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Effect of extract of ginger root and liquorice on the microbiological safety of mutton liver pâté

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ABSTRACT

This work aimed to evaluate the effect of ginger root (*Zingiber officinale*) and liquorice (*Glycyrrhiza glabra*) extract in liver pates on their microbiological safety, water activity and pH values. Four samples of pates were produced: control (without extracts), variant 1 (addition of 1% liquorice root and 2% ginger root), variant 2 (2% liquorice root, 3% ginger root), variant 3 (3% liquorice root, 4% ginger root). The number of mesophilic aerobic and facultative anaerobic microorganisms, lactobacilli, moulds, yeasts, *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* on the day of production and after 1, 3, 6 and 12 months of storage were determined. According to the experimental data, the studied microbiological safety indicators were within the permissible standards during the entire period of storage. The lowest microflora growth was observed in variants 1 and 4. With increasing storage time of the samples, a decrease in the value of water activity and an increase in the pH value was observed. Sensory analysis showed a positive trend in pates' taste, texture, and aroma when introducing sheep fat and plant extracts into the recipe. According to the overall sensory analysis score, variant 2 received the highest score (8.5), while the control sample received the lowest score (7.9). The aroma, consistency and juiciness of the pâtés of variant 2 were significantly better (p <0.05). The studies confirmed the prospects of improving the microbiological stability of liver pâté using different combinations of plant extracts.

Keywords: pate, liquorice root, ginger root, microbiological safety, water activity, pH

INTRODUCTION

Liver pâtés are widely popular among the population of many countries and are considered a delicacy **[1]**. They are made using pork liver **[2]**, duck and chicken liver **[3]**, and ostrich liver **[4]**. However, information on the use of lamb liver and its impact on the quality characteristics of pâtés is very limited **[5]**. Liver pâtés, as ready-to-eat products, have a high risk of food safety concerns. Due to their high nutritional value and significant water content, pâtés can cause foodborne illness due to the excessive growth of pathogenic microorganisms **[6]**. Consequently, they require careful microbiological safety control. In addition to the above, liver pâtés have a low antioxidant and relatively high-fat content (up to 60%), increasing susceptibility to lipid oxidation and rancidity. They also have a high content of non-heme iron (up to 30 mg/g product), which is a promoter of oxidation in meat and meat products and can affect the rate of product spoilage **[7]**. The factors above contribute to instability during storage, susceptibility to oxidation, formation of lipid-derived volatiles, and corresponding changes in colour, aroma, taste, and nutritional properties **[7]**, **[8]**.

Several studies indicate that the use of plant extracts with antimicrobial activity can increase the microbiological safety and shelf life of products such as sausages **[9]**, ready-to-eat foods **[10]** and liver pâtés **[11]**, **[12]**. Positive results of the use of *Arbutus unedo* fruit extracts as an inhibitor of lipid oxidation and pathogenic

microflora in pates **[4]**, the use of *Morus alba* plant leaf extract in liver pates to prolong the shelf life in refrigerators in terms of microbiological safety, resistance to oxidation, etc. are reported **[11]**.

The antimicrobial and preservative potential of 1% and 2% turmeric extract in ready-to-eat foods **[10]**, the antimicrobial effect of liquorice extract against the common foodborne pathogen *Listeria monocytogenes* **[13]**, and aqueous extracts of *Glycyrrhiza glabra*, *Cuminum cyminum*, *Zingiber officinale*, *Origanum majorana* and *Petroselinum crispum* against several Gram-positive and Gram-negative bacterial isolates **[14]** were reported.

The most widely used plants with a strong antibacterial and immune-stimulating effect are liquorice root (*Glycyrrhiza glabra L.*) and ginger (*Zingiber officinale*) **[15]**, **[16]**, **[17]**, **[18]**, **[19]**. Licorice root is known for its anti-inflammatory, antimicrobial, antiviral, anti-allergic, antioxidant and anticancer properties. In traditional medicine, it is used to treat peptic ulcers, asthma, pharyngitis, and malaria, to relieve abdominal pain, and insomnia and against infections of various etiologies **[15]**, **[16]**, **[17]**.

The main active ingredient of liquorice – glycyrrhizin in the highest quantity (up to 23%) is contained in the plant's roots. In liquorice root are found flavonoids, glycinamide A and B16, glucose (up to 15.2%), sucrose (up to 11%), starch, resinous substances, gum, high content of organic acids – salicylic, synaptic, ferulic, caffeic, etc. Coumarins, alkaloids, tannins, steroids, estradiol, vitamins C and B, potassium, calcium, etc., are also determined **[17]**.

Ginger root is also known in Asian traditional medicine, especially in Chinese medicine, in West African folk medicine for its positive effect on inflammatory diseases: cough, colds, rheumatoid arthritis in stomach diseases: dyspepsia, colic, gastroparesis, etc. Analysis of the data shows that ginger root and liquorice are considered by scientists mainly in the composition of food products to prolong the shelf life **[19]**, **[20]**, **[21]**, **[22]**, **[23]**, **[24]**.

The combination of liquorice extract and ginger, according to the data presented in the works of Saeedifar and Mosayebi, has a synergistic effect in the treatment of several diseases, including cancer, increasing apoptosis, the action of lymphocytes infiltrating the tumour, suppression of growth of tumour masses **[25]**.

In our previous work **[26],** we studied the effect of liquorice and ginger root on liver pate's nutritive, chemical and technological properties. The purpose of this work is to study the effect of the extract of ginger root (*Zingiber officinale*) and liquorice (*Glycyrrhiza glabra*) in liver pates on their microbiological safety, water activity and pH values.

Scientific hypothesis

This research hypothesises that the incorporation of liquorice (*Glycyrrhiza glabra*) and ginger root (*Zingiber officinale*) extracts into liver pâtés will enhance their microbiological safety and stability by reducing pathogenic microorganism growth, inhibiting lipid oxidation and maintaining desirable water activity and pH levels, ultimately improving their overall quality characteristics.

MATERIAL AND METHODOLOGY

Samples

To produce mutton liver pâtés, the following components are used:
Mutton liver and butter (72% of fatness) were purchased from Magnum supermarket (Almaty, Kazakhstan).
Dried liquorice root was purchased in Zerde Phyto LLP (Kazakhstan).
Fresh ginger root was purchased from the local supermarket "Magnum" (Almaty, Kazakhstan).

Chemicals

Agar nutrient media: meat-and-peptone agar (State Research Center for Applied Microbiology and Biotechnology, Moscow, Russia).

Biological material

Escherichia coli (NCTC 12241/ATCC 25922), Salmonella typhimurium (NCTC 12023/ATCC 14028), and Staphylococcus aureus (NCTC 12973/ATCC 29213) test strains.

Instruments

Aqualab 4TE water activity meter (Decagon Devices Inc.).
pH meter HI 99163 (Hanna Instruments Inc.).
Ultrasonic homogenizer (Ultrasonic Homogenisers HD 4100, Germany).
Meat grinder MIM-300 (Russia).
Meat cutter ZB-40 (Hualian Machinery, China).
Manual sealing machine MZ04 (Russia).
Autoclave "Malysh Nerzh" with an electronic block EBU (22 l) (Russia).

Laboratory Methods

Microbiological indicators: All studies were conducted in a microbiological box under aseptic conditions. On the day of production and after 1, 3, 6 and 12 months of storage, the quantity of mesophilic aerobic and facultative anaerobic microorganisms (total viable count), lactobacilli, moulds, yeasts, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* was determined by Koch's cup method. All samples were stored in a refrigerated chamber at 4 °C before sampling.

The pre-diluted sample solution was diluted in sterile tubes with 9 ml of physiological solution and plated in Petri dishes with agar nutrient media: meat-peptone agar for determination of total viable count, Chapek-Dox medium for mould fungi, Saburo medium for yeast, and MRS medium for lactobacilli. Incubation was performed at 37 °C and 25 °C (for moulds).

In addition, *Escherichia coli* (NCTC 12241/ATCC 25922), *Salmonella typhimurium* (NCTC 12023/ATCC 14028), and *Staphylococcus aureus* (NCTC 12973/ATCC 29213) test strains were plated as controls. The test strains were purchased from The National Collection of Type Cultures (NCTC, American Type Culture Collection (ATCC)). The research was conducted at the Kazakhstan Association of Human Microbiome Researchers, Nazarbayev University (Astana) **[27]**.

Water activity was measured on an Aqualab 4TE water activity meter (Decagon Devices Inc.). Samples were ground beforehand, weighed, and evenly distributed on the device cup **[28]**.

Determination of pH: The potentiometric method determined the pote's actiome acidity (pH). Twice, the ground sample was mixed with distilled water in the proportion 1:10, followed by stirring on a magnetic stirrer for 30 minutes. pH after extraction was determined on a device HI 99163 (Hanna Instruments Inc.) **[29]**.

Sensory analysis: A sensory analysis was conducted by 30 trained Kazakh Research Institute of Processing and Food Industry employees, with panellists aged 21 to 58 years (15 males and 15 females). The pâté samples were cut into cubic-shaped pieces and distributed to the panellists in plastic disposable dishes, a glass of water, unsalted crackers, and a knife. The samples were evaluated using a 10-point scale, where 0 points corresponded to "highly undesirable" and 10 points corresponded to "highly desirable". To conduct the sensory evaluation, each sample was served in triplicate **[30]**.

Description of the Experiment

Preparation of the extract: Plant ingredients comply with the requirements of the technical regulations of the Customs Union TR CU 021/2011 No. 880 and TR CU 022/2011 No. 881 "On food safety", applicable in the Republic of Kazakhstan. All plant experiments were conducted with relevant institutional, national, and international guidelines and legislation. Dried liquorice root was purchased in Zerde Phyto LLP (Kazakhstan) and milled to powdery. Sifted twice through a sieve with a pore diameter of 1 mm, weighed and added distilled water in a ratio of 1:4. Fresh ginger root was purchased in the local supermarket chain "Magnum" (Republic of Kazakhstan, Almaty), washed, dried, ground in a blender and processed with an ultrasonic homogenizer (Ultrasonic Homogenisers HD 4100, Germany) with distilled water (hydromodule 1:4) (Figure 1).

The obtained extract was centrifuged (1000 rpm, 10 min). The supernatant was poured into a volumetric flask (Figure 2). The precipitate was again poured with water in a 1:2 ratio, repeatedly treated with an ultrasonic homogenizer, and centrifuged. The supernatant was added to the previous extract. The extract was then stored at 2 °C until analysis.

Production of pâté: Mutton liver and other ingredients were purchased from Magnum supermarket (Almaty, Kazakhstan). Production of pâté was conducted in the meat processing shop at Kazakh Research Institute of Processing and Food Industry. Four samples of pâté were produced: control (without extracts), variant 1 (adding 1% licorice root and 2% ginger root), variant 2 (2% liquorice root, 3% ginger root) and variant 3 (3% liquorice root, 4% ginger root) (Table 1).

Table 1 Recipe of control and experimental samples of pâté.

Ingredient	Control	Experimental samples		
		Variant 1	Variant 2	Variant 3
Mutton liver	65	65	65	65
Butter (72.5% fat)	10	10	10	10
Unfiltered broth from boiling lamb's liver	25	25	25	25
Spices and materials, g per 100 kg of raw materials				
Licorice root extract	-	1	2	3
Ginger root extract	-	2	3	4
Black pepper powder	0.1	0.1	0.1	0.1
Iodized table salt	0.1	0.1	0.1	0.1

Bile ducts and film were removed from the mutton's liver. Then it was soaked in running water for 2 hours to remove blood clots, sliced and blanched in hot water for 25 minutes. Afterwards, the liver was washed in cold water and chopped in a meat grinder MIM-300 (Russia). Onions were peeled, washed, sliced, and parboiled in vegetable oil for 10-15 minutes. All the ingredients were ground in a cutter ZB-40 (Hualian Machinery, China) for 5-7 minutes.

Homogenized paste mass was filled into cylindrical tin cans (diameter 72.8 mm, wall height 95 mm) (Figure 3), sealed with tin lids on manual sealing machine MZ04 (Russia), and sterilized on autoclave "Malysh Nerzh" with an electronic block EBU (22 l) (Russia) at a pressure of 0.25 MPa and sterilization temperature 117 °C.

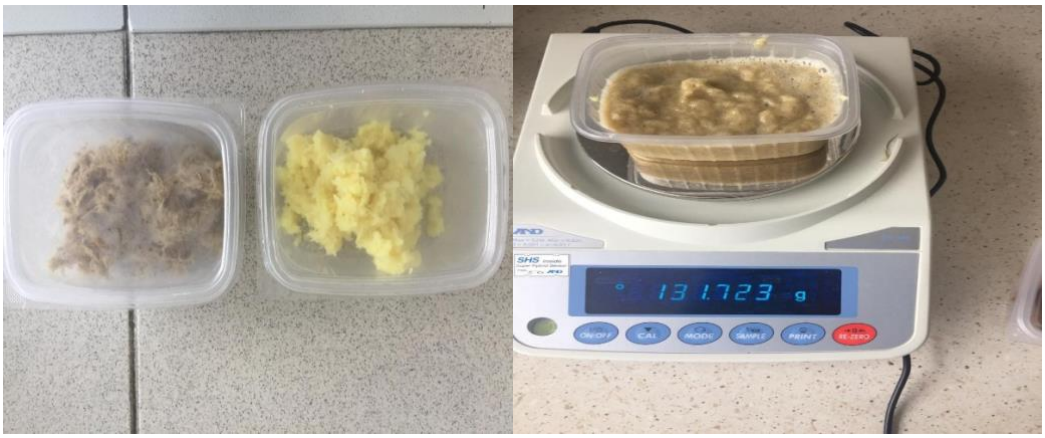

Figure 1 Processed ginger and licorice root.

Figure 2 Extracts and pate samples: a) ready extracts after centrifugation, b) control sample pate, c) experimental sample pate (2% licorice root – 3% ginger root).

Figure 3 Homogenized pâté mass.

Number of samples analyzed: To analyze the microbiological safety of mutton liver pâté, 60 samples of pâté were studied.

Number of repeated analyses: Each study was carried out 3 times.

Number of experiment replications: The study was repeated three times, with the experimental data processed using mathematical statistics methods.

Design of the experiment: At the beginning of the experiment, we analyzed the microbiological parameters of extracts depending on incubation time, the microbiological safety of extracts and liver pates. Water activity and pH of pâté samples during storage, and sensory analysis of liver pates with the addition of licorice root and ginger were studied.

Statistical Analysis

The experiments were performed in triplicate. Standard deviation values were indicated for all measurements. Differences in the measurements of the experimental and control groups were calculated using analysis of variation (one-way ANOVA) using the Tukey test. A *p*-value of <0.05 was considered significant.

RESULTS AND DISCUSSION

The effect of the extract of liquorice root and ginger and their different proportions in the composition of pâtés are shown in Table 2 and Table 3.

Table 2 Microbiological parameters of licorice extract sample after 7 days of storage (incubation time – 48 hours).

Indicator	Test strains	Growth rates
Total viable count, CFU/g	-	nd
Lactobacillus	cg	nd
Mould fungi	-	nd
Staphylococcus aureus	cg	nd
Escherichia coli	cg	nd
Salmonella	cg	nd
Yeast	-	nd

Note: cg – confluent growth.; nd – not detected.

Table 3 Microbiological parameters of licorice extract (incubation time – 48 hours).

Storage time	Indicator	Test strains	Pate samples			
			Control	Variant 1	Variant 2	Variant 3
Day of production	Total viable count, CFU/g	-	nd	nd	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd
After 1 month	Total viable count, CFU/g	-	nd	nd	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd
After 2 month	Total viable count, CFU/g	-	nd	nd	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd

Table 3 Cont.

Storage time	Indicator	Test strains	Pate samples			
			Control	Variant 1	Variant 2	Variant 3
After 3 month	Total viable count, CFU/g	-	nd	nd	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd
After 6 month	Total viable count, CFU/g	-	nd	nd	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd
After 12 month	Total viable count, CFU/g	-	$4x10^2$	$2x10^1$	nd	nd
	Lactobacillus	cg	nd	nd	nd	nd
	Mould fungi	-	nd	nd	nd	nd
	Staphylococcus aureus	cg	nd	nd	nd	nd
	Escherichia coli	cg	nd	nd	nd	nd
	Salmonella	cg	nd	nd	nd	nd
	Yeast	cg	nd	nd	nd	nd

Note: cg – confluent growth.; nd – not detected.

Table 4 presents acceptable microbiological safety standards for plant extracts and liver pâtés.

Table 4 Regulated standards of microbiological safety of extracts and liver pates (TR CU 021/2011 and TR CU 034/2013) **[31]**, **[32]**.

Indicator	Standards, not more
Plant extracts	
Total viable count, CFU/g	$5x10^3$
Mold fungi, CFU/g	100
Escherichia coli	1.0 in 1 g
Yeast	50
Liver pates	
Total viable count, CFU/g	$1x10^3$
Nonspore-forming microorganisms, including lactic acid and/or mold fungi, and/or yeasts	Not allowed in 1 g
Staphylococcus aureus	Not allowed in 1 g
Escherichia coli	Not allowed in 1 g
Salmonella	Not allowed in 1 g

According to the results of experimental studies, during the storage period of pate samples, the least growth of microflora was observed in experimental samples with 1% liquorice root – 2% ginger root and 3% liquorice root – 4% ginger root. All samples during the storage period complied with the regulated norms of industry regulatory documents.

There were no *Escherichia coli, Staphylococcus aureus* and *Salmonella* moulds and yeasts in all experimental samples, which indicated compliance of conditions and modes of production to sanitary requirements. On the 12th month of storage, the growth of total viable count up to $4x10^2$ and $2x10^1$ CFU/g was detected in the control and variant 1, respectively. Similar results on the reduction of total microbial count and Pseudomonas number were obtained by Bilska et al. when studying 0.2% and 0.6% of *Morus Alba* leaf extract in liver pâtés **[11]**.

Martin-Sánchez et al. showed a reduction in the growth of mesophilic anaerobic bacteria with the addition of 7.5% date paste and/or annatto extract in liver pâté **[33]**. These findings suggest that plant extracts containing certain amounts of phenolic and biologically active compounds may suppress the growth of unwanted microflora. Studies conducted by Islam et al. **[34]** and Nicolic et al. **[35]** confirmed the bactericidal effect of ginger extracts against foodborne pathogens, including *Staphylococcus aureus*, *Escherichia coli*, *Salmonella spp.*, and others. Extract of ginger root acts as an antioxidant and antimicrobial agent against pathogenic bacteria **[36]**, **[37]**, **[38]**.

Experimental data obtained by Chabuck et al. **[14]** confirmed the antimicrobial activity of liquorice water extract against *E. coli* (25mm), *Staphylococcus saprophyticus* (23mm), and other microbial pathogens, as well as its effectiveness in combination with antibiotics. Liquorice contains several active components, such as glycyrrhizin, liquiritigenin, licochalcone A, and glabridin, which have been shown to have potent effects in inhibiting the activities of Gram-positive bacteria and Gram-negative bacteria **[39]**, **[40]**, **[41]**. Schilling et al. noted that adding rosemary and green tea extracts effectively suppressed lipid oxidation and slowed bacterial growth in pork sausages **[42]**. Riel et al. added parsley extract powder as a substitute for sodium nitrite in mortadella-type sausages and revealed a reduction of the growth of certain bacteria in the sausages **[43]**.

It is well known that water activity plays a crucial role in preserving food products **[44]**. It affects the growth and development of microorganisms and the rate of physicochemical processes during storage. Water activity is the best indicator for determining the potential growth of microorganisms **[45]**, **[46]**. A product may have a relatively high percentage of water content, but if this water is chemically "bound" with hygroscopic substances, it is not available for developing microorganisms. The kinetics of microbiological and biochemical processes, including those responsible for food spoilage, depend on the water activity level **[47]**, **[48]**.

The experimental samples on the day of production, at the 1st month and 12th month of storage, had significant differences from the control batch. However, at 1, 3 and 6 months of storage, all samples showed insignificant differences between the batches (p <0.05). The water activity values indicated a downward trend in water activity with increasing storage time (Table 5). The values of the control samples were higher than all samples of the experimental batches. Alirezalu et al. found that during a 45-day storage period, no significant differences were observed in the water activity values of sausages that included mixed plant extracts **[49]**, **[50]**.

Table 5 Water activity of pâté samples during storage.

Storage time	Control	Experimental		
		Variant 1	Variant 2	Variant 3
Production day	$0.98^{a} \pm 0.00$	$0.97^{a} \pm 0.00$	$0.97^{a} \pm 0.00$	$0.97^{a} \pm 0.00$
1 month	$0.97^{a} \pm 0.02$	$0.97^{a} \pm 0.00$	$0.96^{a} \pm 0.00$	$0.96^{a} \pm 0.02$
2 months	$0.95^{a} \pm 0.01$	$0.96^{a} \pm 0.00$	$0.96^{a} \pm 0.01$	$0.96^{a} \pm 0.00$
3 months	$0.95^{a} \pm 0.01$	$0.96^{a} \pm 0.01$	$0.96^{a} \pm 0.01$	$0.95^{a} \pm 0.01$
6 months	$0.95^{a} \pm 0.01$	$0.96^{a} \pm 0.01$	$0.95^{a} \pm 0.01$	$0.95^{a} \pm 0.01$
12 months	$0.95^{a} \pm 0.01$	$0.95^{a} \pm 0.01$	$0.95^{a} \pm 0.01$	$0.94^{a} \pm 0.01$

Note: Identical letters in the column mean that the test showed no significant difference between the batches (p >0.05).

The pH values of the control samples were slightly lower than those of the experimental samples (Table 6). The tendency to grow pH with the increase of plant extracts in the composition of the batch is visible. This trend continued at the beginning of storage (day of production) and during the entire storage period. Similar results were obtained by Ibrahim et al. in the study of Jojoba (*Simmondsia Chinensis*), *Jatropha curcas*, *Panax ginseng* and ginger (*Zinger officinale*) on the pH of lamb cutlets **[51]**. Adding liquorice root extract and ginger root extract to the experimental sample appeared to have an initial effect on both water activity and pH, with lower water activity and higher pH. However, after an initial adjustment period, the samples eventually reached similar water activity levels and relatively stable pH values. In conclusion, the addition of liquorice root extract and ginger root extract to the mutton liver pate did not significantly affect the water activity and pH values. The control and experimental samples showed stable water activity and pH levels during the 12-month storage period.

Table 6 pH of pate samples during storage.

Storage time	Control	Experimental		
		Variant 1	Variant 2	Variant 3
Production day	5.90 ±0.11[a]	5.98 ±0.13[b]	6.15 ±0.09[c]	6.18 ±0.07[d]
1 month	5.89 ±0.05[a]	5.95 ±0.03[a]	6.06 ±0.01[a]	6.15 ±0.07[b]
2 months	5.94 ±0.17[a]	5.94 ±0.03[b]	6.05 ±0.06[b]	6.17 ±0.02[c]
3 months	5.94 ±0.02[a]	5.99 ±0.05[b]	6.14 ±0.09[c]	6.22 ±0.07[d]
6 months	5.98 ±0.04[a]	6.05 ±0.08[a]	6.26 ±0.04[a]	6.31 ±0.05[d]
12 months	6.01 ±0.01[a]	6.07 ±0.11[b]	6.25 ±0.02[c]	6.34 ±0.09[d]

Note: [a-d] Values with different letters mean a significant difference between the batches (p <0.05). Identical letters mean that the test showed no significant difference between the batches (p >0.05).

Sensory analysis was conducted to evaluate the experimental batch of pâté compared to the control. The experimental batches of pâté were evaluated by trained panellists as being lighter in colour, having a spreading consistency, and being juicier (Table 7).

Table 7 Sensory analysis of liver pates with the addition of licorice root and ginger.

Parameter	Control	Experimental		
		Variant 1	Variant 2	Variant 3
Color (light – dark)	8.1 ±0.30[a]	8.1 ±0.20[a]	8.0 ±0.22[b]	7.5 ±0.01[b]
Smell (aroma) (intense – faint)	8.8 ±0.21[a]	8.9±0.20[a]	9.0 ±0.28[b]	8.8 ±0.32[a]
Taste (sweet – salty)	8.3±0.32[a]	8.1 ±0.21[a]	8.3 ±0.16[a]	8.2 ±0.29[a]
Consistency (firm – soft)	6.0±0.31[a]	6.3 ±0.20[b]	8.0 ±0.18[c]	8.2 ±0.30[c]
Juiciness (dry – juicy)	7.8 ±0.28[a]	8.2 ±0.33[b]	8.8 ±0.45[c]	9.0 ±0.37[c]
Particles in the mass (insignificant – noticeable)	9.0 ±0.37[a]	9.0 ±0.20[a]	9.0 ±0.21[a]	8.9 ±0.30[a]
Overall score	7.9 ±0.41[a]	8.0 ±0.30[a]	8.55 ±0.27[b]	8.4 ±0.33[c]

Note: [a-d] Values with different letters mean a significant difference between the batches (p <0.05). Identical letters mean that the test showed no significant difference between the batches (p >0.05).

According to the sensory evaluation results (Table 7), all experimental and control samples did not show critical differences in taste and the presence of particles in the liver paste. Differences were noticeable in the evaluation of colour: the experimental samples with 2% liquorice root-3% ginger root (8.0 points) and 3% liquorice root – 4% ginger root (7.5 points) had a pale colour. The texture of the control sample (6.3 points) was evaluated as harder and drier than the experimental samples. Tasters rated the sample with 3% liquorice root and 4% ginger root as the most tender and juicy (8.2 and 9.0 points, respectively). With the increase of plant ingredients in the experimental samples, there was a trend towards a more pronounced tender and spreading consistency. As a result of the sensory analysis of the liver paste samples showed positive changes in consistency, juiciness, aroma, and overall evaluation with the introduction of plant extract ingredients into the recipe. Several studies reported comparable findings, indicating that using rosemary and green tea extracts **[42]**, **[52]**, **[53]** elderberry extract **[54]**, **[55]** guarana seed extracts **[56]** did not deteriorate the overall acceptability of meat products among consumers.

CONCLUSION

Product safety is one of the main selection criteria when consumers choose ready-to-eat foods. Adding a new ingredient to the traditional component composition of the product can significantly vary the microbiological indicators, which in turn are closely related to the values of water activity and pH. Microbiological parameters of experimental and control samples were within the regulated norms during 12 months of storage at 4 °C. Among the experimental samples, the sample containing 2% liquorice root – 3% ginger root, and 3% liquorice root – 4% ginger root showed the most optimal indicators of inhibition of undesirable microflora. During the storage period, a decrease in water activity and increased pH value were observed. The sensory analysis findings indicate that adding lard and plant-based ingredients to the pâté recipe had a beneficial effect on its consistency, juiciness, aroma and overall rating. The results of experimental studies have shown the prospects of using extracts of ginger root and liquorice as new and natural ingredients with functional properties to improve the microbiological stability of liver pates. Future research should investigate optimizing ingredient ratios, texture effects, and nutritional profiling to enhance the sensory appeal and nutritive value of liver pâtés containing liquorice and ginger extracts.

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