potravinárstvo®
OPEN ACCESS
Received: 29.11.2022
Revised: 2.4.2023
Accepted: 5.4.2023
Published: 9.5.2023

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 17, 20238.5.20, p. 371-390
https://doi.org/10.5219/1829
ISSN: 1337-0960 online
www.potravinarstvo.com

Development of new technologies (recipes) to produce pasta with the addition of millet and the determination of organoleptic and physicochemical quality indicators

Gulmaida Karimova, Rimma Niyazbekova, Khaldun Al Azzam, Nurbibi Mashanova, El-Sayed Negim, Ainur Ibzhanova

ABSTRACT

The article presents the organoleptic and physicochemical (humidity and strength) quality indicators of pasta with the addition of millet at 7.7, and 15.5%, as a new recipe for pasta production. Millets can be used to supplement pasta because of their superior nutritional value and health advantages. On the territory of the Republic of Kazakhstan and the Eurasian Economic Union, the quality indicators were calculated while taking into account the practices outlined in the standardized documents. Express drying, accelerated drying, drying to a constant mass, and employing the MA-30 "SARTORIUS" apparatus following interstate standards were all employed. The study aimed to achieve appropriate organoleptic quality indicators and physicochemical indicators of humidity up to 28% (after processing pasta with the addition of millet 7.7, and 15.5%. Approximately 100 trials were carried out at the Federal State Autonomous Scientific Institution "Scientific Research Institute of the Bakery Industry" Russian Federation, Moscow. According to the study's findings, all quality indicators are within acceptable ranges, except for pasta with the addition of millet 23.3%, recipes for pasta with the addition of millet have been developed, a utility model patent has been obtained in the territory of the Republic of Kazakhstan No. 7071, issued by the Republican State Enterprise on the right of economic management "National Institute of Intellectual Property". In conclusion, pasta recipes with the addition of millet have been developed. According to the study's findings, all quality indicators are within acceptable limits except pasta with the addition of millet, which accounts for 23.3% of the total.

Keywords: pasta, indicators, millet, durum wheat, methods for determining quality

INTRODUCTION

On the global market today, there are more than 350 different types of pasta. Additionally, its astounding variety ranges from classic tubes to tennis rackets **[1]**. Italy is the uncontested world leader in pasta manufacturing, with an annual per-capita consumption of 24 kilos **[2]**. According to the International Pasta Organization, Greece is ranked number four in the world for pasta consumption, after Italy, Tunisia, and Venezuela **[3]**. Turkey's demand for pasta increased by 20% during the coronavirus pandemic, according to a survey conducted by the Turkish Pasta Manufacturers Association, and the average yearly pasta consumption among Turks is 8 kg. Based on this indication, Turkey was ninth on the list of nations that consumed pasta in 2021 **[4]**. In Britain, spaghetti is consumed by more than two-thirds (68%). The most often consumed variety of pasta in the UK is fusilli, which is shaped like a spiral. According to a recent YouGov **[5]** research, 19% of respondents favored it. Regarding pasta consumption, Russia rounds out the top 10 nations (Italian pasta). The analytical and statistical division of Barilla published these findings **[6]**.

About 95% of the country's adult population consumes macaroni products regularly **[7]**. According to the Statistics Portal for Market Data for 2022, the number of countries in the world that eat pasta is as follows **[8]**. Figure 1 shows that pasta consumers worldwide are increasingly appreciating pasta as the basis of delicious and nutritious food. Italy, and France, the United States are the largest pasta market. According to the IPO, Italians are a major consumer of pasta: their per capita consumption is 23.5 kg, a total of 1.4 million tons. Next in line: Tunisia (17 kg), Venezuela (12 kg), Greece (11.1 kg), Chile (9.4 kg), Argentina, Turkey, and Iran - only about 8.5-8.7 kg per capita, followed by Portugal and the Czech Republic. Markets are growing dynamically in Asia (growth of 8.6%) and Africa (growth of 2.6%).

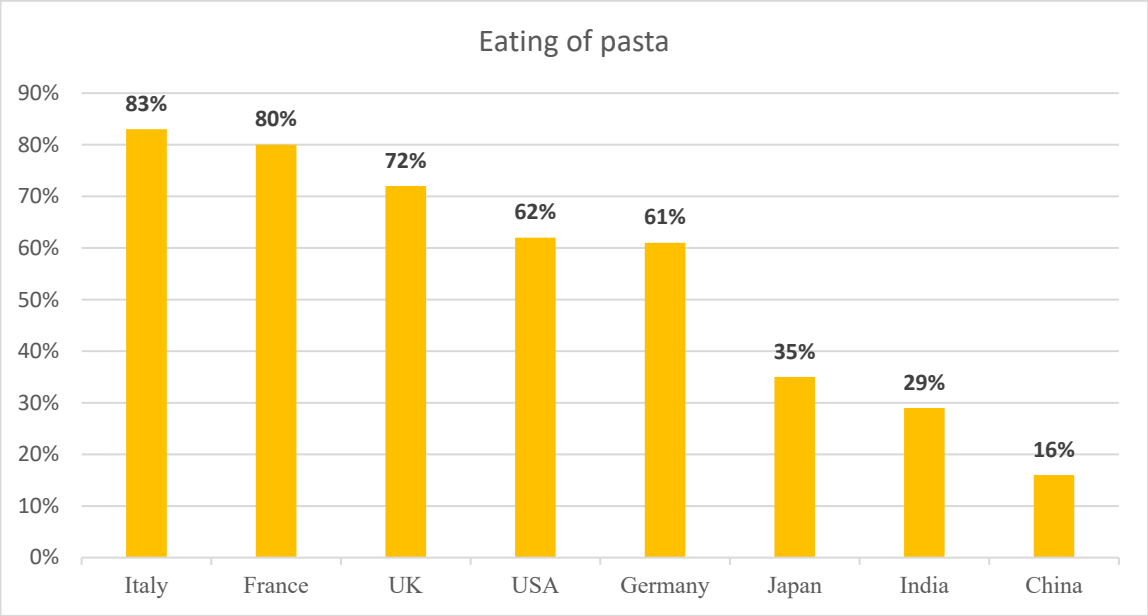


Figure 1 Eating percentages of pasta in the world in 2022.

According to 9 months of 2022, 122.8 million tons of products were produced in the Republic of Kazakhstan. There is an increase in the indicator compared to the same period last year by 5.8% (Figure 2). According to the ministry, 159.8 thousand tons of pasta were produced in 2021. It is noted that Kazakhstanis consume an average of about 130 thousand tons of pasta annually **[9]**.

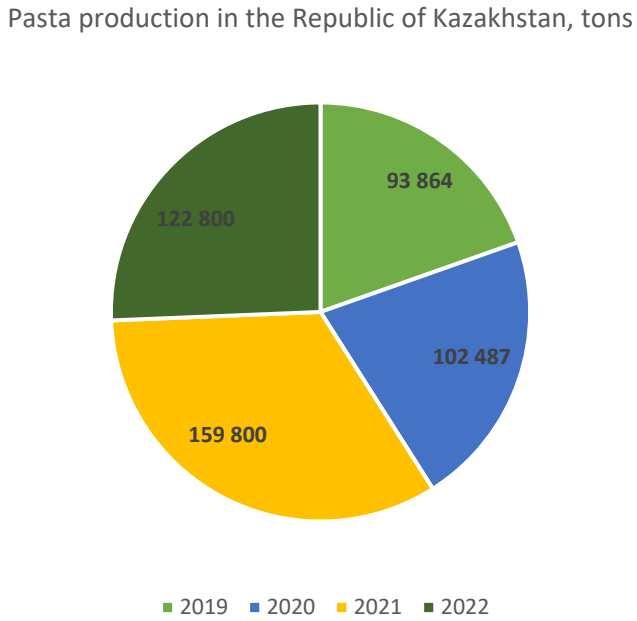


Figure 2 The production of pasta in the Republic of Kazakhstan in the period from 2019 to 9 months 2022, tons.

The Food and Agriculture Organization of the United Nations has published data on the forecast of grain production and trade in the world as of December 02, 2022 (Figure 3).

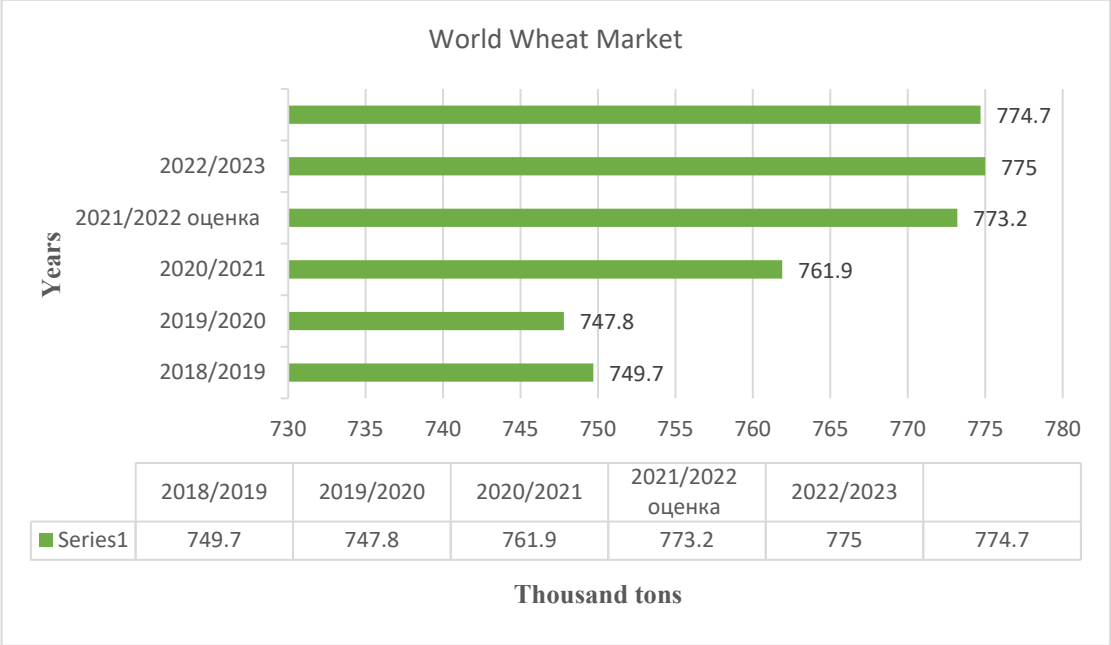


Figure 3 World Wheat Market, thousand tons.

The wheat consumption in the world in the 2022-2023 season remains unchanged at 775 million tons compared to last month, which is slightly higher (by 0.2%) than the level of the 2021-2022 season; at the same time, it is expected that an increase in food consumption of wheat can compensate for the expected decrease in its consumption for feed and, although to a lesser extent, consumption for other needs **[10]**. People of all ages, from young children to the elderly regardless of financial class consume pasta since it is a basic cuisine everywhere in the world, especially in emerging nations. High-quality pasta should have the following qualities: firmness, elasticity, minimized cooking loss, stickiness, ease of preparation, and good firmness after cooking **[11]**. Due to the rising number of Chinese customers who have lived abroad and who follow Western dietary customs, pasta is becoming a more popular Western food item in China. Pasta imports to China totaled $342 million in 2020 **[12]**. There are now several recognized standardized papers (Interstate Standard; further GOST) in the Republic of Kazakhstan that regulate the specifications for pasta, establish the guidelines for their acceptance, and lay out the criteria for determining their quality. GOST 31743-2017's paragraph 3.1 states that “Pasta Products”. General technical specifications " the phrase "Pasta: A food product made from the products of processing of cereals and non-grain crops using additional raw materials and without it, mixing with water, with further molding and drying in various ways" **[13]**.

Pasta is divided into group A (pasta made from durum wheat flour, primarily used for producing high-quality pasta products because of its superior characteristics) and into grades: the highest, first, and second; groups B and C - the highest and first. Depending on the type of source wheat and flour grade, pasta is divided into groups:

- Group A pasta: Pasta prepared from durum wheat flour.
- Group B pasta: Pasta produced from soft wheat flour.
- Group B pasta: Pasta prepared using bread wheat flour or all-purpose wheat flour.

Pasta can be cut, pressed, or stamped according to moulding technique. Pasta is divided into types: tubular, filamentous, ribbon and curly. Pasta of all varieties is separated into long and short pasta. Long pasta may be single- or double-bent, formed into skeins, bows, nests, and more. Long pasta may be cut into skeins, bows, and nests of any weight and size. Pasta must meet the requirements of GOST 31743-2017 "Pasta products. General technical conditions" as listed in Table 1 under organoleptic parameters.

Table 1 General technical conditions of pasta products according to organoleptic parameters (GOST 31743-2017).

Indicator Name	Characteristic

Color	Corresponding to the flour grade. The color of products using additional raw materials varies depending on the type of this raw material.
Form	Corresponding to the type of products
Taste	Characteristic of this product, without extraneous taste
Smell	Characteristic of this product, odorless

According to physicochemical parameters, pasta must comply with the standards of GOST 31743-2017 "Pasta products. General technical conditions" specified in Table 2.

Table 2. General technical conditions of pasta products according to physicochemical parameters GOST 31743-2017.

Indicator Name	Norm						
	Group A			Group B		Group C	
	Top Grade	First Grade	Second Grade	Top Grade	First Grade	Top Grade	First Grade
Humidity of products, %, no more*	13	13	13	13	13	13	13
The acidity of products, deg, no more:							
- tomato - the others	10 4	- 4	- 5	10 4	- 4	10 4	- 4
Mass fraction of protein in terms of dry matter, %, not less	10.5	10.5	10.5	-	-	-	-
Ash insoluble in 10% HCl solution, %, no more	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mass fraction of ash in terms of dry matter, %, no more than vegetable, egg	0.90 1.40	1.20 1.70	1.90 2.40	0.60 1.10	0.75 1.25	0.56 1.10	0.75 1.25
The content of soft wheat flour, %, no more	15	15	15	-	-	-	-
Dry matter transferred to the cooking water, %, no more for small format and filamentous with a diameter of up to 1 mm	6.0 9.0						
Shape preservation of welded products, %, not less	100						
Metallogenetic impurity, mg per 1 kg of product, no more	3 when the size of individual particles is not more than 0.3 mm in the largest linear dimension						
The presence of contamination and contamination by pests of grain stocks	Not allowed						
* For the rest, sent to the Far North and hard-to-reach areas, as well as by sea - no more than 11%							

According to microbiological indicators, pasta must adhere to the requirements established in TR CU 021/2011 Technical Regulations of the Customs Union "On Food Safety" or regulatory legal acts in effect on the state's territory. The content of toxic elements, mycotoxins, pesticides, and radionuclides in pasta must comply with the requirements established in TR CU 021/2011 Technical Regulations of the Customs Union "On Food Safety" or regulatory legal acts in force on the territory of the state **[14]**. Because of increased demand from health-conscious customers, researchers and food producers are increasingly interested in developing pasta products high in minerals, vitamins, fiber, and low glycemic index. The Food and Drug Administration (FDA) and the World Health Organization (WHO) both see pasta as a good vehicle for adding nutritional supplements. Due to its low price, lengthy shelf life, and widespread consumption, pasta, among other functional foods, is suitable for health benefits. Additionally, millets stand out among cereals because of their high calcium, dietary fiber, polyphenol, and protein contents. Millets are a wonderful option for celiac disease patients affected by wheat and other gluten-containing cereal grains since they are gluten-free **[15]**. Being the first crop to be harvested in the year, it provides the indigenous people in many regions of the world with essential food grain. It should be regarded as a necessary

food for ensuring nutritional security since it is a high source of protein (7.7 g/100 g), very rich in carbohydrates (67.0 g/100 g), and low in fat (4.79 g/100 g).

In comparison to other millets and grains, little millet has phosphorus (220 mg), iron (9.3 mg), and fat (4.7 g) per 100 g, iron (9.3 mg), crude fiber (7.7 g), and phosphorus (220 mg) per 100 g which is similar to cereals and other millets. Little millet's high dietary fiber content contributes to its low glycaemic index, and a recent study on little millet found that this increased dietary fiber level causes little millet to have a hypoglycemic impact. It contributes significantly to the diet's supply of considerable levels of phytochemicals and antioxidants. There is a need to address the varied needs for millet-based food items since consumers are becoming more aware of the health advantages of millet **[16]**. Semolina, which is typically used to make pasta, is high in calories but low in dietary fiber, vital amino acids, minerals, and other nutrients **[17]**. According to research, the pasta matrix sustains nutritional stability and can be an excellent transporter to improve dietary components **[18]**. The popularity of multigrain meals has grown due to their health benefits, such as delayed digestion, cholesterol-lowering effects, antioxidant, anti-carcinogenic, and anti-inflammatory qualities **[19]**. Over the last decade, some fascinating research has been conducted to increase the nutritional potential of pasta by combining the flour of various kinds of cereals, such as quinoa and faba bean flour **[20]**, fermented quinoa flour **[21]**, plant proteins made from mushroom powder, Bengal gram flour, and defatted soy flour (DSF) **[22]**, **[23]**.

The current study aimed to develop new technologies (Recipes) for making pasta (as a new technology for pasta production) with millet and determination of organoleptic and physicochemical quality indicators.

Scientific Hypothesis

The purpose of the current study was to develop millet and determination of organoleptic and physicochemical quality indicators. The main scientific hypothesis is to increase traditional pasta's nutritional value and consumer properties by using appropriate organoleptic quality indicators and physicochemical indicators of humidity up to 28% (after processing pasta with millet 7.7 15.5 %). We are expecting to develop pasta recipes with good characteristics to solve some problems such as the fragility to solve the problem of transportation and others.

MATERIAL AND METHODOLOGY

Samples

Millets, wheat flour, starch, pea, soy, amaranth flour, gluten-free flour, durum wheat (genotype), and flax seeds have been purchased from local markets in Almaty, Kazakhstan. As a rule, traditionally, the composition of pasta is wheat flour and water.

Chemicals

The chemical composition (starch and amaranth flour, gluten-free flour, soy, pea) was determined.

Animals, Plants and Biological Materials

Animal and biological materials weren’t used in this research.

Instruments

Eleks - 7M, Russian Federation, Moscow (Manufacturer Limited Liability Company "Tagler"). Drying cabinet SESH-3M, Ukraine, Vinnytsia region, Mogilev-Podilskyi, instrument-making plant. Additionally, MA – 150 "SARTORIUS" infrared humidity analyzer MA-150 is designed to measure the humidity level of liquid, bulk, solid substances, and emulsions during input/output control of products and during scientific research, Germany, Göttingen, Weender Landstrasse 94-108, manufacturer "Sartorius Weighing Technology GmbH". Structurometer ST-1M", designed to determine the rheological characteristics of raw materials, semi-finished products, and finished products, Russian Federation, Moscow, manufacturer "Ochakov Combine of Food Ingredients".

To produce pasta for consumers with gluten intolerance, gluten-free flour was added, such as rice, buckwheat, and corn. Various vegetable and fruit powders such as starch, pea, soy, and amaranth were added to gluten-free flour. Increasing the biological value of pasta products and giving them therapeutic and prophylactic properties was a partial replacement of wheat flour of the highest grade with flour from flaxseeds. Flaxseed flour proteins significantly exceed wheat proteins in the amino acid composition. The fiber in flaxseed flour contains up to 30% of the total weight. Flaxseed flour also contains minerals and vitamins in an easily digestible form.

Many domestic and foreign scientists in search of new sources of raw materials and functional additives for pasta production, which would contribute to reducing calories, increasing nutritional value, and enriching with functional ingredients, talk about the relevance of this direction **[24]**, **[25]**. As part of our research, millet is used as a food additive.

Millet contains about 12-15% protein, 70% starch, and essential amino acids. There is 0.5-8% fiber in cereals, 2.6-3.7% fat, a little sugar – up to about 2%, vitamins PP, B1 and B2, as well as a large amount of potassium, magnesium, and phosphorus. Millet holds the record for the content of molybdenum and magnesium. It is millet

that is considered the least allergenic grain crop. The body easily absorbs this cereal – even people with sensitive digestion can include it in their diet.

Laboratory Methods

Following the requirements of GOST 31743-2017 "Pasta products, general technical conditions", GOST 31964-2012 "Pasta products, acceptance rules and methods of quality determination", studies were conducted on organoleptic parameters (color, shape, taste, smell) and physicochemical parameters, such as humidity.

There are the following methods for determining humidity according to GOST 31964-2012 (Figures 4-6):

- by drying to a constant mass,
- accelerated drying method,
- by the express method,
- on the MA-30 "SARTORIUS".

Following GOST 572-2016 "Millet grain ground. Technical conditions" the organoleptic indicators of millet, which consist of color, smell, and taste, are considered.

The color should be "yellow of different shades", the smell "characteristic of millet groats, without foreign odors, not musty, not moldy" and the taste "characteristic of millet groats, without foreign tastes, not sour, not bitter".

Figure 4 Device used for determining the humidity of food raw materials and products Eleks – 7M, Russian Federation, Moscow (Manufacturer Limited Liability Company "Tagler").

Figure 5 Drying cabinet SESH-3M for determining the moisture content present in pasta by drying to a constant weight (point 2.2), Ukraine, Vinnytsia region, Mogilev-Podilskyi, instrument-making plant.

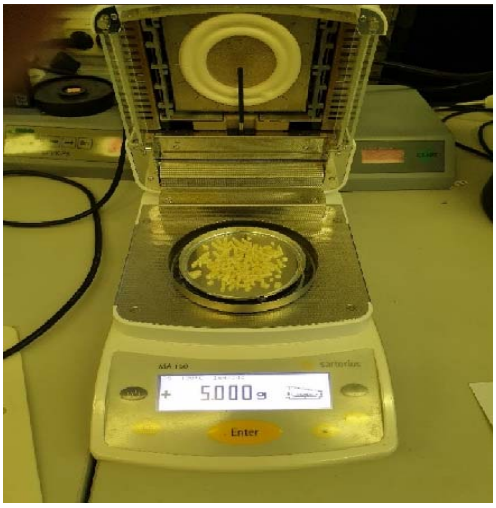


Figure 6 The device MA - 150 "SARTORIUS" infrared humidity analyzer MA-150 is designed to measure the humidity level of liquid, bulk, solid substances, and emulsions during input/output control of products and scientific research (Point 2.2), Germany, Göttingen, Weender Landstrasse 94-108, manufacturer "Sartorius Weighing Technology GmbH".

Description of the Experiment

Sample preparation: Mixing and testing: The research was carried out in one of the leading research institutes of the Russian Federation, Moscow, the Federal State Autonomous Scientific Institution "Research Institute of the Baking Industry". We are considering options for replacing wheat flour with 7.7 and 15.5% of the total mass. The calculation of the added raw materials is determined by the formula below (1):

$$M_D = M_c - \frac{M_c \times \%}{100} \quad (1)$$

Where:
M_D – the weight of the additive; M_c – the mass of raw materials; % - the percentage of input raw materials.

The grits weighed on the KERN 440-45N (Germany, Balingen, manufacturer "KERN & Sohn GmbH") device. Kneading the dough with the addition of millet was carried out for about 30 minutes on the model Sandorina, serial 1861 device (Made in Italy, 2002, Watt 400, Volts 220, Hz 50, Ph 1). The volume of the millet fraction was determined, which amounted to 670 microns. As a control copy, high-grade grits and water were used.

Number of samples analyzed: 36 samples.

Number of repeated analyses: Repeated analyses 9.

Number of experiment replication: Triple.

Statistical Analysis

All data are presented as the mean standard deviation (SD) of three independent experiments, and significance is defined as p <0.05. Utilizing Excel and STATISTICA 13 applications, the research's collected data were statistically analyzed (Dell, StatSoft).

RESULTS AND DISCUSSION

Developing new recipes to produce pasta with the addition of millet can be a great way to increase the nutritional value of this popular food item. Millet is a type of gluten-free cereal grain, high in fiber, and rich in various vitamins and minerals. Gluten protein in durum wheat semolina provides significant features such as low cooking loss, good texture, low surface stickiness, and resistance to surface disintegration **[26]**. Making millet pasta typically involves grinding the millet into a fine flour, which is then combined with water to form a dough. This dough can be shaped into various pasta shapes, such as spaghetti or penne, and then dried. Several organoleptic and physicochemical quality indicators can be measured to determine the quality of the resulting millet pasta. Organoleptic quality indicators include factors such as the pasta's appearance, flavor, texture, and aroma. Pasta is now available in countries all over the world, and it is one of the most popular dishes due to its nutritional content, organoleptic properties, and ease of preparation **[27]**. For example, when cooked, the pasta should have a uniform color and texture, a pleasant aroma, and a satisfying flavor and texture. Physicochemical

quality indicators include moisture content, protein content, and cooking quality measurements. Cooking qualities are an important factor in pasta evaluation **[28]**, **[29]**, **[30]**. Cooking loss is one of the most important criteria that influence consumer approval of this type of product, hence it is very useful in predicting the overall cooking performance of pasta. All fiber-enriched pasta samples had cooking losses that did not surpass the expected values for durum wheat pasta **[31]**, **[32]**, **[33]**.The following cooking parameters are used to evaluate pasta quality: optimum cooking time, cooking loss, water absorption index, and swelling index. The optimal cooking time (OCT), the time required to see the disappearance of the center core when pasta is gently squeezed between two glass slides, is usually one of the first technological criteria checked following pasta manufacturing. Most of the time, OCT is lowered following pasta fortification **[34]**, **[35]**. For example, the pasta should have a low moisture content to ensure a long shelf life, a high protein content to provide adequate nutritional value, and good cooking quality, meaning it should cook evenly and retain its texture and shape **[36]**. The optimal cooking time, according to the American Association of Cereal Chemists (AACC), is when the center core of the pasta simply disappears when squeezed between two glass plates. Pasta fortification increased optimal cooking time and water uptake while lowering the swelling index **[37]**, **[38]**, **[39]**. Water absorption capacity is critical in developing ready-to-eat foods, and a high absorption capacity may guarantee product cohesion **[40]**, **[41]**.

Structure: The millet colour was studied on the equipment CHROMA METERCR-410 (Japan, manufacturer "Konica Minolta Sensing Europe"). As a result of the measurement, the following data were obtained (Table 3):

Table 3 Color characteristics measurement of millet.

Number of measurements carried out	Received data
1	C2-22305 [0090] L* = 73.82 a * = 2.77 b * = 30.19 Δ L *= - 9.33 Δ a * = + 4.24 Δ b * = + 10.67 Δ E * = 14.80
2	C2-22305 [0091] L* = 73.76 a * = 2.73 b * = 30.58 Δ L *= - 9.39 Δ a * = + 4.20 Δ b * = + 11.06 Δ E * = 15.11
3	C2-22305 [0092] L* = 73.64 a * = 2.92 b * = 30.16 Δ L * = - 9.51 Δ a * = + 4.39 Δ b * = + 10.65 Δ E * = 14.94

Note: L – color brightness, measured from 0 to 100%; a – color range in the color circle from green (-120 °) to red (+120 °); b is the color range in the color circle from blue (-120 °) to yellow (+120 °); Δ E: Graph display and evaluation; Δ b: Graph display and evaluation; Δ a: Graph display and evaluation; Δ L: Graph display and evaluation; C2-22305 [0090]: Illuminator C; C2-22305 [0091]: Illuminator C; C2-22305 [0092]: Illuminator C only.

The millet with fractions obtained were 315 microns, 670 microns and 1.25 mm. The distinctive yellow color generated by the high carotenoid content of durum wheat semolina is one of the most essential parameters that define pasta quality. Color is incredibly essential and has a major influence on consumer decision. Some components may significantly alter the color of the new pasta compositions **[42]**, **[43]**, **[44]**, **[45]**. The product's

colour is an important quality element that is highly tied to consumer impression. An increase in pearl millet flour in the blend resulted in a change in the color of uncooked pasta, which is regarded as an undesirable attribute. Pasta with a brilliant yellow color is preferred by most pasta customers **[46]**, **[47]**, **[48] [49]**, **[50]**.

Installation Time: Water, 7.7% millet and premium grain. The dough is kneaded for 30 minutes (according to the timer).The amount of water used to obtain a moisture index of 28% at the "press" stage is given below (Table 4):

Table 4 The amount of water used in kneading the dough to achieve a humidity of 28% after the press.

The amount of added water for kneading the dough						
Volume (mL)	117	119	120	125	128	133
Time (Min)	30	30	30	30	30	30

After the pasta is released, they are laid out on a sieve for drying. An increase in moisture content can accelerate biochemical and microbiological activities, decreasing product quality. The results show that none of the samples exceeds the allowable humidity levels (Table 4) **[51]**. The high moisture content has been related with short shelf life of composite millet flour as they encourage microbial proliferation that cause spoilage **[52]**, **[53]**.

Research method No. 1.: We determine the moisture content of pasta on the ELEKS – 7M device (Russian Federation, Moscow, manufacturer Limited Liability Company "Tagler").
Calculation method:

$$B = \frac{H - C}{H - B} * 100\%$$

Where:
B – raw material moisture, %; H – the weight of the raw material with a paper bag before drying, g; C is the weight of the raw material in a paper bag after drying, g; B is the weight of the dried paper bag, g.

Sample No. 1:

$$B = \frac{5.97 - 4.55}{5.97 - 0.90} * 100\% = \frac{1.42}{5.07} * 100\% = 0.28 * 100\% = 28\%$$

Sample No. 2:

$$B = \frac{5.99 - 4.57}{5.99 - 0.92} * 100\% = \frac{1.42}{5.07} * 100\% = 0.28 * 100\% = 28\%$$

Sample No. 3:

$$B = \frac{5.98 - 4.55}{5.99 - 0.92} * 100\% = \frac{1.43}{5.06} * 100\% = 0.28 * 100\% = 28\%$$

Research method No. 2.: Humidity determination was performed on the device MA-30 "Sartorius". Humidity is 27%.

Research method No. 3.: Determination of humidity by the express method – 28%. The formula calculates the mass fraction of moisture W, %:

$$W = \frac{(m_1 - m_2)}{m} \cdot 100$$

Where:
m_1 – the mass of the bux with a sample for analysis before drying, grams; m_2 – the mass of the bux with a sample for analysis after drying, grams; m – the mass of the sample for analysis, grams.

$$W=\frac{(m_1-m_2)}{m}\cdot 100 = \frac{6.20-4.82}{5}\cdot 100 = \frac{1.38}{5}\cdot 100 = 0.276\cdot 100 = 27\%$$

Research method No. 4.: Determination of humidity by drying to a constant mass – was not carried out. The results are as follows (Figures 5-6):

We continue experimenting with 15.5% millet. The weight was determined on the device KERN 440-45N (Germany, Balingian, manufacturer "KERN & Sohn GmbH"), max 1000 g, d = 0.1 g. Kneading is carried out within 30 minutes on the device Sandorina1861 (according to the timer) (Table 5). Sandorina 1861 made in Italy, 2002, Watt 400, Volts 220.

Table 5 The amount of water used in kneading the dough to achieve a humidity of 28% after the press.

	The amount of added water for kneading the dough	
Volume (mL)	113	117
Time (min)	30	30

Research method No. 1.: We determine the moisture content of pasta on the ELEKS – 7M device (Russian Federation, Moscow, manufacturer Limited Liability Company "Tagler").
Calculation method:

$$B = \frac{H - C}{H - B} * 100\%$$

Where:
B – raw material moisture, %; H – weight of the raw material with a paper bag before drying, g; C is the weight of the raw material with a paper bag after drying, g; B is the weight of the dried paper bag, g.

Sample No. 1

$$B = \frac{5.99 - 4.53}{5.99 - 0.90} * 100\% = \frac{1.46}{5.09} * 100\% = 0.28 * 100\% = 28\%$$

Sample No. 2

$$B = \frac{6.0 - 4.55}{6.0 - 0.94} * 100\% = \frac{1.45}{5.06} * 100\% = 0.28 * 100\% = 28\%$$

Research method No. 2.: Humidity determination was performed on the device MA-30 "Sartorius". The humidity is 28.41%.
Research method No. 3.: Determination of humidity by express method – was not carried out.
Research method No. 4.: The method of drying to a constant mass was not carried out.
The results are as follows (Figures 7-10): Figure 7 shows the findings obtained after adding 7.7% millet to pasta and the influence of humidity using three different methods: MA-30 (Sartorius), express technique, and ELEKS 7M devise. It is obvious that the Sartorius method yielded a humidity of 27% when compared to the other two procedures, which yielded the same findings (28%). Figure 8 represents the form of the pasta after 7.7% millet was added.

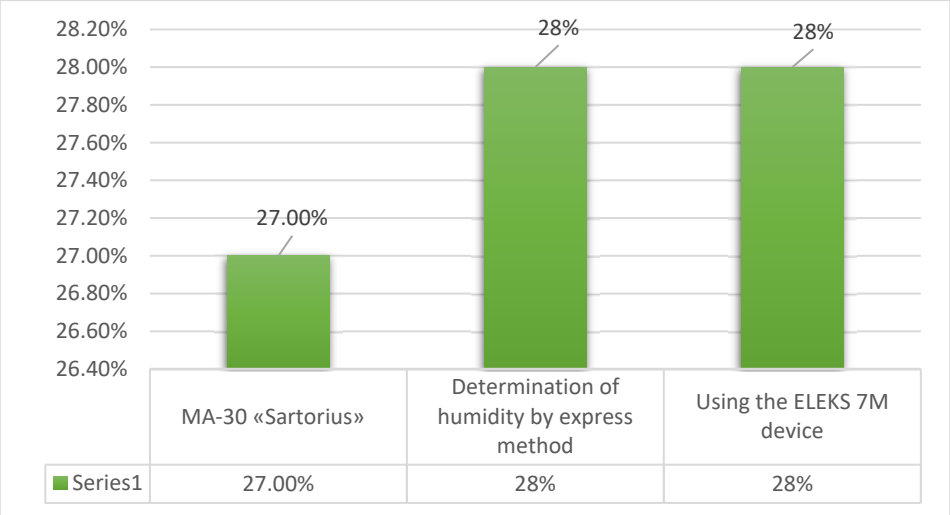


Figure 7 Moisture indicators of pasta with the addition of millet 7.7%.

Figure 8 Pasta with the addition of millet 7.7 %.

Figure 9 displays the outcomes of adding 15.5% millet to pasta and examining the impact of humidity using the MA-30 (Sartorius) and ELEKS 7M devices. It is obvious that the Sartorius method, which yielded a result of 28.41%, was superior to the ELEKS 7M device, which produced a nearly identical result (28%). Figure 10 shows the pasta's shape after being mixed with 15.5% millet.

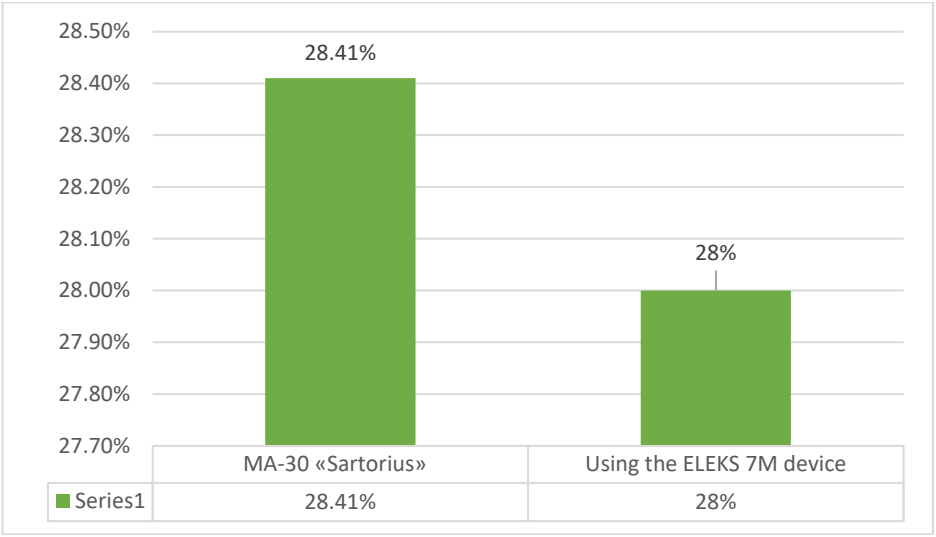
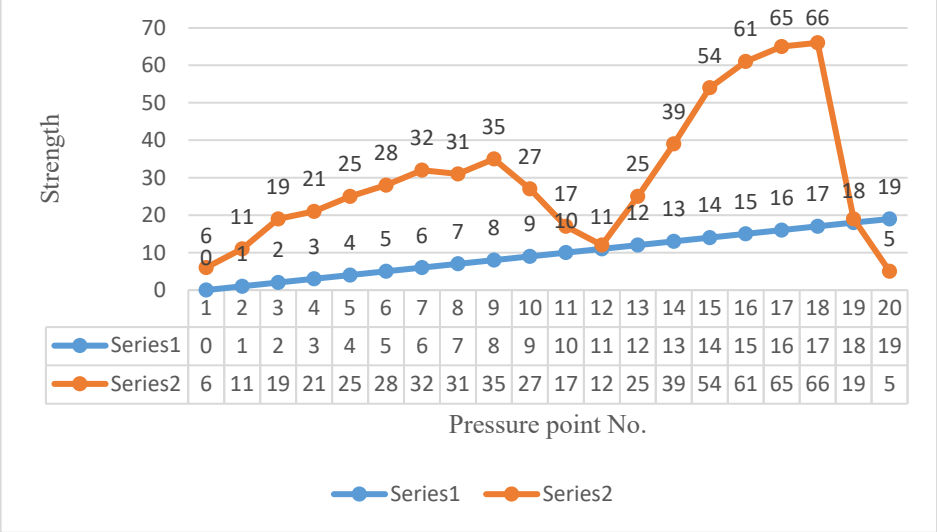


Figure 9 The moisture content of pasta with the addition of millet 15.5%.

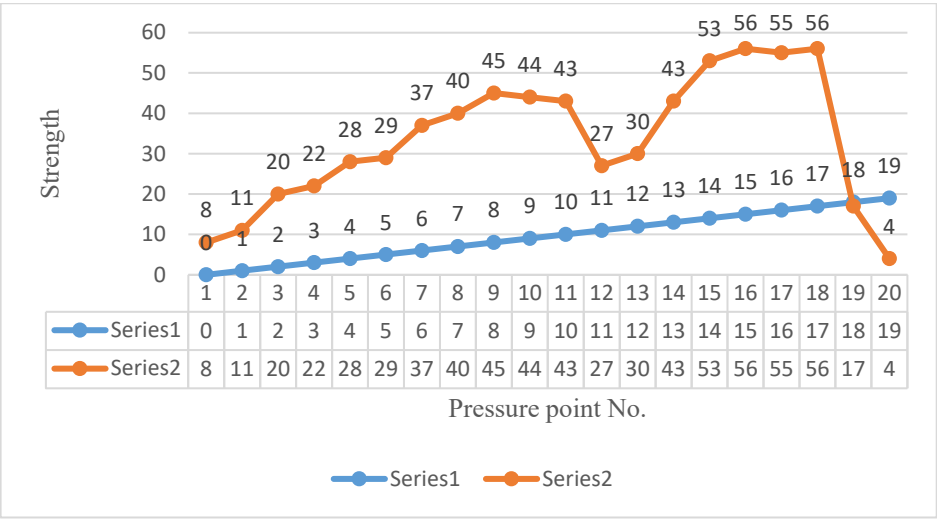
Figure 10 Pasta with the addition of millet 15.5%.

We determine the pasta's strength with adding millet 7.7%, and 15.5%. We preliminarily determine the strength of pasta of the control sample prepared with the highest-grade grits (Samples No. 1, 2, 3) as indicated in Figures 11-13. The studies were carried out on three samples with the addition of 7.7% (Samples No. 4, 5, 6) (Figures 14-16), 15.5% (Samples No. 7, 8, 9) (Figures 17-19).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series2	6	11	19	21	25	28	32	31	35	27	17	12	25	39	54	61	65	66	19	5

Figure 11 Strength indicators of pasta made from the highest-grade twist (Sample control No. 1).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series2	8	11	20	22	28	29	37	40	45	44	43	27	30	43	53	56	55	56	17	4

Figure 12 Strength indicators of pasta made from high-grade twist (Sample control No. 2).

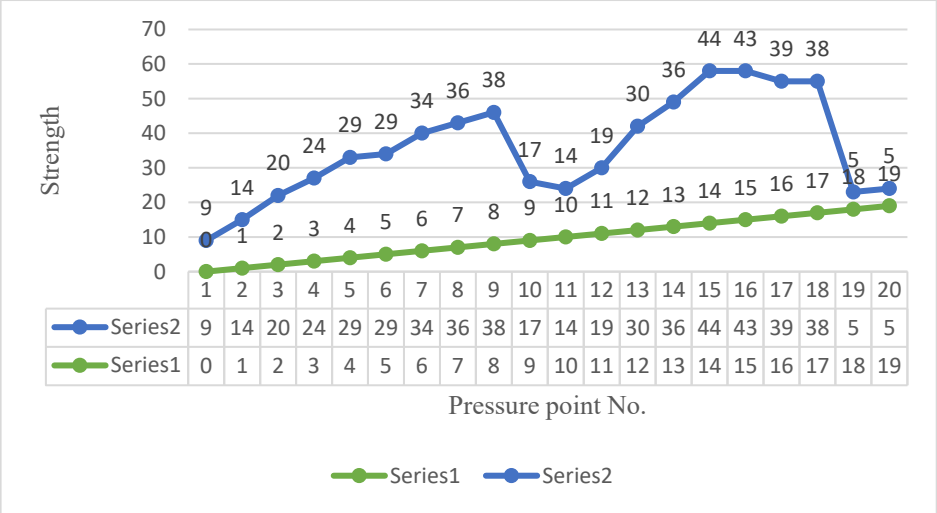


Figure 13 Strength indicators of pasta made from high-grade twist (Sample control No. 3).

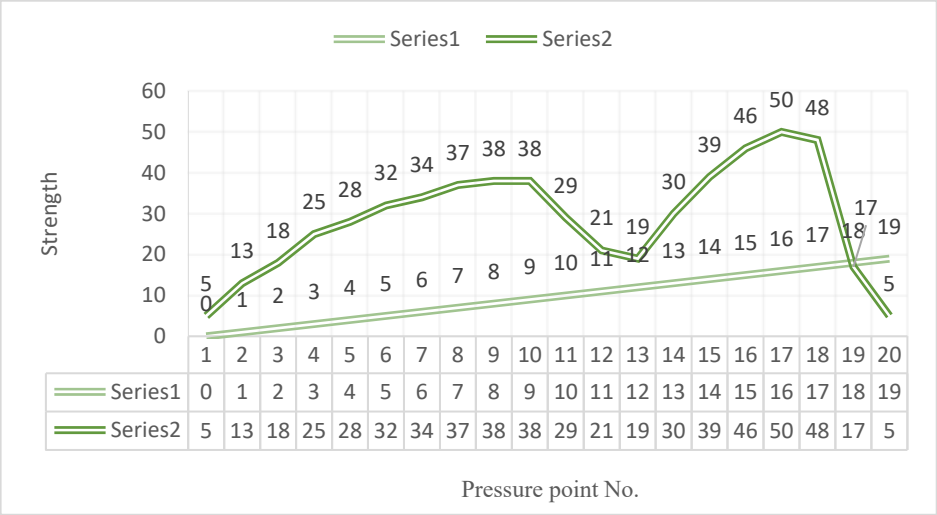


Figure 14 Strength indicators of pasta with the addition of millet 7.7% (sample No. 4).

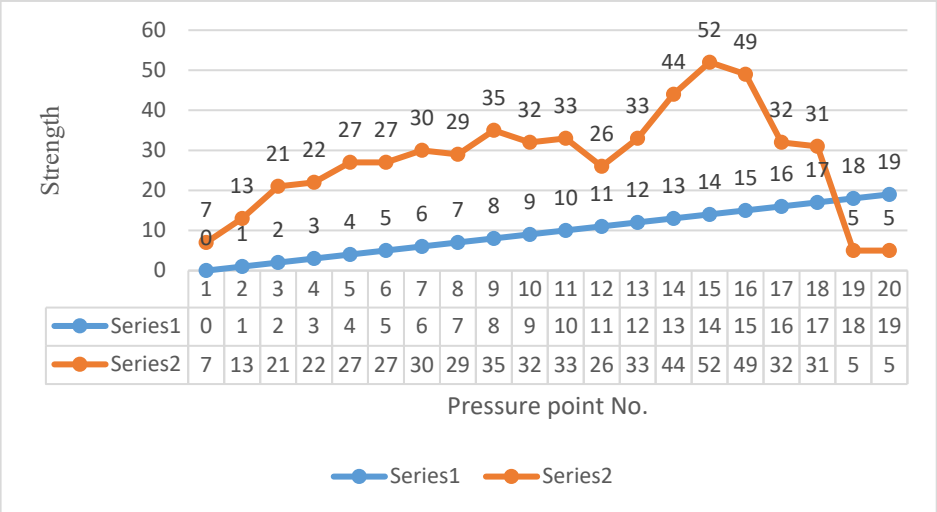


Figure 15 Strength indicators of pasta with the addition of millet 7.7% (sample No. 5).

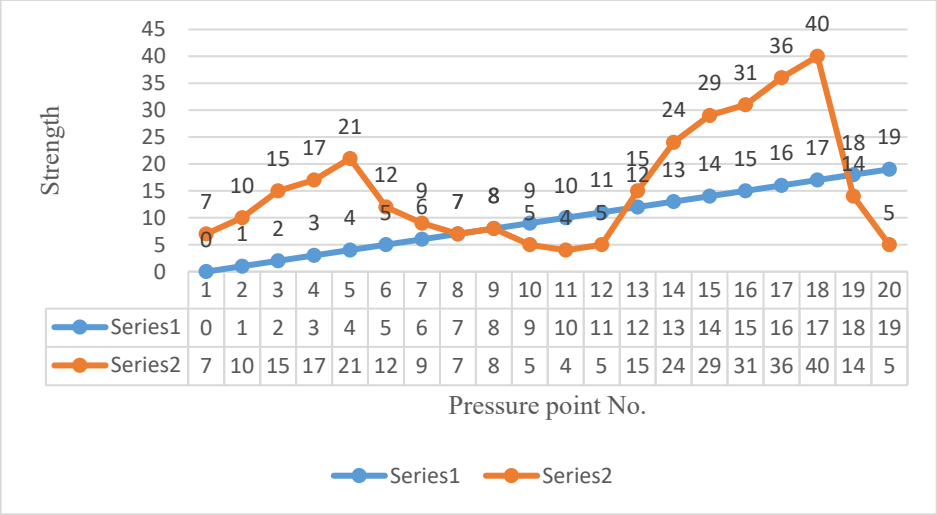


Figure 16 Strength indicators of pasta with the addition of millet 7.7% (sample No. 6).

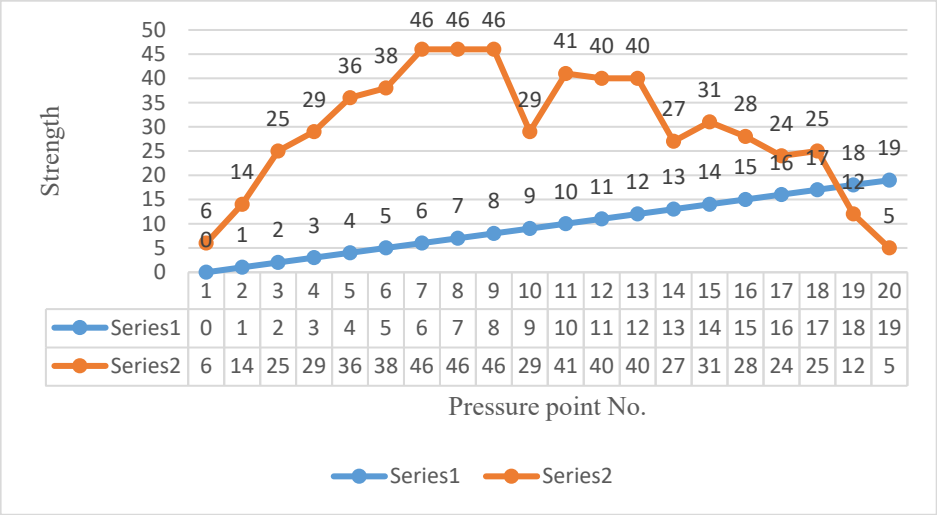


Figure 17 Strength indicators of pasta with the addition of millet 15.5% (sample No. 7).

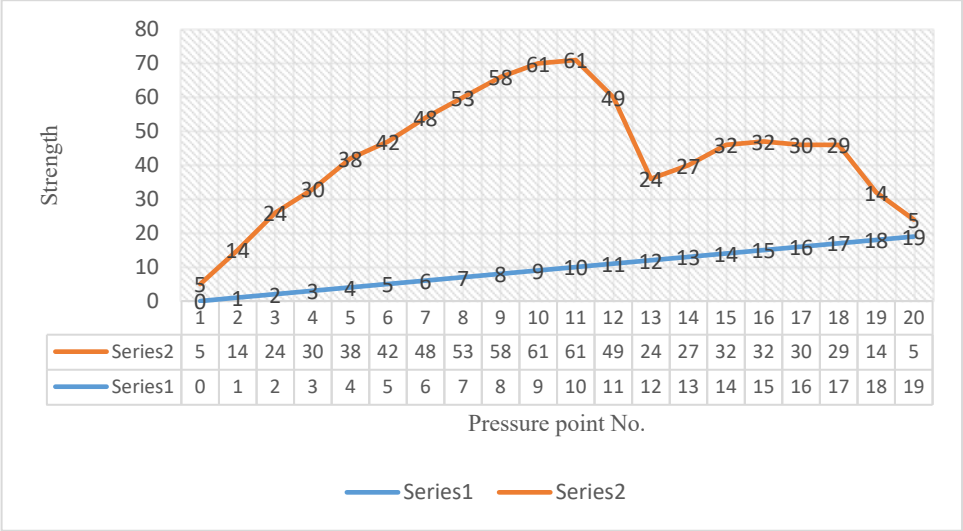
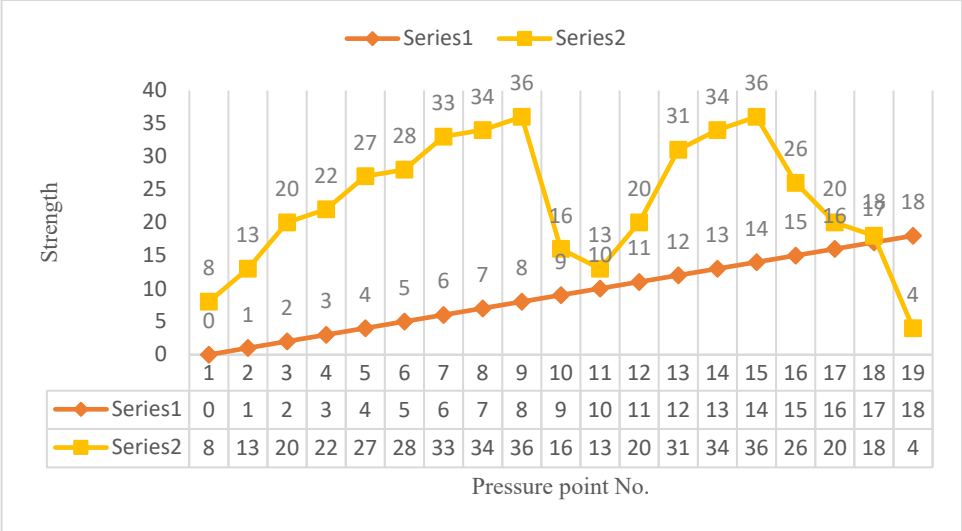


Figure 18 Strength indicators of pasta with the addition of millet 15.5% (sample No. 8).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series2	8	13	20	22	27	28	33	34	36	16	13	20	31	34	36	26	20	18	4

Figure 19 Strength indicators of pasta with the addition of millet 15.5% (sample No. 9).

The tests were carried out from pasta (50 g), and preparation for the analysis was carried out based on clauses 7.7.1 and 7.7.2 of GOST 31964-2012. The pasta was removed from the vessel in an arbitrary order and was subjected to examination on the ST-1M structure meter (Figure 20).

Figure 20 Strength determination device "Structurometer ST-1M", designed to determine the rheological characteristics of raw materials, semi-finished products and finished products, Russian Federation, Moscow, manufacturer "Ochakov Combine of Food Ingredients".

Studies have been conducted according to the methods that are established in interstate standards. Organoleptic indicators were determined according to the results of studies, it was found that with an increase in the amount of millet, the color of pasta becomes more saturated (bright) (Table 6). The taste and smell of pasta with an increase in millet becomes richer.

Table 6 Organoleptic indicators of pasta quality.

The name of the indicator	Characteristics according to GOST 31743-2017	Pasta with the addition of millet, characteristics	
		7.7%	15.5%
Color	Corresponding to the flour grade The color of products using additional raw materials varies depending on the type of this raw material	Yellow	Yellow
Form	Corresponding to the type of products		
Taste	Characteristic of this product, without extraneous taste	There is a certain taste of millet	The taste of millet is observed.
Smell	Characteristic of this product, odorless	A certain smell of millet	A slight smell of millet

According to physicochemical indicators (humidity) with the addition of millet, 7.7% for 3 indicators (except for the method of drying to a constant mass) they amounted to 28% at the pressing stage, with the addition of millet 15.5% according to 2 indicators (with the exception of the express method and drying to a constant mass) amounted to 28% at the pressing stage. Also, according to the physicochemical parameters (strength), studies of pasta were carried out (after the cooking process), and the data obtained were compared with a control sample (pasta made from high-grade grits). The conducted studies show that the strength indicators are close to the control.

CONCLUSION

According to the findings of the experiments, the quality indicators in pasta with millet additions of 7.7% and 15.5% correspond to the control sample. The humidity index at the pressing stage is 28%, the color is yellow, the shape is appropriate for the product, the taste is pleasant when ingested, the scent is typical of the product, and the strength indicators are comparable to the control sample. Additionally, millet pasta recipes have been developed. According to the study's findings, all quality indicators are within acceptable levels, with the exception of pasta with millet, which accounts for 23.3% of the total. Furthermore, investigations of pasta, after cooking, were conducted based on the physicochemical parameters (strength), and the results were compared to a control sample (pasta made from high-grade grits). Based to the results of the investigations, the strength indicators are close to the control.

REFERENCES

1. Italian cuisine. (2022). Article: Italian pasta - types of pasta, recipes, photos, history of appearance.
2. TASS. Article. (2022). Russia has entered the top ten countries in terms of pasta consumption.
3. Zahariu, A. (2022). Greece: Pasta boosts the country's economy. In Athens News. Retrieved from https://rua.gr/news/bissecon.
4. Turkey now. (2022). The population of Turkey consumes 8 kg of pasta per year - survey. Retrieved from https://nowturkey.ru/.
5. Kommersant. (2022). What types of pasta do the British prefer. Retrieved from https://www.kommersant.ru/doc/.
6. TASS. Article: (2022). Russia has entered the top ten countries in terms of pasta consumption. Retrieved from https://tass.ru/.
7. Research store. (2022). Do you love pasta as much as we love them?! Retrieved from https://marketing.rbc.ru/articles/.
8. Armstrong, M. (2022). Where Pasta Is (Not) Always on the Menu. In Statista (p. 1). Retrieved from https://www.statista.com/chart/19776/gcs-pasta-consumption/.

9. ElDala. (2022). Pasta production increased by 5.8% in Kazakhstan. In ElDala.kz (p. 1). Retrieved from https://eldala.kz/novosti/kazahstan/12697-v-kazahstane-na-5-8-uvelichilos-proizvodstvo-makaron.
10. FAO. (2023). Forecast of world grain trade for the season 2022-2023 revised downward again. In FAO (p. 1). Retrieved from https://www.fao.org/worldfoodsituation/csdb/ru/.
11. Brochard, M., Correia, P., Barroca, M. J., & Guiné, R. P. F. (2021). Development of a New Pasta Product by the Incorporation of Chestnut Flour and Bee Pollen. In Applied Sciences (Vol. 11, Issue 14, p. 6617). MDPI AG. https://doi.org/10.3390/app1114661712
12. Asia, Export Guides. (2022). Export guides: pasta (China), flour (Thailand), wheat bran (Vietnam). Retrieved from https://aemcx.ru/2022.
13. GOST 31743-2017, Pasta products, "General technical conditions".
14. TR CU 021/2011, Technical Regulations of the Customs Union, "On Food Safety".
15. Bhuvaneswari, R. (2021). On the Sensory, Colour, Texture and Physiochemical Characteristics of Foxtail Millet and Green Pea Pasta. In Bioscience Biotechnology Research Communications (Vol. 14, Issue 3, pp. 1205–1212). Society for Science and Nature. https://doi.org/10.21786/bbrc/14.3.45
16. Karuna T. D., & Nazni P. (2018). Texture and sensory characteristics of little millet based RTC (Ready-To-Cook) Noodles. In International Journal of Creative Research Thoughts (Vol. 6, Issue 2, pp. 60–71). IJCRT Publication.
17. Yazdi, A. P. G., Rousta, L. K., Tabrizzad, M. H. A., Amini, M., Tavakoli, M., & Yahyavi, M. (2020). A review: New Approach to Enrich Pasta with fruits and vegetables. In Journal of Food Science and Technology (Vol. 17, Issue 103, pp. 129–149). Tarbiat Modares University.
18. Kamble, D. B., Singh, R., Rani, S., & Pratap, D. (2019). Physicochemical properties, in vitro digestibility and structural attributes of okara-enriched functional pasta. In Journal of Food Processing and Preservation (Vol. 43, Issue 12). Hindawi Limited. https://doi.org/10.1111/jfpp.1423219
19. Saleh A.S., Zhang Q., Chen J., Shen Q. (2013). Millet grains: Nutritional quality, processing, and potential health benefits. In Comprehensive Reviews in Food Science and Food Safety (Vol. 12, Issue 3, pp. 281–295).
20. Saleh, A. S. M., Zhang, Q., Chen, J., & Shen, Q. (2013). Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. In Comprehensive Reviews in Food Science and Food Safety (Vol. 12, Issue 3, pp. 281–295). Wiley. https://doi.org/10.1111/1541-4337.12012
21. Rosa-Sibakov, N., Heiniö, R.-L., Cassan, D., Holopainen-Mantila, U., Micard, V., Lantto, R., & Sozer, N. (2016). Effect of bioprocessing and fractionation on the structural, textural and sensory properties of gluten-free faba bean pasta. In LWT - Food Science and Technology (Vol. 67, pp. 27–36). Elsevier BV. https://doi.org/10.1016/j.lwt.2015.11.032
22. Lorusso, A., Verni, M., Montemurro, M., Coda, R., Gobbetti, M., & Rizzello, C. G. (2017). Use of fermented quinoa flour for pasta making and evaluation of the technological and nutritional features. In LWT (Vol. 78, pp. 215–221). Elsevier BV. https://doi.org/10.1016/j.lwt.2016.12.046
23. Kamble, D. B., Singh, R., Rani, S., Kaur, B. P., Upadhyay, A., & Kumar, N. (2019). Optimization and characterization of antioxidant potential, in vitro protein digestion and structural attributes of microwave processed multigrain pasta. In Journal of Food Processing and Preservation (Vol. 43, Issue 10). Hindawi Limited. https://doi.org/10.1111/jfpp.14125
24. Kamali Rousta, L., Pouya Ghandehari Yazdi, A., Khorasani, S., Tavakoli, M., Ahmadi, Z., & Amini, M. (2021). Optimization of novel multigrain pasta and evaluation of physicochemical properties: using D-optimal mixture design. In Food Science & Nutrition (Vol. 9, Issue 10, pp. 5546–5556). Wiley. https://doi.org/10.1002/fsn3.2514
25. Kazakh Research Institute of Processing and Food Industry. (2022). Functional pasta. Retrieved from https://rpf.kz/.
26. Ospanov, A., Muslimov, N., Timurbekova, A., Nurdan, D., & Zhalelov, D. (2022). Mixing of flour mixture components in the production of pasta from nontraditional raw materials. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 375–387). HACCP Consulting. https://doi.org/10.5219/1749
27. Nilusha, R. A. T., Jayasinghe, J. M. J. K., Perera, O. D. A. N., & Perera, P. I. P. (2019). Development of Pasta Products with Nonconventional Ingredients and Their Effect on Selected Quality Characteristics: A Brief Overview. In International Journal of Food Science (Vol. 2019, pp. 1–10). Hindawi Limited. https://doi.org/10.1155/2019/6750726
28. Coello, K. E., Peñas, E., Martinez-Villaluenga, C., Elena Cartea, M., Velasco, P., & Frias, J. (2021). Pasta products enriched with moringa sprout powder as nutritive dense foods with bioactive potential. In Food Chemistry (Vol. 360, p. 130032). Elsevier BV. https://doi.org/10.1016/j.foodchem.2021.130032

29. Bchir, B., Karoui, R., Danthine, S., Blecker, C., Besbes, S., & Attia, H. (2022). Date, Apple, and Pear By-Products as Functional Ingredients in Pasta: Cooking Quality Attributes and Physicochemical, Rheological, and Sensorial Properties. In Foods (Vol. 11, Issue 10, p. 1393). MDPI AG. https://doi.org/10.3390/foods11101393
30. Lisiecka, K., Wójtowicz, A., Dziki, D., & Gawlik-Dziki, U. (2019). The influence of Cistus incanus L. leaves on wheat pasta quality. In Journal of Food Science and Technology (Vol. 56, Issue 9, pp. 4311–4322). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-019-03900-9
31. Hymavathi T. V., Thejasri V., & Pradeepa Roberts T. P. (2019). Enhancing cooking, sensory and nutritional quality of finger millet noodles through incorporation of hydrocolloids. In International Journal of Chemical Studies (Vol. 7, Issue 2, pp. 877–881). AkiNik Publications.
32. Bustos, M. C., Pérez, G. T., & León, A. E. (2011). Effect of Four Types of Dietary Fiber on the Technological Quality of Pasta. In Food Science and Technology International (Vol. 17, Issue 3, pp. 213–221). SAGE Publications. https://doi.org/10.1177/1082013210382303
33. Gull, A., Prasad, K., & Kumar, P. (2018). Nutritional, antioxidant, microstructural and pasting properties of functional pasta. In Journal of the Saudi Society of Agricultural Sciences (Vol. 17, Issue 2, pp. 147–153). Elsevier BV. https://doi.org/10.1016/j.jssas.2016.03.002
34. Benhur, D. R., Bhargavi, G., Kalpana, K., Vishala, A. D., Ganapathy, K. N., & Patil, J. V. (2015). Development and standardization of sorghum pasta using extrusion technology. In Journal of Food Science and Technology (Vol. 52, Issue 10, pp. 6828–6833). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-015-1801-8
35. Bianchi, F., Tolve, R., Rainero, G., Bordiga, M., Brennan, C. S., & Simonato, B. (2021). Technological, nutritional and sensory properties of pasta fortified with agro-industrial by-products: a review. In International Journal of Food Science and Technology (Vol. 56, Issue 9, pp. 4356–4366). Wiley. https://doi.org/10.1111/ijfs.15168
36. Aquino, S. G., & Cruz, Ch. (2021). Cooking properties and sensory quality of gluten-free adlai (Coix lacryma – jobi L.) pasta. In Antorcha (Vol. 9, Issue 1, pp. 15–28). Colegio de San Juan de Letran.
37. Kosiński, J., & Cacak-Pietrzak, G. (2020). Estimation of quality of spaghetti-form commercial gluten-free pastas. In Acta Agrophysica (Issue 27, pp. 5–16). Institute of Agrophysics Polish Academy of Sciences. https://doi.org/10.31545/aagr/125721
38. Boudalia, S., Gueroui, Y., Boumaza, B., Bousbia, A., Benada, M., Leksir, C., Mezroua, E. Y., Zemmouchi, K. R., Saoud, A., & Chemmam, M. (2020). Evaluation of Physicochemical Properties and Sensory Qualities of Pasta Enriched with Freeze-Dried Sweet Whey. In Scientia Agriculturae Bohemica (Vol. 51, Issue 3, pp. 75–85). Walter de Gruyter GmbH. https://doi.org/10.2478/sab-2020-0010
39. Cassares, M., Sakotani, N. L., Kunigk, L., Vasquez, P. A. S., & Jurkiewicz, C. (2020). Effect of gamma irradiation on shelf life extension of fresh pasta. In Radiation Physics and Chemistry (Vol. 174, p. 108940). Elsevier BV. https://doi.org/10.1016/j.radphyschem.2020.108940
40. Patel, P., Bajpali D., Maravi, A., & Shukla S. S. (2022). Study on Physical and Functional Characteristics of Amaranth Fortified Pasta. In Biological Forum – An International Journal (Vol. 14, Issue 3, pp. 1096–1104). Research Trend.
41. Kulkarni S. S., Desai A. D., Ranveer R. C., & Sahoo A. K. (2012). Development of nutrient rich noodles by supplementation with malted ragi flour. In International Food Research Journal (Vol.19, Issue 1, pp. 309–313). Universiti Putra Malaysia.
42. Deshmukh A. S., & Parmar A. (2021). Development of noodles supplemented with pearl millet flour. In International Journal of Scientific Research (Vol. 10, Issue 2, pp. 37–40). https://doi.org10.36106/ijsr
43. Jalgaonkar, K., Jha, S. K., & Mahawar, M. K. (2018). Influence of incorporating defatted soy flour, carrot powder, mango peel powder, and moringa leaves powder on quality characteristics of wheat semolina-pearl millet pasta. In Journal of Food Processing and Preservation (Vol. 42, Issue 4, p. e13575). Hindawi Limited. https://doi.org/10.1111/jfpp.13575
44. Bhalerao, P. P., Chaudhari, N. S., Muley, A. B., Talib, M. I., Parate, V. R., & Kudake, D. C. (2018). Fortification of Wheat Flour With Ragi Flour: Effect on Physical, Nutritional, Antioxidant and Sensory Profile of Noodles. In Current Research in Nutrition and Food Science Journal (Vol. 6, Issue 1, pp. 165–173). Enviro Research Publishers. https://doi.org/10.12944/crnfsj.6.1.19
45. Wood, J. A. (2009). Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality. In Journal of Cereal Science (Vol. 49, Issue 1, pp. 128–133). Elsevier BV. https://doi.org/10.1016/j.jcs.2008.07.016
46. Thejasri, V., Hymavathi, T. V., Roberts, T. P. P., Anusha, B., & Devi, S. S. (2017). Sensory, Physico-Chemical and Nutritional Properties of Gluten Free Biscuits Formulated with Quinoa (Chenopodium quinoa

Willd.), Foxtail Millet (Setaria italica) and Hydrocolloids. In International Journal of Current Microbiology and Applied Sciences (Vol. 6, Issue 8, pp. 1710–1721). Excellent Publishers. https://doi.org/10.20546/ijcmas.2017.608.205

47. Jalgaonkar, K., & Jha, S. K. (2016). Influence of particle size and blend composition on quality of wheat semolina-pearl millet pasta. In Journal of Cereal Science (Vol. 71, pp. 239–245). Elsevier BV. https://doi.org/10.1016/j.jcs.2016.09.007
48. Bresciani, A., Pagani, M. A., & Marti, A. (2022). Pasta-Making Process: A Narrative Review on the Relation between Process Variables and Pasta Quality. In Foods (Vol. 11, Issue 3, p. 256). MDPI AG. https://doi.org/10.3390/foods11030256
49. Boudalia, S., Mezroua, E. Y., Bousbia, A., Khaldi, M., Merabti, W. & Namoune, H. (2016). Evaluation of the Stability of the Physico-chemical Properties and Sensory Qualities of Farfalle Pasta from the Region of Guelma, Algeria. In Malaysian Journal of Nutrition (Vol. 22, Issue 3, pp. 443–453). Nutrition Society of Malaysia.
50. Serin, S., Yarim, K., & Sayar, S. (2020). Marketteki Spagetti Makarna Fiyatları ile Kalite Parametreleri Arasındaki İlişki. In Akademik Gıda (pp. 135–142). Akademik Gida. https://doi.org/10.24323/akademik-gida.758815
51. Drabińska, N., Nogueira, M., & Szmatowicz, B. (2022). Valorisation of Broccoli By-Products: Technological, Sensory and Flavour Properties of Durum Pasta Fortified with Broccoli Leaf Powder. In Molecules (Vol. 27, Issue 15, p. 4672). MDPI AG. https://doi.org/10.3390/molecules27154672
52. Covaliov, E., Deseatnicova, O., Resitca, V., Suhodol, N., Grosu, C., & Siminiuc, R. (2022). Impact of plant additives: Parsley (Petroselinum crispum) leaves and red bell pepper (Capsicum annuum) on the quality of eggless wheat pasta. In Czech Journal of Food Sciences (Vol. 40, Issue 4, pp. 281–289). Czech Academy of Agricultural Sciences. https://doi.org/10.17221/206/2021-cjfs
53. Serwaa, A., Agamba, D., & Abayase, R. (2021). Nutritional Composition and Sensory Evaluation of Wheat and Millet Flour Pasta Noodles. In International Journal of Academic and Applied Research (Vol. 5, Issue 1, pp. 136–141). Bowling Green KY: International Journals of Academic Research World (IJARW).
54. Jakab, I., Tormási, J., Dhaygude, V., Mednyánszky, Zs., Sipos, L., & Szedljak, I. (2020). Cricket flour-laden millet flour blends' physical and chemical composition and adaptation in dried pasta products. In Acta Alimentaria (Vol. 49, Issue 1, pp. 4–12). Akademiai Kiado Zrt. https://doi.org/10.1556/066.2020.49.1.2

Funds:

-

Acknowledgments:

-

Conflict of Interest:

The authors declare no conflict of interest.

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

Contact Address:

***Gulmaida Karimova**, Standardization, Certification and Metrology" (by industry), Technical Faculty, Department of Standardization, Metrology and Certification NCJSC "S. Seifullin, Kazakh Agro Technical Research University", Astana 010011, Kazakhstan,
E-mail: gulmaida@mail.ru
ORCID: https://orcid.org/0000-0002-7190-8847

Rimma Niyazbekova, Standardization, Certification and Metrology" (by industry), Technical Faculty, Department of Standardization, Metrology and Certification NCJSC "S. Seifullin, Kazakh Agro Technical Research University", Astana 010011, Kazakhstan,
E-mail: rimma.n60@mail.ru
ORCID: https://orcid.org/0000-0001-8688-1408

Khaldun Al Azzam, Pharmacological and Diagnostic Research Center (PDRC), Department of Pharmaceutical Sciences, Faculty of Pharmacy, Al-Ahliyya Amman University, Amman 19328, Jordan,
E-mail: azzamkha@yahoo.com
ORCID: https://orcid.org/0000-0003-4097-6991

Nurbibi Mashanova, Technology of Food and Processing Industries NCJSC "S. Seifullin, Kazakh Agro Technical Research University", Astana 010011, Kazakhstan,
E-mail: n.mashanova@kazatu.edu.kz
ORCID: https://orcid.org/0000-0001-8664-5173

El-Sayed Negim, School of Petroleum Engineering, Satbayev University, 22 Satpayev Street, 050013 Almaty, Kazakhstan; School of Materials Science and Green Technologies, Kazakh-British Technical University, 59 Tole bi St., 050000, Almaty, Kazakhstan,
E-mail: elashmawi5@yahoo.com
ORCID: https://orcid.org/0000-0002-4370-8995

Ainur Ibzhanova, Standardization, Certification and Metrology" (by industry), Technical Faculty, Department of Standardization, Metrology and Certification NCJSC "S. Seifullin, Kazakh Agro Technical Research University", Astana 010011, Kazakhstan,
E-mail: ibzhanova83@mail.ru
ORCID: https://orcid.org/0000-0001-6768-3262

Corresponding author: *