



THE USE OF INULIN AND SOY PROTEIN ISOLATE IN PRODUCING HARD-DOUGH BISCUITS FOR SENIOR PEOPLE

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Abstract: *The article reviews the potential rationale of the addition of inulin and soy proteins to hard-dough biscuits recommended for senior people's diet. Hard-dough biscuits were considered as the objects of this nutritional enrichment since they have an optimal balance of proteins, fats and carbohydrates compared to the rest of flour-baked foods. Our study aimed to examine the role that inulin and protein play in the technological processes associated with producing hard-dough biscuits; in particular, special consideration was given to the selection of the optimal proportion of the new raw components, as well as the effect they cause on the quality of the hard-dough biscuits, the emulsion and the dough. The study identifies the role that inulin and soy protein isolate play in the heat treatment processes and storage of hard-dough biscuits intended for senior people. Recommendations have been given as to the healthy diet for senior people. The authors have proved a significant effect of the new raw materials on the structural and mechanical characteristics of dough that assumes additional elasticity due to the increase in the volume of bound moisture in the hydrated flour. It has been established that the addition of inulin and soy isolate prolongs the duration of the heat treatment of hard-dough biscuits. By consuming 100 g of special-purpose hard-dough biscuits, it is possible to fill up to 30% of the daily need for fiber in humans. The study has proved the advisability of using soy protein isolate and inulin when producing special-purpose hard-dough biscuits for senior people because of its enrichment with complete proteins, irreplaceable amino acids and food fibers.*

Keywords: *functional foods, hard-dough biscuits, geriatric dietetics, soy protein, food fibers*

1. Introduction

One of the most promising directions in the development of confectionery industry is the design of new functional food items that are capable of providing the necessary quantity of biologically active substances in the daily ration of a modern person.

In the setting of the rising trend of diminished caloric value of food, the need for macro- and micronutrients remains the same, since their lack can lead to weaker immunity, health deterioration and a poorer quality of life. Among the products

that are considered wholesome are functional foods that contain a high volume of biologically active components (antioxidants, vitamins, amino acids, minerals, food fibers), with a lower caloric value and low in sugar and fat. Consumption of such products improves physiological bodily processes, strengthens immunity and the person's overall well-being, as well as helps prevent chronic diseases [1].

When designing new functional products, a special focus should be placed on the requirements for the diets of certain

categories of population. The nutrition of senior people is studied and advised by geriatric dietetics. Below is some of such advice:

1. An energetically balanced diet aligned with the body's actual energy demands.
2. Nutrition aimed at treatment and prevention of diseases.
3. A ration well balanced in irreplaceable dietary factors.
4. Intake of products that normalize intestinal microflora.
5. Consumption of foods that are easily processed by food enzymes.
6. The diet protein/fat/carbohydrates ratio should be 1/0.9/3.8 [1].

One of the promising ways of making functional products is the enrichment of existing products in biologically active substances through the use of innovative raw materials [2]. Among flour-baked foods, hard-dough biscuits make a good object for this enrichment, as of all other kinds of biscuits this one is characterized by the most balanced chemical composition of proteins, fats and carbohydrates, which makes it an appropriate foundation for designing healthy food recipes.

The list of scientists who conducted research into the design of special-purpose bakery includes such prominent names as A. Tumanova, A. Dorokhovich, O. Yaremenko, M. Levachova, G. Sevryukova, and others [3, 4, 5, 6, 7]. In particular, a vast range of research on baking hard-dough biscuits low in caloric value and sugar was conducted in 2008 by O. Yaremenko [3]. These studies prove the practical sense of using food fibers and sugar substitutes in hard-dough biscuit recipes in order to impart them functional properties [4]. The studies also offer a deep analysis of the impact the new raw materials have on the processes of cooking, heat treatment and storage of biscuits.

To improve the chemical formula of biscuits and align it with the prescriptions of geriatric dietetics, it was decided to enrich it in fiber and protein components, since these components are among the scarcest ones in today's ration of senior people. The inulin has high degree of polymerization, allows it to stay undecomposed in the small intestine and carry out all the functions that are typical for decomposable food fibers. The isolated soy protein was chosen as the source of complete protein.

Inulin is a straight chain of fructofuranose residues connected with β -glycoside links; it belongs to the group of polysaccharides. It has a neutral sweet taste without unpleasant aftertaste, poorly soluble in water. A regular intake of inulin can help lower sugar in blood, which is of great importance for people with diabetes [8]. Consumption of inulin facilitates a whole range of functions in the human body, specifically lowers cholesterol in blood, stimulates intestines, reduces the risk of formation of malignant tumors in it, etc [9]. Inulin is characterized by a low caloric value in the range of 1.0-1.5 kcal/g, which allows using it in functional recipes.

Soy isolate is a source of complete protein, high in irreplaceable amino acids [10]. Soy isolates contain over 92% of protein, 2.5% of carbohydrates, 0.5% of fat, 0.5% of raw fiber and 4.5% of ash, they have a low water content. They are produced through the chemical extraction of protein from defatted protein meal. Food cooked from soy isolates is especially rich in protein and low in fat, calories, cholesterol. Additionally, isolated soy proteins are much better digested than the proteins contained in soy flour. The protein isolate as a finished product is a white amphoteric powder without distinct taste or smell, which allows adding it to biscuit recipes without changing their organoleptic parameters and makes it a cheap and

practicable protein-enrichment substance for functional food products [11].

The study aims at designing a recipe of hard-dough biscuits according to the current recommendations of geriatric dietetics as to the diet of senior people and identifying the way the new raw materials (inulin and soy isolate) affect the quality of hard-dough biscuits, emulsion and the dough used for their production, as well as the heat treatment and storage of those biscuits.

2. Materials and methods

The study examined the following objects: hard-dough biscuits, semi-finished products (dough, emulsion) and the raw ingredients for their recipes. First-grade wheat flour was used as a baseline raw ingredient, and other ingredients included powdered inulin and soy protein isolate and other components present in the hard-dough biscuits recipe. The water content of the biscuits, semi-finished products and raw materials was being controlled using a SESH-3 drying oven. The gluten strength of the dough was measured with a gluten deformation measuring device IDK-2.

The structural and mechanical performance of the dough was measured using the Struktrometer ST-1 device and a Brabender farinograph [12]. The water-binding modes in the examined samples were identified through a thermogravimetric analysis using the Derivatograph Q-1500D device, which involved measuring the speed of water removal and the values of heat effects [13]. The sorption and desorption properties of hard dough and biscuits made of it were examined using a Macben sorption pump [14].

3. Results and discussion

An important stage of designing a new variety of hard-dough biscuits consisted in

determining an optimal quality of novel raw components in the recipe that would ensure that the resulting biscuits would have organoleptic properties no worse than those of customary biscuits. Three biscuit samples were studied: the first sample was a reference one, with the second sample inulin was added in the dough, and the third sample was cooked with soy protein isolate. The quality of the biscuits was evaluated based on their organoleptic properties in compliance with DSTU 3781–14 [15]. The biscuits were cooked according to a traditional technology in laboratory environment [16, 17]. The examined samples of biscuits cooked of the new ingredients are of comparatively bigger volume, a homogeneous structure when broken in parts, a higher density and a better taste. The optimal quality of the biscuits can be observed when the proportion of inulin is 7% and of protein isolate – 12% of the dough weight.

The effect that the raw materials cause on the structural and mechanical properties of hard dough was established through measuring its boundary shear and adhesion value. Research has shown that the changes in the adhesion of hard dough are insignificant, whereas both inulin and soy isolate notably reinforce the dough structure, due to which the boundary shear of hard dough increases by 9% and 14% correspondingly. This can be explained by a greater content of bound liquid in the dough attributed to the active processes of hydration initiated by inulin and soy isolate whose water absorption capabilities are much higher than those of flour.

The quality of the finished hard-dough biscuits is mostly determined by the structural and mechanical properties of the dough they are made of. Dough for the hard-dough variety of biscuits should have an elastic, springy structure and retain it during the kneading, rolling and forming of dough balls. That elastic and springy

structure is attained thanks to the gluten frame of the dough that forms as a result of the hydration of gluten-forming proteins. To establish how inulin and soy isolate affect the properties of the gluten frame of hard dough, the authors tested (see Table 1) the dough samples prepared according to recipes No. 1, 2 and 3 respectively, with inulin and isolated soy protein added to the dough. Having evaluated the obtained data, it is possible to argue that adding inulin and soy protein isolate to the dough slackens the gluten complex of hard

dough; specifically, it reduces gluten stretchability and strength.

The introduction of the new ingredients also results in a reduced content of raw gluten and a significant decrease in its hydration capacity (by 8% and 22% respectively), which indicates the reduced volume of free water in the dough and, obviously, can be attributed to the binding of free water by inulin and proteins added to the dough.

Table 1.

Characteristics of the gluten complex of hard-dough biscuits

Characteristics	Sample No.		
	#1 reference	#2 with inulin	#3 with inulin and protein isolate
Gluten content, % of flour weight	25.3	21.3	19.0
Hydration capacity, %	181.0	173.0	159.0
Stretchability, cm	15	13	12
Strength IDK-2, device units	72.0	81.0	75.0

The dough test conducted using a farinograph (Table 2) verifies the assumptions put forward above as to the effect of the new raw materials on the dough structure.

The dough containing inulin and soy isolate is 18.6% higher in its water absorption capacity and has lower stretchability, and that is a sign of a diminished volume of free water in the

system and slower structure building processes, which is indicated by the double increase in the time needed for the dough to develop.

The water content in dough was measured using thermogravimetric analysis. The analysis was carried out in the temperature range of 20-200°C using the Derivatograph Q-1500D device.

Table 2.

Results of farinogram analysis

Characteristics	Sample No.		
	#1 reference	#2 with inulin	#3 with inulin and protein isolate
Water absorption capacity, cm ³ /100 g	58.6-55.6	44.8-43.3	71.0-69.5
Dough development time, min	1.5	1.5	3.0
Stability, min	0.0	0.0	0.0
Dough softening, device units	120	140	120
Elasticity, device units	120	130	105

The test was applied to dough samples with water content of 27.0%.

Derivatograms were analyzed according to the commonly accepted

methodology, with results given in Table 3.

Table 3.

Results of derivatographic analysis

Characteristic	Sample No.		
	#1 reference	#2 with inulin	#3 with inulin and protein isolate
Total water content, %	27.0	27.0	27.0
Free water content, %	59.6	57.1	53.2
Bound water, %	40.4	42.9	46.8
Activation energy, kJ/mole	5.32	6.76	8.93

The derivatographic analysis shows that the addition of inulin and soy isolate significantly affects the free to bound water ratio in hard dough. The addition of inulin to hard dough increases the volume of bound water by 2.5%, while the addition of soy protein isolate results in an increase of 6.4%. This is accompanied by the increase in the value of activation energy in the samples different from the reference one, which also indicates that when added to the recipe, the new raw ingredients generate stronger forms of bound water in the dough. Such notable increase in the volume of bound liquid can be explained by the presence of stronger forms of water binding in the samples different from the reference one. This is accompanied by the increase in the value of activation energy in the samples different from the reference one, which also indicates the emergence of stronger forms of bound water in the dough and that they require more energy to be broken down.

The increase in the amount of water bound in the dough will affect the duration of the heat treatment of hard-dough biscuits and will require correcting the baking time and temperature for the new hard-dough biscuits. Besides, the reduced content of free water will slow down the hardening of the hard-dough biscuits and positively affect its shelf life during storage. However, the shelf life and storage conditions of the biscuits are determined not only by the amount of bound water, but

also by the intensity of sorption and desorption processes that take place in the course of storage, so the authors examined the aforementioned sorption and desorption processes using a Macben sorption pump for the dough (Fig. 1 and Fig. 2) and for the finished hard-dough biscuits (Fig. 3).

Judging from the moisture adsorption graph, it is possible to say that the samples were adsorbing liquid quite slowly up to the pressure of $P/P_s=0.35$, because the pores inside them were filled before the start of the adsorption and did not clear in time. This is also testified by the practically missing surface, as closed pores do not take in liquid; however later on they got more active, since the sample was being diluted under the pressure of liquid and evaporated water was being absorbed, for the pores in the samples were quite large. Sample #2 demonstrated the lowest moisture sorption capacity, while sample #1 – the highest one. The hysteric loop was also wide in the case of sample #2, which indicates that having sucked in the water, the sample took a while to dry up to its initial state at the same temperature, and did not release all its water because its adsorption capacity at zero pressure is higher than the initial one.

The greatest number of the smallest pores was registered in the sample #1, which is evident when looking at the pore radius distribution graph (Fig. 2); the peak sizes of the pores of the samples #2 and #3 are

almost identical — 16.8 and 16.2 Å (1.68 and 1.62 nm), whereas the sample #1 has

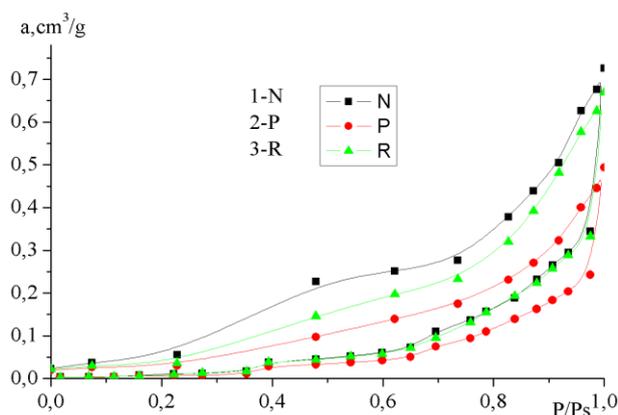


Fig. 1. Sorption/desorption isotherms for the hard dough used to cook the biscuits: 1 – reference sample, 2 – sample with inulin, 3 – sample with inulin and soy protein isolate

slightly narrower pores of 13.2 Å (1.32 nm).

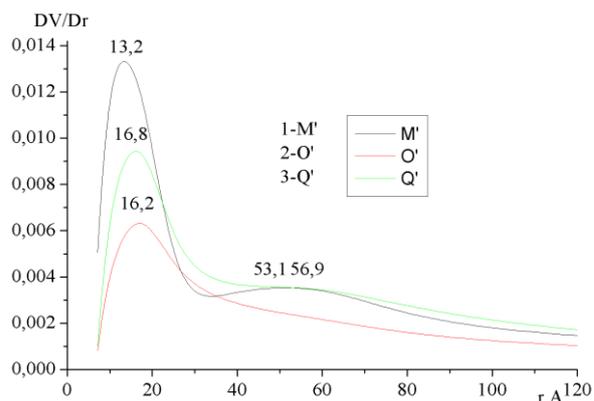


Fig. 2. Pore radius distribution graphs for the hard-dough biscuit sample: 1 – reference sample, 2 – sample with inulin, 3 – sample with inulin and soy protein isolate

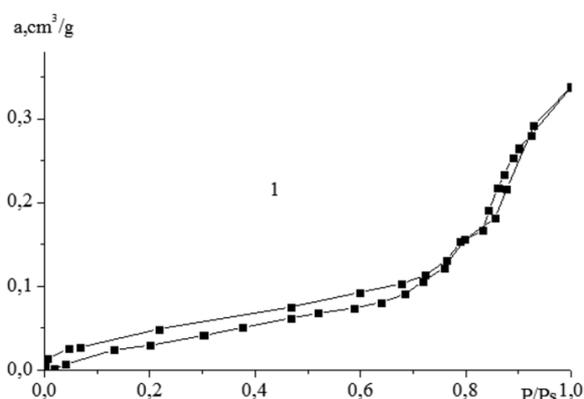


Fig. 3. Sorption/desorption isotherms for the hard dough used to cook the biscuits: reference sample

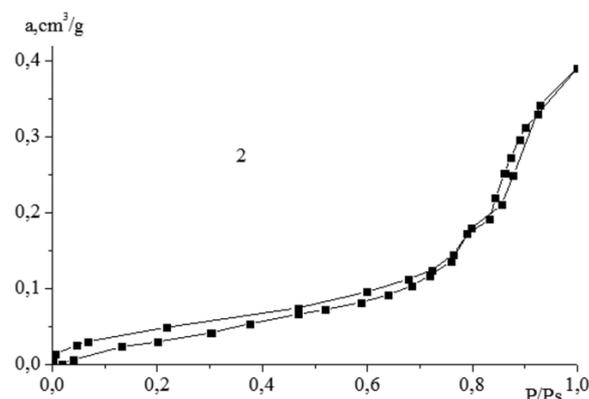


Fig. 4. Sorption/desorption isotherms for the hard dough used to cook the biscuits: sample with inulin and soy protein isolate

The calculation of the adsorption energy based on the obtained data shows that for the sample #1 it is equal to 4.818 kJ/mole, for the sample #2 – 4.869 kJ/mole, and for the sample #3 – 4.419 kJ/mole. Following the analysis of the hard-dough biscuits sorption isotherms (Fig. 3), it was established that the equilibrium moisture values for the reference sample and the sample with inulin and soy protein isolate in the range of $a_w = 0.75 \dots 0.85$ are equal to 12.0–12.5%, which in turns implies that the effect of the new raw ingredients on the

sorption capacity of the biscuits is insignificant. Yet for hard-dough biscuits that are capable of actively absorbing moisture during storage, high sorption capacity would negatively affect the quality of the product and its shelf life, so we recommend packing the finished biscuits in vacuum package.

4. Conclusion

The study has shown that, provided they are used in optimal proportions, inulin and

soy protein isolate do not cause any negative effect on the technological characteristics of the dough and the finished biscuits, which means they can be produced using the existing machinery and equipment. The novel hard-dough biscuits have the closest to optimal balance of proteins, fats and carbohydrates compared with ordinary hard-dough biscuits chosen as a reference product. Since neither inulin nor soy protein isolate have distinct taste or flavor, the organoleptic properties of the finished biscuits are identical to the ordinary hard-dough biscuits. The caloric value of the hard-dough biscuits with soy protein isolate and inulin is 389 kcal/100 g; in addition, it has a higher nutritional and biological value and satisfies 30% of human daily requirement for fiber and 15%

5. References

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of daily requirement for proteins (the content of essential amino acids in 100 g: isoleucine – 0,75 g, leucine – 1,16 g, lizin – 0,65 g, methionine+cystine – 0,36 g, phenylalanine+tyrosine – 0,97 g, treonine – 0,55 g, tryptophan – 0,21 g, valin – 0,75 g), which makes it reasonable to label these biscuits as a functional product.

The chemical formula of these biscuits also takes into account the prescriptions of geriatric dietetics, so these biscuits are recommended for consumption by senior people. Also, due to the absence of white granulated sugar in the recipe of the biscuits, the finished product will also be suitable for consumption by people suffering from diabetes.

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