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Improvement of Macaroni Products Technology on the Basis of Flour from Plant Raw Materials

[1]G.A. Umirzakova, [1]G.K. Iskakova, [1]B.Zh. Muldabekova, [1]M.P. Bayisbayeva and [2]V.Y. Chernykh
[1]Almaty Technological University, Tole Bi 100, 050012 Almaty, Kazakhstan
[2]Research Institute of the Baking Industry, Bolshaya Cherkizovskaya 26A, 107553 Moscow, Russia

Abstract: As a result of particle composition studies, color characteristics, flour whiteness, strength and quality of the finished macaroni products we established that to obtain macaroni products from top-grade bread flour with good physical-chemical and organoleptic parameters it is allowed no >10% of macaroni products from macaroni flour semolina and no >12.5% of fine chickpea flour in recipe, further increasing of fine chickpea flour leads to deterioration of the technological properties of finished products. The use of fine chick-pea flour is advisable to enrich the pasta with valuable food components.

Key words: Macaroni products, top-grade bread flour, macaroni flour, fine chick-pea flour, particle composition, color characteristics, product strength

INTRODUCTION

Today, production of food with the main directions of the state policy in the field of healthy nutrition is to create qualitatively new technologies of food production with a directional change in chemical composition including the products of therapeutic purposes as well as the elimination of vitamins existing deficiency, macro and micronutrients and other essential nutrients. Thus, manufacturers are focused to produce enriched foods targeted at mass consumers (Dolmatova, 2015).

Considering that in Kazakhstan macaroni products are popular and consumed in large quantities it is possible to realistically and effectively carry out prevention of various diseases with the help of high quality value products, due to the various additives. The correct choice of additives for the enrichment of food including macaroni products should be based on the theory of a balanced diet and take into account the content of the active substance in the additive which should be at a level ensuring preventive properties of the product under real technological dosages as well as ensure compliance with the required quality product including storage, cooking, etc. (Iskakova and Umirzakova, 2015).

Derivative products of legumes are used as additives that increase the nutritional value of bakery products. The introduction of legumes derivative products in the manufacture of macaroni products affects the organoleptic and physical-chemical parameters of quality in finished product (Medvedev, 2006).

Seeds of legumes are an important source of high-value dietary protein, starch, dietary fiber, vitamins and most minerals. They serve as a cheap source of vegetable protein and accumulate it in several times larger than cereals (20-40 and 7-14%, respectively) (Muratbaev *et al*., 2015).

Among the variety of non-traditional raw materials in the manufacture of macaroni products chickpea flour is interesting in the framework of this article. Chickpea is nutritionally superior to all other types of legumes including peas, lentils and soybeans. Chickpea flour significantly increases satiety and taste properties of such products as macaroni, bread and pastries. It also has a superior quality it does not absorb vegetable oil. Energy value of chickpea flour is 337 kcal per 100 g of product (Germanceva, 2014; Pashenko and Kuracheva, 2004). Chickpea flour has the following chemical composition: beta-carotene, vitamins A, B1, B2, B5, B6, B9, C, E, K and PP as well as potassium, calcium, magnesium, zinc, selenium, copper, iron, chlorine, sulfur, iodine, manganese, molybdenum, boron, vanadium, tin, titanium, silicon, cobalt, phosphorus, sodium.

Chickpea flour has a unique vitamin and mineral composition in addition to dietary fiber which contribute to the normalization of the bowel it contains saturated and unsaturated fatty acids which have an invaluable impact on the human body (Chang *et al*., 2012). Studies aimed at improving food and biological value of macaroni products, organoleptic and physical-chemical parameters on the basis of the use of chickpea flour are currently important.

Corresponding Author: G.A. Umirzakova, Almaty Technological University, Tole Bi 100, 050012 Almaty, Kazakhstan

MATERIALS AND METHODS

Objects and methods of study: For experimental studies top-grade wheat flour, macaroni flour (semolina), chickpea fine flour was used. Their particle composition and color was studied also we studied the effect of chickpea flour on the quality of macaroni. Particle composition of the different flour samples were determined using Information-Measuring System (IMS) based on the unit "GIU-1".

The operating principle of an optical granulometer "GIU-1", based on the analysis of images from electronic micro copied samples deposited on a glass slide. Special software can search and count the particles, measure light transmission of particles, elongation, smoothness and area. Range of measured particle sizes is 1-250 m/km. Time of one frame processing is 0.4 sec, 10 min are needed to obtain statistically reliable results (10000 particles) for each sample.

Whiteness of flour was determined by Blik-R3.The spectral area of Blik-R3 is within 540±50 nm, range of measured reflection coefficients is 45, 90%, standard deviation of measurements of the reflection coefficients is 0.3%, basic absolute measurement error is 1%, amount of automatically measured fields on the prepared sample is 10 pcs. Whiteness determination time for one sample is not >60 sec.

Color characteristics of flour were determined by using Chromameter Cr-440 device. The operating principle of three-position colorimeter is based on measurements of the light reflection coefficient from the sample. The device produces three measurements at different wavelengths and on the basis of the results the color coordinate in two different systems is determined as well as the whiteness and yellowness of the object.

The strength of the macaroni products was determined by "Strukturometr ST-2" device designed to determine the rheological and strength properties of raw materials, semi-finished and finished food products. Determination of rheological properties of food environments is made on the basis of kinetic analysis (mechanical load changes over time) and dynamics (measurement of mechanical load on the penetration depth of the indenter) of loading force measured by the strain gage (strain gage primary transducer) when moving different indenters in vertical direction for a given speed law. Organoleptic (color, surface condition, shape, smell and taste), physico-chemical (moisture, acidity) quality parameters and cooking properties of macaroni were determined according to the guidelines (Kovalskaya, 1991).

To determine the appearance (color, surface condition, shape, smell and taste) a sample of macaroni was placed on a smooth surface, gently stirred and examined. Moisture was determined by drying thoroughly crushed macaroni in oven SASH-3M at 1300°C for 40 min expressed in percentage.

Acidity of macaroni product was determined by water wash milland expressed in degrees. Cooking properties are characterized by the following parameters: shape, duration of cooking, mass magnification coefficient of product (km), amount of dry matter transferred into the cooking water, condition of the cooking water.

To determine the condition of products after cooking 50-100 g of product was placed in a ten-fold amount of boiling water by weight and cooked until ready. After cooking the macaroni was transferred to a sieve, drained and visually examined the dimensional stability of products and their adhesion to each other.

The duration of cooking was defined by period of time from putting products into the boiling water until the disappearance of floury uncooked layer. During cooking some macaroni products were periodically removed and placed between two bits of glass and squeezed. The disappearance of undercooked layer shows the readiness of products. The mass magnification coefficient of product during cooking was calculated according to the equation:

$$K = M_2 - M_1 / M_1$$

Where:

M_2 = Mass of cooked products, g (determined after draining of the cooking liquid)

M_1 = Mass of dry products, g

Amount of dry matter transferred into the cooking water, determined by accelerated method and expressed as a percentage of the dry mass taking for cooking. Amount of dry matter n (%) transferred into the cooking water was calculated by equation:

$$\Pi = (b - a)\ V/G.50(100)$$

Where:

b = Mass of the cup with dry residue (g)

a = Mass of the empty cup (g)

RESULTS AND DISCUSSION

Particle composition of top-grade wheat flour, macaroni flour (semolina), chickpea fine flour was studied for the production of functional macaroni products. The results of particle composition study of the flour are shown in Table 1 and Fig. 1 and color characteristics in Table 2. It is obvious from Fig. 1 that particle compositions are higher in macaroni semolina and lower in chickpea flour. Table 1 shows the values of the average equivalent

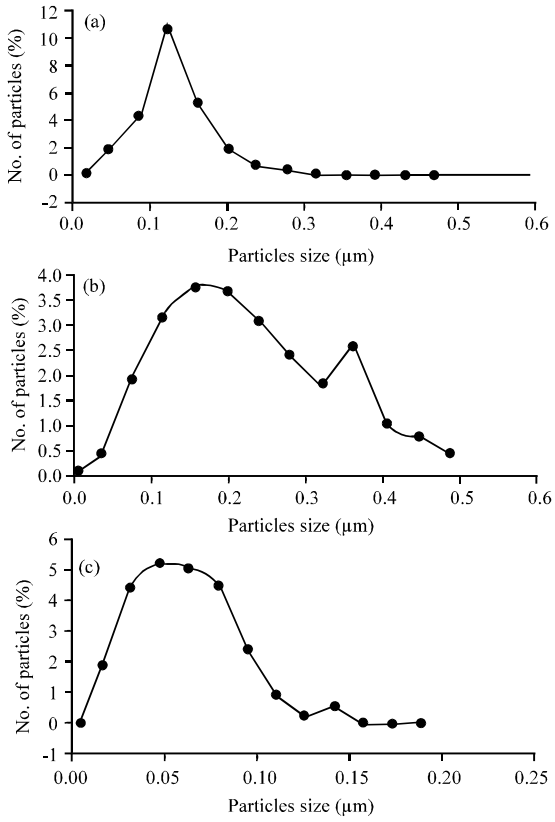

Fig. 1: Particle composition of: a) Top-grade wheat flour; b) Macaroni flour (semolina); c) Chickpea fine flour

Table 1: Particle fineness of the different types of flour and morphological features of its particles

Raw material (flour)	$d_{эКВ}$ (µm)	Smoothness	Elongation	Light transmission
Top-grade wheat	107	2.00	1.66	0.86
Macaroni (semolina)	210	2.15	1.63	0.91
Chickpea	66	2.28	1.94	0.77

Table 2: Color characteristics of dispersed systems controlled with Cr-410 and Blik-R3 devices

	Cr-410				Blik-R3
Type of flour	L	A	B	Yellowness	Whiteness (tr.un)
Top-grade wheat	92.990	0.425	9.345	0.101	56.4
Macaroni	87.935	1.390	23.745	0.270	16.5
Chickpea	88.680	1.400	16.310	0.184	17.5

particle size of analyzed dispersed systems and parameters of their morphological features. Flour color was evaluated using Japanese colorimeter Chromameter Cr-410 and whiteness by Blik-R3 device. The color of the objects was evaluated at the three-dimensional color model of lab coordinate system. The results are shown in Table 2. Analysis of the data in Table 2 showed that macaroni semolina and chickpea flour yellowness index has high index, than baking top-grade wheat flour. The color of products may vary from the color of the primary and secondary raw material and conditions of the technological process of production. Products made from durum wheat will have a yellow color. White or slightly creamy color is common for bread flour. Adding additives such as chickpea flour makes the necessary presentation to the functional macaroni products.

In order to determine the possible dosages of chickpea flour in the recipe of macaroni produced in the laboratory according to recipe and process parameters given in the guidelines. Macaroni products was produced with chickpea flour in dosages of 5; 7.5; 10; 12.5; 15; 17.5; 20% to the mass of the bread and macaroni flour. We evaluated the organoleptic, physical and chemical indicators of macaroni quality. The blank samples were taken from macaroni and bread flour, produced without the addition of chickpea flour. The results are shown in Tables 3 and 4.

In accordance with Table 3 and 4 the best organoleptic parameters were for macaroni products from bread flour and macaroni flour with the addition of up to 10 and 12.5% of finely dispersed chickpea flour. Respectively, the products have the right shape do not stick together the color of products is solid, i.e., there were no significant differences with the blank samples. However, a further increase of chickpea flour dosage will worsen organoleptic properties of the product.

Analysis of the results showed that the additives increase leads to poor product quality. Thus, with increasing dosages of fine chickpea flour from 5-20% the acidity of the products from bread flour increasing from 2.6-4.4 degrees with macaroni flour from 2.6-4.2 degrees while the blank sample is 2.6 and 2.5 degrees. Table 3 and 4 shows that increasing the content of fine chickpea flour from 5-20% will increase cooking time, respectively for 0-2 and 0-4 min compared to the blank samples. Mass magnification coefficient of product decreases, respectively from 1.80-1.34 and from 1.83-1.52.

In close connection with these parameters the main parameter of the macaroni cooking properties is the amount of dry matter transferred into the cooking water. Thus with increasing content of fine chickpea flour from 5-20% to the mass of top-grade wheat flour this indicator is increased by 0.19-3.19% and for macaroni flour from 0.25-2.07% compared to blank samples. As the content of fine chickpea flour is increased the shapes of products deteriorates, resulting in sticking.

Thus, studies have shown that the most positive impact on the quality of the cooked macaroni was reached with fine chickpea flour additives in an amount of 10% to the mass of bread flour and 12.5% to the mass of macaroni

Table 3: Influence of fine chickpea flour on macaroni products quality from bread flour

		Content of chickpea flour (%)						
Name of parameters	Check	5	7.5	10	12.5	15	17.5	20
Organoleptic parameters: surface condition	Smooth				Smooth			
Shape	Typical for this type				Typical			
Color	Cream white	Cream white	Cream white with yellow hint		White yellow			
Taste	Typical for products without strange taste	Typical without strange taste						
Smell	Typical for products without stranges smell	Typical without strange smell	Typical. with a little hint of chickpea flour		With a noticeable smell of chickpea flour			
Physical and chemical parameters: moisture (%)	12.8	13.2	13.3	13.4	13.4	13.5	13.4	13.5
Acidity, degrees	2.6	2.6	2.8	3.0	3.4	3.8	4.0	4.4
Cooking characteristics: shape	Do not deform. do not stick together	Do not deform. do not stick together			Slight sticking		Sticking	
Mass magnification (K_m) coefficient of product	1.80	1.80	1.78	1.75	1.65	1.54	1.43	1.34
Amount of dry matter transferred into the cooking water (%)	8.24	8.05	8.18	8.34	9.36	10.2	11.0	11.43
Condition of cooking water	Clear	Clear			Not clear			
Cooking time until readiness. min	7	7	7	7	8	9	9	9

Table 4: Influence of fine chickpea flour on macaroni products quality from macaroni flour

		Content of chickpea flour (%)						
Name of parameters	Check	5	7.5	10	12.5	15	17.5	20
Organolepticparameters: surface condition	Smooth							
Shape	Typical for this type	Typical						
Color	Amber-yellow	Amber-yellow	Amber with creamy hint			Amber with creamy hint		
Taste	Typical for products. without strange taste	Typical without strange taste						
Smell	Typical for products. without stranges mell	Typical without stranges mell		Typical with a little hint of chickpea flour		With a noticeable smell of chickpea flour		
Physical and chemical parameters: moisture (%)	12.7	12.8	12.8	13.0	13.4	13.4	13.5	13.5
Acidity, degrees	2.5	2.6	2.8	2.8	3.2	3.4	3.80	4.20
Cooking characteristics: shape	Do not deform. do not stick together	Do not deform, do not stick together					Slight sticking	
Mass magnification Coefficient of product (K_m)	1.83	1.83	1.81	1.80	1.77	1.62	1.56	1.52
Amount of dry matter transferred into the cooking water (%)	6.25	6.0	6.12	6.20	6.38	7.39	8.06	8.32
Condition of cooking water	Clear	Clear		Not clear				
Cooking time until readiness (min)	10	10	10	10	10	11	12	14

flour (semolina). Strength is an important indicator of the macaroni quality which has a great value during storage and transportation. The strength of macaroni was evaluated on "Strukturometr-ST 2" device.

A method for determining the dry macaroni strength based on the measurement of the critical load force and limit of deformation by means of the holder span determined by an external diameter of analyzed products and setting the loading rate for the indenter applied to the macaroni with 10±1 g sec^{-1}. Calculation of rheological characteristics, namely the tensile strength and elasticity modulus of dry macaroni taking into the account their load limiting force, limit of deformation by means of the holder span and values of the inner and outer diameters. The results are shown in Fig. 2-5 and Table 5.

As shown in Table 5 critical loading force for macaroni from the top-grade bread flour is 301.77 g for macaroni semolina-83.85 for the macaroni from the top grade bread flour with fine chickpea flour-180.02 g, macaroni from macaroni semolina with fine chickpea flour 132.03 g. As a result of studies it was found that products with fine chick-pea flour are stronger than macaroni

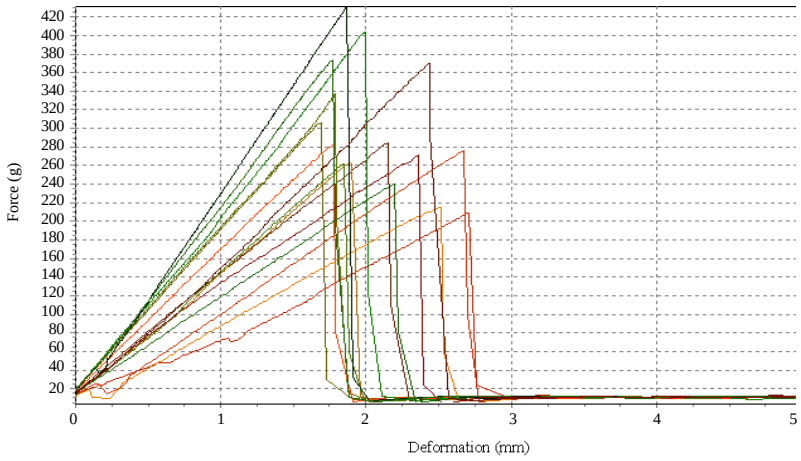

Fig. 2: Results of "Strukturometr-ST 2" device; strength of the macaroni made from bread flour

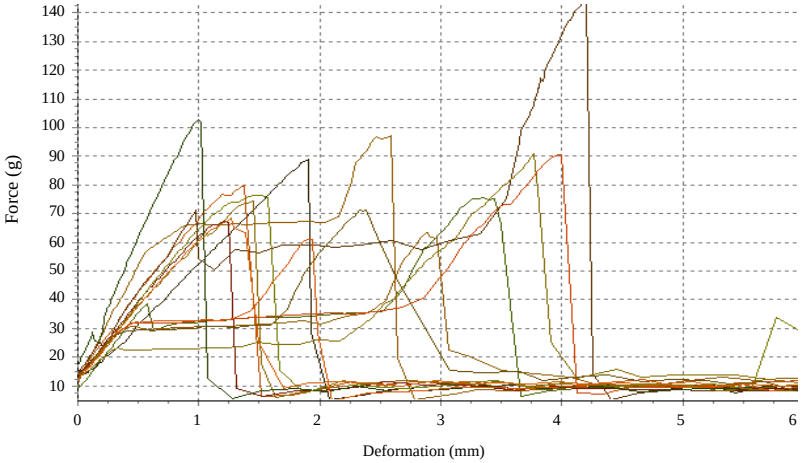

Fig. 3: Strength of the macaroni made from macaroni semolina

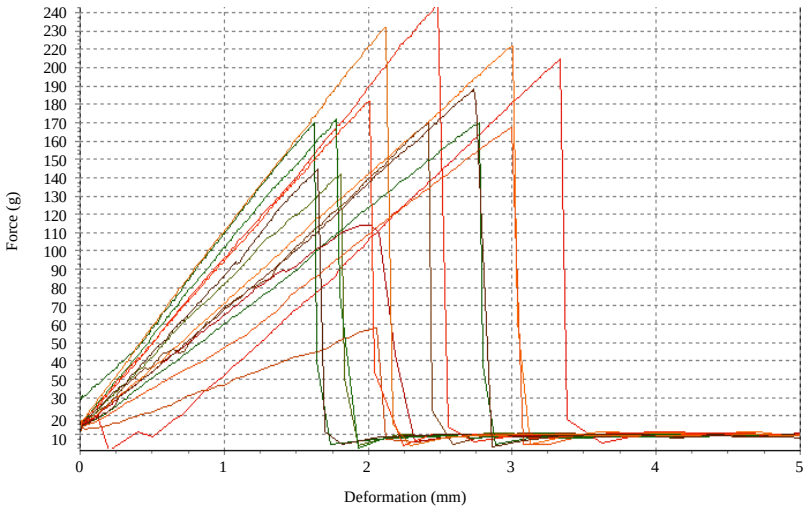

Fig. 4: Strength of the macaroni made from bread flour with using fine chickpea flour

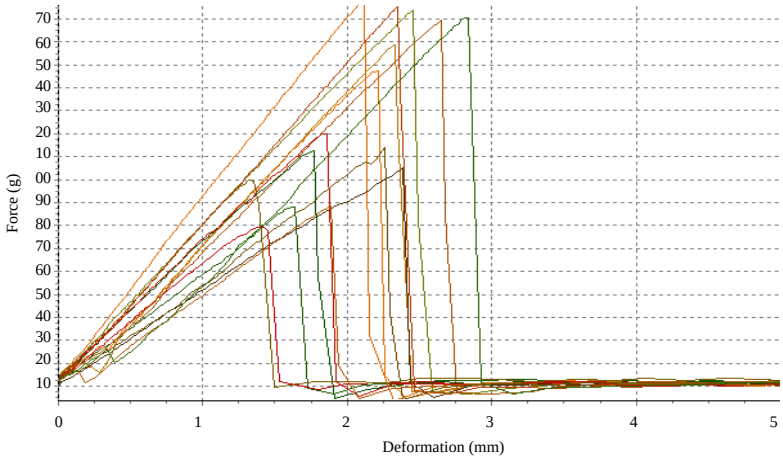

Fig. 5: Strength of the macaroni made from macaroni flour with using fine chickpa flour

Table 5: Structure meter readouts for macaroni products from top-grade bread flour and macaroni flour with fine chickpea flour

	Macaroni products			
Characteristic	From top-grade bread flour	From top-grade bread flour with fine chickpea flour	From macaroni semolina	From macaroni semolina with fine chickpea flour
Average value (g)	301.77	180.02	83.85	132.03
Coefficien to fvariation (g)	21.52%	23.69%	24.36%	26.05%

without additives. Thus, studies have shown that the most positive impact on the quality of the cooked macaroni was reached with fine chickpea flour additives in an amount of 10% to the mass of bread flour and 12.5% to the mass of macaroni flour (semolina).

CONCLUSION

As a result of particle composition studies, color characteristics, flour whiteness, strength and quality of the finished macaroni products we established that to obtain macaroni products from top-grade bread flour with good physical-chemical and organoleptic parameters it is allowed no >10.0% of macaroni products from macaroni flour and no >12.5% of fine chick-pea flour in recipe, further increasing of fine chickpea flour leads to deterioration of the technological properties of finished products. Thus, according to the analysis of the presented data, the use of fine chickpea flour is advisable to enrich the macaroni products with valuable food components.

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