The use of lupine flour in pasta production

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Abstract. A study was made of the possibility of using lupine flour, produced from the seeds of blue lupine and white lupine, in the production of pasta. The possibility of using lupine flour in an amount of up to 15% by weight of durum wheat flour for pasta of the highest grade has been established in order to enrich pasta with biologically valuable nutrients without a noticeable deterioration in physicochemical and organoleptic indicators.

1 Introduction

At the present stage of food industry development, the direction of expanding the range and production of food from vegetable raw materials with improved characteristics is of particular relevance. Promising raw materials for the production of enriched foods are processed products of different lupine types, characterized by a balanced chemical composition and increased biological value. The great technological and economic potential of lupine is not fully realized at present.

Lupine is not demanding of soil and climatic conditions, it is an excellent nitrogen fixator, ensuring the enrichment of soils with nitrogen, increasing soil fertility. Lupine crops mobilize phosphorus and potassium compounds that are difficult to access for other crops from the lower soil layers, enriching the soil with more than 150 kg/ha of biological nitrogen, fixing it from the air. Lupine can grow in almost all regions of Russia, noticeably surpassing soybeans in yield (3.5-4 t/ha).

In the Russian Federation, mainly 4 types of lupine are cultivated: white, blue, yellow, and Washington. The blue lupine, previously used for feed needs, is increasing the interest of food industry specialists. This is due not only to the increased protein content, comparable or superior to other leguminous crops, but also to the biological characteristics and distribution area of this species, characterized by both precocity and increased cold resistance compared to other lupine species. Seeds of blue lupine can contain 28-42% protein and 4-8% oil.

The conducted studies have established that 82-84% of the total protein content of blue lupine is water- and salt-soluble fractions. Against the background of the predominance of albumins and globulins, the alcohol-soluble prolamine fraction is almost absent, which indicates the high efficiency of lupine protein use in food protein production and as raw material for the production of gluten-free foods.

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Lupine seed processing products can be sources of vitamins, macro- and microelements. In addition, the seeds of this valuable legume crop have a high content of beta-carotene (0.30-0.49 mg%) and tocopherols (3.9-16.2 mg%) compared, for example, with grain crops. Due to the high content of β-carotene in lupine

seeds, their processed products can be recommended as valuable raw materials for the creation of therapeutic and prophylactic products with radioprotective properties that increase the body's resistance to radionuclides [1].

The weighted average content of fiber in the seeds of blue and yellow lupine is 11-20%, which allows to recommend the use of lupine processing products in the production of fiber-enriched foods [2-4].

Abroad, the issues of the use of lupine processing products for the production of functional dietary ingredients are being actively studied, including in the development of recipes for gluten-free food production [5].

The effectiveness of food consumption using lupine raw materials has been established to prevent deterioration of human health associated with metabolic disorders [6].

There is evidence of a positive effect of foods enriched with lupine flour on the human cardiovascular system [7].

In the production of bakery, pasta, confectionery, meat processing products, the use of lupine protein isolates shows good results both to enrich products with functional ingredients and to improve their consumer characteristics [3, 8].

There is information about the use of lupine flour for pasta production. Thus, in the USA, lupine flour was substituted for 5-30% of wheat flour in spaghetti recipes. The analysis of the finished products showed that the experimental spaghetti contained more digestible protein and lysine compared to the control [9, 10].

As established by research, the use of lupine flour in the recipe in an amount of up to 15% in pasta production significantly increases the content of protein, fiber, carotenoids in them, the products are characterized by a better consistency after cooking [11]. Native lupine flour in an amount of up to 15% with an acceptable level of alkaloids is advisable to use as a complex, sustainable natural enriching agent that improves pasta nutritional and consumer advantages. At the same time, lupine flour significantly improves the color of pasta made from wheat baking flour and makes it possible to produce products of standard quality without changing the technological process.

In a number of European countries, not only flour is produced from lupine seeds, but also concentrates and isolates of lupine protein. Lupine flour is mainly used in Western countries as a high-protein vegetable supplement for the production of enriched biologically valuable nutrients in food products [12-15].

The development of large-scale industrial production of lupine seed processing products in Russia will contribute to ensuring the country's food security, creating an assortment line of food products of increased nutritional value that are affordable to a wide range of the population. Currently, lupine flour obtained in accordance with the technical specifications (TU 9716-003-00668502-2007) as a result of grinding peeled and roasted seeds of low-alkaloid varieties can be used not only in the baking, pasta, confectionery industries of the food industry, but also in the meat processing industry and in cooking. The National Standardization Plan for 2024-2025 includes the development of GOST R "Lupine flour. Technical conditions".

The direction of expanding research on the use of lupine flour, produced from seeds of different lupine types and varieties, in combination with different-quality basic raw materials for pasta production at the present stage of the Russian economy development can be quite relevant and is of great practical interest to food industry specialists around the world [16-20].

It is obvious that at the present stage of the world economy development, the results of studying the possibility of using lupine seed processing products of domestic selection varieties in the food industry may be of great practical interest to specialists in the food industry of the Russian Federation.

2 Materials and Methods

To confirm the possibility of using lupine seed processing products in pasta production, the effect of the addition of lupine flour "Evolution Food" (Austria) (LM "Evolution Food"), and "Deco 2" (Russia) (LM "Deco 2") was studied. The first flour type is produced abroad from sweet varieties of lupine and imported into the Russian Federation, flour "Deco 2" is produced from seeds of blue lupine of Deco 2 variety (LM "Deco 2"), bred in the RSAU-MAA named after K.A. Timiryazev, and included in the State Register of Breeding Achievements. The variety has been approved for use since 2012 in all regions of the Russian Federation, but it is mainly offered for cultivation in the central and northern regions of the Non-Chernozem zone. The growing season of the determinant variety, medium resistant to anthracnose and fusarium lasts up to 90 days. At the same time, grain yield can reach 3.0 t/ha (green mass - 30-40 t/ha). Seeds can accumulate up to 35% of protein, on average about 5% of fat, 51% of carbohydrates, and 18% of fiber, ash content is at the level of 3.3-4%, and the content of alkaloids is 0.03-0.5%. The weighted average content of some essential amino acids in protein significantly exceeds their content in soybean seeds and is as follows: leucine - 7.4; lysine - 4.4%; isoleucine - 3.5; methionine - 0.8%. Seeds of the considered lupine variety are richer in comparison with soy and important minerals, so the phosphorus content is at the level of 1.7%, potassium – 1.3; calcium – 0.9; magnesium – 0.6%; sulfur – 0.2% [20, 21].

Specialists of the FSBSU "Research Institute of Grain and Products of its Processing" on the basis of a patented method for obtaining pea flour have developed a technology for processing of blue lupine seeds of the Deco 2 variety into flour. Before grinding the seeds, their peeling and crushing was carried out on a laboratory centrifugal husker with a rotation speed of the working disk n = 3000 min^{-1} with a speed at the periphery V=76 m/s. At the next stage, the shells and flour were sifted on a laboratory pneumatic separator "Petkus" at set air velocities in the pneumatic channel in the range from 6.5 to 7.8 m/s, varying depending on the initial moisture content of the seeds to increase the semolina yield to about 72%. At the final stage, the technological operation of semolina grinding from peeled seeds into flour was implemented on a laboratory hammer crusher and a milling unit RSA-5. Extraction of lupine flour was carried out on a flour sieve with a hole size of 220 microns with a total yield of at least 95%. On the first technological system, extraction was at the level of 15-20%; on the second - 25-30, on the third and fourth - 20-25, on the fifth - 7-10, and on the sixth - 2-5% [22].

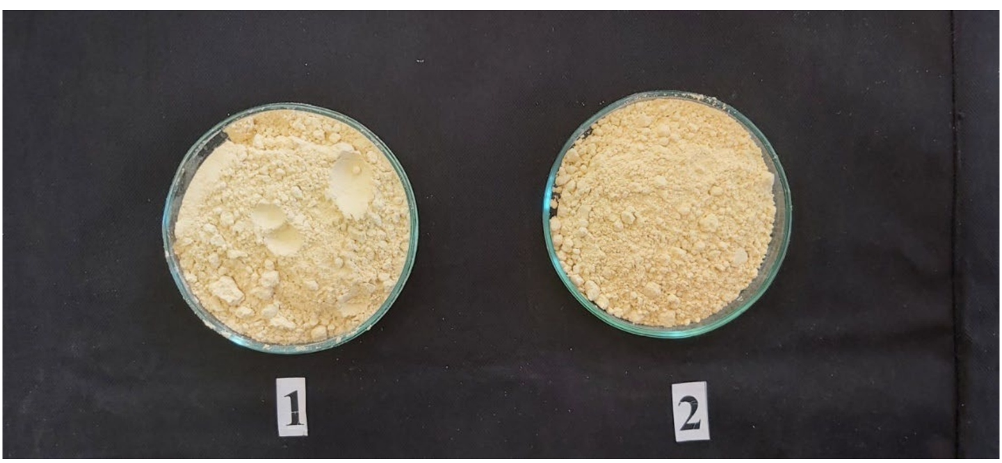
During the research work, the macaroni properties of mixtures with the addition of 5, 10, and 15% of lupine flour from the mass of wheat flour were studied. As the main raw material for the preparation of mixtures, wheat flour from durum wheat for pasta of the highest grade (semolina) "S. Pudov" (PM "S. Pudov") was taken.

The pasta was made on a DOLLY La Monferrina pasta press, drying was carried out in a rack cabinet SRL-0.65 of a set of laboratory baking equipment (SLBE) with air with a constant drying capacity at a temperature of 40°C for 20 hours. The analysis of the physico-chemical parameters of flour mixtures and the determination of the pasta quality was carried out in accordance with the current standards: GOST ISO 3093-2016 "Grain and its processing products. Determination of the number of drops by the Hagberg-Perten method", GOST 27839-2013 "Wheat flour. Methods for determining the quantity and quality of gluten", GOST 27493-87 "Flour and bran. Method of determining the acidity by beaten-up flour and water", GOST 31964-2012 "Macaroni products. Acceptance rules and methods of quality determination". The chemical composition of lupine flour was determined on a spectrophotometer "Spectra Star XT 2600".

3 Results and Discussion

The results of the analysis of lupine flour chemical composition confirmed the expediency of studying the possibility of its use for the purpose of enriching pasta with balanced amino acid composition of legume protein, vegetable fat, and fiber. Thus, the protein content in the studied lupine flour from the seeds of the Deco 2 variety reached 32.5%, fat – 6.6, fiber – 12.6%, and the ash content of flour was 3.7%. In lupine flour "Evolution Food" the protein content was at the level of 46.8%, fat – 11.7%, fiber – 7.6%, ash – 3.8%.

According to the results of the analysis of the physico-chemical properties of wheat and lupine flour mixtures, it was found that the moisture content of both wheat and lupine flour met the requirements of GOST 31463-2012 "Durum wheat flour for pasta" and TU-9716-003-00668502-2007 "Flour from lupine food" and was at the level of 11.6 and 9.3-9.7%, respectively. The wheat flour acidity for pasta was 2.5 deg. The addition of lupine flour led to a noticeable increase in the acidity of flour mixtures: by 2.4-6.2 deg. when using flour from the blue lupine seeds and 1,9-4,7 deg. when adding lupine flour "Evolution Food". Such an increase in the acidity of mixtures is associated with a significant content of amino acids, organic acids, acid salts and high acidity of lupine flour, exceeding 5-10 times the value of this indicator in wheat flour. With a minimum dosage of lupine flour, the mixture met standard requirements for the acidity index for durum wheat flour for pasta of the 2nd grade (no more than 5 deg).



a) b)

Fig. 1. a) - lupine flour produced from blue lupine seeds of variety "Deco 2" (LM "Deco 2")); b) - lupine flour "Evolution Food" (Austria).

When using lupine flour in the minimum dosage, there was an increase in the crude gluten content by 2.3 and 4.6%, which may be due to the retention of lupine flour in the gluten framework formed from durum wheat grains, fat and protein fractions, dietary fibers. A further increase in the content of gluten-free lupine flour of Russian and Austrian production in mixtures from 5 to 10-15% led to a decrease in the content of raw gluten by 1.6-2.2 and 1.6-4.2%, respectively, due to a significant decrease in the gliadin and glutenin protein fractions in the flour mixtures studied.

Gliadin and glutenin gluten fractions of wheat flour can bind free fatty acids contained in non-fat lupine flour, which affects not only the quantitative but also the qualitative characteristics of raw gluten. Saturated (stearic, palmitic) and unsaturated (oleic, linoleic, linolenic) fatty acids present in the composition of lupine triglycerides can affect the elastic properties of gluten and, accordingly, the value of the quality indicator determined by the GDM device (gluten deformation meter). Unsaturated fatty acids, unlike saturated ones, can help strengthen wheat gluten, at the same time, the stronger they are the more unsaturated double carbon-carbon bonds they contain. The gluten strengthening was observed in experiments under the effect of polyunsaturated oleic acid, capable of converting into bound and strongly bound lipids, forming a complex with gluten. [23] This dependence can be traced when using lupine flour mixed with wheat baking flour. [20, 21] Nevertheless, the effect of adding lupine flour to wheat semolina produced from durum wheat grain on the quality index of raw gluten was somewhat different.

Our research has established that the use of lupine flour led to a certain weakening of raw gluten in mixtures with durum wheat grains by 11-23 units of the GDM device. In the variants of the experiment, when using both types of lupine flour in the amount of 10 and 15%, the transition of gluten quality from the I quality group ("good") to the II group ("satisfactory weak") was noted. Nevertheless, in terms of raw gluten gluten, the flour mixture met the requirements of the standard for durum wheat flour for pasta (50-105 units of GDM). The noted features of changes in gluten quality may be related to the strength of the bonds of protein and starch grains and the granulometric composition of wheat semolina produced from high-glass grain durum wheat. Some increase in the fat content in the mixture with lupine flour can lead to changes in the protein-lipid complex, fatty substances, being distributed in a thin layer in the protein spongy structural "framework" along the structural elements of gluten, possibly facilitate their sliding relative to each other.

In the experimental variants, low activity of amylolytic enzymes was noted in terms of falling number (284-354 s). When adding lupine flour, the number of drops in the mixtures decreased by 9-70 seconds, which is explained by the partial substitution of wheat flour starch with high-protein lupine raw materials. This indicator is not standardized for macaroni flour and does not significantly affect the pasta quality.

According to the analysis of the pasta quality, it was found that the humidity of noodles in the experiment options was at the level of 8.28-8.29%, which met the requirements of GOST 31743-2017 "Macaroni products. General technical products". The cooked products hold their shape well and did not stick together during cooking, the shape of the cooked products in all experiment options was 100%.

Table 1. Physico-chemical properties of durum wheat flour mixtures for pasta (PM "S. Pudov") and lupine flour (LM "Deco 2").

Option	Falling number, s	Acidity, deg.	Gluten amount	Gluten quality	
			raw gluten, %	gluten quality, GDM units	quality group
PM "S. Pudov" (control)	354	2.5	29.8	67	I
PM "S. Pudov" + 5% LM "Deco 2"	345	3.9	32.1	80	I
PM "S. Pudov" + 10% LM "Deco 2"	336	5.1	30.5	86	II
PM "S. Pudov" + 15% LM "Deco 2"	316	6.2	29.9	90	II

PM "S. Pudov" + 5% LM "Evolution Food"	313	3,7	34,4	78	I
PM "S. Pudov" + 10% LM "Evolution Food"	290	4,8	32,8	85	II
PM "S. Pudov" + 15% LM "Evolution Food"	284	5,8	30,2	90	II

a) b) c) d)

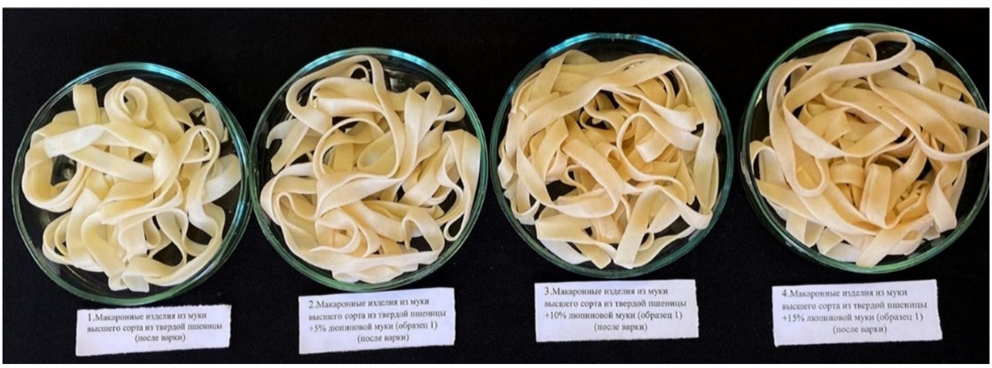
Fig. 2. Ribbon-shaped pasta made from mixtures of durum wheat flour for pasta (PM) and lupine flour (LM): a) - PM "S. Pudov" (control); b) - PM "S. Pudov" +5 % LM "Evolution Food"; c) - PM "S. Pudov" + 10% LM "Evolution Food"; d) - PM "S. Pudov" + 15% LM "Evolution Food".

Table 2. Physico-chemical and cooking properties of pasta with the addition of lupine flour.

Option	Moisture, %	Acidity, deg.	Cooking properties		
			Cooking time, min	Mass increase cefficient	Dry matter transferred to cooking water, %
PM "S. Pudov" (control)	8.49	3.1	9.0	1.60	4.44
PM "S. Pudov" + 5% LM "Deco 2"	8.41	4.6	10.5	1.42	3.90
PM "S. Pudov" + 10% LM "Deco 2"	8.28	5.9	10.5	1.39	6.62
PM "S. Pudov" + 15% LM "Deco 2"	8.28	6.7	11.0	1.36	6.61
PM "S. Pudov" + 5% LM "Evolution Food"	8.68	4.9	9.5	1.49	4.93
PM "S. Pudov" + 10% LM "Evolution Food"	8.69	5.4	10	1.51	6.11
PM "S. Pudov" + 15% LM "Evolution Food"	8.79	6.4	10.5	1.41	6.47

Due to the increased acidity of lupine flour, its use in pasta production led to an increase in the acidity of the latter by 1.5-3.6 deg. The acidity of pasta is related to the acidity of the flour used for their production, but during the drying process there may be a slight increase in this indicator, especially when the process slows down at the initial stage of drying raw products of high moisture. When using different types of lupine flour, the acidity of noodles increased as its content in the initial flour mixtures increased and was at the level of 4.6-6.7 deg., which exceeded the norm of the standard (no more than 4 deg.) by 0.6-2.7 deg. Nevertheless, it should be noted that the acidity level did not exceed the value allowed by GOST for tomato products made from wheat flour of the highest grade (no more than 10 deg.)

When using lupine flour, there was a tendency to slightly increase the duration of product cooking until ready, the weight gain coefficient, on the contrary, tended to decrease by 0.18-0.24 when using flour produced from the seeds of blue lupine of the Deco-2 variety, and by 0.11-0.19 in options with the addition of lupine flour "Evolution Food", which it may be due to a decrease in the content of gluten proteins and hydration ability when replacing wheat flour with lupine. The content of dry substances transferred to the cooking water, in options with lupine flour added in the amount of 10 and 15% of wheat flour weight, increased markedly by 1.67-2.18% and reached the level of 6.11-6.62%, which slightly exceeds the norm established for pasta GOST 31743-2017.



a) b) c) d)

Fig. 3. Cooked ribbon-shaped pasta made from mixtures of durum wheat flour for pasta (PM) and lupine flour (LM): a) - PM "S. Pudov" (control); b) - PM "S. Pudov" + 5% LM "Deco 2"; c) - PM "S. Pudov" + 10% LM "Deco 2"; d) - PM "S. Pudov" + 15% LM "Deco 2".

a) b) c) d)

Fig. 4. Cooked ribbon-shaped pasta made from mixtures of durum wheat flour for pasta (PM) and lupine flour (LM): a) - PM "S. Pudov" (control); b) - PM "S. Pudov" + 5% LM "Evolution Food"; c) - PM "S. Pudov" + 10% LM "Evolution Food"; d) - PM "S. Pudov" + 15% LM "Evolution Food".

The use of an additive in the amount of 5% did not significantly affect the value of the above indicator, which did not exceed the established standard norm in this options (no more than 6%).

In options using 10-15% of the studied additive, a weakly expressed bean flavor of cooked pasta was noted, while the products acquired a more pronounced yellow hue as the content of lupine flour increased due to the carotenoids contained in the lupine seeds. Thus, studies have established that the use of lupine flour in the studied quantities is appropriate for the production of enriched pasta and expanding the range of products.

4 Conclusions

The conducted research has established the possibility of using lupine flour, produced from blue lupine seeds of the variety Deco 2, to increase the nutritional value of pasta. In the options with a minimum dosage of lupine flour (5%), the quality of pasta was at the control level and met the requirements of the standard for the studied indicators. The use of 10-15% lupine flour from the mass of wheat pasta, enriching pasta with biologically valuable nutrients, did not lead to a noticeable deterioration in the quality of finished products.

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