with service speed and overall

customer satisfaction.

H03: There is no significant relationship between satisfaction with cleanliness of facilities and overall customer satisfaction.

H04: There is no significant relationship between satisfaction with affordability and overall customer satisfaction.

H05: Service quality factors (frequency of use, nutritional value, service speed, cleanliness of facilities, and affordability) do not significantly predict overall customer satisfaction in urban hospitality establishments.

LITERATURE REVIEW

Urbanization has profoundly transformed dietary habits worldwide, replacing traditional, nutrient-dense diets with calorie-rich, processed foods. In Nigeria, cities like Ibadan exemplify this shift, where changes in food preferences have been linked to increased public health concerns such as obesity and diet-related diseases (1,3). Urban hospitality establishments are central to this transformation, often prioritizing affordability and convenience over nutritional value (2). Service quality factors, including food quality, cleanliness, and responsiveness, strongly influence customer satisfaction (5, 6). However, challenges persist, such as the limited availability of special diet options (e.g., gluten-free, vegan) and delays during peak hours (7). Cleanliness in dining spaces and restrooms, a key determinant of customer loyalty, is another area requiring improvement (8).

Affordability often forces compromises in food quality and nutritional balance. Although urban consumers increasingly seek healthier options, including organic ingredients and transparent labeling, establishments frequently struggle to meet these demands due to cost constraints (9, 10). This tension between affordability and quality highlights significant gaps in meeting customer expectations.

By addressing these issues, this study aims to bridge gaps in understanding the interplay between dietary habits, service quality, and nutritional satisfaction, with a specific focus on urban Ibadan.

RESEARCH METHODOLOGY

Study Area

The study was conducted in Ibadan, the capital city of Oyo State, Nigeria. Ibadan is one of the largest cities in Africa by landmass and serves as a major urban center in southwestern Nigeria. It is geographically located between latitude 7.3775° N and longitude 3.9470° E. The city spans over a large area and is divided into 11 local government areas (LGAs), which include both urban and rural regions. For this research, focus was placed specifically on the urban areas of Ibadan, which consist of the following five local government areas: Ibadan North, Ibadan Northeast, Ibadan Northwest, Ibadan Southeast, and Ibadan Southwest. These LGAs were selected due to their high population density, advanced urbanization, and concentration of hospitality establishments.

Research Design

A cross-sectional survey design was employed for this study. This design was chosen to provide a snapshot of the relationship between dietary habits, service quality, and nutritional satisfaction among residents who frequently patronize hospitality establishments in urban Ibadan. The cross-sectional approach allowed for the collection of data at a single point in time, making it possible to analyze patterns and correlations between variables across different demographic groups within the study area.

Reconnaissance Survey

Before the main study commenced, a reconnaissance survey was conducted to gain a preliminary understanding of the hospitality landscape in urban Ibadan. This involved visits to various hospitality establishments across the five selected LGAs to observe the types of services offered, customer demographics, and the general dietary preferences of patrons. The reconnaissance survey also facilitated the identification of key areas within each LGA where hospitality activities were most concentrated. This initial exploration was crucial in refining

the research design, identifying potential challenges in data collection, and ensuring that the study would adequately capture the diverse experiences of urban residents.

Sample Size Determination

The sample size (384) for this study was determined using Cochran's formula and proportionally allocated across the five urban LGAs based on their population densities and the concentration of hospitality establishments. The distribution is as follows: **Ibadan North:** 120 respondents, **Ibadan Northeast:** 100 respondents, **Ibadan Northwest:** 90 respondents, **Ibadan Southeast:** 90 respondents, and **Ibadan Southwest:** 100 respondents

Population and Sampling Procedure

The population of the study comprised residents of urban Ibadan who regularly patronize hospitality establishments. The target population specifically included individuals aged 18 and above. A multi-stage sampling technique was employed in selecting the study participants. These approaches systematically narrow down the large population into a manageable and representative sample.

Stage 1: Five urban local government areas (LGAs) in Ibadan were purposively selected based due to their level of urbanization and concentration of hospitality establishments.

Stage 2: Each of the selected LGAs was stratified into different zones based on population density and economic activities.

Stage 3: A compiled list of hospitality establishments within each stratum was was subjected to randomization for establishments selection in the study area. This ensured that the study covered a range of hospitality services, from upscale restaurants to quick-service outlets.

Stage 4: Finally, systematic random sampling was employed within the selected establishments to identify respondents. Every third customer entering the establishment was approached and invited to participate in the study until the required number of respondents for each LGA was reached.

Data Collection Tool

A structured questionnaire was used to collect data on dietary habits, service quality, and nutritional satisfaction. It consisted of four sections: demographic details, dietary habits, service quality, and nutritional satisfaction.

Scales and Their Details

Dietary Habits: Items on meal frequency, diet types, and snacking patterns were adapted from validated studies on urban food consumption.

Service Quality: Based on the SERVQUAL model, 20 items measured tangibles, responsiveness, and reliability on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Nutritional Satisfaction: This scale included 15 items assessing satisfaction with factors like freshness, portion size, and nutrient balance, rated from 1 (Very Dissatisfied) to 5 (Very Satisfied).

Validity and Reliability

Reliability: Cronbach's alpha values demonstrated internal consistency (Service Quality: 0.84; Nutritional Satisfaction: 0.81).

Construct Validity: Factor analysis using PCA with varimax rotation confirmed scale structures:

Service Quality: Five components (67% variance explained)

Nutritional Satisfaction: Three components (72% variance explained).

Pilot Test: Conducted with 50 respondents, ensuring clarity and reliability.

Data Collection

Data collection was carried out using a structured questionnaire, which was administered face-to-face by trained research assistants. The questionnaire was designed to capture information on respondents' dietary habits, perceptions of service quality, and satisfaction with the nutritional content of meals provided by hospitality establishments. The questionnaire included closed-ended questions to allow for a comprehensive analysis of the research

objectives.

The data collection process was conducted over a period of four weeks, with research assistants stationed at various hospitality establishments during peak hours to maximize response rates. Prior to data collection, the questionnaire was pre-tested in a pilot study to ensure clarity, reliability, and validity of the questions.

Data Analysis

The data collected were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including frequencies, percentages, were used to summarize the demographic characteristics of respondents, their dietary habits, and their perceptions of service quality and nutritional satisfaction.

Inferential statistics including Chi-square and Multiple Regression were employed to test the research hypotheses.

The analysis was performed using statistical package for social science (SPSS) version 25.0, and the results were presented in tables for clarity.

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

The study sample comprised a relatively balanced gender distribution, with 53.1% female and 46.9% male respondents (Table 1). This distribution closely mirrors the general population demographics, enhancing the representativeness of the findings. Previous research like that of Ojekalu*et al*. (11) indicates that gender and education significantly influence service quality perception in shopping complexes, with females rating services higher than males. The age distribution showed a predominance of young to middle-aged adults, with 31.3% in the 26-35 age group and 23.4% in the 36-45 age groups. This age distribution is consistent with the typical profile of urban dwellers who frequently patronize hospitality establishments (12). The findings also align with (13, 14) who reported that fast food consumption is prevalent among young adults, particularly university students, with flour-based products being the most commonly consumed items.

Educational attainment among respondents was relatively high, with 46.9% having tertiary education. This finding aligns with previous studies (11) suggesting that higher education levels are associated with increased frequency of dining out and greater awareness of nutritional issues. The occupational distribution, dominated by self-employed individuals (31.3%) and students (25%), reflects the diverse economic landscape of urban Ibadan and may influence dietary habits and service quality expectations.

Table 1. Demographic characteristics of respondents

Characteristic	Frequency	Percentage (%)
Gender		
Male	180	46.9
Female	204	53.1
Age Group		
18-25	96	25.0
26-35	120	31.3
36-45	90	23.4
46-55	48	12.5
56 and above	30	7.8
Education Level		
No Formal Education	24	6.3
Primary Education	60	15.6
Secondary Education	120	31.3
Tertiary Education	180	46.9
Occupation		
Student	96	25.0
Self-employed	120	31.3
Private Sector Employee	90	23.4
Public Sector Employee	60	15.6
Retired	18	4.7

Frequency of Hospitality Service Usage

The frequency of hospitality service usage varied across the five Local Government Areas (LGAs) studied (Table 2). Notably, Ibadan Southwest showed the highest frequency of usage, with 45% of respondents using hospitality services "Often" and 18% "Very Often." This could be attributed to factors such as higher concentration of hospitality establishments or socioeconomic characteristics of residents in this LGA. In contrast, Ibadan Southeast showed the lowest frequency of usage, with only 25% using services "Often" and 10% "Very Often." These disparities in usage patterns across LGAs suggest that geographical and possibly socioeconomic factors play a role in hospitality service utilization, a finding consistent with urban studies in other developing countries (15, 16). Another study has explored various aspects of the hospitality industry in Nigeria and beyond. (17) investigated the distribution of hospitality services in Uyo Urban, finding that these services tend to cluster in areas with high patronage potential to maximize profits. These studies collectively highlight the importance of location in understanding and improving the hospitality industry.

Satisfaction with Nutritional Value

The results reveal varying levels of satisfaction with different aspects of nutritional value in hospitality services (Table 3). Respondents expressed highest satisfaction with food flavor (65% satisfied or very satisfied) and portion size (55% satisfied or very satisfied). However, areas of concern include the availability of special diet meals (55% unsatisfied or very unsatisfied) and low-sodium meal options (45% unsatisfied or very unsatisfied). These findings suggest that while hospitality establishments in urban Ibadan are meeting basic taste and quantity expectations, they may be falling short in catering to specific dietary needs and health considerations.

The relatively low satisfaction with the use of organic ingredients (40% unsatisfied or very unsatisfied) and the presence of food allergens (48% unsatisfied or very unsatisfied) indicates a gap between consumer expectations and current practices in the hospitality sector. This aligns with global trends where consumers are increasingly demanding transparency and healthier options in their dining experiences (18).

Research on customer satisfaction in hospitality services reveals varying levels of satisfaction with different aspects of nutritional value. While consumers express high satisfaction with food flavor and portion size, there are concerns regarding special dietary options and health considerations (19). Studies indicate that the hospitality industry, particularly restaurants, can significantly impact people's eating behavior and nutritional intake (19). Customer satisfaction is crucial in hospitality and tourism industries, with various methods used for measurement (10). Perceived value in food selection when dining out differs between ethnic groups, with African Americans more influenced by lower cost and larger portions (20). A systematic review of consumer satisfaction studies in hospitality journals highlights the need for more specific definitions of consumer satisfaction and a broader range of research methods (21). The positive consequences of satisfaction on loyalty and behavioral intentions are well-established in the literature (21).

Table 2. Frequency of hospitality service usage by LGA

LGA	Very Rarely	Rarely	Sometimes	Often	Very Often
Ibadan North	10%	15%	20%	35%	20%
Ibadan Northeast	8%	12%	25%	40%	15%
Ibadan Northwest	12%	18%	28%	30%	12%
Ibadan Southeast	15%	20%	30%	25%	10%
Ibadan Southwest	5%	10%	22%	45%	18%

Source: Field Survey, 2024.

Service Quality: Speed and Cleanliness

Service speed satisfaction (Table 4) showed mixed results, with higher satisfaction in areas like efficiency of the payment process (55% satisfied or very satisfied) and speed of self-service lines (55% satisfied or very satisfied). However, speed of service during peak hours was a significant concern, with 45% of respondents expressing dissatisfaction. This highlights the challenges faced by hospitality establishments in maintaining service quality during high-demand periods, a common issue in urban food service sectors (22).

Research on customer satisfaction in hospitality services reveals several key factors influencing guest experiences. Service speed satisfaction shows mixed results, with efficiency in payment processes and self-service lines generally rated positively, but challenges during peak hours (23). The relationship between perceived service pace and satisfaction follows an inverted U-shape, with tolerance for faster pace varying by service stage (23). Self-service technology can reduce waiting times, but its effectiveness depends on factors like processing speed and failure rates (23). While self-service kiosks can increase average daily rates, they may not improve perceived service speed and can negatively impact guest loyalty if issues arise (24). Customer satisfaction in restaurants is influenced by staff behavior, professionalism, service speed, food quality, ambience, and comfort (6). Ensuring customer satisfaction requires effective management systems, including human resource management, food safety standards, and space planning (6).

Cleanliness of facilities (Table 5) generally received positive ratings, particularly for dining areas (63% satisfied or very satisfied) and serving utensils (58% satisfied or very satisfied). However, cleanliness of restrooms and outside surroundings showed lower satisfaction levels. These findings underscore the importance of maintaining cleanliness across all aspects of the establishment to ensure overall customer satisfaction, as emphasized in previous hospitality studies (8).

Research indicates that cleanliness in

Table 3. Level of satisfaction with nutritional value

Variable	Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied
Variety of Food Choices	8%	15%	20%	35%	22%
Freshness of Ingredients	10%	18%	25%	30%	17%
Quality of Protein Content	12%	15%	28%	30%	15%
Adequacy of Fruit and Vegetable Portions	5%	12%	30%	38%	15%
Caloric Content Control	15%	20%	25%	28%	12%
Satisfaction with Food Temperature	7%	13%	22%	35%	23%
Use of Organic Ingredients	18%	22%	25%	25%	10%
Balance of Nutrients in Meals	10%	17%	30%	30%	13%
Portion Size	8%	12%	25%	40%	15%
Low-Sodium Meal Options	20%	25%	28%	20%	7%
Gluten-Free Options	25%	20%	30%	15%	10%
Satisfaction with Food Flavor	5%	10%	20%	40%	25%
Availability of Special Diet Meals (e.g., Vegan)	30%	25%	20%	15%	10%
Presence of Food Allergens	28%	20%	25%	17%	10%
Satisfaction with Overall Nutritional Value	8%	12%	22%	40%	18%

Source: Field Survey, 2024.

foodservice establishments significantly impacts customer satisfaction and retention. Barber and Scarcelli (8) found that restroom cleanliness influences consumers' perceptions of overall restaurant cleanliness and their likelihood to return. Barber and Scarcelli (8) demonstrated that servicescapecleanliness positively affects customers' approach behavior, feelings of pleasure, trust, and attributed prestige across various service contexts. Abubakari*et al*. (25) reported that sanitation variables, including dining area cleanliness and employee hygiene, significantly influence customer retention in restaurants. Lap-Kwong (24) identified

Table 4. Level of satisfaction with service speed

Variable	Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied
Waiting Time for Orders	15%	20%	25%	28%	12%
Speed of Service During Peak Hours	20%	25%	22%	25%	8%
Speed of Home Delivery	10%	18%	28%	32%	12%
Efficiency in Handling Complaints	18%	22%	30%	20%	10%
Promptness in Food Preparation	12%	17%	28%	30%	13%
Timeliness of Order Confirmation	10%	15%	25%	35%	15%
Speed of Service in Self-Service Lines	5%	10%	30%	40%	15%
Quickness in Replacing Out-of-Stock Items	22%	20%	28%	20%	10%
Response Time to Online Orders	15%	18%	30%	25%	12%
Efficiency of Payment Process	8%	15%	22%	35%	20%
Satisfaction with Speed of Drive-Thru Service	12%	20%	28%	30%	10%
Satisfaction with Wait Times During Off-Peak Hours	10%	15%	25%	35%	15%
Satisfaction with Takeaway Service Speed	7%	12%	30%	35%	16%
Overall Satisfaction with Service Speed	10%	18%	28%	32%	12%

Source: Field Survey, 2024.

Table 5. Level of satisfaction with cleanliness of facilities

Variable	Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied
Cleanliness of Dining Areas	5%	12%	20%	40%	23%
Cleanliness of Restrooms	15%	20%	25%	28%	12%
Cleanliness of Kitchen Areas	8%	18%	22%	35%	17%
Cleanliness of Serving Utensils	7%	10%	25%	40%	18%
Cleanliness of Waiting Areas	10%	17%	30%	30%	13%
Cleanliness of Floors	12%	15%	28%	30%	15%
Cleanliness of Tables and Chairs	10%	18%	22%	38%	12%
Cleanliness of Outside Surroundings	18%	22%	25%	25%	10%
Cleanliness of Play Areas for Children	25%	20%	20%	25%	10%
Cleanliness of Parking Areas	15%	20%	30%	25%	10%
Satisfaction with Overall Cleanliness	10%	15%	25%	35%	15%

Source: Field Survey, 2024.

cleanliness as having the greatest impact on customer satisfaction among servicescape dimensions in hotel buffet restaurants. These studies collectively emphasize the importance of maintaining cleanliness across all areas of foodservice establishments, including dining areas, restrooms, and outside surroundings, to ensure customer satisfaction and promote positive word-of-mouth recommendations.

Affordability and Value Perception

Affordability (Table 6) emerged as a significant concern for many respondents. Only 40% expressed satisfaction with the overall affordability of services, while 32% were dissatisfied. The perception of value for money was slightly more positive, with 53% satisfied or very satisfied. However, the affordability of special dietary options and extras (like sauces and sides) received lower satisfaction ratings. These results suggest that while hospitality establishments are providing perceived value, there is room for improvement in pricing strategies, particularly for specialized offerings. This aligns with findings from other urban contexts where balancing affordability with quality remains a challenge for the hospitality sector (26).

Research in the hospitality industry consistently highlights the importance of customer satisfaction, which is influenced by factors such as perceived value, service quality, and price. Bojanic (27) found that hotels can achieve competitive advantage through low prices or high quality. Oh (28) emphasized that while quality and satisfaction are important, customers are primarily motivated by value. Kapiki (9) identified key elements of quality service in hotels, including value for money, comfortable rooms, friendly staff, and good food. The study also stressed the importance of continuous improvement and staff training. Foroziaet *al*. (29) focused on Middle Eastern tourists in Malaysian 3-star hotels, finding service quality to be the most significant factor affecting customer satisfaction. Across these studies, the relationship between price, quality, and value emerges as crucial for customer satisfaction in the hospitality sector, with service quality and perceived value being particularly important drivers of customer satisfaction and business success (27, 28, 9, 29).

Dietary Habits and Service Types

The analysis of dietary habits (Table 8) reveals that 46.9% of respondents are regular breakfast consumers, while 25.8% follow high-protein

Table 6. Level of satisfaction with affordability

Variable	Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied
Affordability of Meals	12%	20%	28%	30%	10%
Affordability of Drinks	15%	22%	25%	28%	10%
Value for Money	10%	15%	22%	38%	15%
Special Offers and Discounts	25%	20%	20%	25%	10%
Satisfaction with Pricing of Extras (sauces, sides)	20%	25%	22%	25%	8%
Satisfaction with Portion Size Relative to Price	18%	20%	25%	27%	10%
Affordability of Group Meals	15%	18%	30%	25%	12%
Perceived Fairness of Prices	12%	15%	28%	35%	10%
Affordability of Special Dietary Options	25%	20%	20%	25%	10%
Price Transparency	10%	15%	25%	35%	15%
Overall Satisfaction with Affordability	10%	18%	28%	30%	14%

Source: Field Survey, 2024.

diets. This information is crucial for hospitality establishments in tailoring their offerings to meet diverse dietary preferences. The types of hospitality services used (Table 7) show a preference for quick-service restaurants (26%) and full-service restaurants (19.5%), reflecting the urban lifestyle's demand for convenience and variety.

Recent studies have highlighted changing consumer preferences in the food service industry. Fast food purchases are driven primarily by taste, convenience, and cleanliness, with some consumers seeking healthier options like the Banting diet (30). There's a shift towards poultry, fish, fruits, and vegetables, impacting quick-service restaurants (31). Income levels significantly influence expenditure patterns, with higher-income households favoring full-service restaurants, while younger, urban households prefer quick-service options (15). Food quality remains a crucial factor across restaurant types, with consumers prioritizing quality over service in high-end establishments and service over ambiance in quick-service venues (32). These findings underscore the importance for the hospitality industry to adapt to diverse dietary preferences, offer healthy options, maintain cleanliness, and balance quality, service, and ambiance to meet evolving consumer demands.

Table 7. Types of hospitality services used

Type of Service	Frequency	Percentage (%)
Quick Service Restaurants	100	26.0
Full-Service Restaurants	75	19.5
Cafes and Coffee Shops	50	13.0
Hotel Dining	60	15.6
Catering Services	40	10.4
Takeaway and Delivery Services	59	15.4

Source: Field Survey, 2024.

Table 8. Dietary habits

Dietary Habit	Frequency	Percentage (%)
Regular Breakfast Consumption	180	46.9
Vegetarian Diet	60	15.6
Low-Carb Diet	45	11.7
High-Protein Diet	99	25.8
Frequent Snacking	130	33.9
Avoidance of Sugary Drinks	75	19.5

Source: Field Survey, 2024.

Impact on Family Well-being

Perceptions of family well-being in relation to hospitality services (Table 9) were generally positive. 63% of respondents agreed or strongly agreed that hospitality services enhance family togetherness, and 50% believed they improve family nutrition. However, only 37% agreed that these services are affordable for families. These findings suggest that while hospitality services play a positive role in family dynamics and nutrition, affordability remains a barrier for many urban families, a trend observed in other developing urban contexts (33).

Research on hospitality services and family well-being reveals both positive impacts and challenges. Studies indicate that hospitality services can enhance family togetherness and improve nutrition (34). However, affordability remains a significant barrier for many families (34). The hospitality industry faces challenges in balancing work and family life for employees, with issues such as work interference affecting organizational commitment (35). Despite these challenges, low-income families residing in extended-stay hotels have identified positive characteristics, including family independence, social engagement, and a sense of safety (36). The industry is evolving to address work-family balance, with progressive organizations implementing more flexible workplace policies (35). Future research should focus on developing a holistic model of factors affecting work and family in the tourism and hospitality contexts to improve consistency in this field of study (37).

Inferential Statistical Analysis

The results from the chi-square analysis in Table 10 reveal significant relationships between various service quality factors and customer satisfaction in urban hospitality establishments. Satisfaction with nutritional value is significantly associated with overall customer satisfaction, leading to the rejection of the null hypothesis that there is no relationship between these variables. This result emphasizes the critical role of providing balanced and healthy meal options in meeting customer expectations, aligning with previous studies that highlight the growing demand for nutritionally adequate meals in urban contexts (19, 10, 4). Similarly, the null hypothesis that there is no relationship between satisfaction with service speed and customer satisfaction is rejected. The findings confirm the importance of efficient service delivery, as delays during peak hours often negatively affect customer experiences, making operational efficiency essential for customer retention (26, 23). Cleanliness also emerged as a significant factor influencing customer satisfaction, and the null hypothesis that there is no relationship between cleanliness and satisfaction is rejected. Clean dining areas, utensils, and restrooms are essential to fostering positive perceptions of service quality, consistent with established research showing that poor sanitation reduces trust and the likelihood of repeat patronage (8, 25). Additionally, affordability has a meaningful relationship with customer satisfaction, leading to the rejection of the null hypothesis that there is no such relationship. Customers value fair pricing, but affordability must be carefully balanced with quality to ensure optimal satisfaction and loyalty (28, 27).

The multiple regression analysis in Table 11 indicates that service quality factors significantly predict overall customer satisfaction. The null hypothesis that service quality factors do not predict customer satisfaction is rejected. Among these factors, frequency of use has the strongest effect, suggesting that customers who frequently patronize urban hospitality establishments tend to report higher satisfaction levels. This could be attributed to consistent positive experiences that build trust and familiarity (12). Nutritional value is also a critical predictor, reinforcing the importance of offering meals that meet the dietary preferences and health-conscious needs of urban consumers (19, 4). Service speed further predicts customer satisfaction, confirming that timely and efficient service is crucial for urban consumers, who often value responsiveness due to time constraints. This is consistent with findings that speed and responsiveness significantly enhance customer satisfaction in urban hospitality contexts (26, 23). Cleanliness remains a strong predictor of customer satisfaction, highlighting that maintaining hygienic environments is not only a basic requirement but also a key driver of customer loyalty and positive word-of-mouth recommendations (8). Affordability, while having a smaller effect compared to other

Table 9. Perceptions of family well-being

Perception	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Hospitality services enhance family togetherness	5%	12%	20%	40%	23%
Hospitality services improve family nutrition	10%	15%	25%	35%	15%
Hospitality services provide stress relief for families	8%	12%	22%	38%	20%
Hospitality services are affordable for families	15%	20%	28%	25%	12%
Hospitality services offer healthy food options	12%	18%	30%	28%	12%

Source: Field Survey, 2024.

factors, significantly contributes to satisfaction, demonstrating that reasonable pricing is a priority for customers, especially in competitive urban markets (28, 27).

Generally, the results clearly demonstrate that all null hypotheses have been rejected. There are significant relationships between satisfaction with nutritional value, service speed, cleanliness, affordability, and overall customer satisfaction. Furthermore, these service quality factors collectively and individually predict overall customer satisfaction. These findings underscore the importance of focusing on nutritional value, operational efficiency, cleanliness, and affordability to enhance customer experiences. Urban hospitality establishments must strategically address these areas to improve satisfaction and foster long-term customer loyalty.

CONCLUSION

This study explored the relationships between dietary habits, service quality factors, and customer satisfaction in urban hospitality establishments in Ibadan. The findings revealed significant associations between satisfaction with nutritional value, service speed, cleanliness, and affordability, and overall customer satisfaction. Furthermore, regression analysis demonstrated that these factors, along with frequency of use, are significant predictors of customer satisfaction. These results reinforce existing literature emphasizing the importance of service quality dimensions in shaping customer experiences and satisfaction. For example, the role of nutritional value aligns with studies by (19), which highlight the demand for healthier food options in urban contexts. Similarly, the influence of cleanliness corroborates findings

Table 10. Chi-Square analysis

Hypotheses	Chi-Square Value	df	p-value
There is no significant relationship between satisfaction with nutritional value and customer satisfaction in urban hospitality establishments	18.34	10	0.032
There is no significant relationship between satisfaction with service speed and overall customer satisfaction.	15.78	10	0.045
There is no significant relationship between satisfaction with cleanliness of facilities and overall customer satisfaction	20.56	10	0.015
There is no significant relationship between satisfaction with affordability and overall customer satisfaction	17.45	10	0.028

Source: Field Survey, 2024.

Table 11. Service quality factors (frequency of use, nutritional value, service speed, cleanliness of facilities, and affordability) do not significantly predict overall customer satisfaction in urban hospitality establishments (Regression Analysis)

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Beta		
Frequency of Use	0.380	0.310	5.89	0.000
Nutritional Value	0.290	0.210	3.78	0.001
Service Speed	0.210	0.160	2.98	0.005
Cleanliness of Facilities	0.330	0.270	4.89	0.000
Affordability	0.190	0.150	2.67	0.010

Source: Field Survey, 2024.

by (8), who noted the critical importance of sanitation in enhancing customer perceptions and loyalty.

The results underscore the need for hospitality providers to prioritize nutritional quality, improve operational efficiency, and maintain high standards of cleanliness while balancing affordability with quality. These findings contribute to the broader understanding of customer satisfaction determinants within the urban hospitality sector, offering actionable insights for both industry stakeholders and policymakers.

Recommendations

Based on the statistical findings, the following recommendations are proposed:

1. **Enhance Nutritional Offerings**: Urban hospitality providers should focus on diversifying menu options to include balanced meals and cater to special dietary needs such as low-sodium or vegan diets, as these significantly impact customer satisfaction.

2. **Improve Service Efficiency**: Establishments should streamline operations to reduce delays during peak hours, possibly through staff training or adopting technology-driven solutions like self-service kiosks.

3. **Maintain High Cleanliness Standards**: Hygiene practices should be prioritized across all service areas, including dining spaces and restrooms, to meet customer expectations and build loyalty.

4. **Balance Affordability and Quality**: Providers must adopt pricing strategies that align with customer expectations for value while ensuring that quality is not compromised.

5. **Future Research Directions**: Longitudinal studies are recommended to explore how customer satisfaction evolves over time. Expanding the research to include other urban and rural contexts would enhance the generalizability of the findings. Incorporating qualitative methods, such as interviews, could also provide deeper insights into customer preferences and expectations.

Finally, this study highlights the critical interplay between dietary habits, service quality, and customer satisfaction, offering valuable insights for improving urban hospitality services. Addressing the identified limitations and implementing the recommendations can further strengthen the sector's ability to meet the evolving needs of urban consumers.

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Review Article/Derleme Makale

Kreatinin sporcular üzerindeki etkisi

Effect of creatine on athletes

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Özet

Bir aminoasit olan kreatin, en sık kullanılan ergojenik desteklerden birisidir ve doping sayılmamaktadır. Kreatin tip-2 hızlı kasılan liflerde depo edilir ve kaslarda depolanma formu olan fosfokreatinin (PCr) kas hücrelerindeki biyolojik oluşumu arttıran kreatin yüklemesi ile kas performansındaki artış çeşitli mekanizmalarla açıklanmaktadır. Uygun dozda kullanımında yan etki gözlemlenmese de ozmotik etkisinden dolayı dehidratasyon riski bulunmaktadır ve bu sebeple bol sıvı tüketimi önerilmektedir. Sporcular üzerine birçok olumlu etkisi olduğu iddia edilmektedir. Özellikle kısa süreli, yüksek şiddetli egzersizler ve anaerobik egzersizler için performansı arttırmak için önerilmektedir. Farklı spor dallarında, farklı takviye protokollerine göre, kreatinin sporcu üzerindeki elde edilen sonuçları farklılık gösterebilmektedir. Başlangıçtaki kreatin depolarının durumu, takviye sonrası gerçekleşecek kas kreatin artışını etkilemektedir. Kreatin takviyesi ile ilgili genellikle kırk yaş üzeri olan ve düzenli egzersiz yapan veteran sporcular üzerine yapılan çalışmalarda çelişkili sonuçlar bulunmaktadır. Kreatin takviyesi yapılan çalışmalarda hem yağsız vücut kütlesini hem de yağ kütlesinde artışlar olduğunu gösteren sonuçlar bulunmaktadır. Kreatin takviyesi üzerine yapılan çalışmalarda kısa süreli etkilerine dair sonuçlar elde edilmiş olsa da uzun dönemde gerçekleşecek sonuçlar belirsizliğini korumaktadır.

Extended abstract

Creatine is an amino acid. The vast majority is stored in skeletal muscle, and the form of storage in muscles is phosphocreatine (1, 2). Food sources of creatinine include meat and fish (1). An average 70-pound young man has a creatine pool of between 120 and 140 g (3), which varies according to muscle fiber type and muscle mass. Creatine is produced endogenously in the body. The place where it is most produced is the liver and kidneys (3). The increase in creatine uses first started in Barcelona with the expression of the increased performance of Olympic athletes as a result of creatine supplementation (4). In a survey of 2100 athletes, it was determined that creatine use was most common in wrestlers with a rate of 29% (2). Even if no side effects are observed in creatine supplementation at appropriate doses, caution should be exercised about dehydration, venous thromboembolism (2, 1). Caution should be exercised in long-term use, especially in individuals with kidney and liver disease (1). Although it is stated that kidney dysfunction may occur with excessive creatine load in contradiction with this information; No decrease in glomerular filtration rate was observed in individuals who received five-year creatine supplementation (5). Creatinine has the ability to increase the volume of urine. The reason for this situation is explained as being due to its osmotic effect. Therefore, high fluid consumption is recommended in athletes using creatine (2).

Some of the benefits of creatine are increasing muscle strength, increase in muscle mass, strength adaptations (18). Creatine supplementation is recommended for use in short-term maximum-intensity exercises and anaerobic exercises, and during heavy exercise to conserve energy and gain strength (17,26). In addition, an increase in muscle strength with creatine supplementation is observed in both athlete individuals and non-athletes (18). The appropriate period for creatine supplementation is between 28 days and 10 weeks (3). The increase in muscle performance with creatine loading is explained in two ways: first, obtaining more phosphocreatine provides energy for short-term, high-intensity exercises such as sprinting, throwing-jumping and weightlifting by accelerating ATP regeneration. Latter: Phosphocreatine facilitates the passage of intracellular hydrogen ions required for lactate production, thus reducing fatigue (1). The daily amount of creatine taken with the diet is 1-2 g/day, and this amount saturates muscle creatine stores by 60-80% (4). A loading dose of creatine is usually used before daily dosing. Commonly accepted loading dose method: 20-25 g/day (1) for 5-7 days. In creatine supplementation, it affects the increase of intramuscular creatine depending on the initial levels of creatine stores (8). To achieve positive results after creatine supplementation, 0.03 g/day is recommended for 4-6 weeks (9). The creatine usage protocol is the use of 2-5 g/day of creatine for a total of 20-30 g for 4-5 days (11). Although long-term study results remain unclear, the safe long-term dose is stated to be 5g/day (10).

Potential ergogenic benefits of creatine supplementation: Increased single and repetitive sprint performance, increased work performed during maximum effort muscle contractions, increased muscle mass and strength adaptations during training, improved glycogen synthesis, increased anaerobic threshold, possible enhancement of aerobic capacity by increased binding of ATP from mitochondria, increased work capacity, improved recovery, greater training tolerance (18).

In these two separate studies, a creatine supplement study was conducted on a sample group of 34 untrained men and a creatine supplement study was conducted on a sample group of 30 healthy individuals; Positive results have been obtained in exercise performance (14,15). The results of creatine studies conducted on veteran athletes, who have been training regularly throughout their lives and are generally defined as athletes over the age of 40, are quite contradictory (21, 22). While studies on veteran athletes using creatine supplements may result in negative cardiovascular outcomes, it is also observed that different results are obtained, including improved performance in exercise (22, 24). In a 14-week study conducted on healthy elderly people and 5 g/day creatine supplementation, an increase in lean body mass was observed (23). As a result of a 12-week study conducted on healthy elderly women and 5g/day creatine supplementation, it was found that there were positive effects on exercise performance along with an increase in lean body mass and muscle mass (24). In a 10-week study conducted on veteran athletes, it was determined that the group taking 0.1 g/kg creatine and 0.3 g/kg protein supplements had an improvement in lean body mass and exercise performance (25).

Different results of creatine supplementation are encountered in different sports branches. As a result of a study conducted with seventeen canoeists and creatine supplementation lasting 6 days, an increase in RM strength and a decrease in the strengthening time after optimal individual activation were observed (30). The creatine supplement research conducted with twelve taekwondo athletes lasted 6 weeks and as a result of the research, an increase in fat mass was detected (31). As a result of a 7-day study with twenty-four male football players supplemented

with creatine, no significant difference was detected regarding body composition (32). As a result of the research conducted on creatine supplementation for 5 days with a sample group of 16 elite ice hockey players, performance improvement was detected (33).

Literature was reviewed for this research. The data of this research were obtained from Google Academic DergiPark and PubMed databases. The keywords used in these databases during the research were "creatine", "ergogenic support", "performance", "exercise" and "sports nutrition". As a result, studies have proven that creatine has an important place in sports nutrition and provides various benefits. When the literature is scanned, results of creatine supplement studies that give contradictory results are also encountered, and these contradictions are explained by the authors with many different claims. Many studies with large samples are needed on creatine supplementation. The studies to be conducted will contribute greatly to the literature, especially by addressing issues such as the causes of contradictory results, special groups, long-term studies, effects on various sports branches, and the positive and negative consequences of the dose to be used in creatine supplementation.

GİRİŞ

Bir amino asit olan kreatinin kaslarda depolanma formu fosfokreatindir ve özellikle tip-2 hızlı kasılan liflerde depo edilir (1,2). Kreatin iskelet kasında %95 oranında bulunurken, beyinde ve testislerde ~%5 oranında bulunur . Karaciğerde arginin ve glisinden sentezlenen kreatin, et ve balıkta bulunmaktadır (1) . Vücut ağırlığı ortalama 70 kilogram olan bir genç erkeğin kas lifi tipine ve kas kütlesine göre değişen 120 ile 140 g arasında bir kreatin havuzu vardır . Kreatin, karaciğerde, böbreklerde ve pankreasta endojen olarak günde 1 gram olarak üretilir (3).

Günümüzde en çok kullanılan ergojenik desteklerden birisi olan kreatinin kullanımının artışı; Barselona'da (1992) düzenlenen olimpiyatlarda, kısa sürede yüksek yoğunlukta hız ve güç gerektiren dallardaki sporcuların, kreatin desteği sonucu performanslarını artırdıklarının belirtilmesi ile gerçekleşmiştir (4). Amerikan Kolej Sporları Kurumu'nun 21000 sporcunun üzerinde yaptığı anket çalışmasına göre, kreatin kullanımı %14 bulunmuştur. Ayrıca bu çalışma sonucuna göre kreatin kullanımı %29 oran ile en çok güreşçilerde görüldüğü belirtilmektedir (2).

Kreatin uygun dozlarda kullanıldığında ciddi bir yan etki gözlenmediği belirtilmemesine rağmen, kreatin kullanımının potansiyel yan etkileri arasında subklinik dehidratasyon ve sıcak şok riski bulunmaktadır, ayrıca venöz tromboemboliyi tetikleme potansiyeli de söz konusudur (1,2). Uzun süreli kullanımda böbrek ve karaciğer hastası bireylerde dikkatli kullanılmalıdır (1). Kreatin yükünün fazla oluşu ile böbrek fonksiyon bozukluğu gerçekleşebileceği belirtilse de beş yıl kreatin desteği alan bireylerde glomerüler filtrasyon hızında düşüş gözlemlenmemiştir (5). Kreatin idrar hacmini azaltır, bunun sebebinin ozmotik etkisinden dolayı olduğu bilinmektedir. Özellikle yükleme aşamasında geçici vücut ağırlığı artışına sebep olabilir (1). Kreatin kullanımı esnasında sıvı kas içerisine ozmotik etki ile çekilir ve bu durum dehidratasyon riskini artırabilmektedir. Bundan dolayı, kreatin kullanan sporcuların bol miktarda sıvı tüketmeleri önerilmektedir (2).

Kreatinin etki mekanizması

Ergojenik destek olarak alınan kreatin; kas kreatinini ve fosfokreatinini %20- 40 oranında artırmaktır (4). Kreatin takviyesinin kas gücünü artırmak için etkili bir ergojenik destek olduğu gösterilmiştir ve bu bulgular, sporcular ve sporcu olmayanlar da dahil olmak üzere eğitimli ve eğitimsiz erkek ve kadınları içermektedir (6). Kreatin anaerobik egzersizlerde ve yüksek yoğunluklu sporlarda kullanılır (7). Kreatinin idame kullanımı 28 gün ile 10 hafta arasında değişmektedir (3).

Kreatinin depolanma formu olan fosfokreatinin (PCr) kas hücrelerindeki biyolojik oluşumu arttıran kreatin yüklemesi ile kas performasındaki artış iki şekilde açıklanmaktadır: birincisi, daha fazla fosfokreatin elde edilmesi, ATP yenilenmesini hızlandırarak sprint, atma-atlama ve halter benzeri kısa süreli, yüksek şiddetli egzersizler için enerji sağlamaktır. İkincisi; fosfokreatin, laktat üretimi için gereken hücre-

içi hidrojen iyonlarının geçişini kolaylaştırır, böylelikle yorgunluğu azaltmaktadır. Bu sebepten dolayı kreatin yüklemesi, kasın kasılma şiddetini ve anaerobik aktivitenin süresini uzatarak ergojenik bir etki sağlayabilmektedir (1). Karbonhidratlar veya karbonhidratlar ve protein ile karıştırılmış kreatin takviyesi, kas içi kreatin tutulumunu artırmada etkili görünmektedir, ancak performans sonuçları açısından ek faydalar belirsizliğini korumaktadır (8).

Sporcular için önerilen kreatin dozu

Günlük normal bir diyette 1-2 g/gün kreatin karşılanır ve bu miktar kas kreatin depolarını %60- 80 oranında doyurur (4). Günlük doz uygulanmasından önce genellikle bir kreatin yükleme dozu kullanılır. Yaygın olarak kabul edilen yükleme dozu yöntemi: 20-25 g/gün, 5-7 gün boyunca günde 4'e bölünmesi şeklindedir. En az 3 gün 0,3 g/kg kreatinin yükleme dozu önerilmektedir (1). Kreatin takviyesi, kreatin depolarının başlangıçtaki seviyelerinin daha düşük olması nedeniyle veganlarda, omnivorlara göre kas içi kreatinin daha önemli artışını sağlar ve her iki grup da karşılaştırılabilir ergojenik faydalar alır (8).

Kreatinin olumlu sonuçlarını elde edebilmek için, Hall ve Trojian (2013) ise ortalama 4-6 hafta 0,03 g/gün kreatinin alımını önermektedir (9). Uzun süreli kreatin kullanımında en güvenli kullanımın 5 g/gün olduğu belirtilmektedir (10). 4 gün boyunca 2-5 g/gün toplam 20-30 g kreatin kullanımı, kreatin kullanım protokolünü oluşturmaktadır (11). Olumlu etkiler elde etmek için etkili kreatin takviyesi dozuna dair iki takviye protokolü bulunmaktadır. Birincisi, günde 3-4 kez bölünmüş, 6-7 gün boyunca tüketilmiş ve ardından 9 hafta boyunca 5 g / gün kreatin takviyesi alımı. İkicisi ise, 14 gün veya daha uzun süre 3 mg / kg / gün düşük doz içeren 20-30 g / gün yük dozu tüketimini içermektedir (12).

Kreatin takviyesinin potansiyel ergojenik faydaları: Artan tek ve tekrarlayan sprint performansı, maksimum eforlu kas kasılmaları sırasında gerçekleştirilen artan iş, antrenman sırasında artan kas kütlesi ve kuvvet adaptasyonları, gelişmiş glikojen sentezi, artan anaerobik eşik, ATP' nin mitokondriden daha fazla bağlanmasıyla aerobik kapasitenin olası arttırılması, artan iş kapasitesi, gelişmiş kurtarma, daha fazla eğitim toleransıdır (13).

Wang ark. (14) 30 sağlıklı birey üzerinde 6 gün yürüttüğü çalışmada; Cr grubundaki denekler, 5 g kreatin monohidrat + 300 mL suda çözülmüş 5 g dekstrozu dört kez almışlardır ve Plasebo grubundaki denekler aynı protokolü izlenmiştir ancak Cr yerine karboksimetil selüloz tüketilmiştir. Çalışma sonucunda Kreatin grubunda 1-RM gücü artmıştır, sırt squat sırasındaki maksimum kas gücü plasebo grubuna göre yüksek bulunmuştur ve optimal bireysel aktivasyon sonrası güçlenme süresinin azaldığı tespit edilmiştir (14) . Del Favero ve arkadaşlarının (15) 34 antrenmansız erkek üzerinde 10 gün yürüttüğü çalışmaya göre; 20 g/gün kreatin takviyesi alınması ile Squat ve bench press de güçlenme belirlenmiştir.

Kreatin takviyesinin egzersiz üzerine etkileri

Kreatininin olası faydaları; artan "sprint" performansında, anaerobik eşikte, en yüksek kas kasılması gücünde, glikojen sentezinde, kas kütlesi ve gücünde, egzersiz kapasitesinde, yenilenmede ve egzersiz performansında artış sağlamasıdır (4). Kreatinin sportif performans üzerine pozitif etkileri gözlemlenmektedir (16). Ağır egzersiz esnasında enerjiyi korumak ve kuvvet kazanımı için kullanılmaktadır (17). Ayrıca Uluslararası Spor Beslenme Derneği, yüksek yoğunluklu egzersiz kapasitesini yağsız vücut kütlesini arttırmada ve veteran sporcular için güvenli olarak güç ve dayanıklılık sporlarında kreatin monohidrat önermektedir (18 - 20).

Kreatin takviyesinin veteran sporcular üzerindeki etkileri

Veteran sporcular, genellikle 40 yaş üzerinde olan ve hayatı boyunca düzenli antrenman yapan ve performans düzeylerini uzun süre korumaya çalışan sağlıklı bireylerdir (21). Veteran sporcular için kreatin takviyesi öneriliyor olsa da bir çalışmada kreatin takviyesi alan yaşlı 3 gönüllüde kardiyovasküler açıdan olumsuz etkiler gözlemlenmiştir (22).

Brose ve ark. (23) yaptığı 14 hafta süren ve sağlıklı yaşlılar üzerinde yapılan çalışmada, 5 g/gün kreatin takviyesi sonucunda; yağsız vücut kütlesi ile toplam vücut kütlesini ve bacağın diz eklemi etrafındaki kasların kuvvetini ve gücünü ifade eden izometrik diz uzatma gücünü artırdığı rapor edilmiştir . Aguiar ve ark. (24) yaşlı sağlıklı kadınlarda 12 hafta süren ve 5 g/gün kreatin takviyesi uygulanan çalışmanın sonucunda; yağsız vücut kütlesi ile kas kütlesinde artışa yol açarak, egzersiz hacminde, bench press, diz uzatma gücü ile biceps kıvırma performansında daha fazla artış sağlamıştır. Takviye alan grup submaksimal kuvvet fonksiyon testlerini gerçekleştirmede daha dayanıklı olduğu belirlenmiştir . Candow ve ark. (25) yaptığı ve 10 hafta süren çalışmada kreatin takviyesi (0,1 g/kg) alan grup, kreatin ve protein takviyesi (0,1 g/kg kreatin + 0,3 g/kg protein) alan grup ve plasebo grubu olmak üzere 3 grup belirlenmiştir. Kreatin ve protein takviyesi alan grupta yağsız vücut kütlesi ile bench press kuvvetinde daha fazla artış saptanmıştır.

Spor türüne göre kreatin takviyesinin etkileri

Yapılan çalışmalarda kısa süreli maksimum yoğunluklu egzersizlerde, kas kuvveti, kas

Tablo 1. Farklı spor dallarında kreatin desteğinin etkileri

Çalışmalar	Örneklem sayısı (çalışma süresi)	**Kreatin takviye protokolü**	**Plasebo takviye protokolü**	Çalışma sonucu
Wang ve ark. 2018 (30)	17 kanocu (6 gün)	Kreatin grubu: 5 g saf tatlandırılmamış kreatin monohidrat tozu + 300 ml suda eritilmiş 5 g dekstroz .	Plasebo grubu: aynı protokolü izlenmiştir ancak kreatin yerine karboksimetil selüloz tüketilmiştir.	Cr takviyesi alan grupta; 1- RM kuvvetinde artış, optimal bireysel aktivasyon sonrası güçlenme süresi azaldı.
Manjarrez-Montes de Oca ve ark. 2013 (31)	12 tekvandocu (6 hafta)	Günde 1 doz Cr'den (doz başına 50 mg/kg vücut ağırlığı) oluşuyordu. Her doz, bir su hacminde 3,5 g Cr monohidrat, 30 mg sakaroz.	Plasebo grubunda Cr yerine 3,5 g malto- dekstrin ile süreç yürütüldü.	Cr takviyesinden sonra yağ kütlesi arttı.
Ahmet ve ark. 2019 (32)	24 futbolcu (erkek) (7 gün)	Rastgele 3 gruba ayrılmıştır. 5000 mg DZAA ve 2000 mg kreatin suplementasyonu yapılmıştır. DZAA: Antrenman öncesi ve sonrası 2500 mg. Kreatin: Antrenmandan 30-40 dakika önce 1000 mg ve antrenmanda 1 saat sonra 1000 mg.	Plasebo grubu: diğer gruplara verilen besin desteğine eşit miktarda ve şekilde buğday kepeği verilmiştir.	Vücut ağırlığı ve iskelet kası ağırlığı, vücut yağ kütlesi ve yüzdesi, toplam vücut suyu, BKİ ve metabolizma hızı parametreleri, protein ve mineral seviyelerinde istatistiksel fark bulunmamıştır.
Jonas ve ark. 1999 (33)	16 elit buz hokeyi oyuncusu (5 gün)	Cr grubu: 5 g kreatin monohidrat	Plasebo grubu: 5 g glikoz *10 hafta boyunca da idame doz uygulanmıştır.	Ortalama buz pateni performansı iyileşti

gücü yenilenmesi ve kas hasarını azaltma ile performans ve kuvvet artışı gösterdiğini bildirmiştir (26, 27). Lanhers ve arkadaşlarının yaptıkları meta analiz çalışmasında, 28 gün kreatinin takviyesi alan ve yüksek yoğunluklu egzersiz yapanlarda alt ve üst ekstremitelerde güç artışı göstermişlerdir (28). Kreatin takviyesi, rekreasyon sporcularında anaerobik aktivitelerle birleştirildiğinde, aerobik aktivite nedeniyle oluşan güç kaybını önleyebileceği belirtilmektedir (29).

Cr: Kreatin DZAA: Dallı zincirli aminoasit BKİ: Beden kütle indeksi

Pluim ve ark. (2006), kreatin alımının akut (6 gün boyunca 0.3 g/kg/gün) ve kronik (5 hafta boyunca 0.03 g / kg / gün) etkilerini değerlendirmek için 39 erkek tenisçiye top makinesi yer vuruşu tatbikatları yaptırılmıştır. Performans metrikleri, tekrarlanan yer vuruşlarının hızını ve servis hızını içermektedir. Akut yükleme fazından sonra veya herhangi bir performans ölçümünde 5 haftalık kreatin kullanımını takiben bu performans ölçümlerinde anlamlı bir fark bulunmamıştır. Sonuç olarak, yazarlar kreatinin tenisçilere önerilmemesi gerektiği sonucuna varmışlardır (34).

Yapılan bir meta analiz çalışması, 0,07 g/kg ya da 5 g/gün kreatinin takviyesinin direnç egzersizlerinde olumlu etki gösterdiğini bildirmiştir. Sarkopeni oluşumuna karşı direnç antrenmanı ve kreatin takviyesi planlanan ortalama 12 hafta boyunca direnç antrenmanı yapan 357 yaşlı birey üzerinde yapılan kreatin takviyesi çalışması sonucunda; toplam vücut kütlesi ve yağ kütlesinin arttığı tespit edilmiştir (35).

Takviyeden önce daha yüksek bir başlangıç kreatin seviyesine sahip sporcuların, düşük bir başlangıç kreatin seviyesine sahip bir sporcuya göre fayda sağlama olasılığı daha düşüktür. Bu muhtemelen, bazı sporcuların neden kreatin takviyesine "yanıt veren" göründüğünü, diğerlerinin ise "yanıt vermeyen" olduğunu açıklamaktadır . Kreatinin uzun süreli çalışmaların sayısı sınırlı olduğundan dikkatli olunmalıdır (3). Kreatin Dünya Anti-Doping Ajansı (WADA), Uluslararası Olimpiyat Komitesi (IOC) veya Amerikan Kolej Sporları Kurumu (NCAA) tarafından taranmamaktadır veya yasaklanmamaktadır (3).

SONUÇ

Sporcu performansını geliştirmek adına aranan çözüm yolları her geçtiğimiz gün artmaktadır. Kreatin ise sporcu performansı ve kompozisyonu üzerindeki değişiklikler ve doping sayılmaması dikkate alındığında, sporcu beslenmesi için oldukça ilgi çekici hale gelmektedir. Kreatin takviyesi çalışmalarında, kısa süreli maksimum yoğunluklu egzersizlerde , anaerobik egzersizlerde ve ağır egzersiz esnasında enerjiyi korumak ve kuvvet kazanımı için olumlu sonuçlar alınmaktadır. Bu sebeple doğru spor dalında, uygun doz kreatin takviyesi önemlidir. Çeşitli spor dallarında kreatin takviyesi üzerine birçok çalışma yapılmıştır. Çelişkili çalışmalar literatürde bulunsa dahi sporcu performansı üzerine olumlu etkileri olduğu kabul edilebilir.

Sporcu beslenmesinde takviyelerin popülerliği büyük bir tehlike oluşturmaktadır. Bu sebeple kreatin takviyesi alımında da uzmanların kontrolü dahilinde alınması önerilir. Kreatin takviyesi alımında yan etkiler çok sık görülmüyor olsa da bu konuda geniş örneklemli çalışmalara ihtiyaç duyulmaktadır.

Kreatin takviyesi üzerine olan çalışmalarda çelişkili sonuçların alındığı çalışmalarda neden çelişki gerçekleştiği üzerine birtakım mekanizmaların aydınlatılması gerekmektedir. Kreatin takviyesinin kısa vadede getireceği sonuçlar üzerine birçok çalışma bulunsa da, uzun vadeli çalışmaların yetersizliğinden dolayı daha fazla çalışmaya ihtiyaç duyulmaktadır.

Yazar Katkısı

M. N. Yarar: Fikir/Kavram, Tasarım, Denetleme, Veri Toplama ve/veya İşleme, Analiz- Yorum, Literatür Taraması, Makale Yazımı, Eleştirel İnceleme. E. Parlak: Fikir/Kavram, Tasarım, Denetleme, Veri Toplama ve/veya İşleme, Analiz-Yorum, Eleştirel İnceleme.

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Review Article/Derleme Makale

The relationship between low levels of coenzyme Q10 and oxidative damage in patients with fibromyalgia

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Abstract

Fibromyalgia (FM) is a condition associated with various symptoms, mainly *widespread body* pain and fatigue, and its exact cause is unclear. Many factors such as mitochondrial dysfunction, genetics, epigenetic factors and western-style diet cause the disease. Mitochondrial dysfunction and associated oxidative damage play a role in the basic pathogenesis of FM. Decreased levels of coenzyme Q10, an antioxidant compound, in FM patients is one of the important causes of this condition. When the blood parameters of the patients are analysed, it is seen that most of them have sub-optimal coenzyme Q10 values. Coenzyme Q10 is a fat-soluble antioxidant molecule responsible for energy production in mitochondria. Since it is involved in important physiological mechanisms related to oxidative stress such as cell signalling, gene expression and redox reactions, many studies have recently been conducted on its use in fibromyalgia treatment. In this review, the relationship between low coenzyme Q10 levels and oxidative damage-related chronic pain, fatigue and sleep symptoms in fibromyalgia patients investigated. The results obtained, the direct effect of coenzyme Q10 on mitochondrial function and its antioxidant role have been associated with the prevention of oxidative damage. Increasing coenzyme Q10 levels has been shown to alleviate disease symptoms such as pain, fatigue and insomnia. In order to increase coenzyme Q10 levels in fibromyalgia patients, a personalised nutrition plan

containing antioxidant-rich foods should be prepared and nutritional supplements containing coenzyme Q10 can be added to the diet plan.

INTRODUCTION

Fibromyalgia (FM) is a pathological condition with an undetermined cause, persisting for more than three months, accompanied by chronic headache, fatigue, *widespread body* pain, sleep disorders, depression, and rheumatic diseases. In addition, joint stiffness, ognitive dysfunctions and connective tissue inflammation also accompany this disease (1,2,3). Patients usually consult a doctor because of musculoskeletal pain. They usually describe the pain as stiffness, aching, stinging, swelling, and burning in the neck, back, lower back, shoulders, anterior chest, hips, and knees. The intensity of the pain may decrease from time to time. However, it reappears at the slightest stimulus (4). Some patients are accompanied by symptoms such as IBS, brain fog, restless leg syndrome, increased sensitivity, migraine, tension-type headache, interstitial cystitis, premenstrual syndrome, low back pain and temporomandibular joint complaints (5).

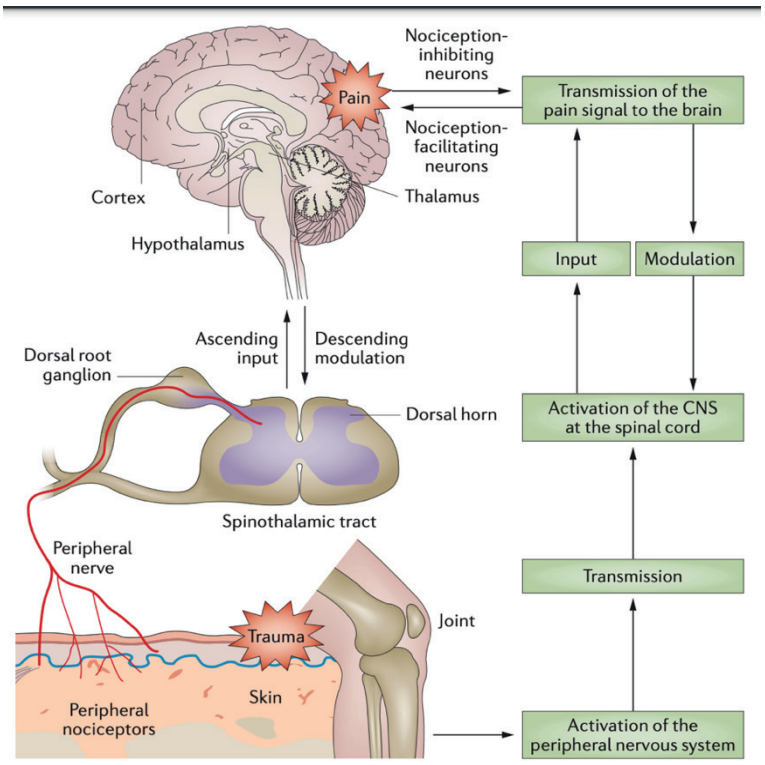
As shown in Figure 1, various stimuli produce signals travelling from the dorsal root ganglion to the spinal cord that induce activation of peripheral pain receptors. The incoming signals are transmitted to the thalamus and cortex via the spinothalamic pathway. In this way, pain is produced and controlled by nociception inhibitory and nociception facilitating neurons (6). The quality of life and psychosocial status of the patient are significantly affected by this mechanism of pain (7). Despite the diagnostic criteria, the diagnosis of fibromyalgia is usually based on negotiations between the physician and the affected individual to address psychosocial issues (8).

The prevalence of fibromyalgia is higher in women than in men. The prevalence increases with factors such as advancing age and weight gain (9).

Since many symptoms are seen in fibromyalgia patients, the treatment should be based on many parameters. Many factors progress the course of the disease. Therefore, the treatment should be handled with a multidisciplinary approach (10,11).

Recent studies have emphasised that the disease

Figure 1. Pain processing and its modulation (6)



is characterized by mitochondrial dysfunction. In the tissues of fibromyalgia patients, adenosine activated protein kinase (AMPK) is not phosphorylated and this has been shown to be responsible for decreased mitochondrial biogenesis, decreased oxygen consumption, decreased antioxidant enzyme levels, and mitochondrial dysfunction (12,13). Decreased levels of coenzyme Q10 also play an important role in mitochondrial dysfunction-related damage. Recent studies have shown that both mitochondrial dysfunction and coenzyme Q10 deficiency may play a role in the pathophysiology of fibromyalgia (14).

Coenzyme Q10 is a fat-soluble antioxidant molecule responsible for energy production in mitochondria. Inside the mitochondria, it exists in both reduced and oxidised states. Coenzyme Q10 increases energy by providing electron transport across the inner membrane of mitochondria. (15). At the same time, since coenzyme Q10 is involved in important physiological mechanisms related to oxidative stress such as cell signalling, gene expression, and redox reactions, many studies have recently been conducted for its use in fibromyalgia treatment. After the inclusion of coenzyme Q10 in the treatment process of the disease by taking coenzyme Q10 with food or supplementation, it has been observed that the symptoms associated with pain and fatigue have decreased in many patients (16,17,18). Impaired oxidative phosphorylation caused by a deficiency of the coenzyme Q10 molecule in plasma is associated with reduced physical tolerance and fatigue, symptoms of the disease. Therefore, it is stated that coenzyme Q10 may have a therapeutic effect on FM (19). It also has an anti-inflammatory function. The body's requirement increases due to oxidative stress, chronic diseases, vitamin B6 deficiency, statin use, and age intake. According to research, the rate is quite low in migraine and fibromyalgia patients (20). In this study, the relationship between oxidative damage in fibromyalgia patients and decreased coenzyme Q10 serum levels were reviewed.

Basıc Features and Therapeutic Approaches in Fibromyalgia

The etiology of fibromyalgia is not clearly known. However, many factors play a role in the emergence of the disease. These are listed as follows: Genetic and epigenetic factors, abnormalities in neuroendocrine cells, and psychological factors (21). The pathogenesis of the disease is primarily due to physiological disorders in the muscles. Then, sleep and neuroendocrine disorders and neuropeptide abnormalities follow each other (22). Most of the patients showed increased alpha waves and disturbances in non-REM sleep (23). This was associated with problems in serotonin and tryptophan levels and receptors. The basis of these problems is that tryptophan cannot be converted into serotonin, resulting in some problems in transition to sleep (24).

Fibromyalgia pain can increase because of various factors. The main ones are stress, exposure to toxins, and nutritional problems. In addition to these three factors, infections, soft tissue traumas, other physical traumas, giving birth, allergies, surgery, traffic accidents, menstruation, insomnia, fatigue, exposure to weather change, traveling, and hormonal changes are among the factors that affect the severity of pain (20).

Since the etiopathogenesis of fibromyalgia has not been clearly determined, treatment methods vary from person to person. The main goal of treatment methods is to provide pain control. In addition to this, the patient's psychological state and functional anomalies are also controlled (25). Treatment methods for fibromyalgia are as follows; regulation of sleep, nutritional approaches, vitamin and mineral supplements, protection of intestinal health, movement-exercise, and other methods (20).

Medical Nutrition Therapy in Fibromyalgia

In fibromyalgia, a nutritional approach based on mitochondrial health is adopted. One of the main goals of this approach is to improve the symptoms of patients by reducing oxidative damage and inflammation (26). An anti-inflammatory nutrition plan is recommended for fibromyalgia patients to prevent oxidative

stress and inflammation. In this nutrition plan, foods rich in omega-3 fatty acids such as fish and flaxseed and foods rich in antioxidants such as fruits and vegetables should be included in the nutrition plan (20). In addition to minerals such as selenium, zinc, iron and magnesium, vitamins B9, B12, A and D should also be included in the diet plan. Vitamin B12 and folate deficiencies in particular can exacerbate fibromyalgia symptoms. Adequate intake of these vitamins should be ensured by consuming meat, fish, dairy products, fortified cereals and dark green leafy vegetables. In this way, nervous health and energy levels can be supported and symptoms related to the disease can be reduced (26).

Based on the methylation cycle, 3 essential vitamins together with B12 have an important effect on FM. These vitamins are B6, B9 and biotin. Especially vitamin B6 is of critical importance because it is used in serotonin metabolism. Improved serotonin metabolism is also important for patients with sleep problems. Another vitamin that is low in FM patients is vitamin D. It plays a fundamental role in the working mechanisms of the body. It is therefore important to prevent deficiency of vitamin D (20).

FM patients should pay attention to water consumption. Adequate water consumption is important to maintain the homeostasis of the body and reduce pain (27). A gluten-free diet should be applied to these patients as another nutritional approach. Since pain may occur due to histamine toxicity, patients should prefer a histamine-poor diet. Studies have shown that digestive symptoms of FM reduced, and a general improvement was observed in other body functions when patients were given a histamine-free diet (28).

Many studies on nutrition in FM have been conducted and are still continued today. In one study, the effects of vegetarian and vegan diets on fibromyalgia were investigated (29,30). When serum values were analyzed, alpha and beta carotene, lycopene, lutein, vitamin C, and vitamin E values were found to be higher in people who were fed in this way compared to the control group, and improvements in the symptoms of the disease were detected (31).

In another study, 17 different diet types were applied to people. People were given a fermented oligo-, di-, monosaccharide and polyols (FODMAP) diet containing low fermentable oligosaccharides and polyols, as well as a vegan and Mediterranean diet. It was seen that most of the symptoms were improved. In FM patients, a combination of Chlorella green algae, coenzyme Q10, acetyl-l-carnitine, and vitamin C, E, and Nigella sativa seeds were found to be particularly effective on pain (32). In addition, some studies have revealed that ketogenic diet reduces pain and inflammation in fibromyalgia patients (33).

Coenzyme Q10 is another component that plays an important role in the energy production of cells and antioxidant defence by supporting the functioning of mitochondria. There have been many studies investigating the effects of coenzyme Q10 on patients' symptoms in conditions such as fibromyalgia that cause chronic pain. One of the studies on coenzyme Q10, fibromyalgia patients were given 300 mg coenzyme Q10 supplements daily. When the results were examined, a significant reduction in strength of the symptoms and an increase in the quality of life of patients taking coenzyme Q10 were observed. In particular, a decrease in fatigue and pain severity has been reported (34). Another study investigated the effects of coenzyme Q10 on the pain and fatigue of fibromyalgia patients. Patients taking coenzyme Q10 supplements showed a significant improvement in pain and fatigue levels. The results of the study suggest that coenzyme Q10 may be an effective adjunctive treatment in managing fibromyalgia symptoms (35). Another study evaluated the effectiveness of coenzyme Q10, tryptophan and magnesium supplementation in fibromyalgia patients. Analyses confirmed the positive effects of the triple combination on pain, fatigue and sleep quality (36).

Metabolism of Coenzyme Q10

Coenzyme Q10 is a lipophilic benzoquinone compound that can be both synthesised endogenously and taken from outside. It is present in all cells (37). It functions as a coenzyme

in the oxidation systems of the body. Chemically, the compound consists of a quinone group and its side chain 10 isoprene. Another name is ubiquinone (38). Its absorption mechanism in the body is similar to that of fatty vitamins, especially vitamin E. It can be absorbed better when consumed with fatty foods. It is absorbed in the intestines by pancreatic enzymes and secretions released from the bile duct and transported in the blood by chylomicrons. It circulates in the lymph system through processes similar to the digestive metabolism of fat. It is mainly distributed from the liver to the body through blood circulation in very low-density lipoprotein (VLDL), low density lipoprotein (LDL), and high density lipoprotein (HDL) (39).

In humans, 95% of coenzyme Q10 is absorbed in the intestines and reduced to ubiquinol. It is mostly distributed to the heart muscle, kidneys, liver, and muscles due to their high metabolic activity and high lipid content. Approximately 40-50% of it is found in the inner membranes of mitochondria and acts as electron transport in the electron transport chain (ETS). Coenzyme Q10 can be metabolized in all tissues. The released metabolism products are phosphorylated in the cells and transported in the plasma. A small portion of those that will not be used is excreted through urine, while the majority is excreted through feces (40).

Coenzyme Q10 is synthesised in all tissues and membranes of the body. However, it is found in higher amounts in the heart (110 mg/g), liver (60 mg/g), kidneys (70 mg/g) and muscles since energy production is high. Its amount decreases significantly over time according to aging or physio-pathological conditions (41).

Function in Biological and Electron Transport System

One of the most important functions of coenzyme Q10 is its active role in energy production in the cell. It is involved in the transport of electrons in the electron transport chain (ETS) from complex 1 (nicotinamide adenine dinucleotide dehydrogenase) and complex 2 (succinate dehydrogenase) to complex 3 (ubiquinone-cytochrome c reductase). Adenosine triphosphate (ATP) production occurs during this transport. In this way, coenzyme Q10 acts as an important cofactor in energy production (38).

Coenzyme Q10 plays an active role in the redox system in mitochondrial membranes. Physiologically, this cofactor plays a key role in any situation that disrupts energy flow. It is responsible for balancing cytosolic NAD+/ NADH, i.e. oxidised and reduced ratios. Since mitochondrial dysfunction is present in fibromyalgia, there are problems in balancing these ratios. In addition, disorders in the mitochondrial energy axis cause fatigue and chronic pain in fibromyalgia patients (42).

Sources of Coenzyme Q10

Coenzyme Q10 is produced in humans at a common site where the synthesis of cholesterol takes place with the help of endogenous acetyl CoA and exogenous tyrosine amino acid (43). Vitamin B6 (pyridoxal-5 phosphate) is required for tyrosine to be involved in the production of coenzyme Q10. The production of coenzyme starts in the endoplasmic reticulum and ends in the Golgi body. From there, it is distributed to other regions, especially mitochondria (44). Sources rich in coenzyme Q10 are foods that contain a lot of muscle tissue. Organ meats containing 8-200 mg/g of coenzyme have the highest concentrations. It is followed by fish products with a content of 4 to 64 mg/g. Pork heart has the highest content which contains 260 to 280 mg/g coenzyme. In vegetable oils, this ratio varies between 0 and 80.8 mg/g. In the egg and milk group, it is between 0.5 to 12.2 mg/g (45). Although serum level normalizes when 100-300 mg/g is taken daily, dietary coenzyme Q10 is not sufficient to increase the serum level. Coenzyme Q10 level in standard human blood is around 1 mg/ml. When 100 mg of coenzyme is taken per day, this value can be doubled. Even if rich sources such as heart and herring are consumed every day, it is very difficult to reach these values (46). The coenzyme Q10 content of some foods is shown in the figure (47).

Effect of Coenzyme Q10 on Fibromyalgia

There are two main factors in the pathophysiology of fibromyalgia. The first one is mitochondrial

dysfunction, and the other one is the deficiency of coenzyme Q10. Therefore, studies have shown that coenzyme supplementation has an important role in the recovery of fibromyalgia (4). Fibromyalgia disease progresses in relation to pain and fatigue. Coenzyme Q10 intake shows a fatigue-reducing effect in these patients. In one of the studies, plasma coenzyme Q10 levels obtained from patients with FM and a healthy control group were analysed. Oxidative stress markers were analysed in plasma cells from FM patients. As a result, higher oxidative stress markers were observed in the plasma of FM patients. Coenzyme Q10 levels of these patients were found to be approximately 40% lower. One of the main causes of this disease is a disorder in the distribution and metabolism of coenzyme Q10 in cells and tissues. The symptoms caused by the disease can be improved with a diet supplemented with coenzyme Q10 (48). In another study, fibromyalgia patients were given 300 mg coenzyme Q10 supplements daily for 3 months. Blood samples were analysed for coenzyme Q10 levels, oxidative stress markers and other biochemical parameters. The results showed that coenzyme Q10 supplementation increased serum coenzyme Q10 levels and produced a significant reduction in oxidative stress markers. Improvement in pain and fatigue levels was also observed (49).

With the addition of coenzyme Q10 to patients' diets, their morning fatigue and sensitivity to pain show a significant decrease. In addition, sleep quality and functional capacity were significantly improved in patients. Despite these favourable results, further research is needed for sufficient evidence (40).

Coenzyme Q10 reduces fatigue in fibromyalgia patients by affecting the mitochondrial energy system. It also alleviates the course of the disease

Table 1. Coenzyme Q10 content in foods

Food	Coenzyme Q10 content (μg CoQ10 / g)				
	Kubo et al. (2008)	**Mattila and Kumpulainen (2001)**	**Weber et al. (1997)**	**Kagan and Quinn (2001)**	**Souchet and Laplante (2007)**
Beef	30.3 ±3.9 – 40.1±1.5	36.5	31	8- 200	-
Chicken	17.1±0.1 – 25.0±6.7	14.0	17	17 – 21	-
Salmon	5.73±0.57	-	4.3	-	-
Tuna	4.87±0.22	15.9	-	-	-
Herring	-	15.9	27	-	15- 24
Mackerel	10.6±1.33	-	-	-	15- 67
Spinach	0.44±0.16	-	-	-	-
Broccoli	7.01±0.42	-	6.6	-	-
Cauliflower	6.63±0.89	2.7	4.9	-	-
Potato	1.05±0.11	0.5	0.52	-	-
Orange	1.02±0.28	1.4	2.2	-	-
Strawberry	0.51±0.11	1.4	-	-	-
Apple	1.21±0.02	1.3	1.1	-	-
Milk	0.31±0.01	0.1	-	0 – 2	-
Yoghurt	0.26±0.01	2.4	1.2	2 – 4	-
Chicken egg	0.73±0.05	1.2	1.5	-	-
Olive oil	-	-	-	4	-
Corn oil	-	-	-	13	-

by reducing inflammation in the body with its antioxidant and anti-inflammatory functions and finally by affecting cell signalling and gene expression.

Antioxidant Function

The second important role of coenzyme Q10 in the energy system is its involvement in the antioxidant system (50). This enzyme is characterised both as a fat-soluble compound and as an antioxidant. Its reduced form, ubiquinol, is an important fat-soluble compound. Coenzyme Q10 in cell membranes is localized close to unsaturated fat chains. Because of this position, it is the first compound that fights free radicals (37). As the first protector of the defence system against free radicals formed as a result of oxidative stress, it destroys them. It prevents free radicals from causing oxidation by reacting with fats, proteins and deoxyribonucleic acid (DNA) (44). It also interacts with antioxidants such as vitamin C and vitamin E while fulfilling its antioxidant function (38). An important critical point is that it replaces antioxidants such as vitamin E and selenium in their absence (51). Coenzyme Q10 is also found in lipoproteins. With this feature, it is revealed in studies that it plays an active role in low density lipoprotein (LDL), which is called bad cholesterol (42).

Central sensitization is observed in fibromyalgia patients. This condition is associated with increased sensitivity in neurons. It occurs as an excessive response of neurons to painful stimuli (52). Glutamate secreted in the body binds to the N-methyl D-aspartate (NMDA) receptor and activates it. This situation causes a vicious circle. Due to its activation, glutamate and glycine increase and stimulate NO (Nitrite Oxide) synthesis. Thus, NO (Nitrite Oxide), known as short-lived free radical, accumulates in the body. NO (Nitrite Oxide) is an important trigger in the sensation of pain (53,54). The antioxidant function of coenzyme Q10 is critical for the scavenging of free radicals such as NO (Nitrite Oxide).

In a systematic review and dose-response meta-analysis, the effects of coenzyme Q10 properties (CoQ10) at 300-400 mg daily on exercise intensity muscle damage (EIMD), physical performance, and oxidative stress in adults can be linked to the dose-dependent endurance period. The meta-analysis results found that serum creatine kinase (CK), lactate dehydrogenase (LDH), myoglobin (Mb), and malondialdehyde (MDA) were significantly reduced in 830 individuals receiving coenzyme Q10 replacement. No significant change in total antioxidant capacity was observed after CoQ10 treatment. Based on this study, coenzyme Q10 may be effective in reducing biomarkers of oxidative stress in individuals (55).

Anti-inflammatory Function and Effect on Gene Expression

The communication between the food ingested into the body and one's genotype contributes to health by altering its phenotype or function. The altered gene expression sends a message to the body functions telling it how it should perform (56). In this respect, the intake of anti-inflammatory nutrients such as coenzyme Q10 is very important.

In fibromyalgia patients, mitophagy is observed as a result of mitochondrial dysfunction. Compensatory mechanisms activated by the self-destruction of the dysfunctional function of mitochondria lead to the inflammatory process. Inflammatory cytokines are released in FM patients due to mitochondrial dysfunction. As a result, serum levels of Tumour Necrosis Factor (TNF-a) are increased (57).

Studies have shown that coenzyme Q10 shows an anti-inflammatory effect by inhibiting the expression of Nuclear factor-kappa B1 (NF-kB1) dependent genes. In addition, it also positively affects the peroxisome proliferator activating receptor (PPAR)-dependent anti-inflammatory response [44]. As a result of this effect, it inhibits the release of cytokines such as tumor necrosis factor-α (TNF-a) and interleukin-6 (IL-6) (58).

In another study investigating the protective role of coenzyme-Q10 (Q10) and piperine (P) on the oxidant and inflammatory effects of cyclophosphamide (CP), the effects of HuH-7 on the distribution of coenzyme Q10, piperine and cyclophosphamide (CP) and the inflammatory

responses of intracellular ROS production were evaluated. The results showed that Q10 and/or piperine suppressed ROS production. In the analysis of proinflammatory cytokine gene expression, it was shown that cyclophosphamide (CP) treatment alone induced only IL-6β expression, while the combined exposure to both Q10 and cyclophosphamide (CP) caused significant suppression of basal IL-1β and TNF-α again expressions. Coenzyme Q10 also suppressed cyclophosphamide (CP)-induced Cox-1 and basal Cox-2 expression (59).

A meta-analysis study investigated the effectiveness of the CoQ10 version in people with the reason why it was updated. This market has been widely investigated the decrease in the distribution of the proinflammatory factors CRP, IL-6 and TNF-a (60). CoQ10 doses varied between 60 and 500 mg. The study was carried out for 1 week to 4 months. During this period, the levels of all biomarkers decreased significantly (58). It was observed that fibromyalgia, including healthy metabolic, responded well to the properties of CoQ10, TNF-a and IL-6 in the circulation appeared and decreased significantly (61). A simultaneous increase in CoQ10 levels in the treatment also resulted in other effects such as improvement in endothelial function, increase in mitochondrial processes and decrease in peroxides (62).

Another meta-analysis study confirmed the potential benefits of CoQ10 properties in reducing inflammatory and oxidative stress, with doses of 200 mg per day and above reducing levels of MDA, TNF-α, and IL-6 in less than 10 weeks (63).

In recent studies on coenzyme Q10, the liver tissues of rats were examined. It was found to have therapeutic and chemotherapeutic effects by regulating hepPar-1, alpha-fetoprotein, inducible nitric oxide synthase, cyclooxygenase-2, and nuclear factor-kB expression in tissues (64). As a result, coenzyme induces an anti-inflammatory response by affecting gene expressions. In this way, it has a therapeutic effect on fibromyalgia patients (42).

CONCLUSION

Mitochondrial dysfunction and associated oxidative damage may play a role in the pathogenesis of FM. Coenzyme Q10 functions as a coenzyme in the oxidation systems of the body. Decreased levels of coenzyme Q10 and related problems mitochondrial dysfunction in the electron transport system are one of the main causes of fatigue and pain attacks in fibromyalgia. In addition, the accumulation of free oxygen radicals due to oxidative stress in the body leads to disruptions in intracellular functions and DNA damage. This disruption of homeostasis triggers the development of the disease and an increase in symptoms. When blood findings in fibromyalgia patients are examined, it is seen that coenzyme Q10 values are below the normal range. In addition to dietary changes such as antioxidant-rich diet in people with FM, coenzyme Q10 values should be followed and nutritional supplements should be provided accordingly. More comprehensive researches including case studies should be planned to demonstrate the role of coenzyme Q10 on treatment of FM.

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Review Article/Derleme Makale

Kahve lezzeti; Bileşim, işleme ve duyusal özelliklerin etkisi

An overview of coffee flavour: Influence of process, composition and sensory properties

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Özet

Dünyada yaygın olarak tüketilen içeceklerden biri olan kahve ekonomik olarak petrolden sonra en önemli tarımsal üründür. Dünyada günde ortalama 2.5 milyar fincan kahve tüketilmektedir. Kahve tüketiminin en önemli nedenlerinden biri kahvenin lezzetidir. İyi kalite kahve lezzeti, lezzet, gövde, aromanın dengeli karışımı ve kusur içermeyen hoş bir duygu olarak tanımlanmaktadır. Kahve lezzetine etki eden birçok faktör olması nedeniyle kahve lezzeti karmaşık bir olgu olarak nitelendirilmektedir. Kahve lezzeti ile ilgili bugüne kadar birçok çalışma yapılmış olmakla birlikte, lezzet oluşumuna etki eden faktörlerin değerlendirilmesi önem taşımaktadır. Kahve lezzetine etki eden faktörlerden biyokimyasal etkiler kahve bitkisi ve kahve tanesinin gelişimi ile başlamakta, kahvenin işleme aşamaları ve hazırlama teknikleri ile devam etmektedir. Kahvenin bileşiminden kaynaklanan etkiler ise kavrulmuş tanedeki uçucu olmayan bileşenler ve uçucu bileşenler nedeniyle oluşmaktadır. Kahvenin bileşimi ile ilgili kimyasal veriler, lezzete etkisi olan temel bileşenlerin kahve lezzetine katkısını tam olarak açıklamaya yeterli değildir. Kahve lezzetine katkısı olduğu düşünülen bileşenlerin neden olduğu duyusal özelliklerin belirlenmesi duyusal değerlendirme ile mümkündür. Kahvenin duyusal özellikleri ve kahve bileşenleri ile ilgili verilerin birlikte değerlendirilmesi kahve lezzetinin tanımlanması açısından ve hangi bileşenin nasıl bir lezzet özelliğine neden olduğunun

belirlenmesi açısından önem taşımaktadır. Kahve çekirdeği, işleme koşulları ve kahvenin bileşimi farklı duyusal karakteristiklere neden olmakta, hepsi birlikte kahve lezzetini oluşturmaktadır. Bu çalışmada, kahve lezzetine etkisi olan işleme, bileşim ve duyusal özelliklere genel bir bakış sağlanması amaçlanmıştır.

Extended Abstract

Coffee is one of the most widely consumed beverages in the world, and it began to take its place as a culture among consumers since the mid-16th century. While the first coffee houses became common in Turkey, Iran, Syria and Arabia in the 15th century, Europe was introduced to coffee in the 16th century (1). According 2023/24 data the coffee consumption of the regions is as follows: Europe 53.7, Asia & Pacific 45.7, North America 30.9, South Amerika 28.0, Africa 12.5 and Caribbean, Central America & Mexico 6.1 million 60-kg bags (2). The countries that consume the most coffee per capita are the Scandinavian countries, and according to 2023 data, Finland (12 kg) ranks first in the world in per capita consumption, followed by Norway (9.9 kg), Iceland (9 kg), Denmark (8.7 kg), the Netherlands (8.4 kg), Sweden (8.1 kg), Belgium (6.8 kg), Luxembourg (6.5 kg), Canada (6.5 kg) (3).

The fact that coffee taste is the most important parameter for the consumer, requires detailed investigation of coffee taste. Coffee flavour and distinctive sensory quality are affected by bean type, geographical location, climate, different agricultural practices, and process parameters. Studies on coffee flavour are mostly limited to determining the basic flavour compounds depending on a single coffee type, style, or geographical origin, and depending on the type of coffee studied and the basic flavour components obtained from one study differ from the data obtained from another study (4). In addition, the effect of the flavour compounds on sensory properties has not been fully determined. Starting from the cultivation of coffee beans, the processing, roasting, grinding, brewing methods and presentation of coffee to the consumer are important factors that affect the taste of coffee. In order to understand the taste of coffee, it is important to examine it from a broad perspective.

Although the sensory properties of coffee have been studied for many years, the importance of coffee flavour in terms of industry and science has increased with the increase in coffee consumption around the world. A sensory language describing coffee flavour has been used in many studies. Some of these sensory attributes were determined as; astringent, body, bitter taste, burnt smell, burnt taste (5), sweet caramel, earthy, roasted, sooty (6), roasted/burnt, spicy, bitter, sour, sweet, salty, astringent, woody, fermented, earthy and tobacco-like (7). Attributes such as coffee, brown, bean-like, hazelnut, cocoa, floral, fruity, green, ashy, sweet aromatic, sour aromatic and pungent have also been used as different aroma terms (8). Studies have shown that brewing enhances the sweet-caramel aroma in *Coffea arabica* , while it highlights the spicy, sharp and earthy aromas in *Coffea robusta* . It has been determined that different roasting degrees applied to *C. arabica* and *C. robusta* cause differences in astringency, body, bitter taste, and burnt odour (5).

In addition to aroma and taste, texture, mouthfeel and chemesthesia (sensitivity of the mucosa) are other components that affect the perception of flavour and are changed by the interaction of the food structure with its mouth-coating feature (9). While the texture and mouthfeel characteristics of coffee are defined as full-bodied, astringent, round, smooth, thick, coarse, granular, hard, oily, and sticky, the overall impression is pure, non-persistent, clear, sharp, moderate, round, soft, balanced, strong. Characters such as, heavy, hard, light, plain, simple, ripe, winey, rich, sharp, astringent, alkaline, easy to swallow were also used (10, 11). In another study conducted in Italy, espresso coffee was described with thick, lingering, fluid, resistant to tongue movement, syrupy, viscous, velvety, pasty, creamy, mouth-covering, smooth, round, granular, full-bodied and rich in character (12).

The formation of coffee flavour begins with the development of the fruit in the coffee plant. Green coffee beans contain over 1000 substances with different chemical and physical properties. Insoluble (cellulose, hemicellulose) and soluble (arabinose, fructose, galactose, glucose, sucrose, raffinose, stachyose, etc.) carbohydrates, lipids, chlorogenic acids and nitrogen-containing compounds are considered as basic aroma precursors (13). Sucrose, glucose, and fructose are responsible for the formation of acids and other volatile compounds during roasting, as Maillard reaction takes place between carbohydrates and amino acids (14). Polysaccharides are responsible for the retention of volatiles and contribute to flavour formation. Nitrogen-containing compounds such as alkaloids (caffeine and trigonelline) and proteins, non-volatile aliphatic acids (citric, malic and quinic acids), volatile acids (acetic, butanoic, decanoic, formic, hexanoic, isovaleric, propanoic acids) are broken down by roasting to form important flavour active metabolites such as pyridines and pyrroles (15). Differences in chemical composition of coffee types affect the taste and aroma obtained from these types. For example, *C. arabica* and *C. robusta* are quite different in terms of taste. The caffeine content of *C. robusta* beans is higher

than *C. arabica*, and their volatile component contents are also different. 2-methylisoborneol, determined in Robusta coffee, causes the typical earthy flavour (16). Differences have been founded even among *C. arabica* varieties due to environmental conditions. It has been stated that environmental factors such as geographical origin, climate, altitude and temperature rise, and shading are effective on coffee quality (17).

The development of complex coffee flavour continues with various coffee processing and preparation techniques. In the processing of green coffee beans, dry processing, wet processing, or semi-wet processing methods are used (17). The results obtained by the fermentation and washing process are main differences of mentioned methods and affect the taste of the coffee. While "hard" coffee with a medicinal taste is obtained with dry processing, better quality, less bodied, high acidity, and aromatic coffee is obtained with wet processing. It has been stated that coffees obtained by the half-wet method have a medium body (18).

Roasting, grinding, and brewing applied to green coffee beans are important processes that affect the taste of the coffee drink. Chemical reactions related to the colour, taste and aroma of coffee occur during roasting (17). During the roasting process, coffee flavour is formed by Maillard reactions, Strecker degradation, pyrolysis reactions, and the breakdown of trigonelline, quinic acid, pigments, and lipids (19).

The coffee flavour is revealed through the grinding process applied for extraction or infusion in the preparation of the coffee drink (8). The degree of grinding and particle size affect the extraction and therefore the quality of the coffee drink. A very finely ground coffee causes bitter coffee due to excessive extraction, while a coarsely ground coffee reduces extraction due to the decrease in surface area, resulting in a weak coffee (20).

Coffee brewing is a crucial step in transferring coffee aromas from the ground beans to the beverage. Extraction time, water temperature, applied pressure, particle size, coffee/water ratio and water quality affects the volatile substances extracted from coffee (21).

Non-volatile compounds found in roasted coffee beans are alkaloids (caffeine, trigonelline), chlorogenic acids, carboxylic acids, carbohydrates and polymeric polysaccharides, lipids, protein, melanoidins and minerals, and these compounds are important for coffee aroma. Variations in coffee growing and processing conditions affect the presence of these components in roasted coffee beans. Compared to *C. arabica*, *C. robusta* has been stated to contain higher amounts of caffeine as green or roasted beans (22, 23).

Volatile compounds formed during roasting of coffee beans are decisive in coffee quality. The mechanism of coffee aroma formation is quite complex and is formed by the interaction of many reactions during coffee beans and roasting. Mechanisms that are effective in the formation of important aroma volatiles during roasting include the Maillard reaction, Strecker degradation, degradation of sulfur amino acids, hydroxy amino acids, proline and hydroxyproline, trigonelline, chlorogenic acid and quinic acid, degradation of pigments and lipids (19).

The key compounds found in coffee are not enough to explain coffee flavour. Similarly, sensory determination of aroma attributes of coffee is insufficient to explain what causes a specific sensory property without chemical data. Evaluating sensory data and physicochemical measurements together is possible with chemometrics, known as multiple data analysis tools. Principal component analysis (PCA) and partial least squares (PLS) regression analysis are used to determine the components that cause specific aroma differences in complex matrices such as coffee (15).

Coffee flavour is affected by differences in the processing and preparation stages, starting from the cultivation of coffee. Differences in these factors cause changes in the flavour and aroma components of green and roasted coffee beans and brewing stages. The effect of volatile and non-volatile components on flavour perception of coffee, consumer preference and coffee pleasure are important. Although information about the chemical composition of coffee flavour is important, the reliable sensory data regarding the aroma composition of coffee is insufficient to explain the importance and contribution of these components to flavour. Matching sensory data with the components that make up coffee flavour will provide a better understanding of coffee flavour. Although studies on coffee flavour have been ongoing for nearly 100 years, detailed studies are needed to understand formation of coffee flavour.

GİRİŞ

Kahve dünyada yaygın olarak tüketilen içeceklerden biri olup, 16. yy'ın ortalarından itibaren tüketiciler arasında bir kültür olarak yerini almaya başlamıştır. İlk kahve evleri 15.yy'da Türkiye, İran, Suriye ve Arabistan'da yaygın hale gelirken, Avrupa 16. yy'da kahve ile tanışıyor ancak kafir içecek olarak düşünüldüğünden yaygınlaşmıyor. Papa VII. Clement'in onay vermesi ile içecek Avrupa ve Amerika'da tüketilmeye başlıyor. 17. yy ortalarında sadece Londra'da 300'ün üzerinde kahve evi olduğu ve bilim insanları, sanatçılar, tüccarlar ve politikacıların kahve içmek için buralarda toplandıkları belirlenmiş ve ilerleyen zaman içinde kahve tüketimi tüm dünyaya yayılmış (1). 2023/24 verilerine göre dünyada en fazla kahve tüketen bölgeler; Avrupa 53.7, Asya & Pasifik 45.7, Güney Amerika 30.9, Kuzey Amerika 28.0, Afrika 12.5 ve Karayip, Orta Amerika & Meksiko 6.1 milyon 60-kg torba olarak sıralanmaktadır (2). Kişi başına en fazla kahve tüketen ülkeler ise İskandinav ülkeleri olup, 2023 verilerine göre dünyada kişi başına tüketimde Finlandiya (12 kg) ilk sırayı almakta, Finlandiya'yı Norveç (9.9 kg), İzlanda (9 kg), Danimarka (8.7 kg), Hollanda (8.4 kg), İsveç (8.1 kg), İsviçre (7.9 kg), Belçika (6.8 kg), Lüksemburg (6.5 kg), Kanada (6.5 kg) izlemektedir (3).

Ticari mal olarak görülen kahve son yıllarda bir dönüşümden geçerek özel bir ürün olarak kabul görmeye başlamış ve üçüncü dalga kahve tüketimi yaygınlaşmıştır. 1960'larda giderek artan tüketime bağlı kitlesel pazarın büyümesi ve yaygınlaşması ile birinci dalga olarak nitelendirilen kahve tüketimi başlamıştır. İkinci dalga kahve tüketimi 1990'larda kahve zincirleri ile ortaya çıkmış, kahve zincirleri kaliteli kahveye ilgi gösteren yeni tüketiciye özel kahveler sunmaya başlamış ve kahve lüks bir ürün olarak görülmeye başlamıştır (24). Üçüncü dalga kahve ise küçük kavurma evlerinin spesifik bölge kahveleri ve yeni demleme tekniklerini kullanmaları ile gündeme gelmiştir. Günümüzde kahve yüksek kalite artizan gıda olarak kabul edilmekte ve şarap ile kıyaslanmaktadır (25). Kahve içme eylemi sadece bir içecek tüketmekten çok daha fazla anlam içermekte, zevk, deneyim, hayat tarzı ve sosyal statü ile ilişkilendirilmektedir (26). Kahve tüketiminin nedenleri araştırıldığında tüketicilerin %83'ünün kahveyi lezzeti nedeniyle tükettiği ve bunu enerji verme (%67), üretimi arttırma (%43), sağlık yararları (%29) ve açlığı bastırma (%0) gibi nedenlerin izlediği belirlenmiştir (27).

Kahve lezzetinin tüketici açısından en önemli parametre olması kahve lezzetinin detaylı araştırılmasını gerektirmektedir. Kahve lezzeti ve ayırt edici duyusal kalitesi çekirdek türü, coğrafi lokasyon, iklim, değişik tarım uygulamaları ve uygulanan işleme parametrelerinden etkilenmektedir. Kahve lezzeti ile ilgili çalışmalar daha çok tek bir kahve tipi, stili veya coğrafi yerine bağlı olarak temel lezzet bileşenlerinin belirlenmesi ile sınırlı kalmakta ve çalışılan kahve türüne bağlı olarak bir çalışmadan elde edilen temel lezzet bileşenleri ile başka bir çalışmadan elde edilen veriler birbirinden farklı olmaktadır. Ayrıca lezzete etkisi olan temel bileşenlerin duyusal özellikler üzerine etkisi de tam olarak belirlenmemiştir. Kahve çekirdeğinin tarımından başlayarak, işlenmesi, kavrulması, öğütülmesi, demleme yöntemleri ve tüketiciye sunulması aşamaları kahve lezzetini etkileyen önemli faktörlerdir. Kahve lezzetinin anlaşılması için bu konunun geniş bir bakış açısı ile incelenmesi önem taşımaktadır. Bu çalışmada kahvenin bileşimi, işlenmesi ve duyusal özelliklerinin kahve lezzeti üzerine etkisi ile ilgili bilgi verilmesi amaçlanmıştır.

Kahvede Lezzet Algısı

Lezzet, aroma, tat, doku, ağız hissi ve kemestezi özelliklerinin karışımı olup kimyasal ve sinirsel uyarıları da kapsayan kompleks bir duygudur (Şekil 1). Ancak kahve lezzeti söz konusu olduğunda aroma (koku) en önemli özelliktir. Birçok tüketici lezzeti algıladıkları koku olarak tanımlamaktadır. Bunun nedeni retronazal algıdır. Retronazal algı, gıdanın uçucu bileşenlerinin ağzımızdan boğazın gerisine ve geniz boşluğuna gitmesi ile uçucu bileşenlerin olfaktori epitel ile reaksiyona girmesi ve beyne sinirler yoluyla uyarı göndermesi ile oluşmakta, beyin ise bu duyusal bilgiyi koku olarak tanımlamaktadır. Ortanazal algı ise

uçucu bileşenlerin burun tarafından solunarak doğrudan olfaktori sistemle etkileşime girmesidir (28). Kahve gibi kompleks lezzete sahip ürünlerde lezzetin bileşeni olan aroma daha çok önem taşımaktadır.

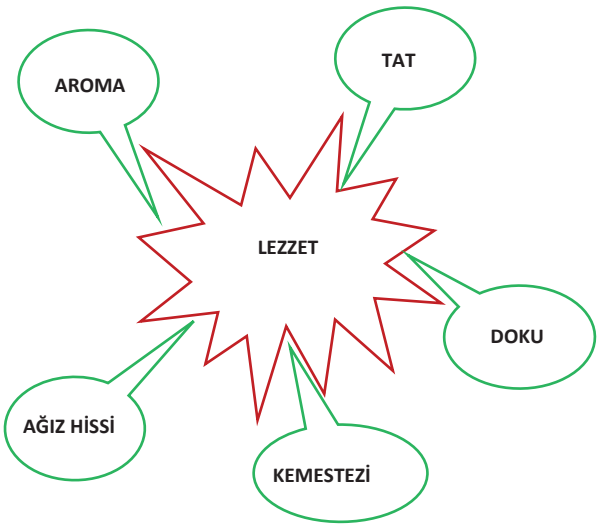
Kahvenin duyusal özellikleri uzun yıllardır çalışılmış olmakla birlikte dünya genelinde kahve tüketiminin artması ile endüstri ve bilim açısından kahve lezzetinin önemi artmıştır. Kahve lezzetini tanımlayan duyusal bir dil pek çok çalışmada kullanılmıştır. Bu duyusal özelliklerin bir kısmı; buruk, gövde, acı lezzet, yanık koku, yanık tat (5), tatlı karamel, toprağımsı, kavruk, isimsi (6), kavrulmuş/yanık, baharatımsı, acı, ekşi, tatlı, tuzlu, buruk, odunumsu, fermente, toprağımsı ve tütünümsü (7) olarak belirlenmiştir. Farklı aroma terimleri olarak kahve, kahverengi, fasulyemsi, fındığımsı, kakao, çiçeğimsi, meyvemsi, yeşil, külümsü, tatlı aromatik, ekşi aromatik ve keskin gibi tanımlar da kullanılmıştır (8). Yapılan çalışmalarda demlemenin *C. arabica* kullanılan kahvede tatlı-karamel aromayı arttırdığı, *C. robusta*'da ise baharat, keskin ve toprağımsı aromaları öne çıkardığını göstermiştir. *C. arabica* ve *C. robusta* kahvelere uygulanan farklı kavurma derecelerinin karakteristik koku, burukluk, gövde, acı lezzet, yanık koku gibi duyusal özelliklerde farklılığa neden olduğu belirlenmiştir (5). Soğuk demleme yöntemi ile yapılan çalışmada ekşilik ve kahve lezzetinin *C. arabica*'da, acılık ve burukluğun ise *C. robusta* soğuk demlemede belirgin olduğu ifade edilmiştir (29).

Aroma ve tat ile birlikte doku, ağız hissi ve kemestezi (mukozanın duyarlığı) lezzet algısını etkileyen ve gıda yapısının ağzı kaplama özelliği ile interaksiyonundan etkilenen diğer bileşenlerdir. Gevreklik, yağlılık, kumluluk, kıvam, yumuşaklık, sertlik gibi özelliklerle birlikte ağız ve dil yüzeyi ile gıda yapısı arasındaki interaksiyon sonucu mukus membranda kimyasal duyarlık ile ortaya çıkan yanma, gıdıklama, karıncalanma, soğukluk gibi daha kompleks algılar da söz konusudur (9). Kahvede doku ve ağız hissi özellikleri olarak gövdeli, buruk, yuvarlak, düzgün, kalın, kaba, taneli, sert, yağlı, yapışkan karakterler tanımlanırken, tüm izlenim ise saf, kalıcı olmayan, net, keskin, ılımlı, yuvarlak, yumuşak, dengeli, kuvvetli, ağır, sert, hafif, monoton, düz, basit, olgun, şarabımsı, zengin, keskin, iğneleyici, kekremsi, alkali, kolay yutulan gibi karakterler kullanılmıştır (10, 11). İtalya'da yapılan başka bir çalışmada espresso kahvede kalın, oyalanan, akıcı, dil hareketine direnç gösteren, şurubumsu, kıvamlı, kadifemsi, hamurumsu, kremamsı, ağzı kaplayan, düzgün, yuvarlak, tanecikli, gövdeli ve zengin karakterler tanımlanmıştır (12).

Kahve Lezzetinin Biyokimyasal Oluşumu

Kahve lezzetinin oluşumu kahve bitkisinde meyvenin gelişimiyle başlamaktadır. Yeşil kahve çekirdeğinde değişik kimyasal ve fiziksel özelliklere sahip 1000'in üzerinde madde yer almaktadır. Çözünmeyen (sellüloz, hemisellüloz)

Şekil 1. Lezzeti oluşturan özellikler



ve çözünen (arabinoz, fruktoz, galaktoz, glukoz, sakkaroz, rafinoz, stakiyoz vb.) karbonhidratlar, lipitler, klorojenik asitler ve azot içeren bileşikler temel aroma öncüleri olarak sayılmaktadır (13). Düşük moleküler ağırlığa sahip sakkaroz, glukoz, fruktoz gibi karbonhidratlar kavurma sırasında, karbonhidratlar ve amino asitler arasında oluşan Maillard reaksiyonu ile asitlerin oluşumu ve diğer uçucu bileşenlerin oluşumuna katkıda bulunmaktadır (14). Polisakkaritler, uçucuların tutulması ve lezzet oluşumunda önem taşımaktadır. Alkoloidler (kafein ve trigonellin) ve proteinler gibi azot içeren bileşikler, uçucu olmayan alifatik asitler (sitrik, malik ve kinik asitler), uçucu asitler (asetik, butanoik, dekanoik, formik, hegzanoik, isovalerik, propanoik asitler) kavurma prosesi ile parçalanarak piridinler ve piroller gibi önemli lezzet aktif metabolitlere dönüşmektedir (15). Kahve cinsleri arasındaki kimyasal bileşim farklılıkları bu cinslerden elde edilen kahvenin lezzetini etkilemektedir. *C. arabica* ve *C. robusta* lezzet açısından oldukça farklıdırlar. *C. robusta* çekirdeğinin kafein içeriği *C. arabica*'ya göre daha yüksek olup uçucu bileşenleri de farklılık göstermektedir. *C. robusta*'da belirlenen 2-metilisoborneol tipik toprağımsı lezzete neden olmaktadır (16). *C. arabica* çeşitleri arasında dahi çevresel koşullar nedeniyle farklılıklar belirlenmiştir. Coğrafi köken, iklim, yükseklik ve sıcaklık yükselmesi, gölgelenme gibi çevresel faktörlerin kahve kalitesi üzerine etkili olduğu ifade edilmiştir (17).

Kompleks kahve lezzetinin gelişimi çeşitli kahve işleme ve hazırlama teknikleri ile devam etmektedir. Yeşil kahve çekirdeğinin işlenmesinde, kuru işleme, yaş işleme veya yarı-yaş işleme yöntemleri kullanılmaktadır (17). Fermantasyon ve yıkama işlemi arasındaki farklar bu yöntemler arasındaki temel farklar olup kahve lezzetini etkilemektedir. Kuru işleme ile ilacımsı lezzete sahip "sert" kahve elde edilirken yaş işleme ile daha iyi kalitede, az gövdeli, yüksek asiditeye ve aromaya sahip kahve elde edilmektedir. Yarı yaş yöntemle elde edilen kahvelerin ise orta derecede gövdeli olduğu belirtilmiştir (18). Bu yöntemler dışında özel stil olarak ifade edilen "sindirimsel biyo-proses" ve "musonlama" yöntemleri de yaygın olmamakla birlikte kullanılmaktadır (30, 31). Kahve çekirdeklerinin Misk kedisinin bağırsaklarında fermente olması işlemi sindirimsel biyo-proses olarak adlandırılırken, musonlama ise gemilerde nemli ortamda uzun süre seyahat eden kahve çekirdeklerinin lezzetinin fark edilmesi ile Hindistan'da geliştirilmiştir (32).

Yeşil kahve çekirdeğine uygulanan kavurma, öğütme ve demleme aşamaları kahve içeceğinin lezzetini etkileyen önemli aşamalardır. Kahvenin rengi, tadı ve aroması ile ilgili kimyasal reaksiyonlar kavurma aşamasında ortaya çıkmaktadır. Kavurma işlemi 180-300 °C sıcaklıkta 3-20 dakika arasında yapılmaktadır (17). Kavurma işlemi sırasında Maillard reaksiyonları, Strecker degradasyonu, piroliz reaksiyonları, trigonellin, kinik asit, pigmet ve lipidlerin parçalanması ile kahve lezzeti oluşmaktadır (19). Maillard reaksiyonu sonucunda piridinler, pirazinler, dikarboniller, diasetil, oksazoller, tiazoller, piroller ve imidazoller, enolonler (furaneol, maltol, sisloten) ile formik ve asetik asitler oluşmaktadır (33, 34). Strecker degradasyonu ile α-amino asitler kahvenin kompleks aromasına katkıda bulunan aldehit ve sülfür bileşiklerine dönüşmektedir (34). Kavurma işlemi sonucunda kahvede en yüksek oranda pirazinlerin oluştuğu, furan, keton ve aldehitlerin pirazinleri izlediği belirlenmiştir (Tablo 1). Kavurma ile yeşil kahvenin bezelyemsi, yeşil kokusu aroma bileşenlerinin artmasıyla kavrulmuş hoş kahve kokusuna dönüşmektedir. Hafif kavrulmuş kahvede kavrulmuş bisküvi, fıstık, karamel, kızarmış ekmek, tahılımsı, tatlı, kakao ve fındığımsı karakterler belirlenmiştir (8, 35). Orta kavurma derecesinde daha kompleks aromalar oluşurken, koyu kavrulmuş kahvede ise yanık, isli, külümsü, keskin ve kavruk karakteristikler oluşmaktadır (8). Akiyama et al. (36), duman/kavruk, fenolik, tatlı/karamel ve yeşil özelliklerin kavurma ile pozitif ilişkili olduğunu, tatlı/meyvemsi ve asidik karakterlerin ise negatif ilişkili olduğunu ifade etmiştir. Kavurma derecesi kişisel tercih olmakla birlikte belirli kavurma koşulları istenen aroma özelliklerinin elde edilmesi amacıyla farklı çeşit, farklı coğrafi kökenden kahveler için kullanılabilir. Örneğin orta kavrulmuş kahve coğrafyadan kaynaklanan yöresel lezzetleri koyu kavrulmuş kahveden

daha iyi ortaya çıkarmaktadır. Kavurmanın *C. arabica* ve *C. robusta* üzerindeki etkilerinin de farklı olduğu bilinmektedir. Kavurma ile *C. arabica*'da yüksek oranda asit, piridin, furan ve aldehit içeriğine bağlı olarak karamel, tatlı kavruk aroma gözlenirken, *C. robusta*'da yüksek oranda pirazin ve türevleri nedeniyle toprağımsı ve baharatımsı kavruk aroma saptanmıştır (16).

Kahve içeceğinin hazırlanmasında ekstraksiyon veya infüzyon için uygulanan öğütme işlemi ile kahve lezzeti açığa çıkmaktadır (8). Öğütme derecesi ve partikül boyutu ekstraksiyonu ve dolayısıyla içeceğin kalitesini etkilemektedir. Çok ince öğütülmüş bir kahve aşırı ekstraksiyon nedeniyle acı kahveye neden olmakta, kaba öğütülmüş kahve, yüzey alanındaki azalma nedeniyle ekstraksiyonu azaltmakta sonuçta zayıf, yavan bir kahveye neden olmaktadır (20).

Kahve demleme, kahve aromalarının öğütülmüş çekirdekten içeceğe aktarılmasında çok önemli bir adımdır. Kahve içeceği hazırlamak için dekoksiyon (kaynatma, Türk, filtre, vakumlu kahveler), infüzyon veya ıslatma (filtre- Napoletana), ve basınç (piston, moka, espresso) yöntemleri olarak çok sayıda demleme yöntemi vardır.

• Dekoksiyon: Öğütülmüş kahvenin belirli bir süre ve yüksek sıcaklıkta suyla temas etmesidir. Diğer yöntemlere göre göre daha yoğun ve hızlı ekstraksiyona neden olurken ısıyla direk kaynatma ve yüksek sıcaklık nedeniyle lezzet kayıpları oluşur.

• İnfüzyon: Kaba veya orta öğütülmüş kahvenin sıcak veya soğuk suyla belirli bir süre ıslatılması ve süzülmesi ile elde edilir. Dekoksiyon ile elde edilen kahveler daha yumuşak, asitliği ve lezzeti daha yüksek kahvedir.

• Basınç yöntemi: Yüksek basınç ve ısı uygulaması ile gözenekli bir ortamdan veya filtreden geçirilerek süzülmesi ile elde edilir (37). Basınç yöntemi ile elde edilen kahvelerin uçucu bileşen profilinin diğer yöntemlere daha geniş olduğu belirlenmiştir (21).

Demleme ile klorojenik asit, kafein, nikotinik asit, melanoidinler gibi suda çözünen bileşenler ve uçucu hidrofilik bileşenler ekstrakte edilmektedir. Ekstraksiyon süresi, su sıcaklığı, uygulanan basınç, partikül büyüklüğü, kahve/su oranı ve su kalitesinin kahveden ekstrakte edilen uçucu bileşenler üzerinde etkili olduğu dolayısıyla kahve lezzetini etkilediği saptanmıştır (12, 38, 39, 40, 41).

Bileşenlerin Kahve Lezzetine Etkisi

Uçucu Olmayan Bileşenlerin Etkisi

Kavrulmuş kahve çekirdeklerinde bulunan ve kahve aroması için önemli olan uçucu olmayan bileşikler arasında alkaloidler (kafein, trigonellin), klorojenik asitler, karboksilik asitler, karbonhidratlar ve polimerik polisakkaritler, lipitler, protein, melanoidinler ve mineraller sayılmaktadır. Bu bileşenlerin kavrulmuş kahve çekirdeklerinde bulunması, kahvenin

Tablo 1. Kavurma işlemi sonucunda kahvede oluşan temel uçucu bileşenler (Wang et al, 2021 (16)'dan uyarlanmıştır)

Bileşen adı	%
Pirazinler	24
Furanlar	20
Ketonlar	12
Aldehitler	11
Piroller	8
Fenoller	6
Furanonlar	6
Piridinler	5
Tiyoller	4
Terpenler	2
Diğer kükürtlü bileşikler	2

yetiştirme ve işleme koşullarındaki değişkenlik nedeniyle oldukça çeşitlidir. *C. arabica* ile karşılaştırıldığında, *C. robusta*'nın yeşil veya kavrulmuş çekirdek olarak daha yüksek oranda kafein ve klorojenik asit içerdiği ifade edilmiştir (22, 23, 29).

Kafein demlenmiş kahvede güç, gövde ve acılığa katkıda bulunmaktadır (19). Saf haldeyken acı bir tada sahip olan alkaloidlerin kahvede fizyolojik bir uyarıcı etki sağladığı bilinmektedir (42, 43). Trigonellin kafeinin aksine *C. arabica*'da yüksek oranda bulunmakta ve kavrulmuş kahve çekirdekleri ve demlenmiş kahvede genel lezzet algısına etkili olduğu düşünülmektedir (22, 23, 29).

Kahve çekirdeğinde bulunan klorojenik asitlerin kahvede burukluk ve acılığa katkıda bulunduğu ayrıca antioksidan etkisi olduğu bilinmektedir (19, 44). Klorojenik asit bitki ve bitki bazlı gıdalarda bulunan önemli polifenoller arasında olup kahve klorojenik açısından diğer içecekler arasında en zengin kaynaktır (45). Bir bardak demlenmiş *C. arabica* kahve (200 ml) 70-200 mg klorojenik asit içerirken, *C. robusta* 70-350 mg klorojenik asit içermektedir (46, 47). Sinamik, kafeik, ferulik, isoferulik ve sinapik asit ile degredasyon ürünü olan kinik asit kahvede acılığa neden olmaktadır (19). Orta derecede kavrulmuş kahvede klorojenik asidin %65'inin parçalandığı, kavurma derecesi arttıkça parçalanmanın da arttığı belirlenmiştir (48).

Asitlik ve ekşilik kahve kalitesinde tatlılık ve acılıkla birlikte önemli özelliklerdir. Asitlik genellikle tatlılıkla zıt ilişkilidir. Demlenmiş *C. arabica C. robusta*'ya göre daha asidiktir. Yeşil kahve çekirdeğinde asitlik %11 civarındayken kavrulmuş tanede asitlik sitrik, malik ve klorojenik asitlerdeki azalmaya bağlı olarak %6 olarak belirlenmiştir (15). Söz konusu asitler kavurma ile laktonlar, fenoller gibi kahve aromasını etkileyen uçucu bileşenlere dönüşmektedir. Orta ve çok kavrulmuş kahvede asetik, formik ve laktik asit miktarlarının arttığı saptanmıştır (48).

Arabinogalaktan, mannan, sellüloz ve hemisellüloz gibi polisakkaritler yeşil ve kavrulmuş kahvenin temel bileşenleri olup uçucu bileşenlerin tutulmasında etkili olup lezzet ve viskoziteyi etkilemektedir. Polisakkaritlerin kuru ağırlık bazında *C. arabica*'da %43, *C. robusta*'da %54'ünü oluşturduğu, sakkaroz miktarının ise *C. arabica*'da %9.32, *C. robusta*'da %6.10'unu oluşturduğu saptanmıştır. Glukoz ve fruktoz olgunlaşmamış çekirdekte saptanırken yüksek miktarda sakkarozun olgunlaşmış çekirdekte birikerek kahvede algılanan tatlılığa neden olduğu belirlenmiştir (44, 49).

Kahvede yüksek miktarda bulunan lipid fraksiyonunun %75'ini trigliseritler oluşturmaktadır. Kavrulma sırasında kahve yağı çekirdeğin yüzeyine çıkmakta ve lipid profilinde değişikler meydana gelmekte ancak trigliseritler ve steroller değişmemektedir. Lipid fraksiyonu demleme ile ekstrakte olmakta, espresso kahvede krema emülsiyon oluşturarak uçucuların ve yağda çözünen vitaminlerin taşınmasına ve algılanan doku ve ağız hissine katkıda bulunmaktadır (44).

Yeşil kahve çekirdeğinin amino asit içeriği kavrulma sırasında Maillard reaksiyonu ile lezzet gelişimine katkıda bulunmaktadır (50). Maillard reaksiyonu sonucunda oluşan azot ve sülfür içeren heterosiklik bileşikler kahve lezzetini etkilemektedir.

Minerallerden potasyum, mangan, demir ve bakır kahvede lezzet bileşenlerinin üretimi ve salınımını etkileyen biyokimyasal proseslerde önemli katalistler olarak yer almaktadır (44).

Kahve çekirdeği ve demlenmiş kahvede bulunan uçucu olmayan bileşenlerin kahvenin duyusal kalitesini olumlu etkilediği gibi olumsuz etkilerinin de olduğu belirlenmiştir. Karbonhidratlar tatlılığı etkilerken, şeker ve amino asitler arasındaki Maillard reaksiyonu sonucunda karakteristik kavrulmuş kahve rengi oluşmakta, klorojenik asit ve kafein acılığa katkıda bulunmaktadır. Yüksek klorojenik asit ise oksidasyon ürünleri ile ilişkilendirilmekte kötü lezzet, ilacımsı, fenolik veya iyot benzeri lezzete neden olmaktadır (51).

Uçucu Bileşenlerin Etkisi

Kahve çekirdeğinin kavrulması sırasında oluşan uçucu bileşenler kahve kalitesinde belirleyici olmaktadır. Kahvede 900'ün üzerinde uçucu bileşen belirlenmiş olmakla birlikte yaklaşık 20 kadar uçucu bileşenin kahve lezzeti üzerinde önemli etkisi olduğu ileri sürülmektedir. Kahve aromasının oluşum mekanizması oldukça kompleks olup kahve çekirdeği ve kavurma sırasındaki birçok reaksiyonun interaksiyonu ile oluşmaktadır. Kavurma sırasında önemli aroma uçucularının oluşmasında etkili olan mekanizmalar arasında Maillard reaksiyonu, Strecker degradasyonu, kükürtlü amino asitler, hidroksi amino asitler, prolin ve hidroksiprolin parçalanması, trigonellin, klorojenik asit ve kinik asit, pigment ve lipidlerin degradasyonu sayılmaktadır (19). Belirlenen bileşenlerin %30-40'ının Maillard reaksiyonu, %12-16'sının Maillard reaksiyonu ve bileşenlerin termal dekompozisyonu, %16-18'inin amino asitlerin Strecker degradasyonu ve %30-37'sinin diğer mekanizmalarla oluştuğu ifade edilmektedir (4).

Aldehitler, asitler, esterler, furanlar, kükürt içeren bileşikler, tiyoller, tiyofenler, tiyazoller, furanonlar, ketonlar, fenolik bileşenler, pirazinler, piridinler ve terpenler kahvede bulunan uçucu bileşen gruplarıdır. Kantitatif olarak furanlar ve pirazinler yüksek miktarda bulunurken kükürtlü bileşikler ve pirazinler kahve lezzetinde önem taşımaktadır (4). Duyusal olarak kahve lezzetine en fazla katkısı olan grupların furanlar, kükürt içeren bileşikler, pirazinler, furanonlar ve fenolik bileşenler olduğu saptanmıştır (14). Bu bileşenlerin konsantrasyonu ve duyusal etkisi kahve lezzetini kompleks hale getirmekte ve değişik kahve tiplerinin farklı, benzersiz ve spesifik lezzete sahip olmalarını açıklamaktadır.

Furanlar kavrulmuş kahvede önemli konsantrasyonda bulunan ve karbonhidratlar, askorbik asit ve doymamış yağ asitlerinin degradasyonu ile kavurma aşamasında oluşan maddelerdir. Tatlı kavrulmuş aromaya neden olan furanların sağlık üzerine olumsuz etkileri nedeniyle ticari kahve kavurma işlemi furan oluşumunu azaltmak amacıyla optimize edilmiştir. Pirazinler kahvede fazla miktarda bulunan ve kahve lezzetinde önemli olan bileşiklerdir ve genel olarak fındığımsı, toprağımsı, kavrulmuş ve yeşil aromaya neden olmaktadırlar (5, 14). Aldehitlerin meyvemsi, ketonların karamel ve terayapımsı, esterlerin meyvemsi, alkollerin çiçeğimsi ve şarabımsı, piridinlerin ise çikolata benzeri hoşa giden aroma karakterleri verdikleri belirlenmiştir (14). Tiyoller gibi kükürt içeren bileşikler düşük konsantrasyonda bulunmakla birlikte kahve lezzetine etki eden en önemli bileşiklerdir. Bir kısmı kavrulmuş aroma, bir kısmı ise etimsi aroma vermektedir (5). Yeşil kahve çekirdeğinde bulunan klorojenik asitlerin ısısal degradasyonu ile oluşan fenolik bileşiklerin kavrulmuş kahvedeki konsantrasyonu kahve çekirdeğinin çeşidi ve coğrafi kaynağına bağlı olarak değişiklik göstermektedir. Klorojenik asitlerin *C. arabica*'ya göre *C. robusta* yeşil kahve çekirdeğinde anlamlı düzeyde yüksek miktarda bulunması nedeniyle söz konusu uçucuların iki çeşit arasındaki lezzet farklılığında anahtar rol oynadığı düşünülmektedir (5).

Duyusal Özellikler ve Kahve Bileşimi Arasındaki İlişki

Kahvede bulunan anahtar bileşikler kahve lezzetini açıklamak için yeterli değildir. Benzer olarak kahvenin aroma özelliklerinin duyusal olarak belirlenmesi de kimyasal veri olmadan spesifik duyusal özelliğe hangi bileşenin neden olduğunu açıklamada yetersizdir. Duyusal verilerle fizikokimyasal ölçümlerin birlikte değerlendirilmesi çoklu veri analiz araçları olarak bilinen kemometri ile mümkündür. Bu amaçla temel bileşen analizi (PCA), kısmı en küçük kareler (PLS) regresyon analizi kahve gibi kompleks matrislerde spesifik aroma farklılıklarına neden olan bileşenlerin belirlenmesinde kullanılmaktadır. *C. arabica* farklı kaynak ve farklı kavurma derecelerinde aroma farklılıkları, Colombiya kahvesinde kullanılan katkıların duyusal özellikler üzerine etkisi PCA ile belirlenmiş, Brezilya *C.Arabica*'da duyusal veriler ile uçucu bileşenler arasındaki ilişki PLS ile belirlenmiş, Türk kahvesinde az, orta ve koyu kavrulmuş kahvenin uçucu bileşenleri ve duyusal özellikleri belirlendikten sonra PCA ile değerlendirilmiştir (8, 52, 53, 7). Kahvedeki temel bileşenler ve duyusal özelliklerin ayrı

ayrı belirlendikten sonra elde edilen verilerin istatistiksel yöntemlerle değerlendirilmesi ile aralarındaki ilişkinin kurulması ve kompleks kahve lezzetinin ortaya konması mümkün olmaktadır.

SONUÇ

Kahve lezzeti, kahvenin tarımından başlayarak işleme ve hazırlama aşamasındaki farklılıklardan etkilenmektedir. Bu etkenlerdeki farklılıklar yeşil ve kavrulmuş kahve çekirdeği ve demleme aşamalarında lezzet ve aroma bileşenlerinde değişikliğe neden olmaktadır. Uçucu ve uçucu olamayan bileşenlerin kahvenin lezzet algısı, tüketici tercihi ve kahve zevki üzerine etkisi önemlidir. Kahve lezzetinin kimyasal kompozisyonu ile ilgili bilgi önemli olmakla birlikte kahvenin aroma bileşimi ile ilgili güvenilir duyusal veri eksikliği bu bileşenlerin lezzet açısından önemini ve katkısını açıklamada yetersiz kalmaktadır. Kahve lezzetini oluşturan bileşenlerle duyusal verilerin eşleştirilmesi kahve lezzetinin daha iyi anlaşılmasını sağlayacaktır. Yaklaşık 100 yıldır kahve lezzeti üzerine çalışmalar sürmekle birlikte kahve lezzetinin anlaşılması için detaylı çalışmalara ihtiyaç duyulmaktadır.

Etik Kurul Onayı

Etik kurul izni gerekli değildir.

Çıkar çatışması

Çıkar çatışması bulunmamaktadır.

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