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EFFECT OF GERMINATED WHEAT (*TRITICUM AESTIVUM*) ON CHEMICAL, AMINO ACID AND ORGANOLEPTIC PROPERTIES OF MEAT PATE

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ABSTRACT

Germinated cereal crops are widely used in the technology of meat products, as they contain a significant amount of vitamins, minerals and protein. This study presents the formulation and processing technology of meat pate with the addition of wheat (*Triticum aestivum*) germ. Three treatments of 10, 15 and 20% of germinated wheat (GW) were prepared. Wheat sprouts were crushed and mixed for 6 minutes in a meat mixer together with broth, oat flour, and spices to obtain a smooth mass. This was mixed with minced meat and grinded on a cutter to obtain a more uniform finished paste that was dosed into lamister or tin containers, sterilized and stored for 2 years. This was followed by the determination of its proximate composition, water-binding capacity, and sensory analysis. Results show that the meat pate with 10% of GW in comparison with the control, contains more protein, is more nutritious with a lower fat content of 6.8%, and a lower carbohydrate content of 11.3%. The results of the organoleptic evaluation showed that the highest average score was for the meat pate with a recipe that contains 10% of germinated wheat, and the lowest was for the meat pate containing 20% of germinated wheat. Meat pate containing 10% of germinated wheat has a higher water-holding capacity and the optimal pH value. This study suggests that wheat can be used in appropriate formulation to improve the organoleptic quality of meat pate.

Keywords: meat pate; wheat; germination; water-holding capacity

INTRODUCTION

The modern approach of nutrition science applies high requirements to food products quality, taking into account not only its energy value but also the presence of components necessary for human health (a complex of biologically active substances, dietary fiber, pectin, organic acids, minerals, etc.) possessing immunostimulating, radioprotective, prophylactic and healing properties **(Kakimov et al., 2017; Kolbábek et al., 2019)**. Due to the deficiency of meat, meat industry experts are developing new methods of production by replacing meat with protein-containing raw materials and protein supplements that are close in quality to meat protein **(Kenenbay et al., 2017; Momchilova et al., 2019)**. Recently, there has been a steady trend in the development and production of combined meat products, where along with meat, the plant raw materials sampled from the local region are used to regulate the protein, lipid, amino acid, fatty acid, carbohydrate, mineral and vitamin composition of the food product **(Arihara, 2006; Kassenov et al., 2019)**. The production of combined meat products based on plant materials is one of the promising areas for the creation of food products for the medical and preventive purposes of the modern food industry (**Nishanova et al., 2020**). Pate is a meat product made of thermally processed ingredients with spreading consistency. The classic pate recipe includes liver, offal, meat, animal fats (lard, poultry fat, and butter), pepper, spices, and salt **(Okuskhanova et al., 2016; Smolnikova et al., 2019)**. The goal of this study was to evaluate the nutritive value of meat pate enriched with germinated wheat as a contribution towards the improvement of the organoleptic quality of this delicacy.

Scientific hypothesis

The scientific hypothesis of this work is the creation of low-waste, resource-saving technologies of new kinds of pate products, using low-grade meat raw materials and wheat sprouts, allowing to increase biological value (chemical, amino acid composition), physico-chemical and organoleptic characteristics of meat pate in a directed way.

MATERIALS AND METHODS

Materials: The technological process of production consists of the following operations

The meat trimmings from the head of cattle were washed and cut into small pieces. Then the pieces of meat trimmings were cooked for 1 – 1.5 hours. After cooking it was weighed and crushed in a meat grinder with a diameter of the plate holes (2 – 3) mm. Onions were peeled, washed, chopped

into cubes, sautéed in butter for 10 – 15 minutes, weighed, then minced in a meat grinder (plate with holes of diameter 2 – 3 mm). Wheat sprouts were crushed and the crushed components were mixed in a meat mixer. Broth, oat flour, spices were added and mixed into a smooth mass. The mixing time was 6 minutes. The minced meat was grinded on
a cutter to obtain a more uniform structure. The finished paste was dosed into a lamister container weighing 200 grams or a tin container weighing 360 grams. Lamister is a combined material that consists of foil and polypropylene film, interconnected by an adhesive layer. The pate was sterilized using the sterilization formula (20 – 40 – 20)/120, 150 – 200 kPa at a temperature of 120 ºC for 20 minutes. The pate was stored at a temperature of 18 – 20 °C with a relative humidity of 80% for 2 years. The technological scheme is presented in Figure 1.

Determination of proximate composition

The determination of the chemical composition of meat was based on the evaluation of the following constituents: moisture, fat, ash, and protein. The methods were performed as described by **Amirkhanov et al. (2017)**. To determine water content, a 2 – 3 g aliquot of each sample of meat was weighed to the nearest 0.001 g using a Mettler Toledo electronic balance (Greifensee, Switzerland) and placed into a metallic cup (IngoLab, Moscow. Russia). It was then dried for 1 h in a drying oven (SNOL 67/350; Umega, Utena, Latvia) at 150 °C. The moisture content was calculated using Equation 1, according to the **GOST 9793-74 (2010)** and **GOST R 51479-99 (2010)** standards.

$$x_1 = (m_1 - m_2) \,.\, 100/(m_1 - m) \qquad (1)$$

Where: x_1 is the moisture content (%), m_1 is the weight of the sample with a cup before drying (g), m_2 is the weight of the sample with the cup after drying (g), m is the weight of the cup alone (g).

After determining the moisture, each dried sample was moved to a glass cup. Then, 15 mL of ethyl ether (100% chemically pure; Skat, Almaty, Kazakhstan) was poured into the glass cup, and the contents were mixed for 3 – 4 min. During the extraction process, the organic fraction containing the fat residues was poured out and replaced with fresh ethyl ether. After 4 – 5 repetitions, the residual ethyl ether was evaporated at room temperature. The metallic cup containing the fat-depleted sample was dried at 105 °C for 10 min. The fat content was calculated according to the **GOST 23042-86 (2010)** standard using Equation 2.

$$x_2 = (m_1 - m_2) \,.\, 100/m_0 \qquad (2)$$

Where: x_2 is the fat content (%), m_1 is the weight of the cup and dry sample before extraction (g), m_2 is the weight of the cup, and sample after extraction (g), m_0 is the weight of the cup alone (g).

To obtain the ash content, the sample from which the fat was extracted was placed into a weighed and preheated (to 150 °C) crucible (50 cm^3; Mankor, Kyiv, Ukraine). Then, 1 mL of magnesium acetate (98% purity; Labofarma, Almaty, Kazakhstan) was added to the crucible and burned on an electric hot plate. After that, it was placed into a muffle furnace set at 500 – 600 °C (SNOL 7.2/1100; Umega) for 30 min. The ash content was calculated using Equation 3.

$$x_3 = (m_1 - m_2) \,.\, 100/m_0 \qquad (3)$$

Where: x_3 is the ash content (%), m_1 is the weight of the ash (in g), m_2 is the weight of the magnesium oxide obtained after mineralization of the magnesium acetate (g), and m_0 is the weight of the sample alone (g).

Protein content was assayed according to the **GOST 25011-81 (2010)** standard and calculated using Equation 4.

$$x = 100 - (x_1 + x_2 + x_3) \qquad (4)$$

Where: x is the protein content (%), x_1 is the moisture content (%), x_2 is the fat content (%), and x_3 is the ash content (%).

Water-binding Capacity

The method used to determine the water-binding capacity (WBC) of the samples was based on exudation of moisture to a filter paper by the application of pressure. The moisture absorbed by the filter paper is evaluated based on the spot area on the filter paper. Specifically, for each sample, 0.3 g of minced meat was placed on a 15 – 20 mm diameter disk plate on a Mettler Toledo electronic balance, (Mettler Toledo, Switzerland). The meat was then transferred onto an ash-free filter (Munktell Filter AB, Sweden) and placed on a glass or plexiglass plate. The sample was covered with the same filter before a 1 kg load was carefully placed on top of the meat. The weight was left for 10 min. Once removed, the top filter was pulled off and bound water was calculated, as described below (see Equation 1 and 2). The filter was scanned using an Xpress M2070 scanner (SAMSUNG, Japan) after the contour of the wet spot was traced on the filter. The area was calculated using the Compas-3D V-10 software **(Kabulov et al., 2014; Okuskhanova et al. 2017)**

$$X_1 = (A\text{-}8.4B) \,.\, 100/m_0, \qquad (1)$$
$$X_2 = (A\text{-}8.4B) \,.\, 100/A; \qquad (2)$$

Where: X_1 is bound water content (expressed as % of meat), X_2 is bound water content (expressed as % to total water), B is a wet spot area (cm^2), m_0 is sample weight (mg), A is the total content of moisture in the sample (mg).

Sensory analysis

Sensory evaluation was done by a panel of twelve (12) skilled persons (aged 23 – 58). In case of defects in flavor and aroma (inadequate pronounced flavor, weedy flavor, and slightly acid flavor), consistency and structure, color, and packaging, the score mark were reduced for each defect according to the special sensory evaluation scale. The evaluation scale ranged from 1 to 5 points, where 1 – Unliked extremely; 5 – Liked extremely.

Table 1 Chemical composition of pate with germinated wheat grain.

Index	Pate with 10% of GW	Pate with 15% of GW	Pate with 20% of GW	Control beef pate "Kubley"
Protein (%)	14.36 ±0.30[a]	12.60 ±0.28[c]	13.20 ±0.31[bc]	14.00 ±0.21[ab]
Fat (%)	6.80 ±0.20[b]	7.77 ±0.21[a]	5.50 ±0.11[c]	7.2 ±0.27[ab]
Carbohydrate (%)	11.30 ±0.26[b]	11.85 ±0.21[b]	13.35 ±0.48[a]	11.5 ±0.36[b]
Water (%)	66.44 ±1.31[a]	66.78 ±1.21[a]	67.10 ±1.65[a]	72.4 ±2.18[a]
Ash (%)	1.10 ±0.03[b]	1.00 ±0.01[b]	0.85 ±0.02[c]	1.30 ±0.04[a]
Calorie value, kCal	161.0	163.0	152.3	154.3

Note: [a, b, c, d] means values within the same row with different superscripts significantly differ (p <0.05).

Table 2 Physico-chemical characteristics of pate with GW.

Index	Pate with 10% of GW	Pate with 15% of GW	Pate with 20% of GW	Control beef pate "Kubley"
Salt weight percent (%)	1.0	1.2	0.9	1.2
pH	6.7	6.9	6.85	6.7
Water-binding capacity (%)	73	71	68	70

Table 3 Organoleptic characteristics of meat pate.

Index	Pate with 10% of GW	Pate with 15% of GW	Pate with 20% of GW
Appearance	4.8	4.6	4.5
Color	4.9	4.7	4.8
Flavor	5.0	4.7	4.6
Taste	4.8	4.6	4.6
Consistency	5.0	4.7	4.6
Average score	4.9	4.66	4.62

Table 4 Amino acid composition of meat pate in g.100g^{-1}.

Amino acid	Pate with 10% of GW	Pate with 15% of GW	Pate with 20% of GW	Control beef pate "Kubley"
Essential	7.742	7.379	7.086	4.3549
Threonine	0.961	0.922	0.883	0.4631
Isoleucine	1.064	1.021	0.977	0.5295
Lysine	1.969	1.873	1.777	0.8087
Methionine	0.588	0.561	0.535	0.2456
Cysteine	0.247	0.241	0.235	0.182
Phenylalanine	0.863	0.834	0.806	0.5285
Valine	0.838	0.806	0.775	0.7024
Leucine	1.212	1.121	1.098	0.8951
Non-essential	10.612	10.222	9.832	4.2042
Tyrosine	1.116	1.074	1.032	0.4122
Arginine	1.483	1.424	1.365	0.7394
Histidine	0.821	0.786	0.751	0.4719
Alanine	1.299	1.243	1.187	0.5823
Aspartic acid	2.088	1.997	1.907	0.7988
Glutamic acid	3.805	3.698	3.59	1.1996
Total	18.354	17.601	16.918	8.5591

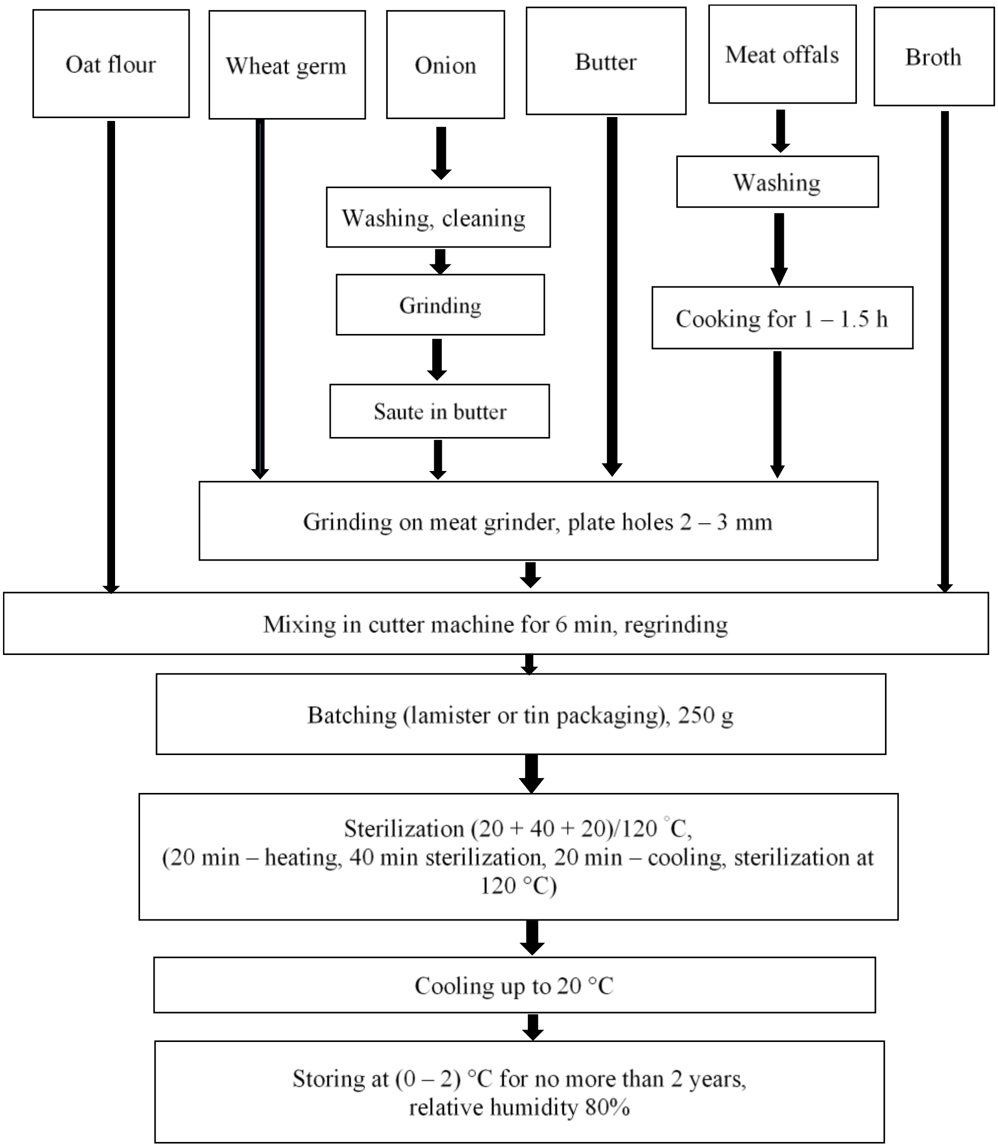

Figure 1 Meat pate processing flow chart.

Statistical Analysis

Statistical analysis was performed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using the ANOVA method. The differences were considered to be statistically significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

Previous studies revealed that meat trimmings from heads of cattle have lower vitamin and microelement contents compared to beef **(Berdutina, 2000; Bondarenko and Elizarova, 2014; Makangali et al., 2018; Verma et al., 2008)**. At the same time, it has a sufficient level of protein content with a higher total content of essential amino acids in comparison with beef – the content of essential amino acids in beef is 37.07 $g.100g^{-1}$ of protein, and in the head of cattle – 38.66 $g.100g^{-1}$ of protein. The chemical composition of meat pates is shown in table 1 in comparison with the control. The obtained results (Table 1) show that meat pate with 10% of GW in comparison with the control, contains more protein and is more nutritious with a lower fat content of 6.8% and a lower carbohydrate content of 11.3%. **Gorlov et al. (2019)** also used germinated lentils (15%) and carrot (15%) in meat pate formulation. In terms of chemical composition, the pate in their study contained more protein 17.44% and lower fat (4.52%) compared with our study. However, the carbohydrates and calorie values were the same. **Lyakh et al. (2016)** proposed an optimal formulation of pate, with a ratio of components: 50% of mutton and 50% of horsemeat with the replacement of meat by dill and addition of 2 g "Policorbovit-95". The sample with replacement of 10% of meat with dill had the best organoleptic indicators. The content of protein (17.8 %) and fat (12.56 %) considerably differs from our results.

Chizhikova et al. (2017) studied the chemical composition of minced meat with the addition of 26% germinated wheat and found that the protein content was 15.8%, fat 12.5%, and ash 1.16%. At the same time, the authors noted that the addition of such amounts of germinated wheat did not worsen the organoleptic properties of minced meat. **Martemyanova and Yasakov (2014)** used wheat bran, sea cabbage, inulin, ginger CO_2 extracts in liver pate formulation. The wheat bran was added from 10 to 20% instead of pork fat. The authors observed an increase in protein content and a decrease in fat as the quantity of plant components increased. As a result, a prophylactic product with probiotic properties was obtained which could contribute to thyroid disease prevention.

Alexeeva et al. (2017) studied the possibility of applying vegetable food additives from wheat germ cake, alfalfa, and albumin seeds to pates from the liver. Their evaluation of the pate quality revealed that the addition of 15% vegetable food additive to the pate recipe had a positive effect on the water-binding, moisture-holding, and emulsifying ability as well as organoleptic characteristics. In terms of chemical composition, the protein content varied from 14.61 to 16.95 g.100g^{-1}, fat from 13.52 to 14.34 g.100g^{-1} depending on the type of pate. The authors emphasize that the addition of vegetable food additives to the food dispersions does not require special technological methods and additional equipment.

Lukyanchenko and Makarova (2009) used germinated grains or lentil sprouts up to 15% to the mass of raw materials in the recipe of chicken liver-based meat pate. Adding to the pate high-protein legumes, such as lentils, allows us to obtain a product of high nutritional value.
Water-binding capacity (WBC) characterizes the ability of a meat product to absorb and retain water **(Goh et al., 2012; Zhang et al., 2010)** and it significantly affects the rheological characteristics, organoleptic and sensory properties **(Rogov et al., 2009; Bakieva et al., 2019)**. The research results showed that meat pate with 10% of germinated wheat has the highest water-binding capacity (73%). This is probably because this sample contains 7% oat flour, which increases its strength and ability to retain moisture. Other samples contain less oat flour.

The degree and strength of water binding in minced meat also depends on the medium conditions (pH, temperature, salt composition) **(Damez and Clerjon, 2008; Rao et al., 1989)**. A similar trend in pH and WBC was observed in the work of **Veretnova and Safronova (2015)**, where combined minced meat with the addition of germinated wheat grain in the amount of 10% was investigated. The authors noted that the pH value of model minced meat coincides with the pH value of the control sample with the addition of up to 10% paste to the mass of minced meat instead of bread. The highest pH value was observed when 10% of germinated wheat grain was added. When more germinated wheat pasta (20 %) was added, the WBC value decreases by 1.5 %.

In the present study, the results of the organoleptic evaluation (Table 3) showed that the highest average score was obtained from the meat pate with a recipe that contains 10% of germinated wheat, and the lowest from the meat pate containing 20% of germinated wheat.

The biological value of proteins is determined by the optimal range of vital amino acids **(Alekseeva and Kolchina, 2019)**. The research results show that the meat pate with a content of 10% germinated wheat has a predominant content of essential and non-essential amino acids, as this sample contains a higher content of animal protein of meat trimmings. The amino acid composition showed a higher content of essential (7.742) and non-essential (10.612) amino acids in the pate sample with the addition of 10% GW. As the proportion of GW increases, these values decrease slightly. However, this amino acid composition is significantly higher in quantity than the amino acid in the pate control sample.

CONCLUSION

This study was focused on the assessment of the nutritional and biological value of meat pate enriched with germinated wheat. It revealed that in terms of chemical composition, meat pate with a content of 10% germinated wheat showed a high protein content of 14.36%. By analysing the amino acid composition, the pate enriched with 10% germinated wheat had an increased content of essential and non-essential amino acids compared to pates prepared with the addition of 15% and 20% of germinated wheat. The meat pate enriched with 10% germinated wheat provided the best amount of essential amino acids, had a denser consistency and maintained high consumer properties. This suggests that the nutritive value of meat pate enriched with germinated wheat is higher, demonstrating that wheat can be used in appropriate formulation to improve the organoleptic quality of meat pate.

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