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RESEARCH ON TECHNOLOGICAL PROPERTIES OF POTATO CELLULOSE FOR BREAD PRODUCTION

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Abstract: *The problem of deficiency of food fibers in food rations leads to the necessity of searching new sources of ballast compounds. One of the perspective ways of solving this problem is the use of potato cellulose to fortify by food fibers daily used products such as bread and bakery products. Potato cellulose is a high dispersive and contains a high amount of food fibers. Water absorption of potato cellulose has been investigated as well as its effect on the quality of dough and bread. Potato cellulose has water absorption between 1.5 ... 2 times higher than in wheat bran thus giving the possibility of making ready products of proper quality. The effect of food cellulose addition to the gluten content in dough has been presented. The expediency of potato cellulose used to enrich ready bread products has been proven.*

Key words: *wheat flour, potato cellulose, food fibers, bread.*

1. Introduction

The main achievement and index of level of state development are health, efficiency and longevity of the population. According to the data of World Health Organization, state of human health is determined by the type of nutrition (on 67 – 74 %), factors of environment and conditions of life and only on 16 … 18 % - by the genetics and 10 … 15 % - by the health services. So, production and consumption of food products – is most important of acquisitions of mankind that may cause health or diseases. Taking into account permanent worst of the ecology, the increasing of people diseases and shortening of human life term the search of natural additives and ingredients based on it that effect to functional properties and creating of technology of its applying in products of mass consumption is urgent task for food technologists [1, 2, 3, 4, 5].

Bread is one of the main food products. It supplies the organism with full complex of necessary nutrients: herbal proteins, digestible carbohydrates, food fibers, vitamins and macro- and micro-elements. But it is well-known that bread, especially from wheat flour of higher and first grade, is a non-balanced product by content of amino-acid, food fibers, vitamins and mineral matters. From other side, this product is consumed by all segment of population non depend on age, lifestyle, health and is suitable product for enriching with different components. Daily consumption of it helps to enrich food diet, decrease effect of damage ecological factors to human organism [2, 3, 4].

Food fibers take important role besides enriching ingredients. Useful action of it effects in strengthening of intestine peristalsis and fastening of food moving, preventing of gallstone diseases and cancer diseases, excretion of toxic products, radionuclides, hard metals oxides, optimal functioning of useful microflora of bowels [6]. Scientists have installed that using of second products of herbal raw materials and concentrates from it as source of food fibers has most physiologically effect [3, 5, 6]. From this point of view new herbal origin – potato cellulose – that consist of food fibers (70 %), mostly cellulose, hemicellulose and pectin deserve attention. Increased content of food fibers in potato cellulose comparing to wheat bran that are traditionally used for enriching of products with food fibers helps to decrease it dosage in recipe of bread with ensuring of daily consumption of ballast matters in healthy/functional food [7, 8, 9, 10, 11].

Due to the high dispersity of potato cellulose such products may be recommended for people with acute diseases of gastrointestinal tract because possibility of irritation of mucous tissue is excluded. Bread with potato cellulose may be used for preventing of diseases linked with endocrine system, digesting and blood circulation system.

Important property of potato cellulose is high water retention and fat bonding ability. It allows to add it in flour culinary and bakery products [8]. So, creating of new bakery products of special and functional purpose with using of potato fibers is one of the actual direction of scientific research.

2. Materials and methods.

The potato cellulose ("Paselli-FP", Netherland), has been used. Addition of the cellulose was calculated for ensuring 30 – 50 % of daily maintenance in food fibers in case of consumption of accepted daily mass of bread enriched with food fibers.

Preparation of bread

The dough was prepared according to recipe, which was 100 % wheat flour (containing 0.73 % ash in dry matter, 27 – 29 % wet gluten), salt 1,8 %, yeast 3 %, sunflower oil 2,0 %, potato cellulose 3, 5 and 7 % to the weight of wheat flour and water to get moisture of dough 43 %. As a control, no cellulose was added to the recipe. The ingredients were mixed during 6 minutes in mixing bowl. After 180 min fermentation, the dough was divided into 250 g loaves, formed on dough former, proofed 45 min and baked in an electric oven during 30 – 35 °C at 200 - 220°C with moisturing of baking camera. Baking trials were performed in triplicate.

Content of food fibers

General content of food fibers in researched products was determined by enzymatic gravimetric method [12]. This method is based on enzymatic hydrolease of starch and non-starch compounds by means of α-amylase, protease and amylohlucosidase to mono-, di- and oligosaccharides and peptides. Food fibers are precipitated by ethyl spirit and are dried. General content of food fibers has been calculated in percent by formula:

$$X = \frac{m_1 - \left[\left(\frac{w_1 - w_2}{100}\right) \times m_2\right]}{m_1} \times 100$$

where X – general content of food fibers, % from low fat sediment weight;

m_1 – mass of dry low fat fraction of product, g; m_2 – mass of sediment, g; w_1 – amount of protein in sediment, %, that was determined by formula:

$$w_1 = \frac{m_3}{m_2} \times 100$$

w_2 – mass of ash in sediment, %, that was determined by formula:

$$w_2 = \frac{m_4}{m_2} \times 100,$$

where m_3 – mass of protein, g; m_4 – mass of ash, g.

Water absorption

Water absorption of the potato cellulose was determined by means of centrifugation. The suspense of products with water (hydromodule 1:20) were made in weighted centrifugal test-tube during 1 min. Then suspense was mixed in laboratory mixer (frequency of rotation 50 c^{-1}) and was leaved in thermostat during 20 min at temperature 30 °C for implementing of colloidal processes. Then suspense was centrifuged in 4000 min -1 during 5 min. Liquid phase was sedimentated and weighted. Content of dry substances was determined by means of refractometer and calculated by formula:

$$WA = \frac{W - (F - m)}{100 \cdot G \div (100 - w)} \times 100 ,$$

where W – amount of water in centrifugal test-tube, g; G – mass of product added in centrifugal test-tube, g; m – amount of dry maters in liquid phase, % was determined by formula

$$m = F \times \frac{dm^f}{100}$$

dm^f – amount of dry matters (measured by refractometer), %; W – moisture mass fraction in product, %.

Titrated acidity, moisture of dough, porosity and volume of bread were determined by standard methods [13].

3. Results and discussions

Content of food fibers

The content of food fibers in potato cellulose has been installed 77,1 % (*Table 1*). It is more than in triply exceeds such index for wheat bran. It let to use less amount of potato cellulose in recipe of bread for ensuring of physiologically justified concentration of food fibers in bread products. Recommended physiological daily norm of consumption of ballast substances is 25 - 30 g.

Table 1
Content of food fibers and its components in raw materials, % dry matters

Fraction	Bran	Potato cellulose
General content of food fibers, % dry matters, including	26.9	77.1
cellulose	10.3	18.9
hemicellulose	12.7	3.0
pectin	2.1	54.6
lignin	1.8	0.6

Cellulose is main component of herbal cell walls. It is practically not digested in organism. Main function of it is to bond significant amount of water. As experimental data of table 1 shows content in cellulose in potato fiber is

almost in 2 times higher than in wheat bran. This fact causes increased water absorption of potato cellulose.

Hemicellulose is main component of polysaccharide complex of food fibers that has a high hydrophilicity. Xylans are belong to hemicellulose that have the same process of water bonding as starch but without retrogradation.

In case of increasing of content of hemicellulose in bread the fragility of crumb decreases, process of staling slows down. But hemicellulose does not effect to the volume of bread and output of bread [9]. *Table 1* indicates content of hemicellulose in potato cellulose in 4 times less than in wheat bran. Pectin substances have complex forming properties that effect to metabolism and excretion of hard metals and radionuclides from human organism. Potato cellulose contains 54.6 % of pectin substances that exceeds it content in wheat bran in 26 times. It indicates preference of potato cellulose from medical and biological aspects of evaluation of using of different sources of dietary fiber. So, the potato cellulose has high grade of dispersity and high content of food fibers comparing to wheat bran.

Figure 1 indicates that water absorption of potato cellulose is higher than in wheat flour in 4.4 – 4.8 times and in wheat bran – in 2.6 – 2.8 times. These meanings are characterized for temperature 30 and 60 ºC. During increasing of temperature till 90 ºC water absorption of cellulose is higher than in wheat flour and bran in 2.4 times. Adding of small quantity of potato cellulose causes significant increasing of water absorption of dough that leads to increasing of bread volume.

The water absorption of cellulose in different temperatures has been investigated with the aim of forecast of effect of potato cellulose to the technological parameters and quality of bread. Temperature 30 ºC refers to starting temperature of dough during kneading, temperature 60 ºC refers to the starting of gelatinization of starch and proteins denaturation during baking, temperature 90 ºC refers to the temperature in the piece of dough at the end of baking.

As water sorption of potato cellulose is significantly higher than it in the flour it is need to made a preliminary hydration of cellulose before dough kneading.

Water absorption

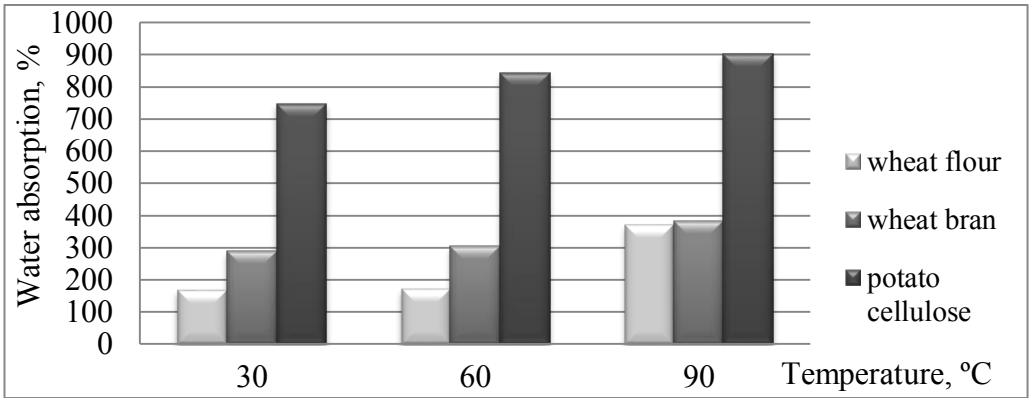

Figure 1. Water absorption of potato cellulose

Studies of gluten

Quantity and quality of gluten have been determined for investigating of effect of potato cellulose to the physical properties of dough. Gluten quality indexes depends not only on technological parameters but also on content and recipe components of dough.

Necessity of investigating of effect of potato cellulose to the quantity and quality of gluten is leaded to features of its chemical composition and high grade of dispersity. High grinding of product causes changes in quantity and quality of some components, enzymatic activity, digestive degree, mechanism of effect to biopolymers of dough.

As results of gluten investigations strengthening of gluten with potato cellulose has been installed (*Table 2*). Gluten is more elastic and less extensible as dosage of cellulose increases. Strengthening effect of potato cellulose deals with high hydrating ability of components of its polysaccharide complex that has significant de-hydrating effect to biopolymers of dough. So, hydrating ability of gluten of dough with cellulose decreases on 0,6…5,8%$_{abs}$ comparing to gluten of control sample dough.

Table 2

Effect of potato cellulose to the quality indexes of gluten

Index	Control sample	Substitute of flour with potato cellulose, %		
		3	5	7
Content of raw gluten,% to the weight of flour	25.10	25.10	24.14	23.64
Content of dry gluten, %	9.29	9.22	9.19	8.99
Humidity of gluten, %	63.7	63.4	62.8	61.0
Hydrating ability of gluten,% the weight of dry gluten	175	171	163	162
Extensibility, cm	13.0	13.0	12.5	11.0
Elasticity of gluten, unit of device DDK	69.3	63.4	59.0	55.6

As a result of decreasing of content of raw gluten the gas retention of dough also decreases that effects to lowering of volume and saving of form of bread.

Research of quality of wheat bread made by direct process with different dosage of potato cellulose shows increasing of acidity of dough on 0.2 – 0.4 grade and, as a result, acidity of bread – increases on 0.3 – 0.6 grade (*Table 3*). Increasing of initial acidity of dough encourages intensification of spirit fermentation that is accompanied with increasing of carbon dioxide, exhausting during fermentation.

Saving of form of bread betters in case of using of potato cellulose «Paselli FP» in amount of 3 … 7 %, but volume of bread decreases on 11 … 12 %, porosity of crumb worsts. So, adding of potato cellulose in amount more 7 % is not expediently. Results of sensorial investigations shows pleasant taste and flavor of bread with potato cellulose, but crumb gets grey colour. Thus, in case of

dosage of potato cellulose 5 % to the weight of flour bread has acceptable quality and daily requirement in food fibers is ensured by 25 %.

Table 3

The effect of potato cellulose on the technological parameters and quality of wheat bread

Index	Control sample	**Dosage of potato cellulose in bread, %** to the weight of flour		
		3.0	**5.0**	**7.0**
Dough				
Duration of kneading, min	10	10	10	10
Duration of fermentation, min	180	180	180	180
Duration of proofing, min	40	40	45	45
Duration of baking, min	40	40	40	40
Titrated acidity, grade				
Initial	1.4	1.5	1.6	1.7
Final	2.0	2.2	2.3	2.4
Bread				
Titrated acidity, degree	1.4	1.4	1.5	1.6
Porosity, %	75	75	74	73
Volume, $см^3/г$	3.7	3.1	3.3	3.4
Moisture content, %	42	43	44	45
Crust colour	light brown			
Surface	smooth			
Texture	Middle, uniform			compacted
Elasticity	Middle, uniform			middle, compacted
Taste and flavor	Proper to bread			

4. Conclusions

The expedient of using of potato cellulose «Paselli FP» (Netherland) as new raw materials for baking has been proven. Potato cellulose is a perspective source of food fibers in bread production. This additive has advantages in high content of food fibers and high dispersity comparing to food fibers of wheat bran, fruits and vegetables.

Taking to account of dispersity of potato cellulose bread with it may be recommended for people with diseases of gastrointestinal tract.

Potato cellulose is advisable to add to the recipe of bread made from wheat flour in amount 5 % to the weight of flour.

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