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International Journal of Food Engineering Research (IJFER) is peer-reviewed journal which provides a platform for publication of original scientific research and applied practice studies. Positioned as a vehicle for academics and practitioners to share field research, the journal aims to appeal to both researchers and academicians.

Aims and Scope

International Journal of Food Engineering Research (IJFER) is an international, peer-reviewed journal devoted to the publication of high quality original studies and reviews concerning a broad and comprehensive view of fundamental and applied research in food science&technology and their related subjects as nutrition, agriculture, food safety, food originated diseases and economic aspects.

IJFER is an international periodical published twice a year (April and October). The journal is published in both print and electronic format.

From The Editor

International Journal of Food Engineering Research (IJFER) has been publishing by Istanbul Aydın University Faculty of Engineering Department of Food Engineering since 2015. The journal covers wide ranges of area such as Food Processing, Food Preservation, Food Microbiology, Food Chemistry, Biotechnology, Nanotechnology, Novel Technologies, Food Safety, Food Security, Food Quality and their related subjects as nutrition, food and health, agriculture, economic aspects and sustainability in food production.

Food Engineering is getting more and more attention because it is directly related to human health. While the food and drinks we eat help to protect our health, on the other hand, improper conditions during the conversion of the raw material to the product, the use of poor quality raw materials, and the employees not working under hygienic conditions can cause the food harmful to health. Our aim in this journal is to include the recent research and reviews on food and beverages from field to fork. Articles submitted to the journal are accepted for publication after being reviewed by expert referees.

In the following years, the journal will include scientific activities such as symposiums, congresses, conferences and workshops held in the field of food science and technology, and information about the books published in this field. We hope that the journal will be a good resource for engineers, experts, researchers and students working in the food industry.

Prof. Dr. Z. Dilek Heperkan
Editor

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Contents

Review Articles

Research Articles

Review Articles

DOI Numbers

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ANTIOXIDANT ACTIVITY AND PHENOLIC COMPOUNDS OF LAWSON MOLECULE EXTRACTED FROM *LAWSONIA INERMIS* (HENNA)

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ABSTRACT

The henna plant (*Lawsonia inermis*) which is known and used as a dye plant from past to present, plays a role in our lives with its cultural effects. The cosmetic feature of this plant is the lawson molecule, a red-orange pigment, which is the main coloring agent found in its leaves, and this molecule is a subgroup of naphthoquinones. Although it comes to the fore with its cosmetic feature, it is a medicinal product that has positive effects on health with its anticarcinogenic, antimicrobial, anti-inflammatory, analgesic, and antipyretic properties thanks to its bioactive compounds such as flavonoids, naphthoquinones, quinoids, naphthalene derivatives, triterpenoids, organic acids, tannins, phenolic and phenolic glycosides. determined to be a plant. This review was mainly written to give information about the phenolic, antioxidant and antimicrobial studies on the henna plant and the coloring agent Lawson molecule obtained from it.

Keywords: *Henna, Lawson molecule, phenolic compounds, antioxidant activity.*

INTRODUCTION

Lawsonia inermis L, known as henna, is a plant in the Lythraceae family with a historical past **[1].** It has been used traditionally for longer than 5000 years in Pakistan, India, Africa, and the Middle East **[2]**. At the end of the

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19th century, the use of henna in Europe became commercialized **[3].** It is commonly used to dye hair, skin for hand and foot decorations, and nails, especially **[1].** Though it is mostly known from a cosmetic perspective, it is rich in terms of health too. It is a desert plant that tolerates long drought and low humidity, along with poor, stony, and sandy soils. It grows in dry tropical and subtropical regions including North Africa, India, Sri Lanka, and the Middle East, and is commercially cultivated in west India, Pakistan, Morocco, Yemen, Iran, Sudan, and Libya. It is a small tree with many-branched hairless shrubs widely grown as an ornamental and dye plant. Young branches are green and rectangular and turn red over time **[1, 4, 5]**. Henna is a fragrant aromatic plant **[6, 7]** because it contains essential oils such as containing citronellol, limonene, linalool, eugenol, and a-terpineol in the leaves and other portions of the plant **[6]**. The diversity of these oils ensures the diversification of the odor and aroma of many henna varieties. In phytochemical studies of *L. inermis L* extract, hundreds of secondary metabolites with various chemical structures were found **[8-12]**. Although there are many pharmacological research findings, studies on antioxidant and antimicrobial activities draw attention with each new phenolic component discovery. This review is to give information about the henna plant and one of the important phenolic components, lawson of naphthoquinone derivative, and its bioactive properties.

Bioactive Compounds in Henna

The henna plant is included among traditional and folk drugs in the present day. Containing nearly one hundred plant compounds, henna is rich in terms of phenolic compounds including coumarins, glycosides, phytosterols, steroids, saponins, tannins, flavonoids, quinones and naphthoquinones. This biological wealth in henna was determined to develop as a result of iversification of active compounds as protective mechanisms against threats in the dry climates in which it grows. Studies showed henna contains nearly 70 phenolic compounds. In Table 1 **[13],** some types of phenolic compounds found in the henna plant and the parts isolated from the plant are given. The pharmacological activities of henna are related to the naphthoquinone dye agents are connected, while terpene and β-ionone were identified to be largely responsible for pungency and hardening of volatile oils isolated from flowers **[13].** Quinones are secondary metabolite molecules formed of six member α, β-dienonic rings and the law-

sone naphthoquinone molecule was stated to be one of the most common quinone species in nature **[14-17].** Flavonoids and glycosides are known to have common antimicrobial activity **[18].** Naturally occurring tricyclic quinone alkaloids have a broad range of biological properties from antimicrobial capacity to cytotoxicity and are reported to be synthetically obtainable. At the same time, bis-naphthoquinones **[19]** are reported to be anti-parasitic agents **[20-24].** Henna, with low health risk **[25-27],** was found to have a variety of pharmacological uses due to antitumor, anti-helminthic, antioxidant, immunomodulatory, burn wound healing, UV protective and antimicrobial properties **[28-32].** A study about the henna plant by Uddin et al. (2011) **[33]** performed solvent extractions from the leaves of *Lawsonia alba* Lam and isolated three new flavonoids of lawsochrysin, lawsochrysinin, and lawsonaringenin with a variety of chromatographic techniques. A study by Zohourian et al. **[34]** obtained extracts with hydrothermal extraction supported by microwaving at 300-700 W power for *Lawsonia inermis* leaves and examined the presence of polyphenolic compounds and antioxidant activities.

They noted that best results were obtained with microwave power producing 100-120 °C temperature with short radiation duration. Strong antioxidant activity against DPPH was determined by the most active compound, 1,2,4-trihydroxy naphthalene-1-O-β-D-glucopyranoside **[34]**. In another study, they determined the antioxidant activity of the extractant obtained from methanol and henna leaves as 71.5 mg/g (dry weight) chlorogenic acid equivalent on dry weight **[13, 35].**

Table 1. Bioactive Component of *Lawsonia inermis* **[13].**

BCH	Phenolic compounds	Parts of the henna plant	Referances
Flavono-ids	Acacetin, Acacetin-7-O-glucoside R=glucoside, Luteolin, Luteolin-7-O-glucoside, Apiin, Apigenin-7-O-β-D-glucopyranoside, cosmosiin, Isoscutellarin, Lawsochrysin, Lawsochrysinin, Lawsonaringenin,3',4'-Dimethoxy flavone, 7-Hyd roxy flavone, 3,3',4',7-Tetrahydroxy flavanone, Rhoifolin , catechin, Luteolin-7-O-rutinoside, Diosmetin-7-O-rutinoside	Aerial parts of henna stems and leaves ha-iry roots	**[9, 13, 25, 27-30]**
Coumarins	Lacoumarin, Fraxetin, Scopoletin, Esculetin, Daphneside, Daphnorin, Agrimonolide 6-O-β-D-glucopyranoside	Whole plant	**[1, 13, 29, 31, 32]**
Tannins	1,2,3,6-Tetra-O-gallolyl-β-D-glucose, 1,2,3,4,6-Penta-O-gallolyl-β-D-glucose, Lawsoniaside, 1,2,4-Trihydroxynaphthale-ne-1-O-β-D-glucopyranoside, Lawsonaphthoate, Lawsonaphthoate, Lawsonaphthoate, 1,2-Dihydroxy-4-Oglucosyloxy-naphthalene	The hairy roots	**13, 30, 33]**

Table 1. (continued)

Naphthalenes	Lawsoniaside R=β-Dglucopyranoside, Lawsonaphthoate A, Lawsonaphthoate B, Lawsonaphthoate C, 1,2-Dihydroxy-4-Oglucosyloxynaphthalene	Stems and leaves of henna	**[9, 13, 34-36]**
Naphthoquinones	2-Methoxy-3-methyl-1,4-naphthaquinone, Lawsone, Isoplumbagin, Lawsonadeem,4-Hydroxy-α-tetralone,3-Amino-2-methoxycarbonyl-1,4-naphthaquinone, 3α,4α-Dihydroxy-α-tetralone,	Leaves of henna leafpetioles	**[9, 13, 28, 37-41]**
Xanthones	Laxanthone-I, Laxanthone-II, Laxanthone-III	Leaves of henna	**[13, 27, 31]**
Lignans	(+)-Syringaresinol-O-β-D-glucopyranoside, (+)-Pinoresinol-di-O-β-D-glucopyranoside, Syringaresinol-di-O-β-D-glucopyranoside	Leaves of henna	**[13, 29]**
Alkylphenones	Lalioside, Lawsoniaside A, 2,4,6-Trihydroxyacetophenone-2-O-β-D-glucopyranoside	Leaves of henna	**[13, 34, 35]**
Other phenolic compounds	Lawsonicin, p-Coumaric acid, Gallic Acid, Lawsochylin A, Lawsochylin B, Lawsochylin C,4-Hydroxybenzaldehyde, Dihydrodehydrodiconyferyl alcohol, Lawsoniaside B, Syringinosol di-O-β-D-glucopyranoside, glucopyranosyl-(1→6)-β-glucopyranoside	Stems and leaves	**[9, 13, 28, 29, 33, 41]**

BHC: Bioactive Component of Henna

In a study on phenolic content, they determined the maximum phenolic content of henna leaves (*Lawsonia inermis*) at 7203.74 mg GAE/100g under optimized conditions determined as 73.78 minutes at 39.57 °C and 48.07% acetone concentration **[51]**.

As a result, Lawson (2-hydroxy-1,4-naphthoquinone), the main active ingredient of *Lawsonia inermis* Linn, has many biological activities such as antioxidant, antibacterial and antifungal, anti-inflammatory, antipyretic and analgesic, anticancer and cytotoxic determined **[52-56].** In another study, the antibacterial effects of henna extracts obtained with different solvents against coagulase negative staphylococci, *Staphylococcus aureus*, ß-hemolytic streptococci and *Pseudomonas aeruginosa* were investigated. In this study, it was determined that alcoholic and oily extracts of henna plant had a higher effect against these pathogenic bacteria than the extracts obtained with water **[28]**. The 1,4-naphthoquinone molecules obtained from henna leaf extracts were determined to have antimicrobial effect against *Staphylococcus spp.*, *Sarcinalutea*, *Streptococcus sp.*, *Corynebacterium* pyo, *Corynebacterium* sp., *Enterbacterium* sp., *Shiegella*, and *Staphylococcus aureus*. At 60-80 mg/mL concentrations, they were determined to have antibacterial effects from 15-26 mm against *Shigella flexneri*, *Escherichia coli*, *Klebsiella aerogenes*, *Mycobacterium phlei*, *Salmonella paratyphi*, *Bacillus subtilis* and *Pseudomonas aeruginosa* **[57].** Similarly, another study **[58]** used aqueous extracts (1.25% and 2.5%) of henna ecotypes and investigated the antibacterial effects against gram-positive and gram-negative bacteria including *Staphylococcus sp.*, *Streptococcus sp., Bacillus sp., Corynebacterium sp., Klebsiella pneumonia* sp., *Escherichia coli* sp. and *Salmonella sp*. *K. pneumonia* and *B. cereus* species were determined to display higher resistance compared to the other bacterial species.

Lawsone Molecule and Dye Properties

Henna, which has pure dye features, was popularized due to intense demand as a natural colorizer used as hair dye **[59].** The colorizing properties of this plant are arised from the lawsone molecule found in the leaves, which has a red-orange dye. The highest concentrations of Lawsone molecules are present in the small young leaves and leaf stems of the henna plant **[6, 60].** The henna plant contains 25-33% water-soluble matter and aqueous solutions have orange color. Lawson molecule, which is the main coloring agent, is found in the dried leaves at a concentration of 0.4-1.5%

and is in the structure of 2-hydroxy-1,4-naphthoquinone **[4, 5, 31, 50, 61, 62].** Lawson molecule, rich in quinones, has two carbonyl groups in the ortho or para positions of the benzyl ring **[63, 64]** and its molecular formula is $C_{10}H_6O_3$. It has a melting point of 190 °C and the most stable form is 1,2-naphthoquinone **[65, 66]**.

Bioactive Compounds in Lawsone Molecule

Naphthoquinone compounds have the ability to act as intermediate agent in the synthesis of heterocyclic compounds. They have become a focus of research in recent years due to displaying a variety of biochemical, therapeutic and additionally photodynamic therapeutic properties like antibacterial, antiviral and anti-inflammatory activities. Additionally, beneficial uses of these heterocyclic compounds include use as dyes, fluorescent material to visualize biomolecules and laser technologies **[24, 67-72].** In the study on the antioxidant activity of the lawsone molecule, derived from naphthoquinone and naphthoquinone derivatives, Lawson molecule was determined as 62.05 μmol·L $^{-1}$ and its derivatives were determined in the range of 22.83-50.26 μmol·L $^{-1}$ **[56].** A study by Tekin et al. (2013) **[73]** obtained extracts from leaves of the henna plant, purified them with a high-pressure liquid chromatography (HPLC) system and obtained the lawsone (2-hydroxy-1,4-naphthoquinone) compound.The lawsone molecule, derived from naphthoquinone with antibacterial properties, was studied as a wound covering material with the aim of using its antibacterial functional features **[74].** In a study, it was determined that dimeric naphthoquinones derived from Lawsone inhibited the proliferation of *Candida albicans*. **[56, 75]**. Among henna ecotypes, the 2-hydroxy-1,4-naphthoquinone Bam ecotype was identified to have highest antibacterial effects. The 2.5% concentration of the Shahdad extract was determined to display highest antioxidant capacity. The lawsone molecule was radio-labelled and injected into mice and they determined it displayed high rates of involvement in the bladder, stomach and prostate compared to other organs. As a result of the study, they showed the lawsone compound may be a resource for more advanced studies about uses with diagnostic and therapeutic purposes. In a study on Lawsone encapsulated chitosan/polyethylene oxide nanofiber mat as a potential antibacterial biobased wound dressing, nanofibrous mats containing chitosan/polyethylene oxide (PEO) fibers containing various concentrations of lawson (10%, 1, 3, 7, 10% by weight) were

electro-spinned. It has been determined that the Lawson molecule, which has antibacterial activity against gram-negative and -positive bacteria, has this effect on the mats produced. It has been determined that it reduces cytotoxicity and increases the cell viability of normal human fibroblast cells. It has been determined that biocompatible nanofiber mats have the potential to use antibacterial dressings **[76].** As a result of food study **[77]** assessed the use of henna leaf extract as oxidizing agent in soya bean oil. Extracts obtained using water increased the peroxide amounts in oil, while extracts with methanol were identified to be lower.

CONCLUSION

With the discovery of valuable compounds contained in the henna plant, is famous for use for cosmetic purposes, in vivo and in vitro studies which will be demonstrated the pharmacological effects of bioactive compounds should be increased. The obtained bioactive compounds should be standardized and developed for use in terms of public health. Thanks to the bioactive properties of the Lawson such as antioxidant and antimicrobial, studies should be increased to improve the physiological functionality of foods and the preservation of foods.

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DETERMINATION OF SOME CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF KIWI VINEGAR PRODUCED UNDER DIFFERENT CONDITIONS

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ABSTRACT

Vinegar, known as a unique product produced from plant-derived raw materials by two-stage alcohol and acetic acid fermentation, is produced in various countries mainly to add flavor to foods and sauces. Fruit peel, which is an important waste product in the fruit processing industry, has at least as much phenolic content as the fruit. Therefore, in this study, kiwi peels were used as raw materials for vinegar production, as well as kiwi fruit. Fermentation was carried out under aerobic and anaerobic conditions, and the total acidity, pH, total phenolic substance and microbiological properties of the produced vinegar were determined. During the fermentation process, the pH in kiwi vinegar decreased from 3.5 to 2.4 on average. Total acidity was determined as 2.3-6.3 g/100 ml after 3 weeks. It has been determined that both vinegars made from fruit and peel have high phenolic content (3.91.26-431.93 mg GAE/L). As the fermentation progressed, a decrease in the number of *Escherichia coli* and mold was observed with the increase in the total acid content.

Keywords: *Fermentation, Kiwi, Vinegar, Asetic acid, Phenolic compound*

INTRODUCTION

Kiwi is an edible fruit belonging to the genus *Actinidia* **[1].** Kiwifruit has many health benefits such as anti-diabetic **[2]**, anti-inflammatory **[3]**, cardiovascular protective **[4]**, antimicrobial and laxative activity **[5, 6]**. Another important feature of kiwi is that it contains a high amount of vitamin C. The amount of vitamin C in some kiwi varieties is as high as 420 mg/100 g **[7, 8]**. In addition to being consumed directly as a fruit, kiwi can also be used into many food products such as fruit juice, vinegar, jam, wine, jelly **[6]**.

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According to the Turkish Food Codex; vinegar, is defined as a food product obtained by subjecting sugary fruits such as grapes, apples and figs to alcohol fermentation and then acetic acid fermentation **[9]**. According to the TSE 1880 vinegar standard, it is defined as "a unique product produced biologically from agricultural liquids or other substances by two-stage alcohol and acetic acid fermentation" **[10]**. Depending on the vinegar raw material; It can be classified as "grain vinegar" obtained from sorghum, rice, wheat or other grains, and "fruit vinegar" obtained from fermented grape or apple juices **[11]**.

In addition to being used as a flavoring in the food industry, vinegar has been added to foods and sauces as an antimicrobial or used as a disinfectant since ancient times. However, due to the belief in its beneficial effects on health, it has started to be accepted as a potential functional foodstuff in recent years **[12]**.

Fruits and grains are generally used as raw materials in the production of traditionally consumed vinegar **[13]**. Water constitutes about 80% of vinegar, while the remaining 20% is composed of organic acids, alcohols, polyphenols and amino acids **[14]**. As a result of the fermentation process, functional compounds such as organic acids, which are not found in raw fruits or are present in trace amounts, are released that increase the antioxidant capacity of the human diet **[13, 15, 16].**

Vinegar is made by converting sugars to alcohol by yeast and converting the alcohol to acetic acid by bacteria **[12]**. In other words, when producing vinegar from sugary fruits, two completely different fermentations take place. These are alcohol fermentation and acetic acid fermentation, respectively. First, the sugar in the fruit or must is converted into alcohol. This process is carried out by yeasts. The resulting alcohol is then converted to acetic acid by the vinegar bacteria. Before the acetic acid fermentation starts, the alcohol fermentation should be completely finished, that is, there should be no sugar left in the environment **[17].**

Vinegar is the product produced by the oxidation of ethanol to acetic acid under aerobic conditions by acetic acid bacteria, following the ethanol

fermentation of fermentable sugars by yeasts under anaerobic conditions **[18]**. The group of Gram-negative bacteria capable of oxidising ethanol to acetic acid is called acetic acid bacteria (AAB) which includes nineteen genera **[19]**. AAB belong to the *Acetobacteraceae* family are Gram-negative or Gram-variable, non-spore forming, ellipsoidal to rod-shaped cells that can occur in single, pairs or in short chains **[20, 21]**. The main species responsible for the production of vinegar belong to the genera *Acetobacter*, *Gluconacetobacter*, *Gluconobacter* and *Komagataeibacter*. These bacteria have high capacity to oxidise ethanol to acetic acid and high resistance to acetic acid released into the fermentative medium **[19, 22]**.

Vinegar production methods can be grouped under 3 main headings as slow method (traditional method, orleans method, also known as French or pasteur method), quick method (German method), deep culture method (submerged process) **[23]**.

Vinegar is produced very slowly with slow method. But the quality of the vinegar produced is quite high. The fermentation occurres at 28-30°C. Since the density of acetic acid produced is higher than alcohol, it accumulates at the bottom of the container. Vinegar mother, which is an important formation, is a gelatinous structure and on the surface of vinegar.

Ma et al., **[6]** reported that products obtained by kiwi fermentation such as vinegar and wine contain more nutrients than products such as fruit juice. It has been stated that the nutrients in the kiwi dissolve better with fermentation. In addition, kiwi fruit and its products contain high amounts of phenolic substances and therefore are a high source of antioxidants **[24, 25].**

In this study, slow method was used for vinegar production. The aim of this study was to produce vinegar in aerobic and anaerobic conditions by using the kiwi fruit and its peels, which contain high levels of nutrients and active ingredients, and to determine some physical, chemical and microbiological properties of the produced vinegars.

MATERIAL AND METHODS

Sample and Sample Preparation

Kiwi fruits were purchased from a local market. After washing, the fruits were separated from their skins and diced and collected in three different 500mL jars that had been sterilized in an autoclave (15 min at 121°C). One of the jars containing the kiwi fruits was covered with thin cheesecloth (aerobic, K1), the second jar was closed with parafilm (K2), and the third jar was sealed with a lid (anaerobic, K3). Kiwi peels were collected in a separate jar and covered with cheese cloth (KK). The jars were filled with water with the head space at the top after adding the fruit and shells, closed as described above and left to ferment in the incubator at 22°C. All jars except the jar closed with the lid were mixed every 2 days. Thus, in the study, 4 different kiwi samples were studied. Samples were taken from the vinegars at 7, 15 and 21 days of fermentation and analyzed. The samples were prepared on the day the vinegars were made.

Determination of Total Acidity

Determination of total acidity in kiwi vinegar samples was carried out with the help of titrimetric method **[26]**. A 20 mL sample was taken from the vinegar sample and made up to 100 mL with distilled water. Then, 20 mL of the mixture was taken into a flask and 1-2 drops of phenolphthalein indicator was added to it. The solution was titrated with 0.1 N NaOH until the pH was 8.1. Total acidity in kiwi vinegars was calculated as % acetic acid.

pH Measurement

A sample of kiwi vinegar was taken into the beaker and pH was measured at room temperature using a pH meter (Mettler Toledo S220) probe. Before each measurement, the pH meter was calibrated with calibration solutions.

Total Phenolic Content

Determination of the total phenolic content was performed spectrophotometrically according to the Folin-Ciocalteu method **[27]**. Before analysis,

2 mL of Folin Ciocalteu reagent (diluted with water at a ratio of 0.5:5) and 1.6 mL of 20 g/100 mL sodium carbonate were added to 4 mL diluted vinegar samples that were filtered through a cellulose acetate membrane filter. Samples were kept in the dark for 90 minutes. 4 mL of water was used as control samples. UV/Vis spectrophotometer (PG INSTRUMENTS-T60+) absorbance measurements were performed at 765 nm. Gallic acid solutions prepared at different standard concentrations (100-2000 mg/L) were used in the calibration curve. The results are expressed as mg gallic acid equivalent (mg GAE/L vinegar).

Microbiological Analysis

Samples for microbiological analysis were taken in 7, 14 and 21 days. To determine the microbiological properties of kiwi vinegar, 25 mL of vinegar sample was taken into a sterile stomacher bag and diluted 1:10 with peptone water (PW, 0.1%, pH 6.3 ± 0.2) under aseptic conditions. The number of microorganisms in 1 mL of vinegar was determined. Enumeration of mesophilic aerobic bacteria in vinegar samples were performed on Plate Count Agar (PCA, casein peptone 5.0 g/L, yeast 2.5 g/L, D glucose 1.0 g/L, agar-agar 14.0 g/L); total coliform on Chromocult Coliform Agar (peptone 3.0 g/L, NaCl 5.0 g/L, NaH_2PO_4 2.2 g/L, Na_2HPO_4 2.7 g/L, sodium pyruvate 1.0 g/L, tryptophane 1, 0 g/L, sorbitol 1.0 g/L, tergitol-7 0.15 g/L, chromogenic mixture 0.4 g/L, agar-agar 10.0 g/L), acetic acid bacteria (AAB), HS in Hestrin-Schramm medium, (2% D-glucose, 0.5% peptone, 0.5% yeast extract, 0.27% Na_2 HPO_4 , 0.115% citric acid, cycloheximide 50 mg/L for prevention of moulds, pH 5.0), ($CaCO_3$)-ethanol medium (% 0.05 D-glucose, 0.3% peptone, 0.5% yeast extract, 1.5% $CaCO_3$, 1.2% agar, 1.5% ethanol); lactic acid bacteria (LAB) Man Rogosa and Sharp Agar (MRS agar, pH 6.2 ± 0.2, Merck) and yeast-mold counts were performed on Yeast Extract Glucose Chloramphenicol Agar (YGC, pH 6.6±0.2, Merck). The media were incubated at the following temperature and time: PCA at 37°C for 48h; MRS at 37°C for 48h; YGC agar at 25°C for 72h. For the determination of acetic acid bacteria, 0.1 mL sample were added to HS agar, previously incubated at 30°C for 3 days in HS medium, incubated at 30°C for 3 days . Cream-beige colored, smooth-edged, sticky colonies with a diameter of 2.5-3 mm were selected and inoculated in $CaCO_3$-ethanol medium at 30°C for 3 days. Colonies that dissolved $COCO_3$ and became transparent were considered as acetic acid bacteria.

RESULTS AND DISCUSSION

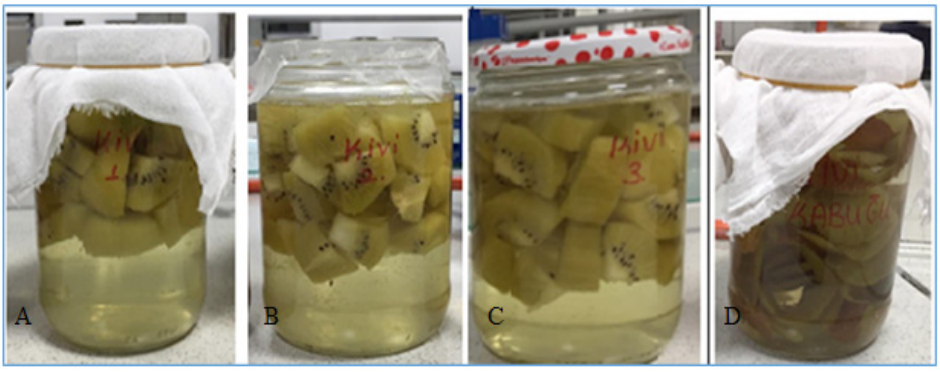
Determination of Total Acidity

Change in total acidity values (acetic acid g/100 mL) in samples taken in 1, 7, 14, and 21 days in kiwi fruit vinegars produced is shown in Table 1.

Table 1. Total acidity values of kiwi vinegar samples

Kiwi samples	Total acidity (g/100ml)		
	Days		
	7	14	21
K1	2.1	3.2	-ND
K2	2.1	4.2	6.3
K3	2.1	-ND	2.3
KK	2.1	4.2	5.3

K1: Vinegar covered with thin cheesecloth (aerobic), K2: Vinegar covered with parafilm, K3: Vinegar covered with an airtight lid (anaerobic). KK: Vinegar from kiwi peels covered with cheesecloth (aerobic), ND: not detected



F**igure 1.** Kiwi vinegars prepared in different conditions. A) Vinegar covered with thin cheesecloth (aerobic, K1), B) Vinegar covered with parafilm (K2), C) Vinegar covered with an airtight lid (anaerobic, K3). D) Vinegar from kiwi peels covered with cheesecloth (aerobic, KK).

It is expected that the amount of acid produced in vinegar during the fermentation process will increase depending on time. It is seen that the total acidity values of kiwi vinegars prepared under different conditions increased during the 21-day fermentation period (Table 1). This is due to the growth of microorganisms that produce organic acid, mainly acetic acid **[28]**. Yeasts convert fermentable sugars to ethanol under anaerobic condi-

tions. Acetic acid is produced by using this ethanol by acetic acid bacteria under aerobic conditions. Acetic acid bacteria not only produce acetic acid, but also improve the flavor of vinegar **[29]**. The kiwi vinegars prepared under different conditions are shown in Figure 1. The least increase in acidity occurred in vinegar with the lid completely closed (anaerobic condition), and the total acidity at the end of 21 days was determined as 2.7 g/100 ml in this vinegar. The acidity level of kiwi vinegar may vary depending on the production method. As a matter of fact, in another study, the amount of acetic acid in kiwi vinegar prepared under different ambient conditions was found to be 6.28 g/100 mL **[30]**.

pH Measurement of Vinegar

pH values in samples taken in 1, 7, 14 and 21 days in kiwi fruit vinegars produced is shown in Figure 2. The pH in kiwi vinegars decreased from 3.5 to 2.4 on average. As a result of microbial activity, the amount of acetic acid in the vinegar increases and therefore the pH of the vinegar decreases. These results showed that the amount of acid in the vinegar increased and the production of vinegar continued in a positive way. In a study, the average pH level of kiwi vinegar produced was found to be 3.41 **[31].** It was determined that the pH values measured in the study of kiwi vinegars were compatible with the literature.

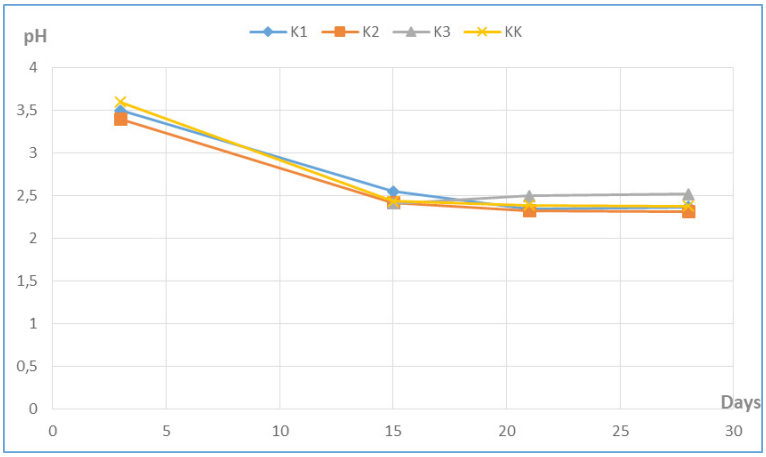


Figure 2. The pH of kiwi vinegars during fermentation

Total Phenolic Content of Vinegar

It was determined that the total phenolic content of the vinegars decreased during the 21-day fermentation period. For example, the amount of phenolic content in the K1 sample, which was 489.6 (mgGAE/L) at the beginning, decreased to 426.37 (mgGAE/L) after 21 days. It was determined that the vinegar with the highest phenolic content among the vinegar samples was K1 coded kiwi vinegar (426.37 mgGAE/kg) covered with cheesecloth. Fruits, vegetables and the foods produced from them are important for human health due to their rich polyphenolic content **[30]**.

Table 2. Total phenolic content of kiwi vineagars

Kiwi samples	Total phenolic content (mgGAE/L)		
	Days		
	7	14	21
K1	489.60	479.93	426.37
K2	417.26	425.26	391.26
K3	413.04	498.71	393.37
KK	439.93	446.93	431.93

K1: Vinegar covered with thin cheesecloth (aerobic), K2: Vinegar covered with parafilm, K3: Vinegar covered with an airtight lid (anaerobic). KK: Vinegar from kiwi peels covered with cheesecloth (aerobic),
GAE: gallic acid equivalent

Kiwi is also known to be a good source of polyphenols **[31].** In one study **[6],** more phenolic compounds were found in kiwi vinegar and kiwi wine compared to kiwi juice. The reason for this is that the vinegar is in contact with the fruit juice for a longer time in the fermentation process and acetic acid bacteria metabolize the polyphenols and help dissolve the nutrients **[6].**

In another study, total phenolic content was measured in kiwi, apple and palm vinegars and the highest phenolic content (754.50mgGAE/L) was found in kiwi vinegar **[33]**. It has been reported that the phenolic content of vinegars is affected by the product used and the production method **[32]**. In another study, the total phenolic content of kiwifruit ranged from 58.45 to 152 mg GAE/100 g FW **[31]**. In another study, the total phenolic com-

ponent contents of different Actinidia cultivars differed as 41.67 ± 5.69 to 710.00 ± 9.54 mg gallic acid/100 g fresh weight **[8]**. In the study, in which antioxidant capacity was largely associated with polyphenol and vitamin C levels, it was stated that the difference in antioxidant capacity was due to the difference in *Actinidia* species and cultivars.

Microbiological Analysis

The findings of the microorganisms examined in kiwi vinegar are given in Table 3. Mesophilic aerobic bacteria, lactic acid bacteria (LAB), total coliforms and the number of yeasts were investigated in kiwi vinegars. It was determined that the number of bacteria and yeast in vinegars decreased as fermentation progressed. It was determined that the total number of bacteria at the beginning was between 2.17 and 4.99 log cfu/mL. At the end of the 21st day of fermentation, the total bacterial count was found to be between 1.00 and 2.47 log cfu/mL. Similarly, it was determined that the number of lactic acid bacteria decreased, while it was between 4.87 and 5.39 log cfu/mL at the beginning, it decreased to 2.00 - 3.70 log cfu/mL at the end of 21 days.

While the yeast-mold count in the samples was 2.00 - 2.77 log cfu/mL at the beginning, it decreased by 1 log cfu/mL in vinegars under aerobic conditions at the end of 21 days. It was determined that vinegar in anaerobic condition increased to 2.65 log cfu/mL. It was thought that the increase (4.38-5.32 log cfu/mL) observed on the 15th day in kiwi vinegars produced under aerobic conditions was caused by the molds formed on the surface of the vinegars.

Table 3. Microbiological analysis of kiwi vinegars

Type of microorganisms	Incubation days	Number of microorganisms (log CFU/ml)			
		K1	K2	K3	KK
Mesophilic aerobic bacteria	7	-ND	4,47	4,11	4,99
	15	4,38	4,62	3,04	5,36
	21	1,00	1,00	2,47	2,00
Lactic acid bacteria	7	4,87	4,32	4,57	5,39
	15	3,87	4,14	3,81	3,69
	21	2,00	3,47	3,70	2,53

Yeast and moulds	7	2,72	2,77	2,00	2,00
	15	3,04	4,38	3,72	5,32
	21	1,00	1,00	2,65	1,00
Total coliforms	7	2,38	4,32	4,27	4,39
	15	3,00	4,47	2,00	5,27
	21	1,00	1,00	1,00	1,00

K1: Vinegar covered with thin cheesecloth (aerobic), K2: Vinegar covered with parafilm, K3: Vinegar covered with an airtight lid (anaerobic). KK: Vinegar from kiwi peels covered with cheesecloth (aerobic), ND: not detected, CFU: colony forming unit

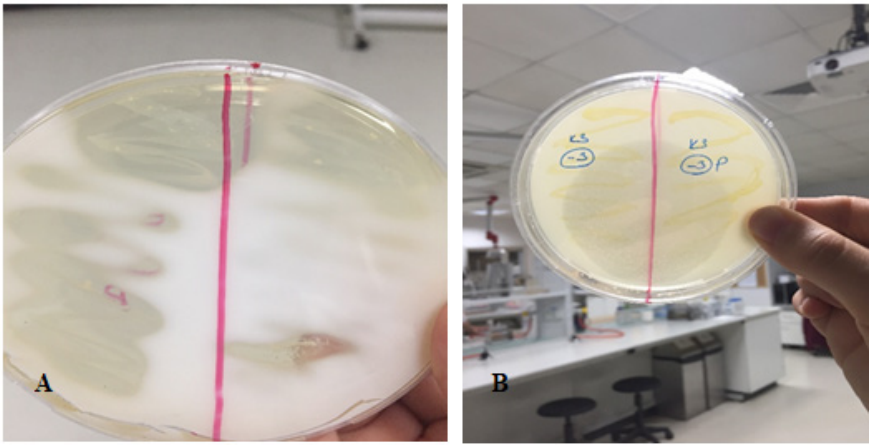


Figure 3. A) Acetic acid bacteria positive on medium, B) Asetic acid bacteria negative on medium.

The number of coliforms detected in kiwi vinegars ranged from 2.38 log cfu/mL to 4.39 log cfu/mL, and decreased to 1.00 log cfu/mL as fermentation progressed. The presence of acetic acid bacteria, which is known to be responsible for acetic acid production, was found only in the KK-coded kiwi peel sample. The presence of acetic acid bacteria was detected by the dissolution of $CaCO_3$ and the formation of transparent areas around the colony as seen in Figure 3. The presence of acetic acid bacteria was not found in other kiwi samples, and only yeast colonies were detected on the medium. It was thought that the high number of total aerobic bacteria and coliforms seen at the beginning of fermentation in kiwi vinegars was caused by the water, fruits and equipment used. It was determined that as the fermentation progressed, detremental microorganisms were eliminated, and at the same time, the number of yeast and lactic acid bacteria

decreased. It has been suggested that the factors determining the vinegar microbiota are environmental factors such as temperature and humidity, as well as the composition of the vinegar **[34].** In addition, it has been stated that ethanol obtained in the first stages of fermentation with lactic acid bacteria and yeast and then acid prevents the development of harmful microorganisms and increases the shelf life of vinegar **[35].** It has also been suggested that vinegars produced by spontaneous natural fermentation carry a great risk of spoilage **[36].**

CONCLUSION

Kiwi is a fruit rich in phenolic content. Although a slight decrease was observed in the fermentation process, it was found that the phenolic content of the kiwi vinegars produced in this study was high. It was determined that the total acidity increased during the fermentation period in all vinegars. With this increase in total acidity, a significant decrease in the total coliform count was observed. It was observed that the phenolic content was lower but the number of lactic acid bacteria and yeast was higher when vinegar was produced in an anaerobic environment instead of an aerobic environment. In this study, it has been reported that molds can be observed from time to time on the surfaces of vinegars produced under aerobic conditions during the fermentation process. However, kiwi fruits have the potential to be used in vinegar production.

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THE EFFECT OF REDUCING SALT IN PASTRAMI PRODUCTION ON QUALITY AND INVESTIGATION OF ALTERNATIVE APPLICATIONS TO SALT

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ABSTRACT

Pastrami is a meat product obtained by subjecting all the muscles extracted from certain parts of cattle and buffalo carcasses to various processes and made ready for consumption by cutting into thin slices. Salt brought together with pastrami in the curing step dissolves functional myofibrillar proteins, increasing the water holding capacity and binding properties of proteins as well as its concentration-dependent bacteriostatic effect, plays a critical role in establishing microbial stability in pastrami. On the other hand, the consumption of table salt, which is desired to be limited to <5 g/day by the World Health Organization (WHO), contradicts the salt composition of pastrami. This review, it is aimed to evaluate the effectiveness of chloride salts such as KCI, CaCI, $MgSO_4$, $MgSO_4$ as an alternative to NaCl, innovative substitution approaches, regulating the quantity with current technologies, and how dried traditional meat products in different geographies are subject to salt reduction activities.

***Keywords**:* Pastrami production technology, Salt reduction, Salt substitutes, Cured meat products

INTRODUCTION

Meat and meat products, which are of great importance in terms of adequate and balanced nutrition and known as a good source of protein. They

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contain lots of macro and micronutrients, especially B group vitamins and iron **[1,2]**. For this reason, in order to preserve meat and meat products for a long time and thus make their consumption accessible, various methods have been developed by trial and error method. Although mostly freezing is preferred today, drying and salting has been accepted as the most effective way considering the limited conditions in the past **[3]**. Pastrami is a salted and dried meat product that has been produced with unique techniques for centuries requiring skill, came to Anatolia by the nomadic Turkish communities and is loved and consumed in many countries even today **[4]**. The pastrami is best known in Kayseri. It was understood that this region was privileged in terms of pastrami production because of weather conditions, the regional nature of the water in the production area and the advanced workmanship **[4]**. Compared to other processed meat products, it has a relatively longer and more intensive production, sales, and marketing period **[5]**. Standardization of pastrami production could not be achieved because of the use of low-quality meat and spices, the drying process in the open air or in closed environments that are not adequately controlled. In addition, the techniques used vary according to the region and the producer **[6]**. Modern technological possibilities are not yet used in pastrami production. In this situation, negatively affects the quality characteristics of pastrami and causes the organoleptic qualities targeted in the product not to be achieved. Recently, studies on various packaging methods and production time on pastrami have increased and fully automatic packaging systems called thermoform have begun to be used **[7]**. Salt has critical importance in the production of pastrami in terms of ensuring the stability of the microbial load, shaping the characteristic texture with the solubility of meat proteins, and clarifying the sensory side of the product such as taste and flavor. As a result of lifestyle adaptations that have become increasingly complex and inert, foods containing low sodium have gained importance in terms of sustaining human health, and some strategies have been developed for the production of products with reduced salt content in food technology **[8]**. There are targets such as keeping the salting time short in order to reduce the salt in pastrami with certain amounts of ingredients to reduce the salt content or to reduce the salt content to below 3%, taking into account consumer preferences **[9, 10]**. Similar purposes were also explained in the protocol dated 2021 published by the Ministry of Health of the Republic of Turkey. In 2012, the amount of salt for pastrami was reduced from 8.5 grams to 7 grams per 100 g of dry matter in the Turkish Food Codex Meat

and Meat Products Communiqué **[11]**. When we look at other dried meat products such as pastrami globally, it is seen that they are subject to salt reduction activities from different perspectives and authority guidelines in terms of appealing to both the people of the region and all consumers to whom international trade has the potential to reach.

Production of Pastrami

Primary purpose in food production is to obtain products that meet the demands and expectations of the consumer, at the appropriate level in terms of health, in line with the measures to be taken in food safety. There are safety precautions that must be taken into account at all stages during the procurement and processing of the raw material, as well as physical, chemical and microbiological factors that may pose a risk. Fresh meat is a product that microorganisms can be very effective on it due to many characteristic features it has and therefore microbiological contamination can occur at all points from the slaughter of the animal to the packaging of the meat. Taking the necessary precautions at all these stages and keeping the production steps under periodic inspection will both increase the commitment to practices such as GMP (Good Production Practices) and SSOP (Sanitation Standard Operating Procedure), and will provide a significant improvement in healthy, clean and safe food production **[12]**.

Pastrami, as seen in the workflow given in Figure 1, is a cured and dried meat product that come from bovine carcasses without heat treatment, obtained by curing, washing, suppressing, drying, fenugreek and re-drying, respectively **[13]**. Since it is mostly consumed raw, the quality of the meat mass chosen as pastrami is of great importance and this situation is directly related to animal health. Considering animal health and fattening adequacy; meat of cows, tosun, toska (non-sterilized buffalo) with an age range of 3-6 can be used. On the contrast of this, ox, female buffalo, heifer, very young and old animal meats are not preferred **[14]**.

Also care should be taken in the selection of animals by paying attention to the adequate feeding and resting of the animal. In animal procurement, the breed, age, some physical characteristics of the animal and whether it is stressed are very important and the quality of the meat should be evaluated according to these criteria and more accurate decisions should be made in animal selection **[15]**.

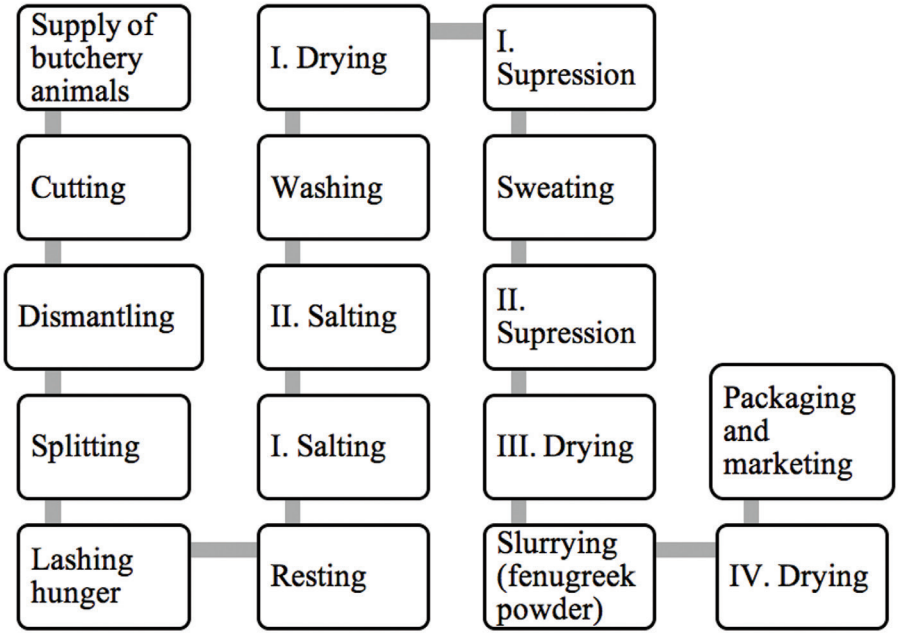

Figure 1. General flow chart of pastrami production **[2]**

It is known that the meat of tired, stressed animals is more likely to spoil as a result of slaughtering and due to the intense blood rate, the meat can quickly show reactions such as putrefaction and rancidity and therefore, by giving importance to the body temperature balance and determining the resting periods according to the seasons, a suitable ground should be prepared for the slaughter of the animal. Stressed animals should be kept longer in summer than in winter in order to provide suitable conditions, and slaughter should be carried out at least 8 hours after the animals are fed, considering that it may pose a microbiological risk **[4]**. The most suitable meat pH for pastrami production is between 5.4-5.8. After slaughter, it is expected that the blood will be shed to a great extent and rigor mortis (hardness of death) will begin. Since the muscles are irreversibly stiffened with rigor mortis, carcass shredding and deboning (removal) are easily performed, so that the muscles can be obtained as a whole without any damage **[2]**.

Since they are separated from the carcass and rested at the beginning of rigor mortis, the pastrami prepared for production are divided into varieties as shown in Table 1, taking into account the places where the meat masses from which they are obtained are found in the animal body. Making this distinction supports the creation of different quality classes according to the characteristics of pastrami (oily, intramuscular oiliness, textural qualities and fenugreek thickness) in the Turkish Standards Institute Pastrami Standard. As a result, privilege designations such as first, second, third class can be obtained and used in the label. Apart from these, different groupings are also made, taking into account the animal species and oiliness **[15].**

In a study conducted by Aksu et al., **[16]** to determine and compare the mineral compositions (Ca, K, Na, Mg, S, P, Pb, Zn, Mn, Fe and Ni) and moisture values of different types of pastrami such as sırt, kuşgömü, şekerpare and bohça, moisture content of kuşgömü type pastrami was determined to be lower than other types of pastrami ($P < 0.05$), while the highest mineral content was Na in each of the 4 types of pastrami. It was followed by K, S, P, Ca, Mg, Zn, Fe, Mn, Pb and Ni followed. In all pastrami varieties, Na was found to be the highest (31.9-47.7 g kg^{-1} dry weight) among other minerals.

Table 1. Types of pastrami and the regions where they are obtained from the carcass **[14]**

Carcass areas	Types of pastrami (traditional names)
Arm	Omuz, bez (orta bez, kanlı bez), bacak, kürek
Back	Mehle, tütünlük, sırt, arkabaş, etek
Thigh	Kuşgömü, bohça, kapak, kenar, dilme, şekerpare
Brisket	Döş, meme, kavram

In another study by Çakıcı et al., **[17]** in which they examined some physicochemical (fatty acid composition, moisture, ash, total fat, residual nitrite, pH and color) and microbiological properties of ridge, sugarpare,

bundle and bird's pastrami types, no difference ($P<0.05$) was observed in the mean pH and b* value and fatty acid composition between pastrami types, except for stearic acid; however, the amount of salt in all samples was stated to be above the maximum acceptable limit.

Salt is a compound with the antimicrobial property. Table salt (NaCI) is the compound that strengthens the characteristic flavor and aroma profiles of foods, increases their durability, allocates microbiological safety with their hygroscopic and antiseptic qualities during their shelf life. Also, have a strong effect on the structure, and therefore has an important role in the production processes and consumption preferences/expectations **[18]**.

After cutting, the front side and the back side of the meat are treated with salt separately and respectively (first and second salting); this process is carried out in conjunction with curing **[18]**. When salt is used on its own, the product gains a hard structure and darkens in color. For this reason, components such as nitrate, nitrite, ascorbic acid and its salts, sugar are added to the meat during curing in order to eliminate undesirable effects during salting and to provide the desired pink-red curing color **[7]**. Curing formulations have been changing recently. Producers resort to natural substitutes by rapidly adapting to changing supply/demand curves and decisions taken by health authorities, increasing scientific outputs with consumer expectations. Regarding this, Sindelar et al., **[19]** used sea salt, evaporated cane juice, raw sugar, turbinado sugar, lactic acid starter culture, natural flavorings, celery juice and celery juice concentrates in natural and uncured meat products. Similar ingredients have been studied in organically processed meat products, and vegetable concentrates have been found to be effective sources of nitrates for naturally cured meat products. After curing, the meat is washed in a container filled with cold water in order to remove the excess salt remaining on them. Then the meat is suspended and dried on the shelves **[2]**.

The main purpose of the drying process is to create a system that performs the desired heat transfer by reducing the water activity of the product and balancing the humidity between the environment and the product **[20]**. In the first drying, the pastrami is hung at a height of 1.5-2.0 meters and adjusted to prevent their contact with each other. Drying time varies as

2-3 days in October-November, when pastrami is mostly made, and 10-15 days in cold weather. It is observed that some changes occur in sensory properties such as texture, color and smell of meat during drying **[9]**.

Meats that start to dry on the top are included in the first pressing, and the meats are placed on top of each other regularly and the first pressing step is processed for one day by applying 0,9-1,0 kg/cm^2 pressure to the meats **[9]**. At this stage, which is also known as the cold pressing, the meat must be cold and it is expected that the meat will acquire a new appearance with the effect of the force to be applied **[4]**. The second drying process, which is also called sweating, is a different type of drying than the first, by hanging the meat for 1-3 days in sunny weather and 8-10 days in cold weather. The reason why it is described as sweating here is that the fat on the meat waiting under the sun melts with the heat and the meat leaves itself by softening **[9]**.

The second pressing process takes place in a shorter time than the cold pressing, since the meats come out of hot and sweaty drying, otherwise the structure of the meats may be negatively affected by the force applied to the hot meat. In addition, performing the cold pressing process makes a great contribution to obtaining the shape of pastrami by preparing a suitable environment for the hot equation in the meats. For this reason, both press applications are very important stages in terms of pastrami structure and affecting each other **[9]**.

After the balancing and drying processes, covering with the fenugreek stage is started. Fenugreek ensures that the pastrami not only acquires sensory and physical properties such as its unique taste, flavor, color, but also protects the pastrami against over-drying and prevents microbiological contamination that may occur by acting as a protective wall **[9]**.

After the third drying stage, the hung meat is lowered and checked for shape, unwanted shape defects are corrected, and then the meats are dipped into fenugreek paste for fenugreek. Pastrami, which is dipped in fenugreek paste at 10°C and kept in this mixture for approximately 1-4 days, absorbs the fenugreek paste thoroughly and matures thanks to this mixture **[4,9]**.

Fenugreek pulp; it is a mixture consisting of fenugreek flour (*Trigonella foenum graecum*), garlic and red pepper mixed with water and adding a small amount of spices to give it flavor, and generally 25-50% buy herb flour, 20-35% garlic and 7-15% red pepper **[15]**. In terms of pastrami quality and microbial load, the most favorable ratios for fenugreek were found to be a mixture containing 50% water, 20% fenugreek flour and 10% garlic **[17]**. Tekinsen et al. **[17]** observed that the use of fenugreek paste containing 15% garlic and 0.30% potassium sorbate kept the pastrami in better microbial quality. The pastrami kept in the cemen is closed by hand in such a way that there is no gap left, preventing it from getting air, and the state of the pastrami before the final drying is revealed. At this point, the final pastrami shape is created by paying attention to the fact that the weight of fenugreek is 5-15% of the total meat weight **[15]**.

The fourth and final drying process takes place by hanging the pas covered with fenugreek in the open air and waiting for 1-7 days **[4,14]**. The preservation of pastrami, on the other hand, can take up to 3-5 months depending on the temperatures lower than 15°C and the suitability of the conditions in which it is stored. Attention is paid to ensure that the characteristics of the environment in which the pastrami is stored do not adversely affect the structure and quality of the pastrami, and that it is adequately ventilated and preserved for a long time **[14]**.

In terms of production processes, pastrami that has completed all the processes properly and took its final shape are packaged, and vacuum packaging is generally used for long-term preservation of dried meat products **[3]**. In addition, modified atmosphere packaging (MAP) technology is generally preferred because it is more sensitive in sliced products **[2]**.

Salt Content and Health Effect in Dried Meat Products

Salt levels increase significantly when fresh foods (such as meat, vegetables, and fruit) that contain limited amounts of salt are processed **[10]**. Industrially processed foodstuffs account for about 75% of salt intake in developed countries. Food groups that contribute the most to sodium intake; processed meats (18%), bread and baked goods (13%), dairy (12%), and sauces (11%) **[21]**. As a result of increasing scientific output and decisions

taken by health authorities, masses of conscious masses are increasing that demand reduced salt meat products from the industry and that a diet with reduced sodium content will be healthier. However, reducing salt in meat products is a major challenge for the industry. With the reduction of the salt content, the intensity of the characteristic flavor also decreases **[10]**. In meat products such as pastrami, whose special product features are given in Table 2, high salt concentration regulates the intracellular and extracellular osmotic pressure and ensures the removal of intracellular water, thereby reducing the water activity and establishing the microbial balance. In addition, salt directly affects the texture by increasing the solubility of meat proteins and doubles its bacteriostatic effect at high salt concentrations **[7]**.

Table 2. Pastrami product features **[11]**

Pastrami	**Limit (by mass)**
Moisture content (except fenugreek)	Max. 50%
pH value	Max. 6.0
Amount of salt (except fenugreek, in dry matter)	Max in dry matter 10%
Amount of fenugreek	Max. 10%

WHO recommends consumption of <5 g of salt (about <2 g of sodium) per day, equivalent to about one heaping teaspoon for adults **[22].** However, on a global scale, it is stated that the average is much higher than the recommended salt consumption, with an average of 9-12 g/day **[23].**

In Turkey, the daily salt consumption amount was found to be 18 g/day in the 24-hour urine analysis (SALTurk-1), which reflects the country in general, carried out in 2008 by the Turkish Hypertension and Kidney Diseases Association. In the "Study of Salt Consumption in Turkey (SALTurk-2)" repeated by the Turkish Hypertension and Kidney Diseases Association in 2012, it was determined that despite the partial decrease in daily salt consumption, it was still at a level that could adversely affect health (15 g/day). According to the results of the spot urine analysis of the "Turkey

Household Health Survey (Prevalence of Risk Factors of Non-Communicable Diseases)" conducted with the Ministry of Health in 2017 in cooperation with WHO, daily salt consumption per person was measured as 9.9 g/day **[11]**. It is pointed out that if salt consumption on a global scale is reduced to the recommended level, approximately 2.5 million deaths can be prevented each year **[22]**. Excessive salt consumption; causes many diseases and systematic damages on a wide scale such as cardiovascular and kidney diseases and blood pressure disorders, stroke, diabetes, osteoporosis, stomach cancer, obesity, multiple sclerosis (MS), cataract **[24]**.

In the report titled "Salt Reduction and Protocol Implementation Guide for the Food and Beverage Industry" (2021), published by the Ministry of Health, solutions that can be applied to reduce salt are based on gradual reduction of salt and substitution of salt with other materials. The special product properties defined for pastrami in the Turkish Food Codex Communiqué on Meat, Prepared Meat Mixtures and Meat Products are as shown in Table 2. In processes such as fenugreek and curing, where product-specific physical and chemical markers are formed, salt is a key element and the maximum amount of salt that can be found in dry matter, excluding fenugreek, is regulated as 10%. In order to avoid the metabolic syndrome, which is called the pandemic of our age, it is on the agenda to reduce the amount of salt, and for this purpose, minerals, potassium chloride (KCI), potassium sulfate (K_2SO_4), magnesium sulfate ($MgSO_4$), trehalose, lactates, glycine, etc. **[11]** innovative reformulation solutions are needed.

In a study conducted by Pleadin et al., **[25]** the mass ratio of salt in 124 samples of traditional meat products from the group of dry sausage, dry and semi-dry meat products and bacon from family farms from three production regions of Croatia was investigated. The highest salt content was found in dry-cured meat products (6.16%), followed by bacon (5.30%), and the lowest salt content was found in dry sausages (4.20%). In a similar study, Slobodan, **[10]** aimed to determine the sodium content from the sodium/chloride ratio in salt and salt using the standard volumetric AOAC method in dry fermented sausages and cured meats from the Serbian market. While the average salt content was 3.17% and the average sodium content was 1247 mg / 100 g in dry fermented sausages, the average salt content was 7.13% and the average sodium content was 2805 mg / 100 g in dried meats. In a market study conducted by Doğruer et al., **[17]** on the

quality of pastrami offered for consumption in Konya, the average salt content was found to be 6.15%. In a similar study, Elmalı et al., **[17]** aimed to determine the microbiological and chemical properties of 60 pastrami samples, 15 of which were selected from the same city and the others were randomly selected. The salt content was evaluated as <8.5% in approximately 47 samples and >8.5% in 13 samples.

There have been various approaches to the development of sodium-reduced meat products against the high salt content that should be avoided in terms of human health. Replacing all or part of NaCl with other chloride salts (KCl, $CaCl_2$, LiCl and $MgCl_2$), mixing salt and substitute (KCl/K-lactate/glycine, NaCl/KCl/$CaCl_2$, KCl/tartaric acid/citric acid/sucrose, transglutaminase/caseinate/KCl/dietary fiber, NaCl/KCl/NaOH/HCl lysine), by the substitution of part of NaCl non-chlorine salts (phosphates, mineral salt mixtures, ascorbates, citrates), and the use of protein and non-protein linkers has been suggested (soy protein, caseinate, egg protein, potato flour, carbohydrates and derivatives, gums/hydrocolloids, fibers, and microbial transglutaminase). The recommendations included the use of pre-rigor meat in heat treatment and high-pressure processing techniques **[26]**.

A study conducted by Aaslyng et al., **[27]** was intended to demonstrate the extent to which moderate (22-25%) and substantial (43-50%) reductions of NaCl how to affect efficacy, organoleptic properties, and microbial growth in hot dogs, bacon, cooked-cured ham and salami. While there was 8% yield loss in sausages and 6% in ham in products with significantly reduced salt content, the production of bacon and salami was not affected by this loss. Reducing the NaCl content to 2% in sausages, 2.3% in bacon, 1.7% in ham and 6.3% in salami (aqueous phase) did not trigger microbial growth mostly, it was found that the decrease from 2.2% to 1.7% and from 2.3% to 1.3% (w/w) in sausage and ham, respectively, had no effect on sensory properties. In contrast, the sensory properties of bacon and salami were significantly altered after a moderate reduction.

Various fenugreek paste mixtures were applied to experimentally prepared pastrami by Nizamlıoğlu et al., **[17]** and the effects of these mixtures on the chemical and sensory qualities of pastrami on the 1st, 7th, 15th, 30th and 60th days were investigated. While the salt content of the pastrami

on structure, flavor, and color. In both product groups, they found flavor defects in substitutions of more than 40% for the three ingredients and additives of over 30% for glycine in dry-cured pork loin. They drew attention to the fact that the textural transformations that they detected by instrumental analysis, especially in dry cured pork fillet, were not noticed by the panelists.

In a study by Zheng et al., **[29]** they aimed to reduce the salt in order to obtain high-quality products by changing the physicochemical properties of chicken meat pastes with heating under pressure application (HUP) during cooking. They showed that the application of pressure had a large effect on HUP-treated samples, but the effects of salt on HUP-treated samples were much less pronounced than those found for heat-treated samples only. It has been understood that the main factor affecting the quality of chicken meat paste when heated under high pressure is salt rather than high pressure, contrary to popular belief, and the application of HUP at a certain pressure would be an excellent process for producing low salt crumbled meat products. However, the degradation of myofibrils and the formation of a fine filamentous gel network both inside and outside the muscle fibers in samples applied with a 400 MPa dose by scanning electron microscopy indicate that excessively high pressure may cause poor quality.

In a study by Yalçın et al., **[30]** it was aimed to determine the effects of the salt and moisture content of turkey breast meat and the pressing process applied on the textural, microstructural and color properties of the meat, adsorption isotherms and microbiological count. The physical properties (color, firmness, cohesion, flexibility and chewing) of freeze-dried turkey meat containing high salt-moisture and low salt-moisture were found to be similar, and it was concluded that the salt content of freeze-dried turkey meat could be reduced by lowering the moisture content in the freeze dryer without adversely affecting the microbial quality.

In Table 3, shows process methodologies of dried meat products similar to pastrami studies in the literature **[31-35].** The preferred animal species in these products varies depending on factors such as slaughter type (piece, strip, etc.), pre-treatments applied (smoking, curing, etc.), and drying method (hanger, stack, etc.). Also, the use of local materials, spices and aro-

samples was 6.18-7.06% on the 1st day, it was found between 9.06% and 10.24% on the 60th day, and there were significant differences in the salt amounts of the samples in all periods in terms of the ratio of water, fenugreek flour and garlic in the fenugreek paste. The lowest values were determined in the samples to which fenugreek pastes containing 40% water, 15% fenugreek flour and 10% garlic were applied. While it was determined that the samples applied with fenugreek paste containing 50% water, 15% fenugreek flour and 20% garlic in terms of chemical quality in most of the periods showed the best properties, in terms of organoleptic properties, it was determined that the samples containing 50% water, 10% fenugreek flour and 20% garlic in fenugreek paste got the highest scores.

Alino et al., **[28]** in their study, where they proposed as a possible strategy to reduce the sodium content of cured meat products, they investigated the effect of partial substitution of NaCl with KCl, $CaCl_2$ and $MgCl_2$ on the physicochemical and microbiological parameters of dry-cured pork loin after curing and drying treatments. Replacing about 70% NaCI significantly increased the firmness and chewiness of dry-cured fillets, so it was found that it was possible to obtain low sodium dry-cured fillet with up to 45% substitution with potassium (25%), calcium (15%) and magnesium (5%). Compared to the sodium chloride commonly contained in conventional products, the substitutions did not have a significant effect on physicochemical properties or microbial counts. Ekmekçi, **[18]** determined options that were cured with four different salt mixtures obtained from two different beef carcasses (*Musculus longissimus dorsi*) to be used in experimental pastrami production. These are listed as follows: Control group (KT) containing standard NaCI, group with 50% reduced NaCI content (DT), group cured with 50% NaCI + 50% KCI (PC) and cured group (CC) with 50% NaCI + 50% $CaCI_2$. Obtained microbiological, physicochemical and chemical results revealed that KCI is the most suitable substitute in pastrami production. It was stated that after curing, the salt content of all determined groups increased and it was determined as 5.85%, 4.26%, 6.19% and 5.31% in the final products of KT, DT, PC and CC groups, respectively ($P<0.05$).

Gou et al., **[10]** used 0-60% potassium chloride, 0-100% potassium lactate and 0-100% glycine as sodium chloride substitutes in fermented sausages and dry-cured pork loin and evaluated the effect of these alternatives

mas allow obtaining characteristic products. So that the mentioned product types to be evaluated as geographical indications that also represent the local consumption habits of the regions. Dried meat products are mostly produced by local people in small scale or industrial type in large quantities by conventional means and some of them are subject to international trade **[2]**.

Table 3. The origin and process methodologies of dried meat products

Traditional cured meat product	Origin	Methodology	References
Pastrami	Turkey / Middle Asia	• Drying • Curing • Equation • Sweating • Fenugreek	**[3,18]**
Charque	South America	• Salting • Drying • Curing	**[3]**
Biltong	South America	• Salting • Curing • Drying	**[2,3,31]**
Kilishi	Africa	• Drying • Marination	**[3,32]**
Kaddid	Africa and South Asia	• Salting • Fumigation • Drying	**[3,33]**
Jerky	North America	• Marination • Curing • Drying	**[2,34]**

Table 3. (Continued)

Traditional cured meat product	Origin	Methodology	References
Ceccina (Spanish)	Spain	• Salting • Smoking • Drying Maturating	**[3]**
Qwanta	Nigeria / East Africa	• Drying • Curing Fumigation	**[2,3]**
Jirge	Africa	• Fermentation • Curing • Drying	**[3]**
Odka	Somalia / East Africa	• Salting • Drying • Frying • Curing	**[2]**
Pemmican	America	• Salting • Drying	**[34]**
Roupu	China	• Curing • Drying	**[3]**
Kundi	Nigeria	• Boiling • Drying • Heat treatment	**[35]**

In Table 4, the chemical properties of some dried meat samples, whose consumption is subject to national and international trade, are compared **[37-41].** It is striking that the amount of salt is low compared to the relative variations of pastrami, which is an important item of Turkish gastronomy.

According to the Turkish Food Codex Communiqué on Meat, Prepared Meat Mixtures and Meat Products, the amount of salt specified for pastrami is determined to be at most 10 % by mass in dry matter **[36].**

Table 4. Comparison of the compositions of dried meat products **[2]**

Products	**M (%)**	**P (%)**	**O (%)**	**A (%)**	**S (%)**	**a_w**	**pH**	**Ref.**
Meat (fresh)	76.1	21.4	1.1	1.1	0.013-0.016	0.99	5.3-6.7	**[3, 37, 38]**
Pastrami	30-35	52.4	2.36	6.7	4.5-6	0.88	4.5-5.8	**[2, 37]**
Charque	46.4	26.3	2.5	23.3	15-20	0.75	5.8-5.9	**[3, 39, 40]**
Biltong	11.5	65.0	1.9	12.5	3-8	0.77	5.5	**[2,3, 31]**
Kilishi	10.0	60.3	14.2	8.8	9.8	0.59	5.8	**[3, 2]**
Kaddid	10.4	-	-	-	10.2	0.54	5.32	**[3]**
Jerky	55	64	-	18.3	14	0.78	5.76	**[2, 41]**

M: moisture content (%), P: protein content (%), O: oil content (%), A: ash content (%), S: salt content (%)

In a study by Bampi et al., **[39]** in which the use of KCl as a substitute for NaCl in charque and the effects of atmospheric pressure (P_{atm}) and vacuum application (4VP) on water gain together with salt reduction, were analyzed by mass transfer kinetics of four vacuum pulses (4VP) resulted in greater salt reduction and less water recovery compared to desalination carried out at atmospheric pressure (P_{atm}). Also, vacuum assisted desalting promoted a homogenate salt dispersion in the product. Replacing NaCl with KCl in both conditions (P_{atm} and 4VP) reduced the ready-to-eat charque sodium content by approximately 50%.

In another study by Bampi et al., **[42]** to test microwave vacuum drying as a rapid drying method for producing salted and dried beef pieces, 100%

NaCl before drying the beef pieces; 75% NaCI and 25% KCI; It was salted by immersion in three different brine solutions, 50% NaCI and 50% KCI, and then the proposed microwave vacuum drying method was compared with convective drying and vacuum drying in terms of drying kinetics and physicochemical and mechanical properties of the samples obtained. The average drying times for the samples to reach a water activity of 0.7 were found to be more than 40 hours for convective drying, 36 hours for vacuum drying and 0.45 hours for microwave vacuum drying, and it was determined that salting at different concentrations and rates had no effect at these times. With this, microwave vacuum drying provided the samples with higher pore and rehydration capacity, and it was concluded that it could lead to the design of new industrial technologies to produce salted and dried meat, especially charqui and jerky with low sodium content.

Vargas et al., **[43]** focused on the physicochemical quality of dry-cured deer cecina and the effect of NaCI substitution on the volatile and sensory profile. Mentioned materials were prepared as 100% NaCI (control), 30% NaCl+70% KCI (salt mixture I) and 30% NaCI+50% KCI+15% $CaCl_2$+5% $MgCI_2$ (salt mixture II). It was shown that the physicochemical composition, volatile compounds and sensory properties of dry-cured deer cecina were affected by salting processes. Nevertheless the texture, color, aroma and flavor did not exhibit significant differences between treatments. Sensory analysis pointed out that cecina produced with control and salt mixture I had the highest acceptance scores, this also showed that the samples differed most in sensory analysis.

CONCLUSION

Low salt product development activities are a sensitive and critical issue for this sector, as the salt contained in the pastrami, which is identified with the Kayseri region, largely determines the taste and aroma, techno-functional properties, stability, and reliability of meat products in general. While blending chloride salts such as KCI, CaCI, $MgCI_2$, $MgSO_4$ with different concentrations of NaCI is the most frequently studied salt reduction activity, innovative substitution preference or the use of processes such as freezing, freeze-drying, high pressure, fermentation are also in question. As it is understood, aiming to reduce the amount of salt directly and not suppor-

ting it with any other means leaves the problem unsolved. Instead, there is a need for R&D studies that require reformulation studies and a combined evaluation of different technologies on the relevant product portfolio. In the future, it is essential to take inclusive marketing actions in order to shape the sodium-reduced prototype with positive and negative controlled sensory analyzes with a holistic approach, without ignoring the consumer attitude, to take the legislation as a basis during the process, provide new packaging material that may be needed and to cover the possible costs.

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