

Study of the nutritional and biological value of meat loaf from chicken meat and chickpea flour

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ABSTRACT

This paper describes the recipe and the method of preparation of meat loaf, the main ingredients of which are chicken meat, chickpea flour, tomato paste, eggs and breadcrumbs. Four variants of meat loaf with replacement of chicken minced meat with chickpea flour in the amount from 0 to 20% are produced. Chemical, amino acid, mineral and vitamin compositions are determined using standard methods. The analysis of chemical composition indicated that the replacement of chicken minced meat with chickpeas flour significantly increases the content of carbohydrates from 4.34% (control variant) to 14.38% (variant 4, $P < 0.001$), protein from 14.84% to 15.55% and ash from 1.30% to 1.62% ($P < 0.01$). In terms of amino acid composition, adding chickpeas flour increases the content of arginine ($P < 0.02$) and phenylalanine ($P < 0.02$; $P < 0.05$) in the 2nd and 3rd variants of the product. The content of calcium ($P < 0.001$), potassium, magnesium and iron and vitamin B1 (from 0.089 mg/100g to 0.231 mg/100g) increases significantly. The proposed variant of preparation of meat loaf increases the nutritional value of the product.

Keywords: Meat loaf; Chicken file; Tomato paste; Chickpea; Roasting; Nutrition.

INTRODUCTION

Meat is a source of animal protein, amino acids, minerals and vitamins, which are of great importance to the human body and are vital to the optimal functioning of vital processes (Zinina *et al.*, 2019; Bolger *et al.*, 2017). There are variety of variants of preparation of meat loaves. As a base can be used any meat: pork, beef, venison, veal, poultry, etc. Eggs, breadcrumbs, flour are added to chopped or minced meat. Spices and herbs, as well as chopped vegetables (onion or green, sweet pepper) have a positive effect on organoleptic characteristics (Zajac *et al.*, 2019; Devatkal *et al.*, 2004).

Poultry meat loaf is of particular interest because it has a comparatively lower price and at the same time is an excellent source of complete protein required for vital activity and growth of the human body. Poultry meat is easily assimilated by human organism and contains less connective tissue (Kassymov *et al.*, 2019; Dalle Zotte *et al.*, 2020). Poultry meat has a high nutritional and biological value and can be recommended for the production of dietary products. It contains a significant portion of protein (up to 22%), a balanced amino acid composition, low cholesterol and fats, includes a wide range of vitamins and minerals. It has low allergenicity and good digestibility (Tang *et al.*, 2009). Chicken meat is the cheapest to sell and, therefore, the most common among the general population (Borchenko, 2015).

The use of vegetable components in the technology of combined meat products provides high nutritional and biological value, enhances the flexibility of formulations, sustainable and uniform distribution of ingredients, minimizing losses in the process of production, which leads ultimately to a product of stable quality. The addition of vegetable ingredients to minced meat can be considered as one of the methods for producing high-quality meat products with controlled properties (Bazhina and Gavrilova, 2014; Kassymov *et al.*, 2020). A more promising and rational way to solve the problem of healthy nutrition, in the opinion of the scientific community, is a combination of meat and plant raw materials. Combination of meat and plant raw materials provides high nutritional and biological value, allows to diversify recipes, as well as uniformly distribute the ingredients, minimize losses during thermal treatment and create a good quality product (Kakimov *et al.*, 2019; Serikkaisai *et al.*, 2014).

The purpose of this work is to study the effect of chickpeas flour on the nutritional value of chicken meat loaf.

MATERIALS AND METHODS

Methods of preparation of meat loaves

The fillet of chicken thighs is chopped on a meat grinder (grid diameter 2-3 mm). Eggs, chopped garlic, salt and pepper are added to the ground meat. After mixing the minced meat thoroughly, it is mixed with tomato paste, finely sliced parsley, breadcrumbs and vegetable oil. Chickpeas flour is added according to the recipe (Table 1) during the minced meat preparation stage. The obtained minced meat is formed into rectangular forms and baked at 180 ° C for 60 minutes. Technological scheme of meat loaf production is shown in Figure 1.

Table 1: Recipe of meat loaves, %

Ingredient	Variants of meat loaf, %			
	1	2	3	4
Minced chicken meat	76	66	61	56
Chickpea flour	0	10	15	20
Breadcrumbs	4	4	4	4
Garlic	2	2	2	2
Egg	4	4	4	4
Tomato pasta	8	8	8	8
Vegetable oil	3	3	3	3
Parsley	2.5	2.5	2.5	2.5
Salt	0.4	0.4	0.4	0.4
Black pepper	0,1	0,1	0,1	0,1

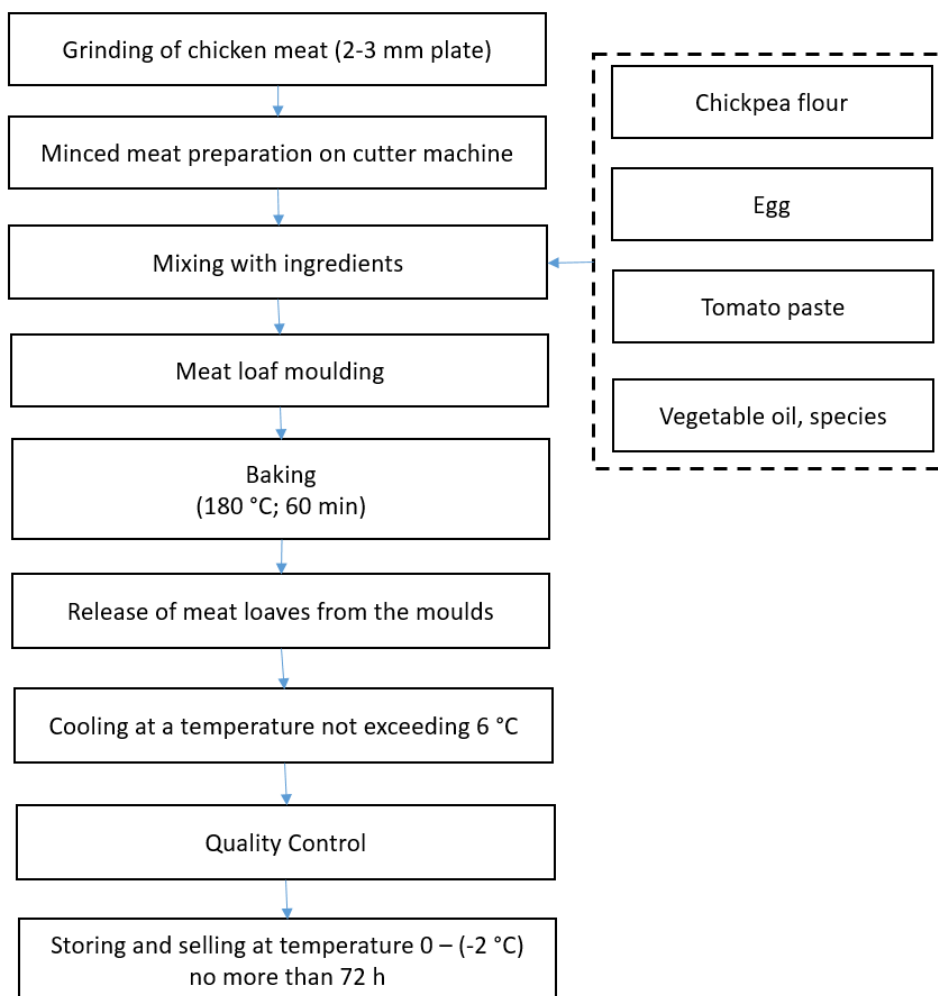


Figure 1: Process flow chart for meat loaf production

The determination of protein mass fraction was carried out according to Kjeldahl method (GOST 25011-81). The method was based on Kjeldahl sample mineralization, ammonia distillation into sulfuric acid solution with subsequent titration of the sample under study. Mass fraction of fat was determined in accordance with GOST 15113.9-77 by using butyrometer. The method was based on treatment of the investigated product with concentrated sulfuric acid in the presence of isoamyl alcohol during heating with the following centrifugation and determination of added fat by butyrometer indications. Determination of mass fraction of moisture (GOST R 51479-99) was carried out by drying the sample hood to a constant mass at a temperature of $(103 \pm 2) ^\circ\text{C}$ (Antipova *et al.*, 2001).

Amino acid composition

The method is based on acid hydrolysis of protein up to complete breakdown into amino acids with subsequent chromatographic determination of the mixture on an automatic liquid amino acid analyzer to determine the composition and mass fraction of the amino acids (GOST 34132-2017).

Mineral composition

The method is based on spraying a mineralizate solution of the test sample into an air-acetylene flame. Metals in the mineralizate solution then fall into the flame and turn to the atomic state. The value of light adsorption with the wavelength of the corresponding resonance line is proportional to the value of metal concentration in the test sample (Guidance, 2004).

Vitamin composition

The method is based on the extraction of water-soluble vitamins by sequential acid and enzymatic hydrolysis, protein precipitation and quantitative determination of vitamins by high-performance liquid chromatography in the ultraviolet (UV) area of the spectrum with a given wavelength (GOST R 55482, 2013).

Statistical Analysis

Statistical analysis was performed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using ANOVA method.

RESULTS AND DISCUSSION

The chemical composition is characterized by such indicators as the mass fraction of protein, fat, moisture, ash, i.e., the basic nutrients required for the human body. The analysis of chemical composition showed that replacing chicken minced meat with chickpeas flour significantly increases the content of carbohydrates from 4.34% (control variant) to 14.38% (variant 4), protein from 14.84% to 15.55% and ash from 1.30% to 1.62% (Table 2).

Table 2: Chemical composition of meat loaves, %

Variants of meat loaf	Moisture	Protein	Fat	Ash	Carbohydrate
1	69,94±1.78	14,84±0.31	9,58±0.26	1,30±0.03	4,34±0.09
2	64,98±1.40	15,19±0.40	9,25±0.24	1,45±0.02**	9,13±0.18***
3	62,35±2.27	15,49±0.44	8,91±0.24	1,55±0.04**	11,70±0.17***
4	59,59±1.71*	15,55±0.45	8,86±0.27	1,62±0.04**	14,38±0.45***

*P<0.02; **P<0.01; ***P<0.001

As carbohydrates increase, the amount of fat decreases slightly. Moreover, the addition of flour leads to a significant reduction in the amount of moisture in Variant 4 (P<0.02).

Proteins are the most essential and deficient component of food. Therefore, the qualitative composition of its amino acids is a determining factor in the protein completeness. The human body is unable to synthesize certain amino acids, and they must be derived from food. These are so-called "essential" amino acids: lysine, leucine, isoleucine, methionine, phenylalanine, threonine, tryptophan, valine (Tsaregorodtseva, 2018; Loveday, 2019).

Table 3: Amino acid composition of meat loaves, g/100g

Amino acid	Variants of meat loaf			
	Variant 1	Variant 2	Variant 3	Variant 4
Arginine	0,89±0.02	0,97±0.02	1,03±0.03*	1,06±0.02*
Valine	0,66±0.01	0,67±0.02	0,68±0.01	0,68±0.01
Histidine	0,42±0.01	0,42±0.01	0,43±0.01	0,43±0.01
Isoleucine	0,63±0.01	0,64±0.01	0,66±0.02	0,65±0.01
Leucine	1,08±0.02	1,10±0.03	1,12±0.03	1,12±0.01
Methionine	0,36±0.01	0,34±0.01	0,34±0.01	0,33±0.01
Threonin	0,58±0.01	0,59±0.02	0,60±0.01	0,59±0.01

Phenylalanine	0,55±0.01	0,59±0.01	0,62±0.01**	0,64±0.01*
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*P<0.02; **P<0.05

In terms of amino acid composition, adding chickpeas flour increases the content of arginine (P<0.02) and phenylalanine (P<0.02; P<0.05) in the 2nd and 3rd variants of the product. For other essential amino acids, no changes are observed (Table 3).

The mineral composition of meat loaf variants is presented in the Table 4. As chicken minced meat is replaced with chickpea flour, the content of calcium, iron, magnesium, manganese, potassium, copper and zinc increases. So, if the content of calcium in control variant without addition of chickpea flour was 18,17 mg/100g, then in the 4th variant (at addition of 20% chickpea flour) increased to 55,63 mg/100g. The increase in mineral substances is explained by their rich content in chickpea flour.

Table 4: Mineral composition of meat loaves, mg/100g

Element	Variants of meat loaf			
	Variant 1	Variant 2	Variant 3	Variant 4
Potassium	451,55±12,31	496,93±13,70	525,42±15,11*	545,97±11,27**
Calcium	18,17±0.47	36,05±1.12***	45,86±0.89***	55,63±1.50***
Magnesium	20,42±0.52	30,55±0.89***	36,48±0.78***	41,63±0.85***
Sodium	121,86±1.87	123,33±3.36	120,00±3.57	124,86±3.02
Sulfur	142,84±3.84	146,03±3.03	148,95±2.96	149,30±3.52
Phosphorus	149,95±4.55	176,29±4.98*	192,71±5.88**	204,93±5.63***
Iron	0,84±0.02	1,01±0.03**	1,11±0.03***	1,20±0.05***
Manganese	0,04±0.01	0,24±0.01***	0,36±0.01***	0,46±0.01***
Copper	0,07±0.01	0,12±0.01***	0,16±0.01***	0,19±0.01***
Zinc	0,11±0.01	0,38±0.01***	0,54±0.01***	0,68±0.01***

*P<0.02; **P<0.01; ***P<0.001

Vitamin composition of developed meat loaves is presented in Table 5. According to the data obtained, the addition of chickpea flour significantly increases the content of vitamin B1. The content of vitamins B2, B6, B12 is slightly reduced. In addition, there is a decrease in vitamin PP from 4,595 mg/100g to 3,888 mg/100g with the addition of 20% of chickpea flour in the recipe of meat loaf.

Table 5: Vitamin composition of meat loaf, mg/100g

Variants of meat loaf	Vitamin B1	Vitamin B2	Vitamin B6	Vitamin B12	Vitamin C	Vitamin PP
1 (control)	0,089±0.002	0,218±0.006	0,423±0.010	0,448±0.009	4,779±0.138	4,595±0.083
2	0,157±0.003*	0,210±0.007	0,402±0.008	0,398±0.010**	4,827±0.096	4,261±0.145
3	0,198±0.006*	0,206±0.003	0,393±0.007	0,372±0.012***	4,465±0.097	4,094±0.113***
4	0,231±0.006*	0,202±0.005	0,379±0.011**	0,342±0.014*	4,772±0.151	3,888±0.118***

*P<0.001; **P<0.05; ***P<0.01

In addition to chicken minced meat and chickpea flour, other ingredients also play a significant role in the nutritional value. Thus, tomato paste is rich in vitamins (PP, A, B1, B2, C, E), minerals (iron, magnesium, calcium, phosphorus, potassium, sodium), organic acids, dietary fibres and other nutrients. Tomato paste contains 35% of the recommended daily potassium content, which is necessary for the smooth operation of the heart (www.dom-eda.com; Meshchaneva, 2019).

Parsley leaves and stems contain indigestible food fibres, which are swollen in the intestine and gather unnecessary slags, toxins and salts of heavy metals from the walls, removing them naturally. Parsley is extremely rich in nutrients and minerals. Its content of ascorbic acid (vitamin C) is superior to many fruits and vegetables. In 100 g of young green shoots of parsley contains about two daily vitamin C levels. This is almost 4 times more than in lemons. Parsley contains a large amount of carotene, and on this indicator is as good as carrots. It is important that in 100 g of parsley contains two daily rates of provitamin A (calorizator). Parsley is rich in vitamins B1, B2, folic acid, and salts of potassium, magnesium, iron. Parsley also contains inulin, which regulates blood glucose metabolism (Tangieva *et al.*, 2014).

The addition of vegetable ingredients to the recipe of meat loaves and its impact on nutritional value are described in some studies. For example, in work (Hayrapetyan and Mangesov, 2019), the formulation and technology of meat loaf was improved by adding vegetable ingredients such as linseed flour, juniper berries and pine nuts. The protein content was 12.8%, fat 26.2% and moisture 42.4%. The authors note that the addition of pine nuts, linseed flour and juniper fruit in the formulation decreased the fat content in the finished product and allowed to enrich it with vitamins, vegetable protein and dietary fiber.

In work (Prokopets and Zhuravleva, 2012) it is noted that the addition of wheat bran to the formula of meat loaf bread up to 10% slightly increases the total amount of protein (13,0 g/100g) and significantly reduces the fat content (31,9 g/100g). The new product contains starch and dietary fiber, which favourably distinguishes it from the control sample without adding wheat bran.

In (Popkova and Anokhina, 2017) in the recipe of meat loaf based on the study of water-binding capacity and organoleptic properties it is considered to add such components as lentils - 30 %, vegetable oil - 5 % and tomato paste 4 % with the addition of 20 % water.

Naumova *et al.* (2016) studied the influence of chia seeds on consumer properties and mineral composition of meat loaf. The authors note that adding 10% of ground chia seeds to the recipe of meat loaf increases the protein content (by 7.2%); vegetable lipids (by 5.6%) by reducing the content of animal fat; mineral elements - calcium (1.7 times), magnesium (27%), copper (25%).

CONCLUSION

On the basis of the performed studies it was revealed that adding chickpea flour to the recipe of meat loaf allows to increase the nutritional and biological value of meat loaf. The content of carbohydrates, minerals (calcium, iron, magnesium, manganese, potassium, copper and zinc) and vitamin B1 increases significantly. The offered method of preparation of meat loaf provides an opportunity to increase nutritional value of the product and reduce the cost of the product by replacing chicken meat with a vegetable component.

Conflict of interest: None declared.

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