DOI: 10.29050/harranziraat.1382823
Harran Tarım ve Gıda Bilimleri Derg. 2024, 28(2):267-279

Research Article/Araştırma Makalesi

Physicochemical and sensory properties of vegetarian pasta produced with pea (*Pisum sativum*) protein powder

Bezelye (Pisum sativum) protein tozu ile üretilen vejetaryen makarnanın fizikokimyasal ve duyusal özellikleri

Sena Nur DOĞAN[1], İlkay YILMAZ[2*]

[1,2]Baskent University, Faculty of Fine Arts, Design and Architecture, Department of Gastronomy and Culinary Arts, 06790, Ankara, Turkey

[1]https://orcid.org/0000-0002-6413-8944; [2]https://orcid.org/

To cite this article:
Doğan, S. N. & Doğan, S. (2024). Physicochemical and sensory properties of vegetarian pasta produced with pea (*Pisum sativum*) protein powder. Harran Tarım ve Gıda Bilimleri Dergisi, 28(2):267-279

DOI: 10.29050/harranziraat.1382823

***Address for Correspondence:**
İlkay YILMAZ
e-mail:
ilkayyilmaz@baskent.edu.tr

Received Date:
29.10.2023
Accepted Date:
18.03.2024

ABSTRACT

Dry legumes are frequently preferred as a protein source in plant-based diets. In this study, the production of "pea pasta" with the addition of pea protein powder was aimed. Moisture, ash, protein, weight loss, volume, and cooking time characteristics of the pasta were examined. Additionally, the sensory properties of the produced pea pasta and its effect on individuals' satiety were investigated, and the results were evaluated. In all sensory analyses, the pasta sample containing 10% pea protein powder was the most preferred among 8 different criteria. It was observed that the satiety lasted longer when consumers consumed pasta containing 10% pea protein powder compared to the control pasta consumption.

Key Words: Vegetarian pasta, pea protein powder, cooking properties, sensory evaluation

ÖZ

Kuru baklagiller bitkisel bazlı beslenmede protein kaynağı olarak sıklıkla tercih edilmektedir. Bu çalışmada bezelye protein tozu ilavesiyle "bezelye makarnası" üretimi amaçlanmıştır. Örneklerde nem, kül, protein tayini ile ağırlık kaybı, hacim, pişme süresi özellikleri incelenmiştir. Ayrıca üretilen bezelyeli makarnanın duyusal özellikleri ve bireylerin tokluk hissine etkisi de araştırılarak sonuçlar değerlendirilmiştir. Tüm duyusal analizlerde %10 bezelye protein tozu içeren makarna örneği 8 farklı kriter arasından en beğenilen çeşit olmuştur. Tüketicilerin %10 bezelye protein tozu içeren makarna tüketimlerinin kontrol makarna tüketimi ile karşılaştırılmasında tokluk hislerinin daha uzun sürdüğü görülmüştür.

Anahtar Kelimeler: Vejetaryen makarna, bezelye protein tozu, pişme özellikleri, duyusal değerlendirme

Introduction

The prevalence of chronic diseases is increasing worldwide and can lead to many deaths. The quality of life of individuals is affected by the difficulty of health care costs and access to healthy food. "Obesity" (Body mass index [BMI] ≥ 30) and "overweight" (BMI 25-29.9) represent abnormal or excessive fat accumulation that can have a negative impact on health. There are many diets for the treatment of obesity. There is ample evidence from prospective cohort studies to support plant-based diets in preventing obesity and chronic diseases. (Gibbs and Cappuccio, 2022) A recent randomized controlled trial found that a low-fat vegan diet increased *Faecalibacterium prausnitzii* and decreased

Bacteroides fragilis, which was associated with greater body weight, fat mass, loss of visceral fat, and increased insulin sensitivity (Ahmad, 2022). Plant-based nutrition reduces total cholesterol and LDL levels and reduces fasting blood sugar, fasting insulin and insulin resistance levels. This nutritional style can be used in the treatment of some diseases, especially obesity (Ivanova et. al., 2021).

Protein is one of the essential nutrients for the human body and its benefits for weight management, satiety, muscle and skeletal development have been recognized for a long time (Ahnen et al., 2019). Protein sources are classified in two ways as plant and animal. Today, animal products are considered the main protein source. However, because of the increasing world population and the inability of every individual to have access to animal-derived protein, the Advisory Board for Dietary Guidelines recommended increasing vegetable protein consumption (Pasiakos and Lieberman, 2015). The plant-based diet, includes less meat and meat products consumption, which includes ecological concerns such as a sustainable life and supporting the global climate crisis, in addition to the desire of individuals to be healthy (Courty, et al., 2015).

Legumes, oil seeds and whole grains are good sources of vegetable protein thanks to their high protein content (Pasiakos and Lieberman, 2015). Food legumes are products of the *Leguminosae* family also called *Fabaceae.* They are grown mainly for their edible seeds and therefore are also called cereal pulses (Iqbal et al., 2006). The *Leguminaseae* family contains three orders within itself. Of these orders, *Phaseolaeae*, beans, and cowpea; *Vicieae*, lentils, peas and chickpeas; *Hedysaraeae* are the orders that include peanuts (Gökhisar, 2018). Beans, peas, soybeans, broad beans, black-eyed peas, etc. from legumes constitute a very important trade area in the world, especially in Latin America and Asia (Ertas, 2013). In Turkey, the production share of legumes progresses as chickpeas, lentils, beans, broad beans and peas, respectively (Yılmaz and Şen, 2021).

Peas (*Pisum sativum L.*), has been cultivated since ancient times. Its homeland is Western Asia and Europe. When the nutritional elements of peas are examined, 70-80% of fresh peas consist of water, 6-8% protein and 12-15% carbohydrates. Dried peas consist of 6-16% water, 18-20% protein, and 20-60% carbohydrates (USDA, 2022). Pea protein contains 9 essential amino acids that are essential for the human body. In addition, it also contains leucine, isoleucine and valine, which we call branched-chain amino acids, which support muscle growth (Tömösközi, et al., 2001). It has been found to be rich in various vitamins and minerals such as P, Ca, Mg, Fe, K (USDA, 2022). Peas, on the other hand, have not been adequately evaluated in the production of gluten-free, vegetarian, vegetable protein foods, the sector expanding daily.

In this context, thanks to the functional properties and high nutritional value of peas, it is thought that developing a product that can be consumed by everyone in the society by using pea protein concentrate and isolate in the food industry. Peas contain very important nutrients in terms of nutrition. In addition to being one of the best plant-based protein sources, it helps individuals stay full for longer with its high fiber content (Temiz and Yeşilsu, 2006). According to USDA data, 100 grams of cooked green peas contains; 134 kcal, 6.3 g protein, 14.4 g carbohydrate, 0 g cholesterol, 0.4 g fat, 2 g dietary fiber, 116 mg phosphorus, 26 mg calcium, 1.9 mg iron, 2 mg sodium, 316 mg potassium, 35 mg magnesium, 0.7 mg Vitamin A, 0.35 mg vitamin B1, 0.14 mg vitamin B2, 35.5 mg folic acid, 27 mg vitamin C, 2.1 mg vitamin E (USDA, 2022).

Foods high in protein increase the levels of certain hormones in the human body that reduce appetite. These hormones are glucagon-like peptide-1 (GLP-1), cholecystokinin (CCK) and peptide YY (PYY). Protein and fiber slow down digestion and increase the feeling of satiety (Wilde and Nakkoul, 2009).

Different products such as pea protein concentrate, pea protein isolate pea and flour can

be obtained from pea grains. Among these products, especially pea protein isolate and concentrate have a better nutritional quality than other forms of consumption of peas and are a good source of vegetable protein. Pea protein isolate typically contains around 80-85% protein content. Pea protein concentrate usually has a slightly lower protein content, ranging from 60-80%, depending on the processing method and specific product (Shanthakumar et al., 2022). Thanks to its protein content, it can be used as a method of enriching foods in terms of protein (Lam et al.,2016)

The flour substituted with pea protein isolate had a good bread making potential compared to the unsubstituted flour. Protein content was increased by more than 20% with pea protein isolate, the specific volume of bread samples with high protein content increased more than the others (Marchaiset al., 2011).

Gluten-free rice pastas and pasta samples containing different legume flours were prepared and examined by adding different proportions of pea, chickpea and red lentil flour to rice flour. Sensory analysis of the surface, chewing, mouthfeel and taste properties of the pastas was performed. It was concluded that the legume flour added pasta samples were acceptable according to the sensory analysis results and the most popular legume flour added pasta in terms of taste was the lentil flour added pasta (Hosta, 2012).

This study aimed to prepare pasta samples with pea protein powder (PPP) that have high nutritional value and will increase the satiety of consumers. Therefore, this study aims to evaluate the physicochemical properties and quality characteristics of pasta after adding pea protein powder as a flour substitute.

Material and methods

Materials

In the production of pasta with added pea protein powder, semolina flour made from durum wheat, ground twice, and 100% natural pea protein powder from Saffoods Food Industry Co. Ltd. have been utilized. Both flours have been stored in a cool and sealed area until use. Additionally, eggs, drinking water, and table salt used in pasta production were sourced from local markets. Pasta production trials and physical as well as sensory analyses were conducted in the culinary workshops of the Department of Gastronomy and Culinary Arts at Başkent University during the study. Moisture, ash, and protein analyses were carried out by Ayşenur & Turan Food Control Laboratory Inc.

Method

Pasta preparation

Preliminary trials were conducted initially for pasta production. In these preliminary trials, pasta was produced using semolina flour. However, the resulting pasta was not preferred due to its granular appearance in terms of texture. Following the failure of the initial trial, the liquid source was changed to increase the protein content of the pasta. However, this change in the liquid source led to increased stickiness, an undesirable characteristic of the pasta dough, resulting in another unsuccessful trial. In the final trial, semolina flour was replaced with semolina flour made from double-milled durum wheat. It was decided to use only water as the liquid source, and the pasta was produced again using traditional methods. In the conducted trials, pea protein powder was added to the pasta at rates of 0%, 10%, 20%, and 30%, and the desired texture was achieved. In the study, which received ethical approval from the Institutional Review Board with the number E-62310886-302.14.05-97460, after passing through three trial stages, the selected pasta sample was presented to the panelists for their evaluation.

The formulation utilized in pasta production is outlined in Table 1. Pea protein powder (PPP) was incorporated into the pasta formulations at rates of 0% (PPP-0), 10% (PPP-

10), 20% (PPP-20), and 30% (PPP-30) (Table 1), while semolina flour was removed at corresponding rates. The doughs were then mixed for 10 minutes. To prevent the dough from drying out, it was divided into portions, covered with cling film, and allowed to rest for 30 minutes. Subsequently, the rested pasta dough was rolled out to the desired thinness using a rolling pin until it could pass through a pasta machine (Marcato In the Ampia 180, Italy). The dough was then passed through the machine twice at the 0 setting and twice at the 3 setting, and shaped into linguine. The shaped pasta was left to dry in sunlight for 24 hours. Pasta dries in 18-24 hours on average. In order to understand that the pasta was dried as desired, the breaking process was carried out (Ficco et al., 2016).

Table 1. Composition of pasta and amount of pea protein powder added to pasta

Raw materials (g)	Control(0%PPP)	10% PPP	20% PPP	30% PPP
Semolina Flour (g)	174	156.6	139.2	121.8
Pea Protein Powder (g)	0	17.4	34.8	52.2
Water (g)	60	60	60	60
Egg (g)	50	50	50	50
Salt (g)	5	5	5	5
Totals	289	289	289	289

Chemical analysis

The Moisture content was analyzed according to the AOAC 977.21:2012 method. The Kjeldahl method was used to analyze the total protein (AOAC 920.176:2012). The color properties were estimated with the tristimulus spectrophotometry method, with CIELAB coordinates (*L*a*b**) in a Konica Minolta CR-400 series equipment where the *L** parameter indicates luminosity, the a* axis shows the variation from red (*+a**) to green (*-a**) and the *b** axis shows the variation from yellow (*+b**) to blue (*-b**).

Cooking analysis

Cooking time

Optimum cooking time of pasta samples were determined by the method applied by Köksel, et al., (2000). 25 g of pasta sample was added into the 200 mL distilled water and brought to the boiling point, and a piece of pasta was taken out every 1 minute and placed between two glass slides. This process was repeated until no white particles remained in the pasta between the slides.

Minutes were measured with a stopwatch. The time elapsed from placing the pasta samples in boiling water to the disappearance of the white-colored particles was recorded as the optimum cooking time (Köksel, et al., 2000).

Volume increase

For volume expansion analysis, each pasta sample was cooked, drained, and then placed in a 100 ml graduated cylinder containing 50 ml of distilled water. Subsequently, the volume changes caused by the sample in the water were noted. The same procedure was repeated for dry pasta samples, and the amount of water displaced was recorded. The difference between these measurements was noted, and the volume expansion was calculated as a percentage (%), following the equation provided by Demir (2008). These procedures were repeated twice, and the averages were recorded. The equation used for volume expansion is provided below.

$$\% \text{ Volume increase} = \frac{(V2 - V1)\ x\ 100}{V1}$$

V1: Cooked pasta volume (ml)

V2: Raw pasta volume (ml)

Weight increase (Water absorption)

Dry weight measurements of 25 g were taken for each pasta sample before starting the analysis. Then, 25 g of sample samples were cooked in beakers filled with 200 ml of distilled water. The cooked pasta was filtered in a porcelain sieve for 5 minutes.

The weight of the filtered pasta was measured with the help of precision scales. The weight gains of the pasta were calculated by determining the differences between the weighing before and after cooking. The equation used for weight gain is given below (Lai, 2001).

$$\%\ \text{Weight gain} = \frac{(G2 - G1) \times 100}{G1}$$

G1: weight of cooked pasta

G2: Weight of raw pasta

Sensory analysis

The research consists of two parts. In the first part of the research, the sample consists of 12 trained panellists. In the second part of the study, the sample consists of 10 participants, 6 female and 4 males, who received nutrition counseling services.

The sensory analysis was determined through a sensory profile by multidimensional approximation. 12 trained panelists were between 20 and 50 years old. As a sensory analysis scale, the characteristics of the panel to be applied were determined concerning the book "Sensory Evaluation in Food" by Altuğ-Onoğur and Elmacı (Altuğ- Onoğur and Elmacı, 2015). A random three-digit code was given to each pasta group and sample plates were presented to the panelists in random order. During the tasting of the pasta samples, they were asked to drink water after the evaluation of each pasta. Cooked Pasta was evaluated for seven properties: color, surface texture, odor, chewiness, taste, appearance, and general taste. The evaluation in the prepared tasting form is based on a 5-point Likert scale with a hedonic scale of 1-5 (5 points: Very good, 4 Points: Good, 3 Points: Acceptable, 2 Points: Not Sufficient, 1 Point: Bad). While preparing the pasta samples for analysis, 100 g sample was cooked in 500 mL water for 10 minutes and the excess water was filtered for 20 seconds (Köten and Ünsal, 2022).

Ten different individuals with similar health backgrounds who received nutrition counseling services had the most acceptable pasta sample added to their diet lists. In the diet plans of these individuals, with pasta being the only variable, the rest of the day's nutrition programs were kept identical, considering macronutrients and physical activities. Individuals receiving dietary counseling were asked to consume both the control pasta and the pasta with added pea protein powder, and then to note the duration of satiety they experienced throughout the day.

Statistical analysis

Statistical analysis of all data obtained from the analysis was made. Analyzes were carried out using the statistical package program (SPSS). Standard deviation and mean among descriptive statistics were used in the analyses. Kruskal Wallis test was applied to the data that did not fit the normal distribution. Bonferroni Post Hoc test was used to test the difference between the groups and it was accepted as significant ($p<0.05$).

Results and Discussion

Chemical composition and physicochemical properties of pasta

According to the analysis results, the ash value of the control (0%) pasta sample is 2.73% ± 0.49%, the 10% PPP added pasta sample is 3.11% ± 0.56, and the 20% PPP added pasta sample is 2.58 ± 0.46%. It was determined that the pasta sample with 30% PPP addition had an ash value of 3.74% ± 0.67%. It is observed that ash values increase as PPP addition in foods increases, except for pasta with 20% PPP addition. Since PPP is richer in vitamins, minerals and protein, the ash value is expected to be higher than the control (0%) (Pınarlı et al., 2004). In a study in which sensory analysis

was performed by adding wheat germ to pasta samples, it was observed that as the amount of wheat germ, which is considered rich in fiber, increased, the amount of ash in pasta increased (Pınarlı et al., 2004). It is observed that the ash value increases as the amount of carob flour, which has high vitamin and mineral value, increases in the pastas for which chemical analyzes were made by adding carob flour in different proportions, showing results consistent with our study (Yılmaz and Şen, 2021).

Table 2: Results of moisture, ash and protein content of pasta samples (%)

Pasta Samples	Moisture Analysis (%)	Ash Analysis (%)	Protein Analysis (%)
PPP-0	9.77±0.39 [a]	2.73±0.49 [c]	15.92±1.75 [d]
PPP-10	9.27±0.37 [c]	3.11±0.56 [b]	20.51±2.26 [c]
PPP-20	9.13±0.37 [d]	2.58±0.4 6 [d]	24.72±2.72 [b]
PPP-30	9.53±0.38 [b]	3.74±0.67 [a]	29.59±3.25 [a]

-Parameters are given on the dry matter. Protein calculated with a factor of 5.75

-Means ± standard deviations that do not share the same subscript in the same column are significantly different from each other ($p < 0.05$).

According to Table 2, it is observed that as the PPP addition in foods increases, the moisture content decreases compared to the control pasta. From this result, it can be said that PPP-added pasta is more resistant to negative conditions such as mold and toxin formation compared to the control (0%) pasta sample. In the studies examined in the literature, the moisture holding ability decreases as the protein content increases (Yılmaz and Şen, 2021).

The protein powder used contained 85 grams of protein per 100 grams and semolina contained 11,5 grams of protein per 100 grams. As a result of the analysis, the protein content of 15.92 ± 1.75% in the control (0%), 20.51% ± 2.26% for pasta with 10% PPP added, 24.72 ± 2.72 % for pasta with 20% PPP added, for the pasta sample with 30% PPP addition, it was recorded as 29.59% ± 3.25%. It was determined that the protein values of the pasta increased as the PPP addition increased. As can be seen from the ash and protein analysis, pasta with PPP is richer in terms of nutrients and protein (Messia et al., 2021). This result positively affects the fact that pasta, which is one of the aims of the study, increases the protein and fiber ratio and provides a greater feeling of satiety. In a study where pasta production was carried out with the addition of broad bean flour, it was observed that the ash and protein ratio in the pasta increased as the bean ratio increased (Jayesena and Nasar -Abbas, 2011).

Physical properties

Cooking properties

Cooking time analyzes of control and pasta with pea protein powder are given in Table 3. The cooking time of pasta is one of the factors that determine the quality of pasta. The fact that the pasta is cooked in a short time is a feature that increases the liking and acceptance of the consumer (Gull, Prasad, & Kumar, 2015). While the pasta sample with 0% pea protein powder was cooked for 8 minutes, it was observed that the pasta with 10% PPP was cooked in 9 minutes, and the pasta samples with 20% and 30% PPP added in the 11th minute were cooked and no starch particles remained when compressed between two slides. As can be seen, greater the pea protein powder increases, the longer the cooking time in pasta samples. One reason may be that there is more protein surrounding the starch (Yang et al., 2018).

In studies investigating the effects of protein on starch hydrolysis, it has been

observed that protein can intervene in nutritional properties and facilitate the malabsorption of starch by blocking enzyme binding sites (Oates, 1997).

Table 3. Cooking analysis results

	Cooking Time (Seconds)	Weight increase %	Volume increase %
PPP-0	513± 1.43^{d}	211.00±1.00^{c}	280.67±0.58^{c}
PPP-10	547 ± 1.44^{c}	193.00±2.65^{d}	454.67±1.15^{a}
PPP-20	600 ± 0.00^{b}	307.33±1.15^{a}	372.00±1.73^{b}
PPP-30	633 ± 1.43^{a}	226.00±3.46^{b}	180.00±8.66^{d}

Parameters are given means ± standard deviations

Means ± standard deviations that do not share the same subscript in the same column are significantly different from each other ($p < 0.05$).

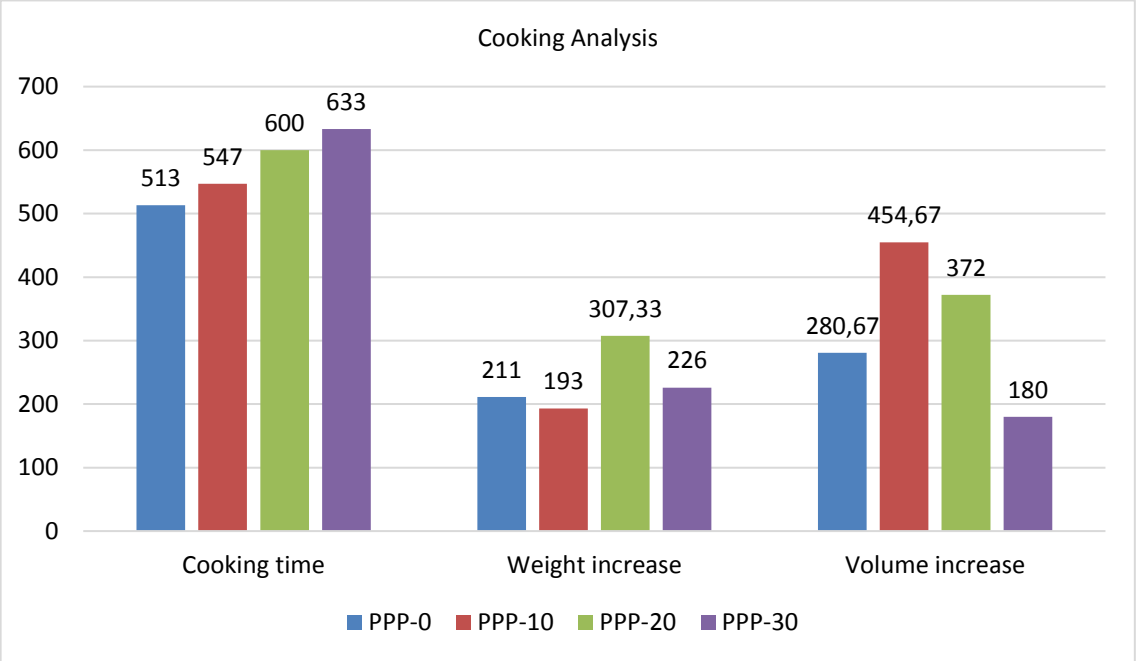

Figure 1. Cooking analysis results

In studies conducted to determine the contribution of pulse flour to weight gain in the literature, Giuberti, Gallo, Cerioli, Fortunati and Masoero (2015) found that the optimum cooking time increased as the amount of white bean flour increased in the pasta formulations they developed by adding 10%, 20% and 40% white bean flour.

In weight gain, 211 ±1.00 weight gain was observed in the control sample containing 0% PPP, 193 ± 2.65 in the pasta sample containing 10% PPP, 307.33 ± 1.15 in the pasta sample containing 20% PPP, and 226 ± 3.46 in the pasta sample containing 30% PPP.

The means were found statistically significantly different from each other, X^2 = 10.458, $p < 0.05$. Pairwise comparisons indicate that the only significant difference was found between the pasta sample containing 10% PPP and 20% PPP. In line with these results, it was determined that the maximum increase in weight was in the pasta sample containing 20% PPP. As a result of the exposure of the pasta to the cooking process, it is expected that the mass and volume increase of the pasta samples will be high. Mass a low increase indicates a weak water binding capacity. Poor water binding capacity causes an increase in hardness, which is an undesirable feature in pasta.

When the volume increase analysis results of the prepared samples were examined, a volume increases of 280.67 ± 0.58 was observed in the control pasta, an increase of 454.67 ± 1.15 in the pasta with 10% PPP, and 372 ± 1.73 in the pasta sample with 20% PPP.

Also, an increase of 180 ± 8.66 was observed in pasta with 30% PPP. The means of the volume increases were found statistically significantly different from each other, X^2 = 10.583, p < 0.05. Pairwise comparisons indicate that the pasta sample with 30% PPP has significantly lower volume increase compared to 10% PPP. In 3 samples with PPP addition, it was observed that the pasta sample with the lowest volume increase compared to the control pasta was the pasta with 30% PPP. The reason for this may be the decrease in water absorption capacity due to the increased protein content. Table 4 shows the color analysis results of pasta samples.

Table 4: Color analysis results of pasta samples

Pasta Samples	*L**	*a**	*b**
PPP-0	68.39±0.20[a]	5.72±0.87[a]	20.96±0.10[a]
PPP-10	57.87±1.57[b]	5.37±0.18[b]	15.22±0.08[b]
PPP-20	55.11±0,10[c]	5.12±0.03[c]	15.25±0.07
PPP-30	52.49±0,70[d]	5.07±0.03[c]	10.53±0.02[c]

Parameters are given means ± standard deviations

Means ± standard deviations that do not share the same subscript in the same column are significantly different from each other ($p < 0.05$).

When the results in Table 4 are evaluated, it is seen that the colour criteria change as the protein ratio increases.

Sensory analysis

When the findings given in Table 5 are examined, it is seen that the criteria that the panelists gave the highest score regarding 0% PPP as expected. And then 10% PPP added pasta was color with a mean score of 4.58±0.51, followed by an appearance with a mean score of 4.25±0.75 and appearance with a mean score of 4.17±. It is followed by stickiness with an average score of 0.72. The criteria that the panelists gave the lowest score for pasta with 10% PPP added were smell with an average score of 3.42±1.08, surface texture with an average score of 3.58±0.79, and taste with an average score of 3.83±0.72. is seen. According to the results, pasta with 10% PPP added was mostly liked in terms of all criteria. While it was seen that the criterion that the panelists gave the highest score for pasta with 20% PPP added was stickiness with a mean score of 4.08±0.90, it was followed by a general liking with a mean score of 4.00±0.60, and a mean score of 3.83±0.83, respectively. For color, the highest value was obtained in 10% PPP sample with 4.58±0.51, while the color decreased as the pea flour ratio in the samples increased and the smallest value in this sense was obtained from 30% PPP sample with 2.83±0.72.

Table 5: Sensory analysis results of pasta samples

Criteria	0% PPP	10% PPP	20% PPP	30% PPP	*p*
Color	4.88±0.41^{ab}	4.58±0.51^{a}	3.83±0.83^{c}	2.83±0.72^{e}	.000
Surface Texture	4.28±0.90^{e}	3.58±0.79^{g}	3.17±1.03^{h}	2.50±0.67^{g}	.000
Smell	4.40±0.80^{d}	3.42±1.08^{h}	3.50±0.80^{f}	2.92±0.67^{c}	.000
Chewability	4.92±0.52^{a}	3.92±0.90^{e}	3.75±0.75^{d}	3.17±0.72^{b}	.000
Stickiness	4.56±0.82^{c}	4.17±0.72^{c}	4.08±0.90^{a}	3.50±0,80^{a}	.000
Flavor	4.83±0.24^{b}	3.83±0.72^{f}	3,58±0.79^{e}	2.67±0.65^{f}	.000
Appearance	4.55±0.13^{c}	4.25±0.75^{b}	3.25±0.75^{g}	2.92±0.79^{d}	.000
General Liking	4.85±0.57^{b}	4.08±0.67^{d}	4.00±0.60^{b}	2.83±0.72^{e}	.000

Parameters are given means ± standard deviations

Means ± standard deviations that do not share the same subscript in the same line are significantly different from each other ($p < 0.05$).

The criteria that the panelists gave the lowest score for pasta with 30% PPP were color, surface texture, smell, chewability, stickiness, flavor and appearance.

In accordance with the table, an increase in the protein content has a negative effect on the sensory properties.

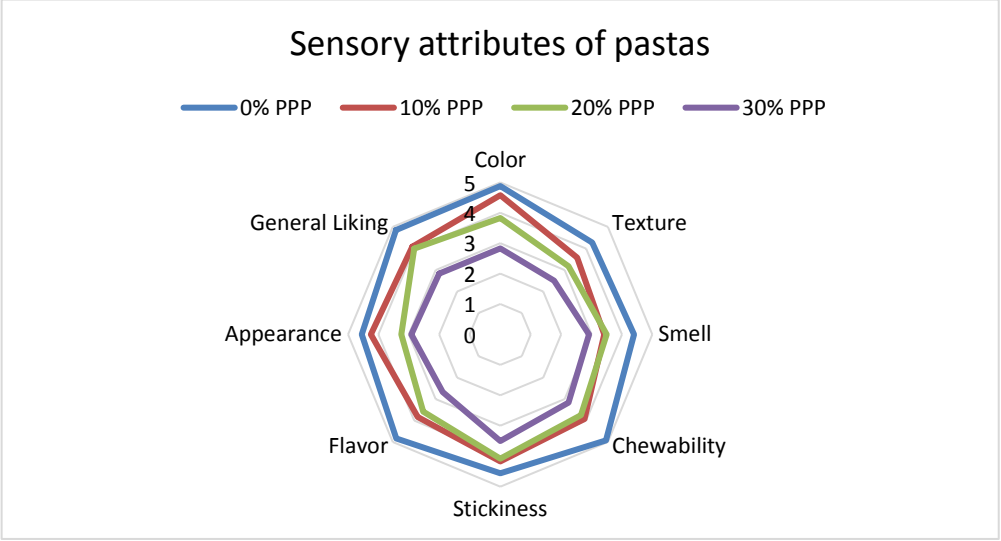

Figure 2. Sensory attributes of pastas

The effect of protein powder addition applied at different ratios on the sensory properties of pasta is as shown in Figure 2. Increasing protein ratio was found to have a negative effect on the sensory evaluations of the panelists.

In the analyzes made, it was determined that many criteria other than chewability and stickiness remained below the "3" value and were classified as "bad". The reason for this is that as the amount of pea powder increases, it does not meet the pasta criteria desired by the consumer, as it creates an undesirable woody odor, rough surface and hard texture.

Repeated measures ANOVA was conducted to test the differences in the sensory analysis results among pasta samples. The results in Table 5 show that, statistically significant differences were found between pasta samples in all sensory analysis criteria, $p < 0.05$. Post-hoc analyses revealed that pasta with 0% PPP has significantly highest scores in surface texture, chewability, flavor and general liking criteria while pasta with 30% PPP has lowest scores and pasta with 10% and 20% PPP were statistically did not differ from each other. In terms of color criteria, all pasta samples differed significantly from each other with 0% PPP has the highest score and 30% PPP has the lowest score. Also, in terms of smell criteria, pasta with %0 PPP has significantly the highest score while other pasta samples (10%, 20%, 30%) did not differ significantly from each other. In terms of stickiness, pasta with 30% PPP

has significantly the lowest score while other pasta samples (0%, 10%, 20%) did not differ significantly from each other. Lastly, in terms of appearance criteria, pasta with 0% and 10% PPP have higher scores than pasta with 20% and 30% PPP.

Table 6. Repeated measures variance for comparison of general liking criteria analysis results

General liking results of pasta	Mean	Std. deviation	F	p	Post-hoc
10% PPP	4,08	0.67			
20% PPP	4.00	0.60	30,143	0.000	1>3
30% PPP	2.83	0.72			

Repeated measures variance to compare 3 different BPT-added pastas According to the results of the analysis, Table As shown in Table 6, a significant difference was found, $F(2, 22) = 30.143$, $p < 0.05$. A test was conducted to determine between which groups the significant difference was found. According to the Bonferroni Post-hoc test, the pasta with 10% BPT addition received in the general appreciation criterion score was found to be significantly higher than the other pastas.

Table 7. Hedonic scale findings (n=12)

Pasta	mean(x)	Overall Rating Average(x)	Standard deviation
10% PPP	4.08		
20% PPP	4.00	$\bar{x}$ =3.63	0.87
30% PPP	2.83		

According to the data in Table 7, it was determined that the most liked pasta ($\bar{x}$ =4.08) was the pasta with 10% pea protein powder on average. It was determined that the 20% PPP added pasta sample ($\bar{x}$ =4.00) had an average level of liking. ($\bar{x}$ =2.83) and the pasta with 30% PPP addition was determined to be the pasta with the least liking level. The general liking level of 3 kinds of pasta ($\bar{x}$ =3.63) has an average. Pasta with 10% and 20% PPP added were described as “Good” by the panelists based on the hedonic scale. Unlike the pasta with 30% PPP, the other two pasta samples have the potential to be added to the diet of consumers.

In the study, each sensory analysis criterion was subjected to a comparative analysis of variance. According to the results of the analysis, there was a significant difference in chewiness, stickiness, taste, appearance and general taste criteria, but no significant difference was found in the odor criterion by the panelists.

These differences occurred because the increase in the amount of protein powder changed the texture of the pasta dough. All of these criteria constitute the quality of pasta and affect the acceptability of pasta by consumers.

In the results of the analysis, pasta with 10% PPP and 20% PPP added positive feedback from the panelists. Pasta with 30% PPP was not considered an acceptable pasta by the panelists. According to the results of the analysis of variance of repeated measurements made to compare 3 different pea protein powder (PPP) added pasta, significant differences were found between the evaluations for the color criteria. The most popular pasta in terms of color was the pasta with a 10% PPP addition. The addition of pea protein powder gives a darker color to the pasta. It is thought that the pasta with 30% PPP addition gets fewer points in terms of color due to the darkening of the color of the pasta as the PPP addition increases.

When the repeated measurements were made to compare the pasta with 3 different pea protein

powder (PPP) additions were examined in terms of chewiness, stickiness and surface texture criteria according to the results of analysis of variance, the pasta with 10% PPP added was the most popular pasta, while the pasta with 30% PPP addition received the lowest score by the panelists. The pasta was an example. PPP adds a rough texture to the pasta dough. As the PPP powder used in pasta samples increases, it is thought that consumers prefer it less because the quality criteria of pasta deteriorate.

Table 8. Opinions of consumers about pea protein pasta

	f	%
The effect of pasta enriched with pea protein on your feeling of fullness		
Very good	5	50
Good	4	40
Acceptable	0	0
Bad	1	10
Too bad	0	0
The effect of pasta not enriched with pea protein on your feeling of fullness		
Very good	0	0
Good	4	40
Acceptable	5	50
Bad	1	10
Too bad	0	0
Total	10	100

Ten consumers who participated in the study were asked to indicate their feelings of fullness for the pasta with 10% pea protein powder and the control pasta. Individuals who had the same diet meals during the day were asked to fill in the questionnaire, considering the time of hunger after consuming pasta with PPP and the time of hunger after consuming control pasta. Considering the findings in Table 8, 50% of the consumers defined the pea protein-enriched pasta as very good, 40% as good, and 10% as bad when they evaluated the feeling of satiety. When consumers were asked to evaluate the control pasta, 50% defined it as acceptable, 40% as good and 10% as bad. Considering these findings, it can be said that the pasta enriched with pea protein gives a feeling of satiety for a longer time than the control pasta sample.

In a randomized controlled trial conducted in Oxford, participants were randomly assigned to test glucose (control), glucose with 25 g pea protein (test 1) and glucose with 50 g pea protein (test 2) on three separate days. The result was that consumption of pea protein reduced postprandial glycemia and stimulated insulin release in healthy adults with a dose-response effect, supporting its role in regulating glycemic and insulinemic responses (Thondre et al., 2021).
In a randomized, crossover acute feeding study consisting of four treatments: chocolate beverage alone (50 g carbohydrate), or added with 24 g oat, pea or rice proteins tasted by Chinese males and blood tests were taken after consuming the beverages. The result shows alone chocolate beverages effects desire to eat. Plant-based beverage option has more useful glycemic control and suppression of hunger (Tan et al., 2018).

Conclusion

In this study, vegetarian pasta formulations incorporating three different ratios of pea protein powder were developed, and a sensory analysis test was conducted to assess the acceptability of the pasta among twelve panelists trained in sensory analysis. Following the sensory analysis test, trained panelists were tasked with evaluating the satiety-inducing effects of the

pasta samples with the highest overall acceptability by incorporating them into the diet plans of ten individuals who received nutritional counseling, consisting of six females and four males.

The sensory evaluation of the pasta samples, assessed across seven criteria, revealed that those with 10% and 20% pea protein powder (PPP) additions received positive feedback from consumers. Conversely, the pasta sample with the highest protein content, containing 30% PPP, was not preferred by the panelists and received lower scores in the quality assessment criteria of the sensory analysis test. Analysis of variance demonstrated significant differences in the results across various sensory attributes, including general taste, color, flavor, stickiness, chewiness, appearance, and surface texture, excluding odor.

The study highlights the potential of pea protein powder as a valuable food ingredient, enriching the nutritional profile of pasta with its abundance in vitamins, minerals, and protein content. Furthermore, findings from the analysis of satiety feelings among consumers who received nutritional counseling revealed that pasta with 10% PPP addition, favored by the panelists, elicited prolonged satiety compared to other samples, aligning with one of the research objectives. Future investigations should consider additional factors influencing satiety, such as daily physical activity, water intake, and sleep duration.

This study represents the first attempt to produce pasta formulations solely using pea protein powder at varying inclusion rates. It is anticipated that these findings will promote the consumption of pasta, a staple food widely consumed and easily stored in our country, particularly among individuals seeking alternative protein sources due to limited access to animal protein.

Future research endeavors should focus on developing pasta and similar food products with higher PPP inclusion rates, aiming to enhance protein content and nutritional value while ensuring consumer acceptance and satisfaction.

Acknowledgments

This study was carried out as a master's thesis at Başkent University Institute of Social Sciences Gastronomy and Culinary Arts Master's Program.

The authors thank all the participants who devoted their time to participate in this study. We are grateful for their helpful and sincere cooperation and for their warm acceptance of the work.

Conflict of Interest Statement:

The authors of the article declare that there is no conflict of interest between them.

Informed consent

All participants included in the study were informed and their consent was taken before filling out the questionnaire.

Author Contribution:

Ilkay YILMAZ contributed to the conceptualization, methodology, formal analysis, writing–original draft, writing–review, editing and visualization of the article. Sena Nur Dogan contributed to the article in terms of methodology, formal analysis and statistical analysis. The authors have read and approved the final version of the article.

References

Ahmad S. R. (2022). Plant-based diet for obesity treatment. Frontiers in nutrition, 9, 952553.

Courty, P. E., Smith, P., Koegel, S., Redecker, D., D. Wipf. (2014). Inorganic nitrogen Uptake and Transport in Beneficial plant Root Microbe interactions. *Critical Reviews in Plant Sciences,* 34(1-3), 4–16. doi:10.1080/07352689.2014.897897.

Demir, B. (2008). A Research on the Possibilities of Using Chickpea Flour in Traditional Pasta and Couscous Production, Published Master's Thesis, Selcuk University, Institute of Science, Department of Food Engineering, Konya.

Ertas, N. (2013). Dephytinization processes of some legume seeds and cereal grains with ultrasound and microwave applications. *Legume Research-An International Journal,* 36(5), 414-421.

Ficco, D. B. M., De Simone, V., De Leonardis, A. M., Giovanniello, V., Del Nobile, M. A., Padalino, L., ... & De Vita, P. (2016). Use of purple durum wheat to

produce naturally functional fresh and dry pasta. Food Chemistry, 205, 187-195.

Gibbs J, Cappuccio FP. (2022). Plant-based dietary patterns for human and planetary health. Nutrients. 14:1614. 10.3390/nu14081614

Giuberti, G., Gallo, A., Cerioli, C., Fortunati, P., F. Masoero. (2015). Cooking quality and starch digestibility of gluten using free cake new bean flour. *Food Chemistry* .175, 9.

Gokhisar, O. K. (2018). Investigation of red lentil (*Lens Culinsris*) pasta production. Mersin University Institute of Science and Technology, Doctoral thesis. Mersin.

Gull, A., Prasad, K., P. Kumar. (2015). Effect of nation flours and carrot pomace on cooking qualities, color and texture of the developed cake, LWT - *Food Science and Technology* 63, (1), 470-474.

Hosta H.G. (2012). *Different Legumes Enriched with Flour Investigation of Quality and Some Nutritional Properties of Gluten-Free Rice Pastas* (Published Master's Thesis), Hacettepe University, Department of Food Engineering, Ankara.

Iqbal, A., Khalil, I.A., Ateeq N, M.S. Khan. (2006). nutritional quality of important food legumes *Food chemistry.* 97, 331-335.

Ivanova, S., Delattre, C., Karcheva-Bahchevanska, D., Benbasat, N., Nalbantova, V., & Ivanov, K. (2021). Plant-Based Diet as a Strategy for Weight Control. Foods (Basel, Switzerland), 10(12), 3052. https://doi.org/10.3390/foods10123052

Jayesena, V., S.M. Nasar -Abbas. (2011). Development and Quality Evaluation of High-protein and High-fiber Pasta Using Lupin flour, *Journal of Textures Studies*, 43(2), 153–163.

Köksel H., Sivri D., Özboy Ö., Baflman A., H.D. Karacan. (2000). Hacettepe University, Faculty of Engineering. Publication No: 47, Grain Laboratory Handbook. Ankara.

Köten, M., Ünsal, A.S., (2022). Nutritional, Chemical and Cooking Properties of Pastas Enriched with Terebinth (Pistacia Terebinthus) Fruits Roasted at Different Temperatures. Food Science and Technology, doi: https://doi.org/10.1590/fst.47120. v42, e47120. s:1-9.

Köten, M., Ünsal, S., Atli, A., (2014). Türkiye'de Üretilen Makarnaların Bazı Kimyasal Bileşimlerinin Ve Pişme Kalitelerinin Belirlenmesi. Gıda, 39 (1): 33-40.

Lai, H.M. (2001). Effects of Rice Properties and Emulsifiers on the Quality of Rice Pastry. *Journal of the Science of Food and Agriculture*, 82: 203-216.

Lam, A.C.Y., Can Karaca, A., Tyler, RT, & M.T. Nickerson. (2016). Pea protein isolates Structure, extraction, and functionality. *Food Reviews International*, 34(2), 126–147.

Messia, M. C., Cuomo, F., Falasca, L., Trivisonno, M. C., De Arcangelis, E., & Marconi, E. (2021). Nutritional and Technological Quality of High Protein Pasta. Foods (Basel, Switzerland), 10(3), 589. https://doi.org/10.3390/foods10030589

Mikić, A., Medović, A., Jovanović, Ž., & N. Stanisavljević. (2014). Integrating archaeobotany, paleogenetics and historical linguistics may cast more light onto cropped domestication: the case of pea (Pisum sativum). *genetics Resources and Crop Evolution,* 61(5), 887–892.

Onoğur Altuğ, T., Y. Elmacı. (2015). Sensory Evaluation in Foods. Sidas Media, Izmir.

Pasiakos SM, Lieberman HR, V.L.Fulgoni. (2015). Higher - protein diets are associated with higher HDL cholesterol and lower BMI and waist circumference in US adults. *J Nutr*. 145:605–614.

Pınarlı, İ., İbanoğlu, Ş., M.D. Öner. (2004). Effect of storage on the selected properties of macaroni enriched with wheat germ _ *Journal of Food Engineering*, 249-256.

Shanthakumar, P., Klepacka, J., Bains, A., Chawla, P., Dhull, S. B., & Najda, A. (2022). The Current Situation of Pea Protein and Its Application in the Food Industry. Molecules (Basel, Switzerland), 27(16), 5354. https://doi.org/10.3390/molecules27165354

Tan, S. Y., Siow, P. C., Peh, E., & C. J. Henry. (2018). Influence of rice, pea, and oat proteins in attenuating glycemic response of sugar-sweetened beverages. *European journal of nutrition*, 57(8), 2795–2803.

Temiz H. & A.F. Yeşilsu. (2006). Edible films and coatings of vegetable protein origin. *Electronic Journal of Food Technologies,* (2), 41-50.

Thondre, P. S., Achebe, I., Sampson, A., Maher, T., Guérin-Deremaux, L., Lefranc-Millot, C., Ahlström, E., & H. Lightowler. (2021). Co-ingestion of NUTRALYS® pea protein and a high-carbohydrate beverage influences the glycaemic, insulinaemic, glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-1 (GLP-1) responses: preliminary results of a randomised controlled trial. *European journal of nutrition*, 60(6), 3085–3093.

Wilde P.J. (2009). eating for life _ foods for appetite control. *Journal of diabetes science and technology*, *3* (2), 366–370.

Yılmaz İ. & B.B. Şen. (2021). Carob flour (Ceratonia siliqua L.) on physical, chemical, and sensory properties of pastas. *Harran Journal of Agricultural and Food Sciences*, 25(3).