Journal of Experimental Biology and Agricultural Sciences

<http://www.jebas.org>

ISSN No. 2320 – 8694

EFFECT OF BEAN FLOUR ON THE CHEMICAL COMPOSITION, VITAMIN, MINERAL LEVEL AND ORGANOLEPTIC PROPERTIES OF MEAT ROLL

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Received – September 26, 2020; Revision – November 13, 2020; Accepted – December 11, 2020

Available Online December 15, 2020

DOI: [http://dx.doi.org/10.18006/2020.8\(Spl-2-AABAS\).S368.S373](http://dx.doi.org/10.18006/2020.8(Spl-2-AABAS).S368.S373)

KEYWORDS

Bean

Meat Roll

Minced Beef

Yield Stress

Consistency

Vitamin C

ABSTRACT

This study was carried out to evaluate the effect of bean flour on the nutritional value and the yield stress of meat rolls. The main components of meat rolls are minced beef, eggs, bread, milk, and beans, but in the current study, the author mixed bean flour with these active ingredients and evaluated the effect of this on the various nutrient parameters of meat rolls. Four samples of meat rolls were prepared, with 0% to 20% beans flour. Results of the study found that depending on the concentration of beans, the moisture content, level of carbohydrate, and other nutritive parameters of meat roll have changed significantly due to the specific chemical composition of the bean flour. In terms of vitamin composition, significant changes are observed in the content of vitamin C and vitamin B1. The addition of bean flour (up to 15%) to minced rolls gradually increases the yield stress and improving the consistency of the product. According to organoleptic evaluation, the addition of up to 15% of beans has a positive effect on the consistency of the product due to improved water-binding ability. Results of the study suggesting new data related to the impact of bean flour on the nutritional value and consistency of meat rolls. The developed technology and recipe can be used for large scale meat rolls production.

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Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

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1 Introduction

A nutritious diet is an important factor for maintaining the health and productivity of the human. Meat is one of the most important sources of protein, essential amino acids, fatty acids, vitamins, and minerals required for normal body growth. Various by-products of red and white meat are produced under the name of meat products. The short-term expansion of the meat products production is due to the ease of production, variety of products, increasing employment, and the need for ready-made materials (Devatkal et al., 2004; Nurgazezova et al., 2016; Irshad et al., 2016). Meat products take a special place in the nutrition of modern humans because these are supplying complete proteins containing essential amino acids, vitamins, fatty acids, minerals, and trace elements (Kabulov et al., 2020). One of the types of meat dishes is meat rolls; a meat roll is a product of meat wrapped or filled with some ingredients or a mixture of ingredients. The rolls are made from the front and back hams of the carcass, with or without skin, removing bones and making the meat rolled up like a roll. Mostly these rolls are made up of lamb and beef. These rolls are cooked in boiled-smoked or raw-smoked. Sometimes these are dry, but dense consistency of dark red color muscle tissue (Devatkal et al., 2004; Nurgazezova et al., 2016; Irshad et al., 2016). It is important to combine raw plant materials as an additional ingredient with these rolls. The use of raw plant materials as a protein source is one of the effective methods of human nutritional status regulation, this makes the food enrich with necessary micronutrients and compensate for the deficiency of animal proteins (Nina et al., 2019; Rauf et al., 2020).

In terms of chemical composition, the beans are rich in carbohydrates and protein. High protein content in beans makes this one of the important sources of proteins that help in solving protein deficiencies in the diet of consumers. Using the beans as food and food ingredients is an important strategic and economic policy for the country as a whole. Depending on the variety, beans contain on average 18-25% protein (Bodoshov, 2015). Further, bean's proteins included all

essential amino acids and are almost identical in nutritional value to proteins of animal origin. The mature bean seeds contains 17-33% protein, 0.8-3.6% fat, 50-60% carbohydrates, 5-8% fiber. The amount of essential amino acids in the bean seed protein varies with the types (%): arginine (8.1-9.9), histidine (2.3-3.6), lysine (3.4-5.7), methionine (1.7-1.9), tyrosine (2.4-3.0), tryptophan (0.8-1.8), and cystine (1.2-1.6). Also, it has a significant concentration of vitamins (thiamine, riboflavin, niacin, and vitamin E) and various minerals such as potassium, calcium, magnesium, sulfur, phosphorus, iron, copper, manganese. The total amount of ash in bean flour is 2.6-3.7% (Vavilov, 1986; Spaar, 2000; Gorbatoevskaya et al., 2015). The content of non-protein nitrogenous substances (salts of nitric acid, peptides, glutamine, asparagine, and other free amino acids) is up to 0.3%, and the total nitrogen was up to 8.8% (Arora, 1986).

The development of new kinds of products, the main component of which is meat, requires the most possible use of various kinds of plants in technological processes, including cereals, legumes, and vegetables. Increases the protein concentration in the human diet leading to the development of immunity and increases the resistance against harmful environmental factors (Kaldarbekova et al., 2019). The present experiment aimed to study the effect of the addition of bean flour on the chemical and vitamin composition, organoleptic and structural-mechanical properties of minced meat roll.

2 Material and Methods

2.1. Preparation of minced meat rolls

At the first stage, mincemeat is being prepared. The beef minced meat is mixed with an egg, onion, and bread crumbs pre-soaked in milk. The obtained minced meat is rolled out in the form of an oval with a thickness of 0.7-1.0 cm. On the rolled out surface, the finely sliced cooked egg, grated cheese, and greens are placed evenly. Then, it is rolled up as a roll and greased with sour cream. The meat roll is baked for 40 minutes at 200 °C (Table 1).

Table 1 Formulation of meat rolls

Ingredient	Variants (%)			
	Variant 1	Variant 2	Variant 3	Variant 4
Beef minced meat	55	45	40	35
Bean flour	0	10	15	20
Wheat bread	4	4	4	4
Milk	10	10	10	10
Egg	15	15	15	15
Cheese	5	5	5	5
Onion	3.5	3.5	3.5	3.5
Wheat flour	5	5	5	5
Sour cream	2	2	2	2
Salt	0.4	0.4	0.4	0.4
Black pepper	0.1	0.1	0.1	0.1

The evaluation of the meat chemical composition was based on the determination of the constituents includes moisture, fat, ash, protein, and other related indices. The processes were performed with the protocol described by Antipova et al. (2001).

2.2. Water binding

The water-binding ability (WBC) of meat roll is based on the exudation of moisture to a filter employing the pressure. The absorption of moisture through the filter is estimated with the spot region on the filter. In unique terms, 0.3 g of minced-meat samples used to be positioned on the 15 to 20 mm diameter disk on a Mettler-Toledo digital balance (Mettler Toledo co., Switzerland). This was followed by the meat transferred on an ash-free filter (Munktell Filter AB, Sweden) and positioned on a glass or plexiglass plate. The pattern was protected with the filter before a 1 kg load was placed on the pinnacle of meat. The used weight was removed after 10 min. Once weight removed, the used filter pulled off, and certain water used to be estimated, as described under (Equations 1 and 2). The filter has been scanned with an Xpress scanner (SAMSUNG Co, Korea) after the contour of the wet spot used to be traced on the filter. The region was calculated using Compas 3D V.10 software program (Okuskhanova et al., 2017).

$$X_1 = (A - 8,4B) \cdot 100 / m_0, \quad (1)$$

$$X_2 = (A - 8,4B) \cdot 100 / A; \quad (2)$$

where X_1 : bound water content, as % of meat; X_2 : bound water content, as % to total water; B : wet spot segment (cm^2); m_0 : weight (mg); A : total content of moisture (mg).

2.3. Yield stress determination

The yield stress of the product was determined by immersing the cone in minced meat in the automatic universal device "Strucrometer" with a software package which is designed by the research and production company "Radius" (Russia). For each sample, the yield stress values are calculated for θ_0 (Pa) with a fixed immersion duration:

$$\theta_0 = K \frac{m}{h^2} \quad (3)$$

Where K - cone constant, m – mass of the cone and all movable parts, h - cone immersion depth.

Taking into account that the device "Strucrometer" instead of the mass of the cone and all movable parts gives the value of loading in grams, and the depth of the cone immersion in millimeters, respectively, for the convenience of calculations formula (3) is transformed into the following dependence:

$$\theta_0 = K \cdot \frac{P \cdot 9,81 \cdot 10^3}{h^2}, \text{ Pa} \quad (4)$$

Where P - instrument force (g)

Accordingly, the cone constant, for a cone of a device having an angle at the apex equal to α , is calculated by the formula:

$$K = \frac{\cos^2(\alpha/2)}{\pi \cdot \text{tg}(\alpha/2)}, \quad (5)$$

Where α – cone-apex angle ($\alpha=45^\circ$ and $\alpha=60^\circ$).

The average arithmetic value of yield stress for each variant of investigated samples is calculated by:

$$\theta_0 = \frac{\sum \theta_i}{i} \quad (6)$$

Where i – number of measurements.

2.4. Evaluation of organoleptic indicators

The quality of the uncut and semi cut finished product was assessed first. The quality indexes for the whole product are evaluated in the following sequence:

- I. Appearance, colour, and surface condition measured visually by external inspection.
- II. Odour of the product was determined by the needle method from the surface (For this special needle was used, it is introduced into the deep thickness of the product and quickly removed and the odour was determined).
- III. Consistency of the product was determined by pressing the product with a finger or a pallet.

The color, appearance, and pattern of the cut product as well as the distribution of ingredients were also determined. Further, the smell, aroma, flavor, and juiciness of the product are also well evaluated by paying attention to the absence or presence of foreign smell, the degree of the aroma of spices and flavors. The obtained results are evaluated by a point system or descriptively, for compliance of quality indicators with the requirements of standards and specifications (GOST, 1991).

2.5. The Statistical analysis

Statistical analysis was conducted using Statistica version 12.0 (STATISTICA, 2014, USA). The differences between means were evaluated by the ANOVA method.

Table 2 Chemical composition of meat rolls (%)

Variants	Moisture	Protein	Fat	Ash	Carbohydrate
Variant 1 control (0% of bean flour)	71.10±1.16	15.22±0.24	6.09±0.10	0.89±0.03	6.70±0.22
Variant 2 (10% of bean flour)	66.20±0.75*	15.29±0.41	5.97±0.15	1.14±0.03***	11.40±0.25***
Variant 3 (15% of bean flour)	63.72±1.54**	15.33±0.39	5.94±0.16	1.27±0.04***	13.75±0.49***
Variant 4 (20% of bean flour)	61.24±1.87***	15.36±0.44	5.91±0.13	1.39±0.04***	16.10±0.42***

* $P<0.02$; ** $P<0.05$; *** $P<0.01$

Table 3 Vitamin composition of meat rolls (mg/100g)

Vitamin	Variants			
	Variant 1 control (0% of bean flour)	Variant 2 (10% of bean flour)	Variant 3 (15% of bean flour)	Variant 4 (20% of bean flour)
Vitamin A	0.057±0.001	0.058±0.001	0.059±0.001	0.059±0.002
Vitamin B1	0.053±0.001	0.097±0.004*	0.119±0.004*	0.141±0.002*
Vitamin B2	0.176±0.003	0.179±0.004	0.181±0.004	0.182±0.005
Vitamin B6	0.238±0.007	0.291±0.007**	0.318±0.006*	0.344±0.006*
Vitamin B12	0.130±0.003	0.127±0.003	0.131±0.002	0.130±0.002
Vitamin C	0.130±0.002	0.580±0.016*	0.805±0.020*	1.030±0.026*
Vitamin PP	5.219±0.160	5.039±0.067	4.949±0.103	4.859±0.140

* $P<0.001$; ** $P<0.01$

3 Results and Discussion

The biochemical profile, bioactive components, and chemical compositions of the prepared roll are presented in Table 2. The composition of water, carbohydrates, and ash significantly varied and depending on the concentration of beans formulation, as a consequence of the chemical composition of bean flour. Thus, the content of carbohydrates in the control sample without beans was 6.70%, but the addition of beans leads to significant increases to 16.10% ($P<0.01$). With a significant increase in carbohydrates and ash, the amount of moisture in the roll is reduced. While in the case of fat and protein, these are not significantly different than the control.

Results of the study suggested a significant change ($P<0.001$) in the content of vitamin C when adding bean flour to mince rolls. Thus, in the case of the absence of beans flours, the content of vitamin C was 0.130 mg/100g, while the addition of 10% beans increases this index by almost five times (0.580 mg/100g). Further, increasing the concentration of bean flour content accordingly increases the vitamin C content to 0.805 mg/100g and 1.030 mg/100g in variants 3 and 4 respectively. Also, there is a significant increase in the concentration of vitamin B1 (Table 3). Vitamin C is essential for body metabolism and tissue nutrition. Further, it is a powerful antioxidant and participates in many physiological processes. The presence of vitamin C is required for

the process of collagen production in the body (Rajasulochana & Krishnamoorthy, 2013; Suychinov et al., 2019). In the case of other tested vitamins, a slight increase was reported in the concentration of vitamin B6, B2, B12, PP, and A, but these are not statistically different than the control without bean flours.

At the next stage, the effect of bean flour on the mineral composition of different variants of meat rolls is analyzed. From the results of the study, it is revealed that adding 20% of bean flour increases the proportion of magnesium from 16.79mg/100g to 32.79mg/100g, calcium from 41.59mg/100g to 65.99mg/100g, potassium from 235.33mg/100g to 387.26mg/100g and phosphorus from 157.38mg/100g to 212.58mg/100g (Table 4). The amount of iron ($P<0.001$) is also increased but as compared to control, this was not significantly different while in the case of sodium and sulphur, these two decreases slightly.

The flavour and nutritional value of meat rolls depend mainly on the right ratio of ingredients in the recipe. For example, meat and eggs are the main sources of protein, while vegetable protein is provided by adding beans. Creamy cheese with 34% fat and sour cream with 10% fat also played an important role in the fat content of the roll. Carbohydrate composition is formed by adding beans, wheat bread, and wheat flour. Moreover, the addition of cheese not only improves the taste but also enriches with vitamin A, calcium, potassium, and magnesium.

Table 4 Mineral content and composition of meat rolls (mg/100g)

Mineral	Variants			
	Variant 1 control (0% of bean flour)	Variant 2 (10% of bean flour)	Variant 3 (15% of bean flour)	Variant 4 (20% of bean flour)
Potassium	235.33±5.58	311.33±6.39*	349.33±8.24*	387.26±8.56*
Calcium	41.59±1.36	53.79±1.60**	59.89±1.62*	65.99±1.80*
Magnesium	16.79±0.62	24.79±0.60*	28.79±0.88*	32.79±1.08*
Sodium	72.29±1.68	70.59±2.06	69.74±2.51	68.89±1.70
Sulphur	156.59±5.33	150.32±3.85	147.18±5.07	144.05±3.23
Phosphorus	157.38±2.95	184.98±4.62***	198.78±5.81***	212.58±5.29*
Iron	1.32±0.02	1.74±0.04*	1.96±0.06*	2.17±0.06*

* $P<0.001$; ** $P<0.002$; *** $P<0.01$

Table 5 Organoleptic evaluation of meat rolls

Characteristic	Variants			
	Variant 1 (0% of bean flour)	Variant 2 (10% of bean flour)	Variant 3 (15% of bean flour)	Variant 4 (20% of bean flour)
Appearance	4.7	4.7	4.7	4.6
Color on cutting place	4.5	4.5	4.6	4.6
Odour	4.8	4.8	4.8	4.5
Taste	4.5	4.5	4.5	4.4
Consistency	4.3	4.4	4.4	4.2
Averaged score	4.56	4.58	4.60	4.46

Yield stress characterizes the transformation of the system from the state of rest to the state of the slow movement of one layer relative to another (creeping) without significant destruction of the structure (Sun & Gunasekaran, 2009; Kakimov et al., 2015; Kakimov et al., 2017). Also, bean flour in the minced meat roll, a gradual increase in yield stress indicators was reported. This might be due to the tight binding between water and dry components of the minced meat system. Further, it was noted that by the addition of 20% bean flour yield stress reached up to 500 Pa and the consistency becomes dense. These characteristics are undesirable and not typical for minced compositions. The water-binding capacity (WBC) change pattern shows that the maximum value (67.5%) is determined by adding 15% bean flour to the minced meat recipe (Figure 1). Further increases of bean flours lead to a decrease in the WBC value. This trend is explained by changes in the structure and consistency of the minced meat, increased dry matter content, which leads to compaction of the structure and increased density of the minced meat.

The organoleptic evaluation of the meat rolls indicated that the addition of 20% bean flour negatively affects various indicators such as consistency, taste, and odour. While a lower concentration

of bean flours improved the overall organoleptic performance, it is mainly due to improved consistency. The addition of up to 15% beans has a positive effect on the consistency by improving the water-binding capacity (Table 5). Excess moisture, remaining on the surface of the minced meat is more tightly bound to the minced meat system due to the presence of bean flour, capable of hydration of water layers.

Figure 1 Yield stress and WBC variation of minced meat depending on the content of bean flour

Conclusions

Based on the above, the impact of vegetable filler (beans) on the quality characteristics of meat roll is revealed. The addition of up to 15% of beans in the recipe of meatloaf has a positive effect on nutritional value: increased content of carbohydrates, protein and minerals, vitamin C and B1. However, the bean content of more than 15% worsens the consistency of the product and organoleptic properties.

Conflict of Interest

The authors of the present study declare there no conflict of any interest.

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