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The Effect Of Various Dosages of Poly-Cereal Raw Materials on The Drying Speed and Quality of Cooked Pasta During Storage

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Abstract

This article explores the influence of poly-cereal pasta ingredients on drying kinetics and finished product quality. The experiments were carried out on three formulations of poly-cereal flour mixtures with the addition of 25% dry wheat gluten during drying at temperatures of 40, 50 and 60°C. The quality of the cooked pasta is assessed using sensory analysis and the score methods. According to the results of studying the rheological properties, the drying rate increases with increasing drying temperature. The maximum drying duration before reaching a moisture level of 10% corresponds to the formulation containing barley and peas. Sensory analysis on quality assessment showed that pasta with a high content of millet and oats received the highest score 93. Other mixtures also received good grades, indicating a balanced composition of all formulations. The optimum drying temperature for these mixtures was found to be 60°C from the point of view of preserving the nutritional properties, quality characteristics of dry food products and energy efficiency in industrial production.

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Keywords

Dry Wheat Gluten;
Drying Kinetics;
Drying Process;
Mc;
Unconventional Raw Materials;
Wholegrain.

Introduction

In the modern world, pasta is an integral part of the daily human diet. These flour products have gained their popularity due to their nutritional properties, as well as taste, ease of preparation and the ability to store for a long period.[1,2] Traditional pasta formulations contain a large amount of complex carbohydrates, proteins, vitamins B, iron, and low amount of sodium and fat.[3,4] In addition to wheat flour, in order to increase the nutritional value of these foods, legumes5 or other cereal ingredients6 are introduced into the composition. Another important aspect affecting the quality of products is the applied technology of grinding grain7 and cooking pasta. In previous studies, the use of new approaches in grain processing technology made

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it possible to increase the degree of preparedness of food products by using extrusive technologies of ready-mixed cereal grain cereal mixture.[8-10]

Pasta production consists of such phased technological operations as preparing raw materials for production, dosing raw materials and various ingredients, kneading dough, pressing and forming fresh macaroni, cutting and stacking fresh macaroni, drying and packaging of ready products.[11] Drying is one of the most common processes for increasing the shelf life of food products, but also for maintaining or improving their taste and nutritional qualities. In the drying process, food moisture decreases to a certain level in order to minimize microbial spoilage.[12] For pasta, this level is about 11%. During the drying process, moisture first evaporates from the surface of the dough, and then moisture migrates from the inside of the dough. As a result, a moisture content gradient forms in the center of the macaroni and on its surface, and the time required for balancing depends on the thickness of the pasta and the rate of moisture diffusion.[13]

To describe the relationship between moisture content and equilibrium relative humidity, moisture sorption isotherms are studied. These data are useful for understanding the phenomena that occur during the drying or rehydration of food.[14] The equilibrium moisture content allows to optimize the drying time and energy use. In addition, the data gained may be useful for assessing storage stability of food products. Depending on the moisture and temperature conditions, microbial growth, enzymatic reactions, non-enzymatic browning and lipid oxidation are controlled.[15,16] Also, these factors strongly affect the physical properties of pasta - the appearance of cracks and splits, crumbling, shrinkage or swelling,[17] which leads to loss of the products' vendibility, therefore, to unnecessary costs. The duration of pasta storage also depends on the level of protein and fat enrichment. Fortified foods have a shorter shelf life (2 to 6 months) due to fat deterioration. Without any enrichment, pasta can be stored for one year; it is best stored at lower temperatures.[18] However, in the literature there are no studies of the effect of various poly-cereal ingredients on the sorbing properties of macaroni products, which is very important in connection with an increase in demand for these products.

In previous studies of traditional crops grown in Kazakhstan, we developed formulations of three poly-cereal flour mixtures with high, medium and minimum nutritional values for the production of various food products.[19-22] According to the results of experimental studies of the rheological properties of the test, the addition of dry wheat gluten in an amount of 25% increases the testament elasticity of all formulations.[23] From the point of view of technological processes of kneading and pressing, the optimal moisture level of the test was 31.5%.[24] The aim of this work is to study the effect of these three poly-cereal ingredients on the kinetics of drying pasta, affecting the quality of the finished product in terms of taste and presentability of appearance.

Materials and Methods

All experimental and analytical studies were conducted in the research laboratory of the *'Technology of Processing Industries'* research Centre and in the research laboratory of the AgriTech Hub, attached to the Kazakh National Agrarian University.

The object of the study was three types of pasta with various poly-cereal ingredients according to the patented formulations,[19,25] the composition of which is presented in Table 1.

To knead the dough, flour mixtures were used that were obtained by extruded technology[26] under three formulations. Pasta from unconventional poly-cereal raw materials was made using the laboratory press machine Götz GmbH.

The rheological properties of poly-cereal dough were studies using modern devices, such as the AlveoConsistograph (CHOPIN Technologies) and the farinograph (Brabender). The drying kinetics of unconventional pasta was studied at a drying temperature of 40°C, 50°C and 60°C. For storage purposes, the required moisture content in a mix is 10%.

Sensory analysis of samples dried and prepared at different temperatures was carried out in accordance with ISO 5496-2005 and ISO 5495-2005 by a qualified tasting group of 5 people from Kazakh

National Agrarian University. To assess the quality of food products for several quality indicators, the ISO 3972-2005 scoring method[38, 56] was used on a 100-point scale.

Table 1: formulations of pasta from poly-cereal raw materials[25]

Name of ingredient	formulation 1 (%)	formulation 2 (%)	formulation 3 (%)
Barley	0	0	16
Corn	33.33	50	25
Qat	33.33	16.66	15
Buckwheat	0	16.66	27,33
Millet	16.66	0	0
Pea	0	0	16.66
Soy	16.66	16.66	0
Protein	18.028 (discrepancy in protein - 4.248)	17.824 (discrepancy in protein - 3.654)	18.5
Starch	60.256	63.076	56.7
Cellulose	8.076 (discrepancy in the carbs -0.008)	6.684 (discrepancy in the carbs - 0.0299)	13.23
Fats	8.610 (discrepancy of fats - 9.27)	8.348 (discrepancy of fats - 7.692)	7.76
Ash	3.664	2.946	5.34

Dry wheat gluten (DWG) was added to each mixture in an amount of 25%.

Results

Figure 1 shows the drying kinetics of unconventional pasta with 25% DWG added for all formulations. As can be seen from Fig. 1 isothermal curves at 40, 50 and 60°C showed different drying rates, which are non-linear. The results of measuring time values upon reaching the required humidity level (10%) are presented in Table 2. With temperature increasing, the drying time decreases by 65-70 minutes. In addition, the drying values for formulation No. 3 at all temperatures are 30-35 minutes longer compared with formulations No. 1 and 2. The shift in drying time that was observed in this case is a result of a complex formulation, including barley and peas, which have high heat capacity.

Table 2: Values of drying time at different temperatures for the three studied formulations with 25% DWG pasta

Drying temperature (°C)	Time (min)		
	formulation No. 1	formulation No. 2	formulation No. 3
40	150	150	185
50	125	125	150
60	85	85	115

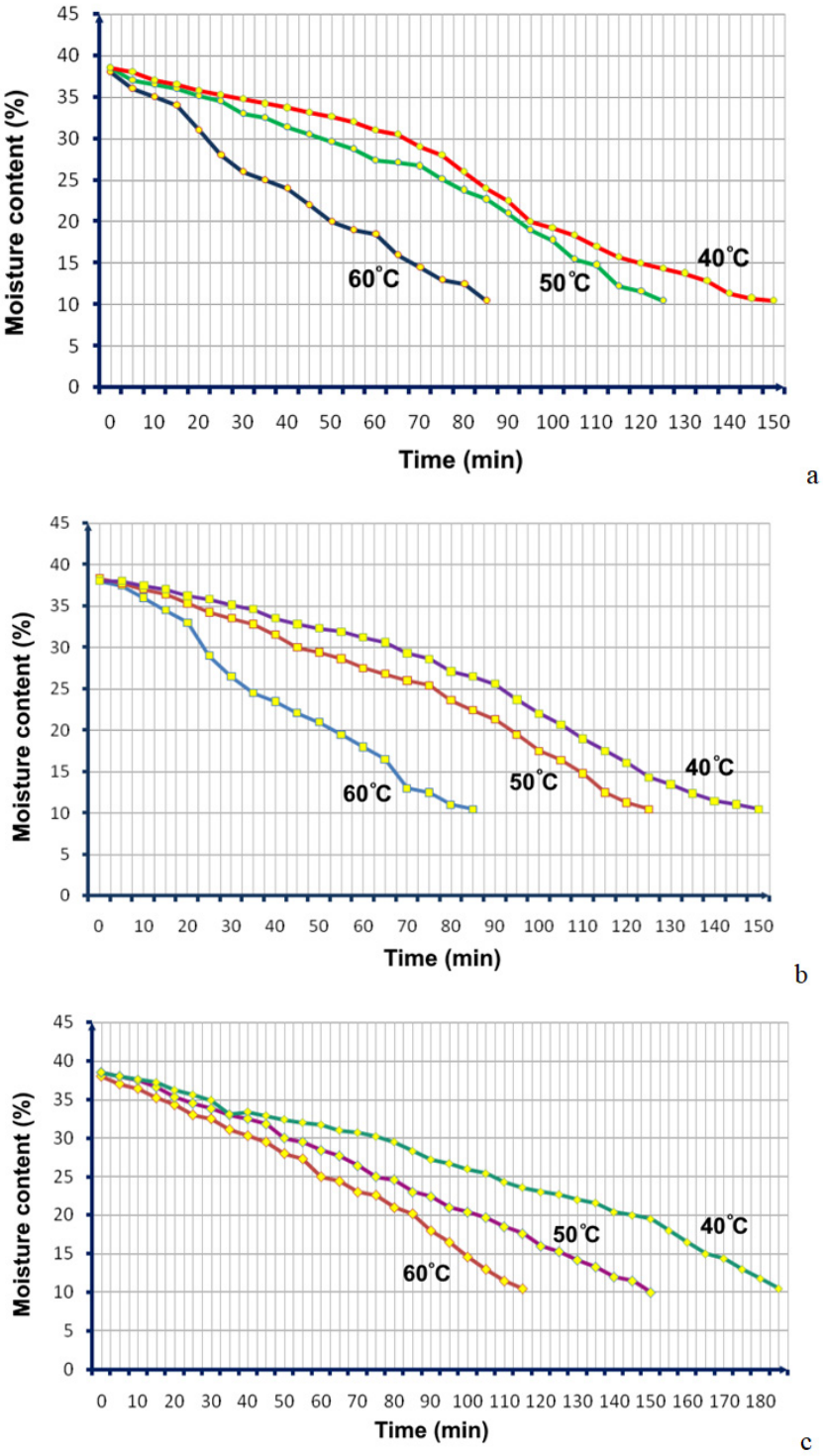

Fig.1: The Drying Curve for Pasta with 25% DWG Added for Formulation No. 1 (a), No. 2 (b) and No. 3 (c) at temperatures of 40, 50 and 60°C

The nonlinear nature of the isothermal curves can be explained by the fact that the evaporation process can be broken into two stages. During the first stage of drying, the moisture content is related to the heat temperature linearly, due to intense removal of loosely bound moisture. For pasta, the average stage lasts 55 to 65 minutes at 40°C, 35 to 45 minutes at 50°C, and 20 to 25 minutes at 60°C until a critical point, when pasta passes from a plastic to a solid state.

The second stage of drying is characterized by the removal of physico-chemically bound moisture. During this stage, the inclination angle of a curved line of drying decreases until the standard moisture content is reached. Further drying is energy-intensive.

Sensory analysis of 25% DWG pasta of three types after drying at different temperatures shows that all products had a rough surface, rough texture and slight cracks, without extraneous odors and obvious tastes. The differences were only in the color of the products due to the different compositions of the ingredients. Pasta with a high corn content is light yellow, with buckwheat they are light brown. Thus, at this stage, there were no particular differences from the drying temperature.

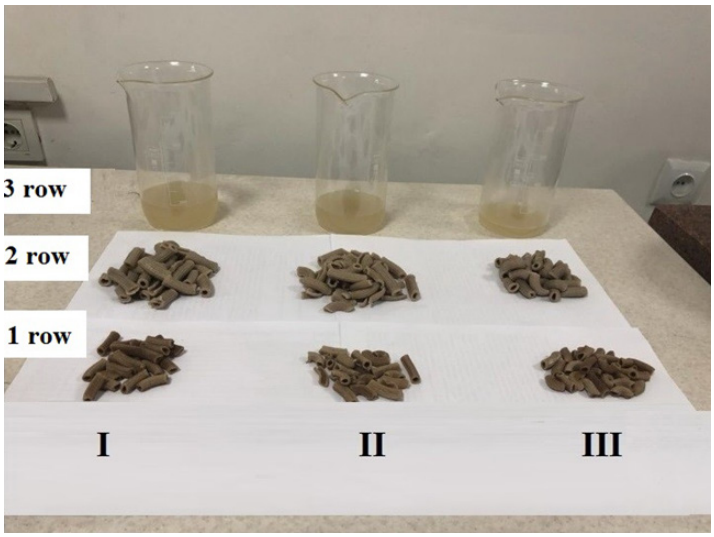

Fig. 4: Comparative Quality Analysis of Pasta from Poly-Cereal Flour under Three Formulations

The next step was testing the cooked pasta. Figure 4 shows all three kinds of pasta dried at 60°C before (row 1) and after cooking (row 2) together with the cooking water that left after the fact (row 3). As can be seen, after cooking, all pasta samples approximately doubled the volume. The cooking water became slightly cloudy, with few pasta fragments left floating in the water. However, all types of poly-cereal pasta have retained their hollow horn shape, resilient texture and color.

Formulations

Data on the sensorial quality of cooked pasta is presented in Table 2. The sensory analysis of cooked pasta indicates high quality of cooked products.

Thus, sensory analysis ranks pasta that was made as follows:

Good

These are products, made under formulations No. 1 and No.3, which scored 89 points and 93 points, respectively.

Description

slight acceptable sticking; cloudy water after cooking; slightly darker or brighter color; strong taste and odor, which are specific to this grade of pasta;

Table 2: Sensorial Findings regarding the Quality of Cooked Unconventional Pasta

Quality	Description	Score	formulation		
			1	2	3
Appearance	Smooth surface, regular shape, not mushy and not stuck together	25			
	Rough surface, regular shape, with soft edges, not mushy and not stuck together	23	23	23	23
	Smooth surface, regular shape, slightly stuck together, partly soft	22			
	Smooth surface, seriously stuck together, some soft or with cracks	15			
	Stuck together completely, most is soft or with cracks	5			
	Most is soft, turned to mush	2			
Color	Uniform, specific to this grade	15			
	Uniform, slightly darker or brighter than the standard	12	12	12	12
	Critically darker or brighter than the standard	10			
	Non-uniform	5			
	Grey/brown	2			
Aroma/Odor	Specific to this grade, strong	10			10
	Good, mild	8	8		
	Weak	6		6	
	Absent	4			
	Foreign	0			
Taste	Specific to this grade, very strong	25			
	Specific to this grade, strong	23	23		23
	Specific to this grade, weak	20		20	
	Absent	10			
	Foreign	0			
Texture	Firm to the bite	15	15		15
	Slightly soft	12		12	
	Soft	8			
	Soft, partly falls apart	5			
	Falls apart	0			
Pasta water	Slightly cloudy	10			10
	Slightly cloudy, with few pasta fragments floating, without pasta fragments at the bottom	9			
	Slightly cloudy, with few pasta fragments floating and at the bottom	8	8		
	Cloudy	7		7	
	Cloudy, with few pasta fragments at the bottom	5			
	Very cloudy, with many pasta fragments floating and at the bottom	2			
Total Score		100	89	80	93

Thus, sensory analysis ranks pasta that was made as follows:

Satisfactory
These are products, made under formulation No. 2, which scored 80 points.

Description
mild taste and odor; noticeable sticking after cooking; dark or excessively bright color; cloudy water; soft texture.

Discussion
Considering the results above, the quality of pasta under the three formulations does not change with increasing drying temperature. Thus, from the point of view of energy efficiency in industrial production, the optimal drying temperature will be 60 C, with higher rate of moisture evaporation compared to low temperatures. In addition, at this temperature, the qualitative and nutritional properties of pasta associated with the appearance of cracks and the deterioration of taste characteristics are preserved. Organoleptic analysis of the prepared pasta indicates the high quality of the cooked product. High scores for formulations No. 1 and 3 indicate a balanced composition not only in nutritional qualities, but also in sensory characteristics. According to 17, 18, pasta with a lower fat content can be stored for up to a year under conditions of moderate temperature and room humidity of 70%. Since the studied pasta formulations contain a relatively low fat content, while a high level of nutrition depends more on the protein content and low humidity of the dried products, we can assume that the shelf life of the obtained products is 12 months for formulation No. 3 and from 6 months for formulations No. 1 and 2.

In a study of various technological treatments of pasta enriched with 35% legumes showed,[27], that drying at 55°C is optimal for maintaining the nutritional properties, digestibility levels of starch and protein network at the macromolecular level. The results of adding bean flour to wheat grits on the quality of cooking and the total phenol content in the paste at drying temperatures of 60, 70 and 80° C[28] show that the drying temperature affects the humidity level and cooking time, which increases with the temperature. In addition, the nutritional and qualitative properties of pasta depend only on the amount of the ingredient, which agrees well with the results of this work.

The effect of drying on the pasta structure, starch and protein digestibility, and potential allergenicity at 55, 70, and 90°C were studied in.[29] According to rheological measurements, insignificant changes in the structure are observed at drying temperatures up to 70°C. A further increase in temperature leads to a decrease in the starch digestibility and a significant decrease in the protein digestibility. Similar studies of millet-based pasta quality depending on the drying temperature12 showed that with increasing temperature, water absorption decreased and the color of the product changed. Temperature of 60°C was optimal in terms of product quality. In addition, a number of works also show similar results.[13, 14, 30] This comparative analysis with other studies indicates the reliability of the results obtained in this paper and the assumptions made.

Conclusion
Thus, based on the results obtained and discussions, we can draw the following conclusions. It was established that the evaporation process occurs in two stages, where in the first the moisture content and the heating temperature are linearly related due to the intensive removal of weakly bound moisture. The time range of this stage is inversely proportional to the drying temperature. At the drying stage, physically and chemically bound moisture is removed inside the dough, with the decrease of the pasta drying speed. A longer process in drying time at all temperatures occurs for formulation No. 3 due to the high thermal resistance of peas and barley, which are part of the mixture. The shortest drying time to a moisture level of 10% is realized at a temperature of 60°C for all three types of pasta. According to sensory analysis of ready products, the qualitative properties of pasta do not depend on the drying temperature, but are only determined by the composition of the additives in the mixture. The highest scores of 93 and 89 after organoleptic analysis were obtained by formulations No. 1 and 3, respectively. Based on the results, the optimum drying temperature is 60°C in terms of product quality and energy efficiency in production for all poly-cereal pasta recipes.

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Conflict of Interest

The authors do not have any conflict of interest.

References

1. Beleggia, R., Platani, C., Papa, R., Di Chio, A., Barros, E., Mashaba, C., ... & Rauscher, J. (2011). Metabolomics and food processing: from semolina to pasta. *Journal of agricultural and food chemistry*, 59(17), 9366-9377.
2. Krishnan, M., & Prabhasankar, P. (2012). Health based pasta: redefining the concept of the next generation convenience food. *Critical reviews in food science and nutrition*, 52(1), 9-20.
3. Fuad, T., & Prabhasankar, P. (2010). Role of ingredients in pasta product quality: A review on recent developments. *Critical reviews in food science and nutrition*, 50(8), 787-798.
4. Capozzi, V., Menga, V., Digesu, A. M., De Vita, P., van Sinderen, D., Cattivelli, L., ... & Spano, G. (2011). Biotechnological production of vitamin B2-enriched bread and pasta. *Journal of agricultural and food chemistry*, 59(14), 8013-8020.
5. Foschia, M., Horstmann, S. W., Arendt, E. K., & Zannini, E. (2017). Legumes as functional ingredients in gluten-free bakery and pasta products. *Annual review of food science and technology*, 8, 75-96.
6. Hager, A. S., Czerny, M., Bez, J., Zannini, E., & Arendt, E. K. (2013). Starch properties, in vitro digestibility and sensory evaluation of fresh egg pasta produced from oat, teff and wheat flour. *Journal of Cereal Science,* 58(1), 156-163.
7. Cubadda, F., Aureli, F., Raggi, A., & Carcea, M. (2009). Effect of milling, pasta making and cooking on minerals in durum wheat. *Journal of Cereal Science,* 49(1), 92-97.
8. Ospanov, A. A. (2014). On a new relationship between the energy consumption and particle size in a processes of crushing and grinding. Journal of EcoAgriTourism, 10(1), 195-197.
9. Ospanov A., Gaceu L., Timurbekova A., Muslimov N., Dzhumabekova G. Innovative technologies of grain crops processing. Brasov: Infomarket Publishers: 2014.
10. Ospanov A. A., Timurbekova A. K., Muslimov N. Z. H., Dzhumabekova G. B. Method for manufacturing of extruded poly-cereal products of high degree of preparation. Technologies for the food and processing industry of AIC – healthy foods 2015; 1: 38-45.
11. Carini, E., Curti, E., Minucciani, M., Antoniazzi, F., & Vittadini, E. (2016). 10 Pasta. Engineering Aspects of Cereal and Cereal-Based Products, 211.
12. Gull, A., Prasad, K., & Kumar, P. (2017). Drying kinetics of millet, poamce and wheat based pasta and its effect on microstructure, color, water absorption and pasting properties. *Journal of Food Measurement and Characterization,* 11(2), 675-684.
13. Ogawa, T., Hasegawa, A., & Adachi, S. (2014). Effects of relaxation of gluten network on rehydration kinetics of pasta. *Bioscience, biotechnology, and biochemistry,* 78(11), 1930-1934.
14. Chuma, A., Ogawa, T., Kobayashi, T., & Adachi, S. (2012). Moisture sorption isotherm of durum wheat flour. *Food Science and Technology Research*, 18(5), 617-622.
15. Bell, L. N. (2007). Moisture effects on food's chemical stability. Barbosa-Canovas GV, Fontanta AJ, Schmidt SJ, Labuza TP. Water Activity in Foods. Ames, Iowa: Blackwell Publishing and Institute of Food Technologists. p, 173-198.
16. Van Boekel, M. A. (2008). Kinetic modeling of food quality: a critical review. *Comprehensive Reviews in Food Science and Food Safety,* 7(1), 144-158.

17. Chernov M. E. Production of instant pasta. Moscow: DeLi print; 2008.
18. Medvedev G. M. Pasta technology. St. Petersburg: GIORD; 2006.
19. Ospanov A. A., Muslimov N. Z. H., Timurbekova A. K., Dzhumabekova G. B. Chemical Composition of selected grain samples: protein, starch, fiber and ash. Research, Results 2015; 3: 93-102.
20. Ospanov A., Muslimov N., Timurbekova A., Jumabekova G., Kamzabekov S. Research poly-cereal energy value of food products by extruding. Research, Results 2017; 2: 94-99.
21. Ospanov A., Muslimov N., Timurbekova A., Jumabekova G., Kamzabekov S. Research efficiency extrusion process flour poly-cereal mixture. Research, Results 2017; 1: 24-30.
22. Ospanov A. A., Muslimov N. Z. H., Timurbekova A. K. Technology of manufacturing of poly-cereal products: Textbook. Almaty: Almanach Publishing House; 2017.
23. Ospanov A., Nurzhan N., Timurbekova A., Jumabekova G. Research of rheological behavior of the dough from poly-cereal flour mix for manufacture of pasta. *Scientific Journal KazNau of Research and Results* 2018; 3(79): 63-69.
24. Ospanov A., Muslimov N., Timurbekova A., Jumabekova G. Effect of Humidity of poly-cereal flour mixture and screw rotation rate on efficiency of extrusion process. IJESE 2016
25. Ospanov, A., Muslimov, N., Timurbekova, A., Jumabekova, G., Almaganbetova, A., Zhalelov, D., & Nurdan, D. (2019). The study of indicators of the quality test of poly-cereal whole meal flour for making pasta. *Journal of Hygienic Engineering and Design*, (27), 32-38.
26. Ostrikov A., Shakhov S., Ospanov A., Muslimov N., Timurbekova A., Jumabekova G. Mathematical modeling of product melt flow in the molding channel of an extruding machine with meat filling feeding. *J. Food Process Eng.* 2018; 41(8): e12874.
27. Petitot, M., & Micard, V. (2010). Legume-fortified pasta. Impact of drying and precooking treatments on pasta structure and inherent *in vitro* starch digestibility. *Food biophysics,* 5(4), 309-320.
28. Gallegos-Infante, J. A., Rocha-Guzman, N. E., Gonzalez-Laredo, R. F., Ochoa-Martínez, L. A., Corzo, N., Bello-Perez, L. A., ... & Peralta-Alvarez, L. E. (2010). Quality of spaghetti pasta containing Mexican common bean flour (Phaseolus vulgaris L.). *Food Chemistry,* 119(4), 1544-1549.
29. Petitot, M., Brossard, C., Barron, C., Larré, C., Morel, M. H., & Micard, V. (2009). Modification of pasta structure induced by high drying temperatures. Effects on the in vitro digestibility of protein and starch fractions and the potential allergenicity of protein hydrolysates. *Food Chemistry*, 116(2), 401-412.
30. Villeneuve, S., & Gélinas, P. (2007). Drying kinetics of whole durum wheat pasta according to temperature and relative humidity. LWT-Food Science and Technology, 40(3), 465-471.