UDC 664.68:664.16

THE INFLUENCE OF GRAPE POWDERS ON THE RHEOLOGICAL PROPERTIES OF DOUGH AND CHARACTERISTICS OF THE QUALITY OF BUTTER BISCUITS

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Abstract. The effect of grape powders on the rheological properties of dough and the indicators of butter biscuits quality have been investigated. Butter biscuits were cooked with the addition of powdered grape seeds and grape skins from the grape pomace obtained in the southern regions of Ukraine. The grape powders were added to the dough in an amount of 15.0% of the weight of the wheat flour. It has been shown that the presence of powdered grape skins increases the dough's effective viscosity by 3.9 times, of powdered grape seeds – by 5.4 times, as compared to the reference sample, and it makes the dough more resistant to destruction. Adding powdered grape skins increases the plastic viscosity of the samples by 31.4%, powdered grape seeds – by 38.1%. The higher plastic properties of the dough allow the biscuits to hold their shape better and to retain the pattern on their surface. With grape powders added, the adhesive strength of the dough decreases. When powdered grape skins are added, the adhesion strength decreases by 23.0%, and if we add powdered grape seeds, by 33.0%. It facilitates the work of moulding equipment and reduces the production losses of the dough during processing and moulding. The values of physicochemical parameters of the quality of butter biscuits – the specific volume and the wetting ability – slightly increase as compared to the reference sample. Products hold their shape better, and do not become runny during baking, because of a higher degree of form stability. Organoleptic indicators of the quality of butter biscuits with experimental additives are becoming better. Biscuits acquire a pleasant nutty taste after adding powdered grape seeds, and the taste and flavour of prunes and raisins after adding powdered grape skins. Butter biscuits take a deep chocolate colour or chocolate with a violet tint.

Keywords: grapes, powders, dough, butter biscuits, rheological properties, organoleptic characteristics, specific volume, wetting ability.

ВПЛИВ ВИНОГРАДНИХ ПОРОШКІВ НА РЕОЛОГІЧНІ ВЛАСТИВОСТІ ТІСТА ТА ПОКАЗНИКИ ЯКОСТІ ЗДОБНОГО ПЕЧИВА

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Анотація. Досліджено вплив виноградних порошків на реологічні властивості тіста та показники якості здобного печива. Печиво готували з додаванням порошків з виноградних кісточок та виноградних шкірочок, отриманих з вичавків винограду південних регіонів України. Показано підвищення ефективної в'язкості тіста у присутності обох порошків, що робить його стійкішим до руйнування, підвищення пластичності та зменшення адгезії, що полегшує процес його формування. Додавання порошків з виноградних кісточок та виноградних шкірочок приводить до покращення органолептичних показників якості печива, воно набуває приємного смаку та аромату, шоколадного кольору або шоколадного з фіолетовим відтінку, зберігає надану йому форму та рельєфний рисунок на поверхні. Значення фізико-хімічних показників якості готової продукції – питомого об'єму та здатності до намокання – незначно збільшуються порівняно з контрольним зразком.

Ключові слова: виноград, порошки, тісто, здобне печиво, реологічні властивості, органолептичні показники, питомий об'єм, здатність до намокання.

DOI: http://dx.doi.org/10.15673/fst.v12i2.945

Introduction. Formulation of the problem

In recent years, much attention has been paid to creating new health-improving bakery confectionary products with high concentrations of biologically active substances (BAS). To this end, various food additives are used. Among them, secondary products of processing raw materials of plant origin are of special

interest. First of all, these are fruit and vegetable pastes and purées, powders made of oilcakes, press cakes, pomace, flour of different grain crops, etc. [1]. By enriching wheat flour dough with these additives, we change its structural and mechanical properties that can affect the formation of bakery confectionary products and pastry. That is why, when using non-traditional materials, special consideration should be given to studying its functional and technological characteristics, as well as to its influence on the quality parameters of semi-finished and finished products – particularly, on dough rheology as its change can complicate the technological process.

We have chosen such enriching additives for butter biscuits as grape seed and grape skin powders extracted from pomace of different grape varieties grown in southern regions of Ukraine. The powders, labelled as *Oleo Vita* trademark, were made of secondary wine products at the enterprise *Orion* (Odessa), under gentle conditions. Both powders have a highly dispersed structure, taste and smell delicious, and are attractively coloured: the grape seed powder is of chocolate colour, the grape skin powder is of chocolate colour with a violet tint. Partial replacement of wheat flour allows enriching biscuits with biologically active compounds and making it health-improving. However, a different chemical composition of the flour and of the selected powders suggests that the additives can affect the dough's organoleptic properties and the physicochemical quality indicators of the finished biscuits.

Analysis of recent research and publications

There are works devoted to studying the organoleptic properties of dough for muffins enriched with additives (in particular, with wheat germ oilcakes and sugar beet fibres [2-4]), of cakes made of non-traditional flour types [5], of confectionary dough with buckwheat flour added [6], of bread dough with the addition of oat [7] and pea [8] flour, of biscuit dough with *Zdorovye* flour [9]. We have studied the influence of orange purée on the rheological characteristics of the dough for crackers [10], the influence of cryopowders made of grape pomace on the rheological characteristics of biscuit dough, shortcrust pastry, and yeasted dough [11], etc. It has been determined that by adding enriching additives of plant origin to biscuit dough (biscuit dough and shortcrust pastry, dough for muffins, etc.), we influence its rheological properties that affect the quality of the finished product. An analysis of foreign publications on the use of products of grape pomace processing shows that they are widely used when developing technologies of health-improving flour products. It is noted that adding grape powder to pasta in the amount of 25 g per 1 kg of the product improves its organoleptic characteristics, and enriches it with polyphenolic compounds [12]. Adding 5.0% of fat-free grape seed powder to biscuits slows down the formation of free fatty acids during their storage [13]. A comparison of different forms of additives – a powder and an extract of grape seeds – shows that the best effect (a distinct colour, high antioxidant activity of the additive) is achieved when using powdered grape seeds [14]. The publication [15] underlines that the addition of 5.0% of grape skin powder into biscuits also improves the organoleptic characteristics of the product and increases the content of agents with antioxidant properties in it. The value of processed grape pomace products is determined by a high content of biologically active substances that have a positive impact on human health [16]. That is why, by adding them into butter biscuits, we will expand the range of health-improving baked confections.

Though in these publications, there is quite a lot of data on how components of plant raw material affect the structural and mechanical properties of dough, the mechanisms of dough formation in the presence of grape seed and grape skin powders have not been fully found out yet.

The aim of the study is to determine the effect of grape seed and grape skin powders on structural and mechanical properties of dough for butter biscuits, and on the quality of the finished product.

To achieve this goal, it was necessary to solve these **tasks**:

– to define the viscosity of dough in the presence of grape seed and grape skin powders;

– to study the effect of additives on dough's springiness, elasticity, and plasticity, and its adhesion properties;

– to study the organoleptic and physicochemical parameters of the quality of butter biscuits.

Research Materials and Methods

Butter biscuits were baked by the recipe shown in Table 1. Grape seed and grape skin powders were added in the amount of 10.0 to 20.0% of the wheat flour mass. Raw and other materials taken for the studies met the requirements of the existing standards and regulations.

Table 1 – Recipe for butter biscuits formed by piping (reference sample)

Raw material	Solids content,%	Raw material consumption per 1.0 kg of products, g	
		fresh	in dry solids
Top-grade wheat flour	85.50	486.00	415.53
Chicken eggs	26.00	117.00	30.42
Butter	82.50	417.00	344.03
Sugar powder	99.80	167.00	166.67
Total	-	1187.00	956.65
Yield	9.5	1000.00	955.00

Grape powders were made of fresh unfermented pomace extracted from grapes grown in the southern regions of Ukraine by the following technology: pomace was dried at a temperature of not more than 60°C, cleaned from impurities, and split into parts, or fractions. Grape oil was obtained from seeds by cold pressing. Grape-cake remaining after the pressing had the form of solid plates and granules. It was crushed thoroughly to obtain grape seed powder containing less than 8–9% of fat. It is of chocolate colour and nut flavour. The fraction that consists of skins and stalks was also dried and crushed till obtaining grape skin powder. The powder is of chocolate colour with a violet tint. Its taste and flavour are similar to those of raisins and prunes.

Butter biscuits with the addition of the powders under study are characterised by perfect organoleptic characteristics, a high biological value, and an extended period of remaining fresh due to the addition of food fibres with high moisture-retaining capacity, which helps slow down the product's staling. Owing to polyphenolic compounds with a high antioxidant capacity, the fat oxidation processes slow down during the storage period of the finished product [17].

As for the organoleptic and physicochemical indicators of the quality of biscuits, the best results were obtained by adding grape powder in the amount of 15.0% from the wheat flour mass [18]. That is why, this proportion was used in the further study.

The effective viscosity of the dough was determined with a rotational viscometer Reotest 2. The moduli of immediate elasticity, springiness, and plastic viscosity of the dough were determined with Tolstoy's elastoplastometer. The adhesion properties were determined with a special device developed at the Department of Physics and Energy of Kharkiv State University of Food Technology and Trade [19]. The physicochemical parameters of butter biscuits were studied by generally accepted methods: the moisture was determined by drying up to a constant weight in an electric drying apparatus SECh-3. The specific volume and the wetting ability were determined by the methods described in the document [20]. The shape stability of butter biscuits was determined as the ratio of its height to diameter.

Results of the research and their discussion

Butter biscuits can be formed by piping and moulding with piping or forming machines. To achieve a high quality of butter biscuits, the dough should meet certain requirements that determine its ability to resist deformation under the influence of external forces during processing. When developing the technology of biscuits with the addition of enriching raw materials, particularly, grape powders, it is important to provide for the required structural and mechanical properties of dough contributing to good formation and holding the shape of products.

Biscuit dough is a complicated multicomponent system that is characterised by a complex of structural and mechanical properties, such as a viscosity, elasticity, and plasticity. One of the most important indicators is effective viscosity, a generalised characteristic describing a balanced state between the processes of renewal and destruction of the dough structure system in the flow. The results of an effective viscosity analysis for the samples of butter biscuits dough are shown in Fig.1.

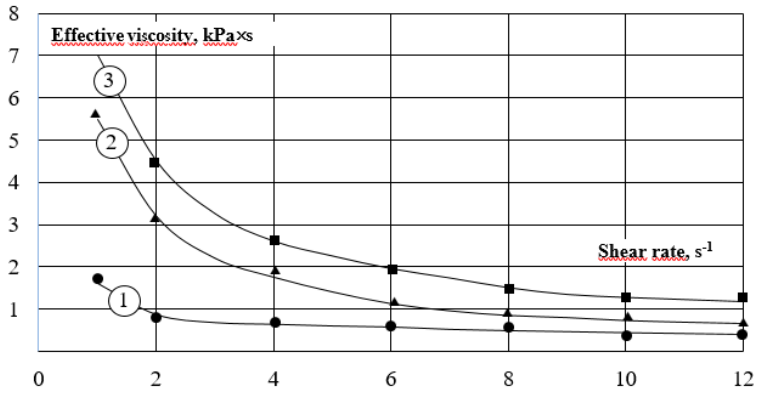

Figure 1. Dependence of the effective viscosity (kPa/s) on the shear rate (s^{-1}) in butter biscuits dough: 1 – without additives (reference sample), 2 – with grape skin powder added, 3 – with grape seed power added.

As proved by the results presented, the viscosity curves look typical of non-Newtonian fluids, which are characterised by a decrease in the viscosity value and an increase in the shear rate. It is obvious that the presence of both powders significantly increases the parameter under analysis. That is, the effective viscosity of the reference sample is 0.8 kPa x s, with the shear rate of 2 s^{-1}. The addition of grape skin powder leads to an increase in the viscosity by 3.9 times, the addition of grape seed powder leads to its increase by 5.4 times.

It should also be noted that the zone of 'explosive' destruction of the structure in the test samples having the same shear rate occurs at higher values of the shear rate than in the reference sample.

Consequently, the use of grape skin and seed powders increases the viscosity of butter biscuits dough and makes it resistant to destruction. From a technological perspective, this is an advantage, since it contributes to increasing the system's stability during its formation, and to biscuit's better holding its shape and the pattern on its surface.

The important rheological characteristics of dough include springiness, elasticity, and plasticity. Dough springiness is a capacity of returning to its original shape after the load is removed. Dough elasticity characterises its capacity to restore its shape after a certain period. If due to the influence of external forces, non-recoverable deformation takes place, but the integrity is not violated, it indicates the dough's plasticity. The combination of these properties can provide a required level of rheological characteristics that determine the behaviour of the dough during the entire process cycle. The results of the study of these indicators are shown in Fig. 2.

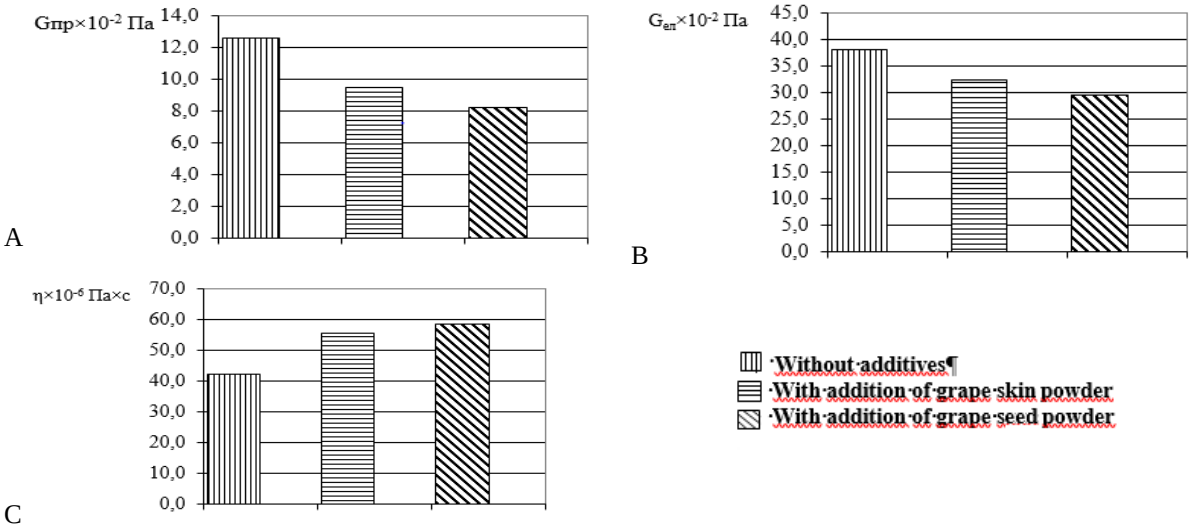

Fig. 2. Structural and mechanical properties: A – modulus of springiness; B – modulus of elasticity; C – plastic viscosity of butter biscuits dough

The analysis of the data provided shows that with the addition of grape skin and grape seed powder to the dough, the modulus of instantaneous springiness decreases by 24.6 and 34.9%, respectively, comparing to the reference sample. This evidences the decrease in the springiness of butter biscuits dough when there are additives in it.

The elasticity modulus of the dough samples containing grape skin and grape seed powders, too, decreases by 15.2 and 22.3%, respectively, comparing to the dough without the additives. It should be noted that the elasticity modulus value is significantly higher than that of the instantaneous springiness modulus. It means that the elastic properties prevail over the springy ones.

Comparing to the reference value, the plastic viscosity of the samples containing additives increases: by 31.4% with the addition of grape skin powder, and by 38.1% with the addition of seed powder. That is, the dough containing additives demonstrates higher plastic properties comparing to the reference sample, and products made of the experimental dough samples will hold their shape better.

An important characteristic of butter biscuits dough is its adhesion properties. They characterise the adhesive forces of bodies of different types, whose surfaces come into collision, and play an important role when the dough contacts with the operating elements of moulding equipment. It has been found that the tearing-off of the reference sample of dough and the experimental ones is adhesive, i.e. along the line of contact. The results of the study of the effect of grape skin and grape seed powders on the adhesion strength are shown in Table 1.

Table 1 – Effect of grape seed and grape skin powders on the adhesive strength of butter biscuits dough

Dough sample	Adhesive strength, kPa
Reference sample (without additives)	0.48
With addition of grape skin powder	0.37
With addition of grape seed powder	0.32

According to the above data, the adhesive strength of dough with the addition of grape powders decreases comparing to the reference sample. That is, adding grape powder results in a 23.0% decrease of this parameter comparing to the reference sample, and adding grape seed powder decreases it by 33.0%. The results obtained prove that while processing and moulding the dough with grape powders added, it will stick less to the operating elements of moulding equipment, which will facilitate their operation and reduce dough wastes.

The results of the study of physicochemical quality characteristics of butter biscuits with the addition of

grape powders are shown in Fig. 2.

Table 2 – Effect of grape powders on the quality of butter biscuits

Biscuit sample	Moisture,%	Specific volume, cm^3/ g	Wetting ability,%	Form stability, H/D
Reference sample (without additives)	4.5±0.2	1.70±0.07	140±6.1	0.34
With addition of grape skin powder	4.7±0.2	1.74±0.07	148±6.2	0.44
With addition of grape seed powder	4.7±0.2	1.72±0.07	146±5.5	0.50

It has been found that with the powders added, the specific volume of the biscuits increases slightly – 1.2–2.4%, and their wetting ability – 4.3–5.7%, as compared to the reference sample. The moisture in the biscuits increases by 4.4%. Products retain their shape better, do not become runny during baking, as evidenced by a higher value of form stability.

The organoleptic parameters of biscuits quality improve with the experimental additives. The product acquires a pleasant flavour of nuts after adding grape seed powder, and that of prunes and raisins after adding grape skin powder. The biscuits become chocolate-coloured or of chocolate colour with a violet tint. They completely retain the distinct pattern on their surface, unlike the reference samples that slightly deform, the surface pattern becoming somewhat blurred. Thus, using grape seed and grape skin powders makes it possible to produce butter biscuits of high quality, to enrich them with biologically active compounds contained in the additives, and to expand the range of health-improving baked confectionary products.

Conclusions

1. Adding grape seed and grape skin powders into butter biscuits dough results in the increase of its apparent and plastic viscosity, the decrease of the springiness and elasticity moduli. This contributes to facilitating dough processing and helping biscuits retain their shape and a distinct pattern on their surface.

2. When adding grape powder, the strength of dough adhesion decreases comparing to the reference sample, therefore, while moulding the dough, it will not stick to the operating elements of a dough moulding machine so much. That will facilitate the machine's operation and reduce the dough wastes during processing and moulding.

3. Adding grape seed and grape skin powders leads to the improvement of the organoleptic (external appearance, taste, and smell) and the physicochemical (specific volume, wetting ability, form stability) characteristics of the quality of butter biscuits.

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Отримано в редакцію 26.12.2017
Прийнято до друку 06.04.2018

Received 26.12.2017
Approved 06.04.2018

Цитування згідно ДСТУ 8302:2015

Brykova T., Samohvalova O., Grevtseva N., Kasabova K., Grygorenko A. The influence of grape powders on the rheological properties of dough and characteristics of the quality of butter biscuits // Food science and technology. 2018. Vol. 12, Issue 2. P. 3-10. DOI: http://dx.doi.org/10.15673/fst.v12i2.945

Cite as Vancuver ctyle citation

Brykova T, Samohvalova O, Grevtseva N, Kasabova K, Grygorenko A. The influence of grape powders on the rheological properties of dough and characteristics of the quality of butter biscuits. Food science and technology.2018; 12(2): 3-10. DOI: http://dx.doi.org/10.15673/fst.v12i2.945.