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THE STUDY OF LENTIL FLOUR AS A RAW MATERIAL FOR PRODUCTION OF SEMI-SMOKED SAUSAGES

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При виробництві ковбас як додатковий компонент здебільшого використовують сою і продукти її переробки, різновиди харчового соєвого борошна. При дослідженні безпечності використання сої встановлено, що протягом останніх років з'явилася велика кількість генетично модифікованих організмів, котрі використовуються в якості продуктів харчування. Можливість використання гороху, квасолі, сочевиці, нуту забезпечить збагачення виробів високоякісним харчовим білком, що легко засвоюється організмом людини. Сочевиця багата вільними амінокислотами, у своєму складі містить глютамінову і аспарагінову кислоти, велику кількість тирозину.

У статті обґрунтовано технологічні параметри пророщування сочевиці, встановлено ступінь подрібнення борошна сочевиці, виявлено вплив пророщування на зміни амінокислотного складу сочевиці, вивчено рівень засвоюваності білка сочевиці коефіцієнт надлишковості.

Дослідження проводили з зерном сочевиці. Пророщування здійснено у спеціальному резервуарі круглої форми, що включає в себе решітку. Дно резервуару оснащено отвором для спускання води. Резервуар для води, що розміщено під решітками, заповнено водою, з метою замочування сочевиці протягом 8 год та за температури 17±2 °C до утворення паростка довжиною 1 см, у спеціальному резервуарі.

Розмелювання зерна сочевиці здійснено за допомогою лабораторних млинів, до розмірів частинок 1…1,5 мм та 0,2…0,4 мм. Встановлено, що використання борошна сочевиці з розміром частинок 0,2…0,4 мм призводить до покращення технологічних властивості фаршів – підвищенню кількості зв'язаної вологи, що становить 83,25 %, та забезпечує пластичність фаршу – 7,81 см²/г. Це сприяє інтенсифікації осмотичних процесів у фарші. Для знезараження мікрофлори та забезпечення відповідності виробів показникам безпеки використано НВЧ-сушарку, час роботи якої складався із 6 циклів по 6 хв роботи модулів та 7 хв вимкненні модулів.

За результатами дослідження амінокислотного складу виявлено, що пророщування впливає на зростання частки незамінних амінокислот на 15 % краще порівняно із борошном не пророщеної сочевиці. Рівень засвоюваності білка пророщеної сочевиці становить 62,91 %, коефіцієнт надлишковості – 21,25 %, що дозволяє його використання у технології напівкопчених ковбас.

Встановлено, що використання борошна сочевиці пророщеної покращує коефіцієнт ефективності використання білка організмом в середньому на 30 %

Ключові слова: тест-організми, рослинна сировина, хімічний склад, біологічна цінність, амінокислотний склад, мікроорганізми, напівкопчені ковбаси

1. Introduction

The interest in using vegetable proteins in sausage production has appeared due to the rapid scientific and technological progress in foodstuff production. Production of foodstuffs from secondary resources, non-traditional sources of raw materials based on natural and scientific potential in the field of fundamental biology, physical chemistry and technology has found rapid development for a rational use of raw materials [1].

One of the lines of production of food protein from soy is its extraction from raw material with maximum yield and minimum costs, preservation of biological value as well as removal and decontamination of undesirable and innutritious substances. At the present time, there is information on vegetable dietary proteins of the three main types which differ in protein content and chemical composition. The first type includes products with 30–50 % protein content (soy flour). The second type has protein content of about 70 % (concentrates). The corresponding figure for the third type is about 90 % or more (isolates). The latter are high-quality plant products of high cost price.

Lentil is an alternative source of protein not inferior to soybeans due to its chemical composition and functional properties. Thus, production of protein ingredient from lentil flour which is cheaper than soya is advantageous [2, 3].

2. Literature review and problem statement

For the most part, soy and products of its processing such as varieties of food soy flour are used as an additional component in production of sausages. During the study of safety of soy use, it was established that a large number of genetically modified organisms used as foodstuffs have emerged in recent years [4]. More and more information come about ability of modified organisms to accumulate significant amounts of toxins, phytohormones and pesticides making their consumption unsafe. However, the problem of obtaining highly effective and safe vegetable protein for sausage production which would not be inferior to soybeans due to its technological properties and chemical composition remains unresolved so far.

Possibility of using peas, beans, lentils, and chickpeas would ensure enrichment of products with a high-quality protein easily digestible by the human organism. Protein of these crops is rich in essential amino acids, especially arginine whose content is 1.5 times higher in lentil than in soy. Lentil is rich in free amino acids, it contains glutamine and aspartic acids and a large amount of tyrosine [5].

The ways of additional processing of lentil have been investigated in order to reduce negative influence of oligosaccharides, such as raffinose and stoichiose, and high-polymeric protein structures on the digestive process. Pre-treatment is recommended, namely soaking, to reduce duration of thermal treatment [6]. Also, the possibility of using lentil-based puree-like products in prophylactic nutrition has been studied. Advantages and disadvantages of lentil and its influence on digestive processes and food assimilation have been considered and formulations of dishes for prophylactic nutrition were worked out [7].

A technology of sprouting lentil is described in detail in [6]. Its chemical composition before and after sprouting has been investigated. Comparative analysis of amino acid composition in sprouted and non-sprouted lentil was made. Its advantages and disadvantages were established in comparison with other leguminous plants [8]. Also, the author has established a characteristic feature of lentil protein, i.e. a good balance of essential amino acids. A comparative analysis of lentil and soy was made. It was established that lentil is practically not inferior to soy in content of essential amino acids and even exceeds soy in some essential amino acids (valine, isoleucine, arginine) [9].

Sprouting is accompanied by an exclusive increase in activity of enzymes and splitting of complex spare substances into simpler, more soluble ones fostering development of germs [10]. According to other studies, safety of using lentil in sausage production has been proved, since no contents of toxic elements and radionuclides exceeding admissible values were established [11].

However, there is not enough data on the possibility of sprouting lentil and obtaining flour with its further use as a process ingredient in production of semi-smoked sausages. Therefore, there are reasons to consider this issue not sufficiently studied which determines the need for studies in this direction.

3. The aim and objectives of the study

The conducted studies were aimed at establishing chemical composition and technological properties of sprouted and non-sprouted lentil flour.

To achieve this goal, the following tasks were addressed:

– substantiate the process-dependent parameters of lentil sprouting which would ensure maximum yield of sprouted grains;

– establish the degree of lentil flour grinding, its influence on the technological properties of minced meat, i. e. the content of bound moisture, plasticity and appearance;

– determine the effect of sprouting on changes in the amino acid composition of lentil;

– study the level of assimilation of lentil protein, redundancy coefficient for the use in the technology of semi-smoked sausages.

4. Materials and methods used in the study of sprouted lentil flour

4. 1. The studied materials and equipment used in the experiment

Studies with lentil grains were conducted in a special round-bottomed tank with a grid. The tank bottom had an aperture for draining water. The water tank placed under the grids was filled with water for lentil soaking.

Lentil was ground with the help of laboratory mills installed in the training laboratory of the department of meat technology, meat and oil-and-fat products of Lviv Gzhytsky National University of Veterinary Medicine and Biotechnology, Ukraine.

To study influence of lentil flour on technological parameters of minced meat, experimental samples of minced meat were prepared including meat of chicken broilers in the amount of 90 % for 100 % of meat raw material and lentil flour with a particle diameter of 1.0...1.5 mm and 0.2...0.4 mm in the amount of 10 % per 100 % of the meat raw material.

Influence of lentil flour, both non-sprouted and sprouted, on relative biological value of products in order to confirm the possibility of its use in the technology of semi-smoked sausages was determined using test organisms of *Tetrahymena pyriformis* infusoria. For this purpose, samples of minced beef and chicken meat with lentil flour at ratios of 40:25.5 – 30:5– 15 % per 100 kg of raw meat material were prepared. Minced meat without adding lentil flour was taken as a control sample.

4. 2. The procedure used in determining properties of the samples

The mass fraction of moisture was determined according to DSTU ISO 1442:2005 Meat and Meat Products. The Method for Determination of Moisture Content (Control Method).

The content of bound moisture and plasticity of minced meat was determined by pressing. Appearance was determined by organoleptic methods.

Amino acid composition of proteins in the plant raw material and semi-smoked sausages was determined using the method of ion-exchange chromatography in columns using the T339 analyzer.

Biological value of the proteins was calculated by the amino acid score (C_j) which is the ratio of content of a certain AAC in the product protein to the content of the same AAC in the reference protein:

$$pj = \frac{A_j}{A_{jr}} \cdot 100, \quad (1)$$

where A_j is the content of the j-th EAA in the product protein, g per 100 g protein; A_{jr} is the content of the j-th EAA in the reference protein, g per 100 g of protein.

Total assimilability of the protein was estimated according to the utility factor (u,%), which is calculated from equation:

$$u = C_{\min} \frac{\sum_{j=1}^{e} A_{jr}}{\sum_{i=1}^{e} A_j} \cdot 100, \quad (2)$$

where $C_{\min}$ is the amino acid whose score is the smallest; A_j is the content of the j-th EAA in the product protein, g per 100 g of protein; A_{je} is the content of the j-th EAA in the reference protein, g per 100 g of protein.

The redundancy coefficient ($\sigma_{Redundancy}$) as the mass fraction of EAA in 100 g of the product protein that is irrationally used by the organism:

$$\sigma_{Redundancy} = \frac{\sum_{i-1}^{8} \left(A_j - C_{\min} \cdot A_{jr} \right)}{C_{\min}} \cdot 100, \quad (3)$$

where $C_{\min}$ is the amino acid whose score is the smallest; A_j is the content of the j-th EAA in the product protein, g per 100 g of protein; A_{jr} is the content of the j-th EAA in the reference protein, g per 100 g of protein.

The coefficient indicating the average excess of the amino acid composition of the EAA (CIAE):

$$CIAE = \frac{\sum \Delta pac}{n}, \quad (4)$$

where Δ_{pac} is the difference between the amino acid score and the amino acid whose score is the smallest; n is the number of essential amino acids.

The biological value is determined from formula:

$$BV=100-CIAE, \%, \quad (5)$$

where CIAE is the coefficient indicating the average amount of excess of the amino acid composition of the EAA.

The relative biological value is determined by the following procedure. The amount of nitrogen obtained by the test organism for its growth and reproduction was determined with the help of the test organisms of *Tetrahymena pyriformis* infusoria. The number of cells that have grown over a certain period of time in 1 cm^3 of the nutrient medium was the criterion for relative biological value in its use. The result was compared with the number of cells grown in the medium with an addition of standard protein. Counting was carried out in a counting chamber in pieces and converted to volume.

Relative biological value (RBV), in %, was calculated from formula:

$$RVB = \frac{A}{B} \cdot 100, \%, \quad (6)$$

where A is the number of infusoria cells grown in the experimental nutrient medium; B is the number of infusoria cells grown in a standard nutrient medium.

The coefficient of efficiency of protein use (CPE) in % was calculated from formula:

$$CPE = \frac{A}{(RVB * 100\%)}, \%, \quad (7)$$

where A is the number of infusoria cells grown in the experimental nutrient medium; RBV is relative biological value.

Effectiveness of biological action in protein assimilation (EBA), in %, was calculated from formula:

$$EBA = \frac{CEP_1}{CEP_2} \cdot 100, \%, \quad (8)$$

where (CEP_1)is the coefficient of efficiency of use of the experimental protein; CEP_2 is the coefficient of effectiveness of use of protein of the experimental control sample.

Standardized relative protein efficiency of minced meat (SRPE) in %, was determined from formula:

$$SRPE = \frac{CEP_1}{CEP_0} \cdot 100, \%, \quad (9)$$

where CEP_1 is the coefficient of efficiency of use of the experiment protein; CEP_0 is the coefficient of efficiency of use of protein of the standard sample.

The comparative analysis of increase of essential amino acids of lentil flour was calculated in accordance with the rules of proportion and obtaining of equation: the content of AA, g per 100 g protein of non-sprouted lentil flour was 100 %, the content of AA, g per 100 g of sprouted lentil flour protein: x, %.

5. Results obtained in the study of lentil flour and its influence on qualitative indicators of the experimental minced meat damples

Since the use of lentil can ensure enrichment of sausage products by one or a combination of certain indicators, this will contribute to obtaining a product improved in its nutritional and biological value. Besides, the use of lentil will expand the product range as there is information about the need to reduce negative effects of components on digestion and assimilation of products, such as oligosaccharides and high-polymer protein structures [7, 9]. One of the methods for solving this problem is sprouting which also changes the fractional composition of lentil protein.

5. 1. Substantiation of technological parameters of lentil sprouting

The lentil was washed twice in cold running water before its sprouting and placed in a uniform layer in the sprouting tank where grains were soaked for 8 hours. In the process of soaking, water penetrated the grain germ and then in the grain through the side shells. Water absorption capacity depends on duration of soaking, temperature, and grain size.

During lentil soaking, absorption of moisture does not correspond exactly to the rapid and uniform moistening of the floury body as water distribution is uneven and excessive water absorption by the grain leads to the germ death.

It should be noted that the initial moisture content of lentil was 15 % and reached 35 % after 8 hours which affected the processes of growth and metabolism in the grain as well as formation of enzymes (Fig. 1).

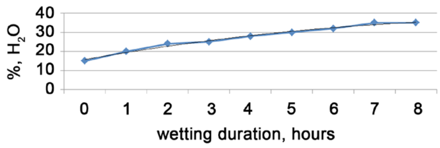

Fig. 1. Content of water in lentil depending on the time of wetting. Note: $y=-0,171x^2+4,1433x+11,81$, $R^2=0,9875$

Sprouting temperature was 17±2 °C, which is sufficient to minimize nutrient losses during sprouting. Sprouting was stopped when germs reached 1 cm in length which took in average 72 to 88 hours. According to [9], in these conditions, maximum accumulation of extractives is up to 29.9 mg/100, maximum yield of sprouted lentil grains at given technological parameters is 92 % and losses of germs are reduced.

Sprouting was terminated by draining water to prevent further growth of the germ roots. Simultaneously with termination of sprouting, dissolution was ended, further splitting processes were stopped and grains dried.

5. 2. Establishment of the degree of grinding of lentil flour and its influence on the technological properties of minced meat

Dried sprouted and non-sprouted lentil grains were ground to flour. For this purpose, lentil grains were ground using laboratory mills to the size of particles in a diameter range of 1.0...1.5 mm and 0.2...0.4 mm in accordance with the technological characteristics of the equipment. Since the degree of flour grinding influences its technological properties, it has been studied in laboratory conditions (Fig. 2, 3).

As it can be seen from Fig. 2, 3, lentil flour with particle diameter size of 1.0...1.5 mm had appearance of yellow balls and that with particle size of 0.2...0.4 mm had more homogeneous, fine structure and creamy color.

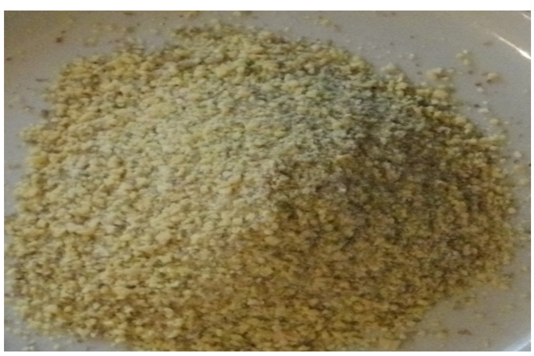

Fig. 2. Lentil flour with particle size of 1.0...1.5 mm

Fig. 3. Lentil flour with particle size of 0.2...0.4 mm

In order to study influence of lentil flour on technological properties of minced meat, experimental formulations of minced meat have been worked out with dosage of lentil flour in an amount of 10 % per 100 % of chicken meat.

When adding lentil flour to the minced meat, its interaction with water was observed and hydration, swelling and peptization of high molecular organic compounds of flour took place. When water was added to lentil flour, the mass fraction of moisture in the minced meat was different. The study results are shown in Table 1.

Table 1

The study of influence of the degree of lentil grinding on technological characteristics of minced meat

Sample 1		Sample 2	
Raw material, %:		Raw material, %:	
broiler chicken meat	90	broiler chicken meat	90
lentil flour with particle diameter of 1.0–1.5 mm	10	lentil flour with particle diameter of 0.2–0.4 mm	10
Moisture content, wt. %	57.2±0.2	Moisture content, wt. %	62.01±0.3
Content of bound moisture, % to the minced meat	65.61±0.5	Content of bound moisture, % to the minced meat	83.25±0.5
Bound moisture, % to the total moisture	75.17±0.3	Bound moisture, % to the total moisture	82.91±0.5
Minced meat plasticity, cm^2/g	8.01±0.2	Minced meat plasticity, cm^2/g	7.81±0.4
Minced meat appearance: non-uniform, with visible clusters of the lentil flour particles		Minced meat appearance: uniform, with uniform distribution of the lentil flour particles	

The protein molecule of flour osmotically absorbing water is significantly increasing in its volume. When composing minced meat, swollen particles of proteins cluster together under mechanical action and form a structure that provides plasticity to minced meat. Milling of lentil flour to a particle diameter of 0.2–0.4 mm contributes to intensification of osmotic processes in minced meat, swelling of proteins, increase in the bound moisture content to 83.25 % and provides plasticity of minced meat: 7.81 cm^2/g (Table 1).

A microwave dryer was used to disinfect microflora of the raw material and ensure its compliance with requirements of microbiological purity. Application of this drying method ensures high quality of products, saving of energy and resources. Heating occurs throughout the volume of the product and destruction of biologically active substances decreases. Length of operation of the dryer modules for processing lentil flour: 6 cycles by 3, 6, 9 minutes and switch-off took 7 minutes. The number of cycles is indicated in the microwave oven operation parameters.

It should be noted that in order to confirm the use of microwave oven with the above parameters, the number of mesophilic anaerobic and optional anaerobic microorganisms in lentil flour before and after drying has been established. The results are shown in Table 2.

When using a microwave dryer during 6 switch-on cycles by min each and a 7 min switch-off cycle, the kMAFANM indicator before and after processing flour of sprouted and non-sprouted lentil was $2.3{\cdot}10^3/1,8{\cdot}10^4$ and $1.5{\cdot}10^2/3.4{\cdot}10^3$, respectively. The use of a technological mode of work consisting of 6 switch-on cycles by 3 min each of the module operation and a 7 min switch-off cycle does not provide sufficient level of microflora disinfection. When using the microwave dryer for 6 switch-on cycles by 9 min each and a 7 min switch-off cycle, color of lentil flour changed and a bitter taste appeared. Use of such raw materials can adversely affect taste of semi-smoked sausages. Use of the microwave dryer for processing and stopping development of microflora in the flour will be efficient in its operation during 6 cycles by 6 min each and switch-off during 7 min.

Table 2

The number of mesophilic aerobic and optional anaerobic microorganisms, (CFU/g) of lentil flour

Raw material	Norm, not more	Switch-on of 6 cycles for 3 min and switch-off for 7 min		Switch-on of 6 cycles for 6 min and switch-off for 7 min		Switch-on of 6 cycles for 9 min and switch-off for 7 min	
	kMAFANM, (CFU/g),						
		before processing	after processing	before processing	after processing	before processing	after processing
Flour of sprouted lentil	$5\cdot10^5$	$2.3\cdot10^3$	$1.9\cdot10^3$	$2.3\cdot10^3$	$1.5\cdot10^2$	$2.3\cdot10^3$	$1.0\cdot10^2$
Flour of non-sprouted lentil		$1.8\cdot10^4$	$5.7\cdot10^3$	$1.8\cdot10^4$	$3.4\cdot10^3$	$1.8\cdot10^4$	$2.5\cdot10^3$

5. 3. Studying the effect of sprouting on changes in the amino acid composition of lentil

It was found in the study of the amino acid composition of lentil flour that its amino acid composition changes during sprouting. There is an increase in all essential amino acids, in particular, leucine by 8.23 %, isoleucine by 37.6 %, methionine+cystine: by 5.7 %, lysine: by 1.6 %, tyrosine+phenylanine: by 20 %, threonine: by 3 %, valine: by 12.8 %, tryptophan: by 65.6 % (Table 3).

Table 3

Estimation of balance of protein composition of lentil flour

Amino acid name	Ideal protein at FAO/WHO g/100 g	Raw material type			
		Sprouted lentil flour		Non-sprouted lentil flour	
		AA content, g per 100 g of protein	Score, %	AA content, g per 100 g of protein	Score, %
Leucine	7.0	8.55	1.22	7.90	1.15
Isoleucine	4.0	3.99	0.99	2.90	0.75
Methionine + + cystine	3.5	9.3	2.65	8.80	2.50
Lysine	5.5	7.52	1.36	7.40	1.32
Tyrosine + phenylalanine	6.0	5.88	0.98	4.90	0.81
Threonine	4.0	3.91	0.98	3.80	0.90
Valine	5.0	3.95	0.80	3.50	0.70
Tryptophan	1.0	2.65	2.65	1.60	1.69
Protein content, %	–	26.00		24.00	
Utility coefficient, %	–	62.91		63.31	
Redundancy coefficient, %	–	21.25		20.85	

For a complete assimilation of lentil protein as a component of the formulation for semi-smoked sausages, the content of essential amino acids in it should be balanced. According to Table 3, the overall level of assimilability of sprouted lentil protein is 62.91 %, the mass fraction of protein irrationally used by the organism makes only 21.25 %. Since the difference between coefficients of utility and redundancy of the experimental samples is insignificant, it is possible to use flour of sprouted and non-sprouted lentils in the technology of semi-smoked sausages.

5. 4. Studying the level of assimilability of lentil protein and the redundancy coefficient

When developing the technology of producing new types of semi-smoked sausages using lentil flour, it is important to determine its impact on quality of the finished product. Biological value is one of the main quality criteria and serves as an integral indicator for displaying various product properties. Biological study methods using experimental animals are popular. However, they require significant material costs. Methods that are convenient to carry out in laboratory conditions are widely used at present. These include methods for determining biological value of proteins where protozoal organisms act as test objects, in particular *Tetrahymena pyriformis* infusoria.

This method determines influence of flour of both non-sprouted and sprouted lentil on the relative biological value of products in order to confirm the possibility of its use in the technology of semi-smoked sausages. To do this, minced meat samples were prepared. Their formulations are given in Table 4.

Table 4

Formulations of minced meat samples

Sample number	Raw material, kg per 100 kg			
	Beef of top quality	Poultry meat	Flour of sprouted lentil	Flour of non-sprouted lentil
Control sample	40	30	–	–
1	40	28.5	5	–
1.1	40	28.5	–	5
2	40	27	10	–
2.1	40	27	–	10
3	40	25.5	15	–
3.1	40	25.5	–	15

As can be seen from Table 3, the study was conducted using beef and poultry meat with addition of lentil flour in the following proportions: 40:25.5–30 and 5–15 % per 100 kg of meat raw material. Minced meat without adding lentil flour was taken as a control sample.

The use of lentil flour in various amounts (from 5 to 15 %) lead to improvement of product quality. Relative biological value of experimental samples using flour of sprouted lentil exceeded that of control sample by an average of 30 %. In particular, this indicator was 96.68 %; 88.94 % and 89.34 % in specimens using flour of sprouted lentil in amounts of 5 % (minced meat No. 1), 10 % (minced meat No. 2), 15 % (minced meat No. 3). This is explained by the rate of *Tetrahymena pyriformis* infusoria growth. The number of their cells grown in a nutrient medium using a control sample was 288.34 cell/mm^3. Corresponding figures for experimental samples were 457.55; 420.95 and 422.84 cell/mm^3 (Table 5).

Table 5

Comparative characteristic of relative biological value and relative efficiency of protein use

Sample number	Protein content, %	Number of cells, cell/mm^3	Relative biological value (RBV), % relative the standard*)	Coefficient of protein efficiency (CPE), %	Efficiency of biological action (EBA), in protein assimilation, %	Standardized relative protein efficiency of minced meat (SRPE), %
Milk casein	100	473.25	100	0.047	–	–
Control	20.40	288.34	60.92	0.141	–	298.66
1	20.80	457.55	96.68	0.219	155.63	464.81
1.1	21.20	305.00	64.44	0.143	101.78	303.99
2	24.90	420.95	88.94	0.169	119.60	357.22
2.1	25.20	311.15	65.74	0.123	87.35	260.90
3	24.90	422.84	89.34	0.169	120.14	358.82
3.1	25.7	338.4	71.50	0.131	92.90	277.47

Note: nutrient medium with milk casein was used as a standard sample

As can be seen from the data in Table 5, the relative biological value in samples with non-sprouted lentil flour added in quantities of 5, 10, 15 % tended to decrease by an average of 26 % compared to the previous experimental minced meat and made 64.44 % in minced meat No. 1.1; 65.74 % in minced meat No. 2.1 and 71.50 % in minced meat No. 3.1. However, when using lentil flour, the relative biological value of finished products improved by 10 % compared with the control sample. The number of infusoria cells in nutrient media using minced meat with non-sprouted lentil flour was from 305 (minced meat No. 1.1) to 338.4 (minced meat No. 3.1).

The coefficient of protein efficiency (CPE) for the organism in specimens with lentil flour in amounts of % in minced meat No. 1 and No. 1.1 was 0.219 and 0.143 which was 55 % and 1.1 % more than in the control sample. In minced meat No. 2 and No. 3 containing 10 % and 15 % sprouted lentil flour, CPE was 0.169 and 0.169. It is 19.85 % better than that of the control sample. Protein efficiency in minced meat No. 0 2.1 and No. 0 3.1 decreased to 0.123 and 0.141. It was 12.750 % and 7.090 % worse than for the control sample. Although the use of lentil flour in amounts of 10–150 % lead to an improvement in the weight portion of protein in the products, growth of infusoria weight per each gram of consumed protein was slower during the experimental period (1–40 days).

Effectiveness of biological action (EBA) in assimilating the protein relative to the control sample was considerably better in minced meat with added flour of sprouted lentil: 155.630 % for minced meat No. 0 1; 119.600 % for minced meat No. 0 2; 120.140 % for minced meat No.0 3. The samples using non-sprouted lentil flour were inferior to them, for example, 34.60 % for minced meat No. 0 1.1 (101.78); 43.90 % for minced meat No.0 2.1 (87.35); 40.30 % for minced meat No.0 3.1 (92.90).

The standardized relative protein efficiency (SRPE) of minced meat with the use of plant raw material was more complete than that of the control sample (298.66) and exceeded it by 55.60 % and 1.70 % for minced meat No.0 1 (464.81) and minced meat No. 0 1.1 (303.99). This figure was smaller by 19.60 % and 20.10 % (357.22 for minced meat No. 2 and 358.82 for minced meat No. 0 3) in minced meat using sprouted lentil flour in quantities of 100 % and 150 %. The samples using non-sprouted lentil flour in the same had worse indicators in comparison with the control sample. In particular, SRPE of minced meat No. 0 2.1 and No. 0 3.1 was 260.900 % and 277.470 %, which is by 12.60 % and 7.060 % worse than that of the control sample and by 14.150 % and 8.70 % compared to minced meat No. 0 1.1 containing 50 % lentil flour.

6. Discussion of results obtained in studying lentil flour and its influence on qualitative indicators of minced meat

In the course of this study, we tried to find the answer to the questions concerning technological parameters of lentil sprouting. Peculiarities of the solutions obtained consist in soaking of the raw material for 80 hours in order to reach the grain moisture content of 350 % and sprouting at a temperature of 17±20 °C until 10 cm long germs are formed and maximum yield of sprouted grains is ensured. In contrast to the results of studies [8–11], the degree of lentil grinding was established in this work which is an advantage over above works as lentil flour improves technological properties of minced meat, i. e. the content of bound moisture in minced meat, its plasticity and appearance. The proof of this is the study results shown in Fig. 2, 3.

Disadvantage of using lentil flour with a degree of grinding of 1.0–1.5 mm consists in presence of flour specks in minced meat which worsen organoleptic characteristics of products. This disadvantage can be eliminated by a finer degree of grinding and the use of water for hydration of lentil flour. The mechanism of using technological modes of the microwave dryer provides micro flora disinfection of the flour and consists of 6 cycles by 6 minutes of module operation and 7 minutes of shutdown. The results of the studies are given in Table 2.

The results of studying the amino acid composition of sprouted and non-sprouted lentil flour are given in Table 3. It was found that the portion of essential amino acids grew 15 % better in sprouted lentil flour compared with non-sprouted lentil flour. Of particular interest is the study of assimilability of sprouted lentil protein which was 62.91 % and the redundancy factor was 21.2 5%, which makes it possible to use it in the technology of semi-smoked sausages.

According to the results obtained in studying relative biological value of minced meat using *Tetrahymena pyriformis* ciliary infusoria, the follows can be stated: the use of sprouted lentil flour improves protein efficiency by an average of 30 %. Such results are explained by changes in composition of protein substances of lentil during its sprouting. The total nitrogen content practically does not change during sprouting. Proteins are hydrolyzed by about half, most of which accumulate in germs in a state of qualitatively different proteins. This conclusion can be considered expedient from the practical point of view provided that the amount of lentil flour used in semi-smoked sausages does not exceed 5 % per 100 kg of basic raw material. Further studies may be conducted to confirm the use of lentil flour in the amount of 5 % per 100 kg of basic raw material. Certain difficulties may be caused by the excessive moisture absorption capacity of raw materials which leads to excess moisture in the products and their damage. Compliance of products with the requirements of normative documents as respects the index of moisture content can be ensured by determining the most favorable content in the lentil flour formulations.

7. Conclusions

1. Technological parameters of lentil sprouting were established, namely: soaking of raw material for 8 hours, sprouting at 17±2 °C until 1 cm long germs are grown.

2. The degree of lentil flour grinding of 0.2–0.4 mm improves technological properties of minced meat: the content of bound moisture in minced meat, its plasticity and appearance.

3. According to the results of the study of the amino acid composition, it was found that sprouting affects growth of the portion of essential amino acids by 15 % better than that of non-sprouted lentil. Assimilability of fermented lentil protein is 62.91 %, redundancy ratio is 21.25 %, which allows its use in the technology of semi-smoked sausages.

4. As it was found from the study results, the use of sprouted lentil flour improves efficiency of protein use by an average of 30 %.

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