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INVESTIGATION OF THE INFLUENCE OF PEAS DIETARY FIBERS ON THE PROCESS OF FORMATION OF WHEAT DOUGH

Tetiana Sylchuk[1], Vira Zuiko[1*], Mariana Nazar[2], Vita Tsyrulnikova[1], Olena Tyshchenko[1], Olga Pushka[1], Oksana Kyrpichenkova[1], Oleg Bortnichuk[1]

[1]Faculty of Hotel, Restaurant and Tourism Business, National University of Food Technologies Kyiv, Volodymyrska str. 68, 01601 Kyiv, Ukraine
[2]Detached Structural Subdivision of Lviv State College of Food and Processing Industry of National University of Food Technologies, I. Pulyuya str. 42, 79060 Lviv, Ukraine

[*]e-mail: virazuiko@gmail.com

Abstract

Since it is well known that bread is consumed by all groups of the population, it can be convenient for the enrichment of useful components. Daily consumption of bread allows to enrich the diet, and reduce the impact of harmful environmental factors on the human body. It is worth noting that enriched varieties of bread products are in high demand among consumers of restaurants. The aim of our research was to investigate the problem of bakery products enrichment of with dietary fibers, or more precisely, adaptation of traditional technology to the conditions of mini-productions.

Materials for this research was pea's fibres "EmfibreEF 200", by-products of vegetable processing, which was added in an amount of 3-7% by weight of flour. There was scientifically proved by many authors that a promising source of dietary fiber is pea's food fiber. The chemical composition and influence of pea's food fiber on the formation of wheat dough are determined by gravimetric method. We studied the influence of pea dietary fibers on biochemical processes in the dough, which characterize the balance of sugar changes during dough preparation and gas formation under the condition of using pea's food fiber during fermentation. Also content of sugars in the finished products was analyzed by iodometric semi-micromethod. Influence of pea's food fibers on the yeast activity was analysed by gas-forming ability of semi-finished products. The total amount of released carbon dioxide in semi-finished products was determined by a volumetric method at the device AG-1M.

It was established that the total content of food fibers in pea's food fibers is 61.6% to the mass of dry matter, which is 2.3 times higher than the content of food fibers in wheat bran. This makes it possible to reduce the percentage of dosage of the studied raw material compared to wheat bran to ensure a physiologically justified concentration of dietary fiber in bakery products. Pea's food fibers contain 20.3% of pulp dry substances and 31.1% of pectin dry substances represented predominantly by protopectins, which allows predicting the potential detoxification effect of bread with this raw material. We established that the introduction of pea's food fibers has positively affects the activity of yeast.

The use of pea`s dietary fiber allows to expand the range of useful bread products and adapt the technology to the conditions of mini-production.

Key words*: Bakery products, Food fibers, Pea's food fibers, Nutritional value.*

1. Introduction

A persistent dietary fiber deficiency is a problem in many countries of the world [1]. This was due to the overload of the diet with highly refined foods. The consequence of a lack of dietary fiber in the body is a decrease in the body's resistance to the negative effects of the environment and the progressive growth of a number of diseases [2].

Bread products are quite unbalanced product in its chemical composition. On the other hand, all segments of the population consume this product, it is convenient enough to enrich the useful components, and the daily consumption of bread allows enriching the diet, reducing the impact of harmful environmental factors on the human body [3]. It is known that the most effective source of usage of dietary fibers ape secondary products of vegetable raw materials [4].

Advanced sources of dietary fiber is a new type of raw materials - pea's dietary fiber (DFP) [5].
The modern market offers a limited range of bakery products enriched with dietary fiber [6, 7]. These are products which recipe includes mainly wheat boltings. However, due to the large size of boltings, using of then as a source of dietary fiber is limited for people with diseases of the gastrointestinal tract in the acute form, which prevents them from solving the problem of dietary fiber deficiency.

In this regard, research of improving the technology of bakery products enriched with dietary fiber peas is relevant. The aim of our research was to investigate the problem of bakery products enrichment of with dietary fibers, or more precisely, adaptation of traditional technology to the conditions of mini-productions.

2. Materials and Methods

In our research, a new raw material was used: dietary fiber peas "EmfibreEF 200" (Germany, "Emsland Group"). DFP is a light yellow powder with a high content of dietary fiber (60%) and protein (9%), high hydrophilic properties and the ability to bind up to 11 g of water per 1 g of fiber [5]. Its peculiarity is high dispersity - the size of the main fraction is 100 - 200 μm.

Wheat dough was prepared according to the accelerated technology with using multicomponent acidulents [3]. DFP was added to the dough in the amount of 3, 5 and 7% instead of wheat flour. The amount of dietary fiber was set at the rate of providing 30 - 50% of the body's daily need for dietary fiber.

To establish the effect of whole pea's fibers on the processes of formation and maturation of dough which was made from wheat flour, we performed experiment model. Their implementation involved wheat flour of the highest grade (control) and a mixture of wheat flour of the highest grade and peas fibers in the amount of 3 - 7% by weight of flour (experimental sample). The total amount of released carbon dioxide in semi-finished products was determined by a volumetric method at the device AG-1M [8]. To determine the amount of accumulated and fermented sugars in the dough, we prepared yeast and yeast-free straight dough (control) and with the addition of 3 - 7% of whole pea's fibers by weight of the flour. Duration of dough fermentation was 240 minutes at a temperature of 30 ^{0}C. The amount of sugars determined by an iodometric method, which is based on quantifying the amount of oxidation copper before and after the reduction of the alkaline solution of copper by sugar [8].

3. Results and Discussion

3.1 Results of the theoretical research

In the conducted theoretical researches is carried out the study of dietary fibers.

Dietary fiber is a complex consisting of polysaccharides (cellulose, hemicellulose, pectin substances), as well as lignin and related protein substances that form the cell walls of plants. The percentage and composition of dietary fiber in the raw material depends on the percentage of its dosage to ensure the physiological efficiency and quality of the final product [7].

The direction of action of dietary fiber on the human body depends on the ratio of the main components of the polysaccharide complex, each of which characterized by specific physiological properties [7].

To characterize the chemical composition of dietary fiber in peas, both the total content and the content of the constituents of dietary fiber: cellulose, hemicellulose, lignin and pectin substances were determined.

Cellulose is a major component of plant cell walls. The body does practically not absorb it. Its main function is the ability to bind significant amounts of water.

Hemicellulose is the main component of the polysaccharide complex of dietary fibers, which have high hydrophilicity. However, hemicelluloses do not have a significant effect on increasing the volume of bakery products. Hemicelluloses include xylans, which have a starch-like process of moisture binding but do not undergo retrogradation. Increasing the content of hemicellulose in bakery products reduces crumb fracturability and slows down the hardening of products.

Lignin is a non-carbohydrate component of plant cell membranes and consists of polymers of aromatic alcohols. Its presence in food stimulates the motor action of the intestine, it is an enterosorbent that promotes the binding of toxic substances and their excretion from the body [9].

Pectin substances have complexing properties, which determine their participation in metabolic processes and the ability to remove heavy metals and radionuclides from the human body [7].

Pectin substances affect the course of biochemical and microbiological processes in the dough, change the rheological characteristics of semi-finished products and structural and mechanical properties of the finished products [10]. They contribute to activation of the fermentation process and acceleration of dough maturation, strengthening the gluten framework. This ensures improvement of bread quality indicators, including its volume yield and form stability. In addition, pectin contribute to improvement of porosity and slow down the process of staling of ready products, improve the quality of the finished products and at the same time give it a preventive orientation. An important factor that determines the degree of this effect is the ratio of water-soluble and insoluble fraction of pectin components [7].

The results of our research compared with the most common carrier of dietary fiber in the baking industry - wheat bran [7].

3.2 Results of the experimental researches

In previous studies [7] was determined the total content of dietary fiber in DFP by enzymatic-gravimetric method [11]. The content of fiber (cellulose) - was performed according to DSTU ISO 6865: 2004 on the device Velp five 6 - by Vende; lignin by Wilshtetter and Zeichmeister [12], pectin substances by calcium pectate method [12], and the total content of hemicelluloses was determined according to the method [12].

There was found that the total content of dietary fiber in the DFP is 61.6% to the mass of dry substances. It is in 2.3 times higher than their content in wheat bran, which traditionally used to enrich bakery products with dietary fiber.

This, in turn, will reduce the percentage of pea's fiber dosage in the bread recipe to meet the physiological need for food fibers when consuming bakery products.

Analysis of the components of the polysaccharide complex of pea's fibers showed that pea's fibers fully contain important fractions of dietary fiber for the human body (Table 1).

Our experimental data show (Table 1) that the greatest amount of cellulose is contained in the DFP - 20.3%. This is a positive prerequisite for increasing the water-holding capacity of dough, increasing the yield of finished products and extending the shelf life of bread enriched with DFP.

Table 1.The content of dietary fiber and their individual components in the raw material

Fraction	Wheat bran	Pea's dietary fiber
Total content of dietary fiber, % on a DM basis including	26.9	61.6
cellulose	10.3	20.3
Hemicellulose	12.7	7.3
Pectin substances	2.1	31.1
Lignin	1.8	2.9

The content of hemicelluloses in dietary fiber of peas is 7.3% by weight of dry matter, which is 11.77%, respectively, of the total content of dietary fiber in the studied raw materials (Table 2). While in wheat bran, the content of hemicelluloses is 43.5% of the total amount of dietary fiber. The low percentage of hemicelluloses in DFP is a positive factor, as a large number of them can lead to deterioration of the structural and mechanical properties of dough and bread, increase the stickiness of bread crumbs.

It was found (Table 1) that the lignin content in dietary fiber of peas is 2.9%, which exceeds its content in wheat bran by 61%. The lignin content is 4.77% of the total content of dietary fiber of raw materials that was studied (Table 2).

The research of the content of pectin substances in the raw materials showed (Table 1), that dietary fiber of peas contains in its composition 31.1% of pectin substances to the mass of dry substances. This constitutes 50% of the total dietary fiber content in the studied raw materials (Table 2). The content of this component in dietary fiber exceeds its content in wheat bran by 14.8 times. This indicates the predominance of dietary fiber in peas in terms of medical and biological aspects of evaluating the use of different sources of dietary fiber.

It is known that the balance of changes in sugars can characterize biochemical processes in the dough during preparation. Their depth effects the gas-forming ability of the dough during fermentation.

Table 2. The ratio of the individual components of the polysaccharide complex in the studied raw materials

Raw materials	Ratio of individual components of dietary fiber,%				
	Cellulose	Hemicellulose	Pectin	Lignin	Total
Wheat bran	38.3	43.5	7.8	10.4	100
Pea's dietary fiber	32.96	11.77	50.5	4.77	100

Gas formation is the main indicator that characterizes the intensity of alcohol fermentation in the process of dough preparation. It reflects the activity of yeast cells and their nutrition (sugars and nitrogenous substances). The addition of polysaccharides to the dough increases the gas-forming ability of semi-finished products.

Evaluation of the effect of DFP on the intensity of gas formation in wheat dough was performed using the device AG-1 for 240 min, which includes the stage of fermentation and aging of semi-finished products. The dough was prepared by straight dough method with the introduction of 3 - 7% DFP.

The obtained results showed (Figure 1) that when adding dietary fiber of peas, the gas-forming ability of the dough increases by 6 - 20% compared with the control sample (without additives). This is due to the additional introduction of nutrients into the dough due to the higher content of sugars in the dietary fiber of peas. Respectively the amount of fermented sugars increases, which creates the necessary conditions for active gas formation in the dough with dietary fiber of peas.

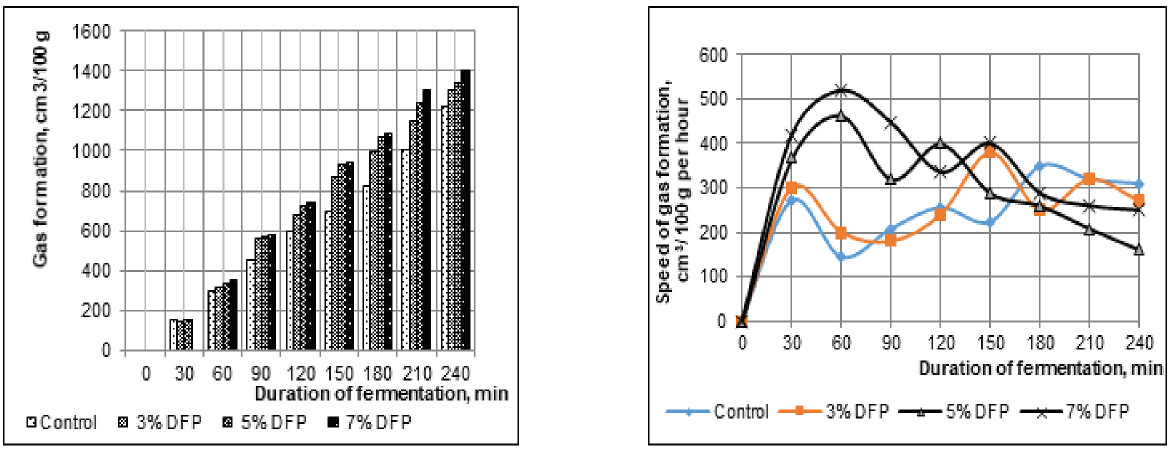
Analysis of the dynamics of carbon dioxide formation in the dough with dietary fiber of peas showed (Figure 2) that the introduction of 3 - 7% DFP intensifies the release of carbon dioxide during the entire fermentation period of the dough. If you add to the wheat dough peas dietary fiber it receives additional nutrition in the form of mono - and disaccharides, proteins, micro and micronutrients, and the fermentation activity of yeast are increasing. As a result, gas formation in the dough increases. When the dough considered ripe the second extremum release of the maximum rate of CO_2 it observed earlier than in the control sample. This makes it possible to reduce the total duration of the technological process in the dough with dietary fiber peas.

It is known that the intensity of fermentation processes in the dough can be characterized by the balance of changes in sugars in the dough preparation process. Their depth affects the gas-forming ability of the dough during fermentation.

The balance of sugar changes characterizes the intensity of dough formation. Four samples of wheat dough were prepared (control - without additives and with the replacement of wheat flour with DFP in the amount of 3, 5, and 7%). Yeast wasn't added to the dough in order to avoid the influence of yeast enzymes and the fermentation process on the sugar content. 4 more dough samples were prepared similarly, but with the addition of 3% yeast. Determination of sugar content was performed immediately after dough kneading and after 3 hours of fermentation of the dough at a temperature of 32 ^{0}C.

After kneading and after 180 minutes of dough fermentation was determined sugar content by the Schorl's iodometric method (Table 3). Accumulation of sugars was determined by the difference between their content in unleavened dough after kneading and after 80 minutes of fermentation. By comparing the amount of sugar formed in the unleavened dough and residual sugars in the yeast, dough after 180 minutes of fermentation, the amount of fermented sugar was determined (Table 3).

In the dough with DFP, the accumulation of sugars and their fermentation exceed the level of control in all dough samples. In 180 minutes in the samples of dough with dietary fiber peas in the amount of 3%, 5%, 7% were formed, respectively, 55, 62 and 69% more reducing sugars than in the control sample.



a) b)

Figure 1. The effect of DFP on gas producing in wheat dough:
a) Kinetics of gas producing, b) Dynamics of gas producing

Table 3. The effect of pea's dietary fiber on the content of reducing sugars in wheat dough and bread (n = 3, p ≤ 0.05)

Object	Reducing sugars content (in terms of maltose),% on a DM basis							
	Without yeast				With yeast			
	Control	Replacement 3% DFP	Replacement 5% DFP	Replacement 7% DFP	Control	Replacement 3% DFP	Replacement5% DFP	Replacement 7% DFP
Dough after kneading	2.54	2.34	2.02	1.81	2.58	2.35	2.04	1.91
Dough after 180 minutes of fermentation	5.02	6.19	6.06	6.01	3.28	3.68	3.39	3.37
Accumulated sugar	2.48	3.85	4.04	4.21	0.7	1.33	1.35	1.48
Fermented sugar	-	-	-	-	1.78	2.52	2.69	2.74
Sugar content:								
-in bread crumbs	-	-	-	-	4.38	4.79	4.88	4.92
-in the crust	-	-	-	-	4.87	5.06	5.43	5.56

Increasing the amount of reducing sugars can be explained by the increase the activity of enzymes because of lowering the pH of the dough with addition of DFP. It leads to a deeper hydrolysis of starch. The amount of fermented sugar in the dough with DFP was 41 - 53% higher than in the control sample, due to the intensification of the fermentation process. This creates the conditions for reducing the fermentation time and curing of bakery products. Intensive accumulation and fermentation of sugars in dough with addition of DFP samples is important under the ground for intensification and reduction of the dough fermentation process.

4. Conclusions

- DFP is a promising source of dietary fiber for the production of bakery products. The high dispersion of this product makes it possible to consume products enriched with dietary fiber by all segments of the population, including people with acute diseases of the gastrointestinal tract.
- The introduction of pea dietary fiber into the dough has a positive effect on the fermentation intensity of wheat dough. The intensification of the process of carbon dioxide release in the dough and the rate of gas formation is the basis for reducing the total duration of dough preparation with pea dietary fiber by 30 minutes. This must be taken into account when the fermentation and curing time of dough pieces adjusting to obtain finished products of proper quality.

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