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Effect of hop extracts on rheological properties of wheat dough

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Abstract. The choice of technological equipment and the mode selection in bakery industry is determined by the rheological properties of the processed or transported food masses, pre-ferments, and products. In this aspect, the effect of new ingredients in bakery production such as two types of hop extracts (the hop-water and hop-milk whey systems) and their percentage in the formula on the rheological properties of wheat dough during kneading and fermentation has been investigated. The effect of extracts and their percentage in dough formula on time development and strength of the dough has been studied. It was found, using the Brabender Farinograph, that hop extracts lead to decreasing of the elasticity and degree of softening of wheat dough with hop-water extract by 9—27% compared to the control, and hop-milk whey - by 33—41%. Brabender Extensograph carried out the assessment of changes in physical properties of the dough with hop extracts during fermentation after 45, 90 and 135 min. It was found that hop extracts increase the strength of the dough and resistance to extension, which also indicates strengthening effect of hop extracts on wheat gluten. The changes in the quality characteristics of wheat bread with different dosage of hop extracts have been investigated. It was found that the addition of the extract based on water increases the ability to hold the shape of baked bread, on average, by 2—17% whereas extract based on whey increase this index by 8—25%.

Key words: hop extract, rheological properties, wheat dough, bread.

1. Introduction

The strategic task of bakery industry is to ensure a guaranteed supply of the people with safe and high-quality bakery products. An integral condition for its achievement is the stability of internal sources of energy and raw materials. The circumstances of many enterprises do not allow to control the chemical composition of bakery raw materials, the activity enzyme activity of flour, the species composition and properties of its microbial population and therefore often their uncertainty, which significantly complicates the prediction and organization of the processing process.

Up to 80% of enterprises solve the problem of processing low-quality flour in a simple and effective way - they use baking improvers for miscellaneous purposes. Depending on the purpose, they may add additives of oxidizing or reducing action, surfactants, modified starches, dry wheat gluten, enzymes, etc., which are able to correct the properties of gluten, enzyme activity, increase the water absorption flour, regulate the rheological properties of the dough, increase the yield and quality of finished products. Maximum dosages permitted may vary depending on countries. Some of the additives can be permitted in one country and forbidden in another. Nevertheless, most improvers do not improve nutritional value,



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they are biologically inert and physiologically reactive to the human body. And taking into account the constant and mass consumption of bakery products, even an insignificant content of potentially dangerous compounds of a chemical or microbiological origin creates a long and constant great strain on the body, albeit of low intensity, which can be one of the risk factors for human health. In such conditions, it is important to search effective safe ways for controlling the baking properties of flour using natural ingredients that will help not only adjust the quality of the main raw materials, ensure the production of high-quality and competitive products, but also increase its physiological properties. Currently, in many countries around the world the modern technologies for healthy and safe food bakery products have been developed based on the use of natural additives and preservatives.

Some types of herbs, such as hop, are considered as a valuable source of pectin, enzymes, vitamins and unique micro-, macronutrients. The hop plant *Humulus lupulus L.* used for breadmaking since old times [1]. Every year the tendency to increase the demand for hops and products of its primary processing is more and more clearly observed. Evidence of this is the growth of world trade in hop products over the past 20 years more than doubled. This is due not only to the increase in beer consumption in the world, but also to the increasing demand for the use of hop extracts in non-brewing industries: bakery, pharmaceutical industries, due to new discoveries in the properties of this plant. Analysis of chemical composition [2-4] and information about physiological and biochemical effects [5, 6] some of hop substances indicates the possibility of their use to regulate the intensity and direction of colloidal, biochemical processes in the breadmaking technology and improve the quality of pre-ferments and baked products. For example, hop extract was recently demonstrated to be an effective antifungal ingredient in bread making [7]. In addition, the content of pectin, tannins, phenolic compounds, organic acids, minerals that can interact with proteins and can affect redox reactions, enzyme activity, etc., point on technological potential as improvers for breadmaking. The biggest part of research work related with applying hop in breadmaking devoted to sourdough technology [8]. At the same time, this question has not been studied for a straight dough technology.

The aim of the research is to study the effect, which has hop extract on rheological properties of dough for developing new approaches of using a natural source of bread improvers.

2. Materials and Methods

2.1. Materials

We have used granulated hops type 90 local crop «UA-AROMA», wheat flour, whey. Granulated hops type 90 is a granulated powder of dry hops, which was grounded to a particle size of 1...5 mm, the moisture content was 9 %. To make the extracts the hop pellets were poured into the water or whey with the temperature of (90...95) °C in the ratio of 1:100, after that it was boiled during 90 min and filtered over Whatman No.1 paper.

2.2. Methods

The moisture content of granulated hop was determined by drying the sample to constant weight at a temperature of 160°C in an oven and calculated by mass difference. To study the rheological properties of the dough, a comprehensive assessment of the shape of biopolymers and the effect of biochemical processes on the behaviour of the dough during kneading and fermentation, we used the Brabender Farinograph and Brabender Extensograph also the quality assessment of bread was made. The dough was kneaded from flour and water to a consistency of 500 units, for the experimental samples the water in the amount of 25, 50, 75, and 100% was replaced with hop extracts (hop-water and hop-whey). Since the whey can significantly effect on the proteins and proteolytic enzymes of wheat flour, as the second control sample we used dough, where 100% of the water was replaced with whey, which has been heated to inactivate enzymes. Such rheological characteristics as consistency, dough development time, stability and degree of softening were determined according to ISO 5530-1:2013. Extensional properties, which determine the course of dough expansion during proofing and baking determined by Extensograph using method ISO 5530-2:2012.

2.3. Statistical Analysis

Data analysis was performed using support software Statista. Results were presented as mean values $\pm$ standard deviation of three replications.

3. Results

The strength of the flour, determined by the structural and mechanical properties of the dough, has more integrated features, is more objective and allows a comprehensive assessment of the state of biopolymers and the influence of enzymatic processes on the behavior of the dough during the process. The strength of flour can be assessed only in the complex, because it depends not only on the quantity but also on the quality of gluten. Farinograph and Brabender Extensograph were used to study the properties of the dough during kneading and fermentation, respectively. The obtained research results after processing a number of farinograms are given in Table.1.

Table 1. Rheological characteristics of wheat dough according to the data of Farinoram.

Index	Control sample	Hop extract, %			
		25	50	75	100
hop-water					
Consistency, FU	500	500	500	500	500
Dough development time, min	2	2	2	2,5	2,25
Elasticity, FU	110	100	90	85	80
Stability, min	7,5	8	8	9	10
Degree of softening, FU	96	87	82	73	70
hop-whey					
Consistency, FU	500	500	500	500	500
Dough development time, min	3	3	3,4	3,2	3,4
Elasticity, FU	90	60	57	55	53
Stability, min	5	8	8	12	12
Degree of softening, FU	85	65	60	60	55

It was found, using the Brabender Farinograph, that hop extracts lead to decreasing of the elasticity and degree of softening of wheat dough with hop-water extract by 9—27% compared to the control, and hop-whey - by 33—41%. The mix tolerant index characterizes the structure and stability of proteins in the dough. The results have indicated a positive effect of hop extracts on rheological properties of the dough. When using the extract based on water, the elasticity is reduced by 8—23%, and on whey - by 23—36%. The data correlate with previously obtained results on the effect of hop extracts on the quality of gluten. The use of hop extract based on whey to a greater extent improves the stability of the dough. These results go beyond previous reports [9], showing that hop extract (*Humulus lupulus L.*) have highest inhibitory activity, on the rheological properties of doughs even prepared from the bug damaged wheat cultivars. This study has also shown that the dough development time and stability values of high protease activity flours increased considerably with hop extract at the lowest addition level (10:1, flour to hop extract ratio).

The degree of softening characterizes the ratio of solid and liquid phases, the state and stability of proteins in the dough. The dough has both the properties of a solid and a liquid, so it must have a certain ratio of viscous and elastic properties. The results obtained indicate a positive effect of hop extracts on the structural and mechanical properties of the dough during its kneading. The changes in the properties of the dough with hop extracts during fermentation after 45, 90, and 135 min were evaluated too. The results of decoding extensograms are shown in Figure. 1.

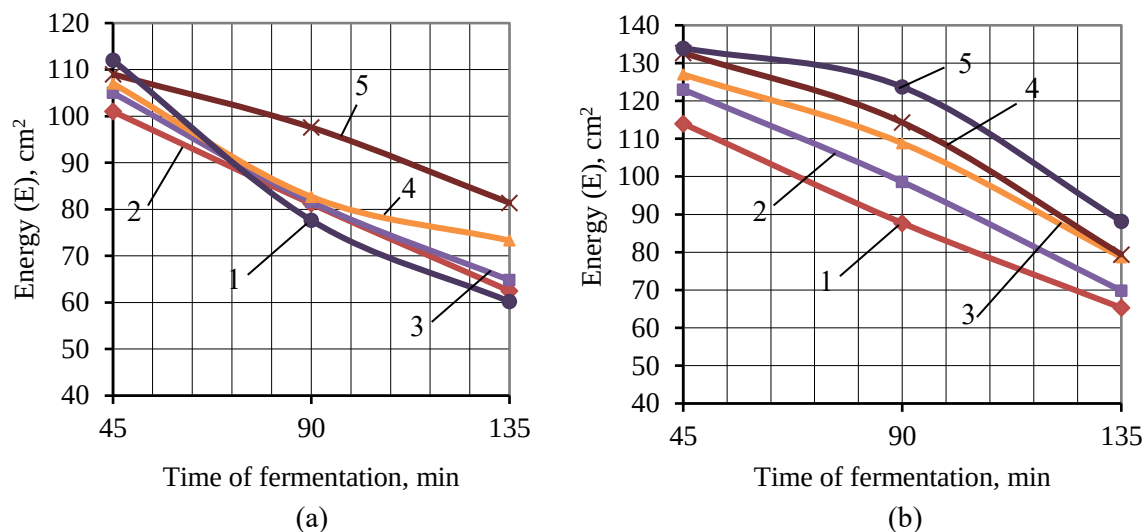


Figure 1. Changes of energy index of wheat dough during fermentation according to Extensogram, when the water was substituted on hop-water extract (a) and hop-whey extract (b): 1 – control sample; 2 – 25 %; 3 – 50 %; 4 – 75 %; 5 – 100 %.

It was established that the use of hop extracts leads to an increase in the tensile deformation resistance of the dough, which confirms their strengthening effect on gluten (Figure. 2).

The energy in the fermentation process of wheat dough makes it possible to estimate the change in the strength of the flour, because the greater the energy, the stronger the flour. As can be seen from, the energy of the test samples of the dough during fermentation increases proportionally with increasing amount of hop extract in recipe.

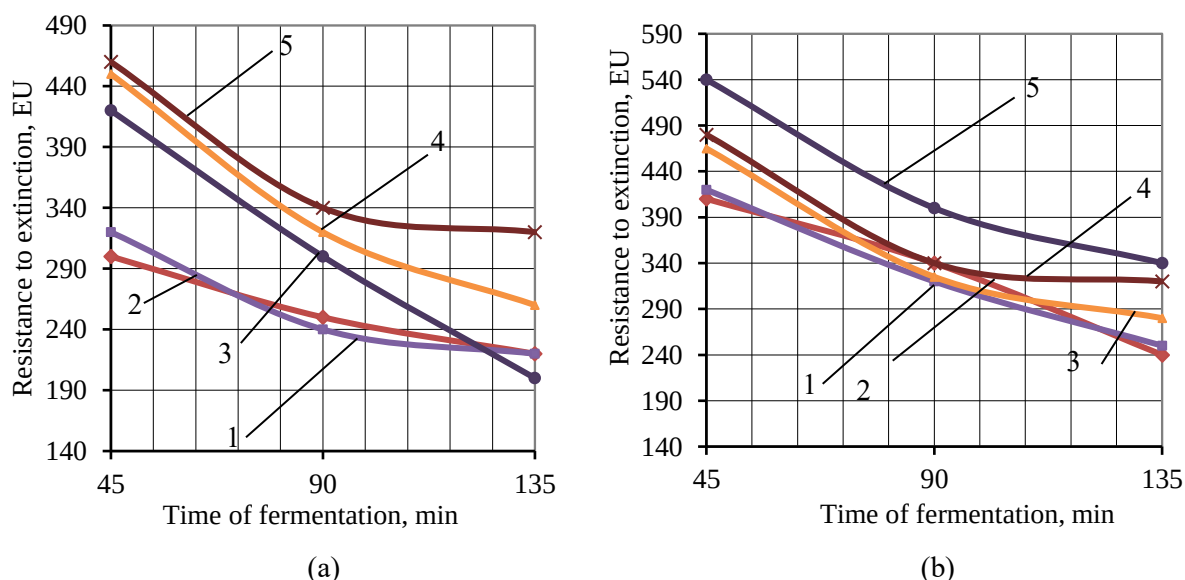


Figure 2. Changes of resistance to extension of wheat dough during fermentation according to Extensogram, when the water was substituted on hop-water extract (a) and hop-whey extract (b): 1 – control sample; 2 – 25 %; 3 – 50 %; 4 – 75 %; 5 – 100 %.

The influence of granulated hop and hop cones on the rheological properties of wheat dough was studied by Klindukhova, Y. O. et al [10]. The hop products were added to the dough at the dosages of 0.5; 1.0 and 1.5% relative to the flour weight. It was studied that addition of powdered granulated hop and hop cone decreases plastic and elastic properties of wheat dough.

The different effects of the hop extracts was even more pronounced in the differentiation of dough resistance to extension - ratio number, which calculate as indicates the balance between dough strength and the extent to which the dough can stretch before breaking.

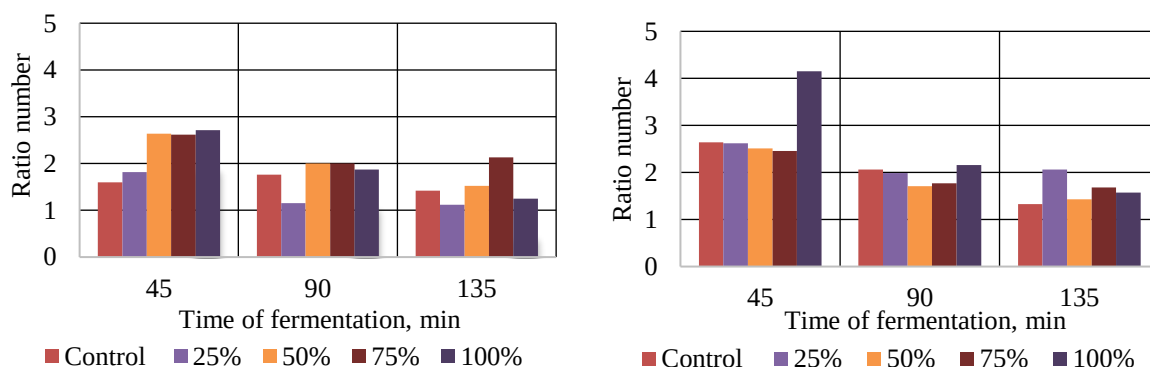


Figure 3. Changes of ratio number during fermentation according to Extensogram, when the water was substituted on hop-water extract (a) and hop-whey extract (b): 1 – control sample; 2 – 25 %; 3 – 50 %; 4 – 75 %; 5 – 100 %.

The dough combines properties such as elasticity, strength, viscosity, the ability to relax stresses and elastic aftereffect. The rheological properties of the dough depend on such factors as temperature, duration and intensity of kneading, recipe, method of preparation and duration of fermentation, baking properties and the strength of flour. It was found that hop extracts increase the strength of the dough in terms of its resistance to deformation, which confirms their strengthening effect on gluten. This trend continues throughout the entire fermentation period. At the same time, whey-based hop extract is more effective, since all indicators of these dough samples was higher compared to dough samples based on water hop extract.

4. Conclusions

The data obtained naturally overlap with the previously put forward hypothesis about the effect of hop extracts on the properties of wheat flour proteins, the ratio of -SH and disulfide bonds, complexation with active ingredients of hops. Thus, hop extracts can be considered in terms of improving the quality of baked products when processing flour with weak gluten structure.

Summarize the above facts, it is possible that hop extracts can be effective improver for wheat flour with a relatively weak gluten network. They help strengthen the structure of the dough. Presumably, pectin and polyphenolic substances, organic acids, forming complexes with dough proteins, compact the system and form a more "rigid" spatial network. The mechanism of such an effect on the properties of the dough of hop extracts remains unclear and requires more detailed study, which will become a further subject of research.

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