



EFFECT OF PLANT PROTEIN ISOLATES ON THE STRUCTURAL – MECHANICAL PROPERTIES OF WHEAT DOUGH

Valeriy MAKHYNKO¹, Vira DROBOT¹, *Tatjana GOLIKOVA²,

¹Educational-scientific Institute of Food Technologies, National University of Food Technologies,
Volodymyrska str. 68, Kyiv, Ukraine, makhynkovaleri@gmail.com,

²Technology of Nutrition and Restaurant Business Dept., National University of Food Technologies,
Volodymyrska str. 68, Kyiv, Ukraine, tatjana.golikova12@gmail.com

*Corresponding author

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Abstract:

The results of using isolates of soya, pea and rice flour as well as of dry wheat gluten in the making of bread dough have been presented. Taking into account the high water absorption capacity of these products, effect of the protein isolates on the structural-mechanical properties of the dough has been investigated. On the basis of farinogram curves the additional quantity of water needed to obtain proper structure of dough made from all types of raw materials has been determined. A formula of calculation the additional quantity of water has been proposed. It proves that most quantity of water is needed for dough with isolate of soya protein – 2.3 g per 1 g of added isolate. Isolate of pea protein needs additionally 1.5 g of water, dry wheat gluten – 1.3 g, and isolate of rice protein – 0.9 g of water. The proposed calculation has been checked for mixes with different proportion of raw materials and its effectiveness has been proven. The calculation method was used to determine the additional quantity of water required to obtain wheat dough with necessary structural and mechanical properties.

Keywords: soya, pea, rice, gluten, Farinograph, protein isolate, water absorption.

1. Introduction

Bread products (especially made from wheat flour of a high extraction rate) have non-balanced chemical composition: poor protein content and over-saturated with carbohydrates [1, 2]. It seems topical to increase nutritional value of bread products as daily-used products. The main part of carbohydrates is brought about in bread products by flour, so it is hard to decrease significantly its content without losses of technological properties of dough and quality of ready products [2, 3]. The use of additional high protein raw materials is a perspective way to approximate chemical content of bread to the physiological norms [1, 2, 3, 4, 5]. In order to choose protein

fortifiers, it is necessary to take into account safety, price, and protein content and balance by the main essential amino acids [2, 3]. The additional advantage of such fortifiers is a certain surplus of the lysine amino acid due to fact that protein of most bread products has poor lysine content. Protein of vegetable crops (soya, pea, nut etc.) is mostly met to the mentioned demands [2, 6, 7]. But legumes contain certain amount of anti-nutritional substances. So, it is advisable to use highly purified forms of this protein – isolates. Technology of isolates' obtaining provides almost full purifying of all anti-nutritional substances, and high protein content – near 90 % - encourages minimizing the dosage of the isolates [2, 7]. It does not exert

significant impact on the technological properties of dough, and, at the same time, it provides ready products with increased protein content. Due to their high nutritional and biological value, isolates are being more applied in different food productions [5, 6, 7, 8].

2. Materials and methods

Isolates

Isolates of soya protein (ISP) ISOPRO 900 EM-UPI Shandong Sinoglory Group Co., Ltd (PRC), isolate of pea protein (IPP) Cosucra Groupe Warcoing S. A. (Belgium) and isolate of rice protein (IRP) Growing Naturals, LLC (USA) have been investigated.

Flour

The wheat flour of a high extraction rate with gluten content 26 % that had quality estimation as acceptable strong (extensibility – 12 cm, elasticity – 75 units of device DDK), type of flour is 550 units was used in the making of control sample [9].

Taking into account the fact that bread with no more than 20 % of additional protein raw materials is present on the market of high-protein bread products we have decided to replace 20 % of wheat flour in samples by a certain type of isolate.

The dry wheat gluten (DWG) (Cargill, Kazakhstan) was used as control protein additive in the same quantity.

Structural and mechanical properties

The effect of the researched high-protein plant raw materials (HPRM) on the structural and mechanical properties of the dough have been estimated by means of Farinograph[®] – TS (Brabender, Germany).

3. Results and discussion

Farinograms of the researched samples are shown in figures 1-5.

The farinogram analysis of dough with addition of 20 % high-protein plant raw materials shows that all samples absorb

It is known that extraneous protein has negative effect on the forming process of dough from the wheat flour and on its structural and mechanical properties. This problem has been investigated by different researchers [1, 3, 6].

The instrument consists of a drive unit with continuous speed control and an attached measuring mixer for mixing the dough to be tested.

The Farinogram shows the quality characteristics of the analyzed flour.

Water absorption: The more water a flour can absorb at a definite consistency of a dough, the greater the dough yield per sack of flour;

Dough development time - optimum mixing time for optimum doughs

Stability - the longer the stability, the greater the fermentation and the higher the forces required for mixing.

Degree of softening - the sooner the weakening, the shorter the fermentation and the less the abuse the flour can withstand.

The trial samples with general weight 300 g were prepared according to the instruction. Quantity of water for kneading the dough has been chosen experimentally in order to obtain dough with standard texture 500 units. Registration of the changes of rheological characteristics of test samples was determined during 25 min from the moment of start kneading. This method is widely accepted for estimating the water binding as well as structural and mechanical properties of the dough [10].

higher amount of water than the control sample: the least of all - with addition of rice isolate – 5 % more than control sample, the most – with addition of soya isolate – 32 % more than control. The

dough development time changes too: the sample with rice isolate has less duration than the control and with soya isolate – 2 times longer, with pea isolate – in 4 times longer.

The most deviation takes place in sample with dry wheat gluten – 8 times longer than control sample.

We believe that this difference is caused by fraction protein content of different types of high-protein plant raw materials. In particular, it is well known that more than 60 % of protein nitrogen of rice is a

glutelin fraction. It is the largest of all the types of raw materials used. The structural-mechanical properties of hydrated glutelin promote high dough development. Isolate of soya protein contains till 10 % of glutelin, and isolate of pea protein contains no more than 5 %, so it exerts some impact on the process of dough kneading. Dry wheat gluten as well as flour contains prolamin and glutelin protein fractions, but its proportion differs significantly, it also has an impact on the behavior of dough during forming [11].

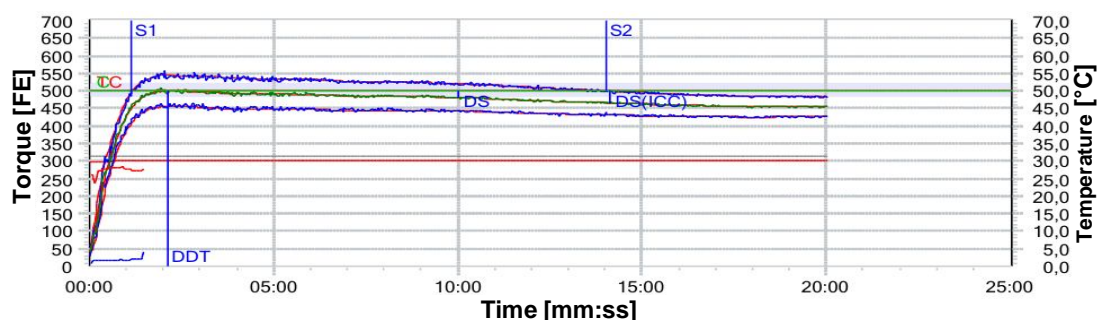


Fig. 1. Farinograms of control sample

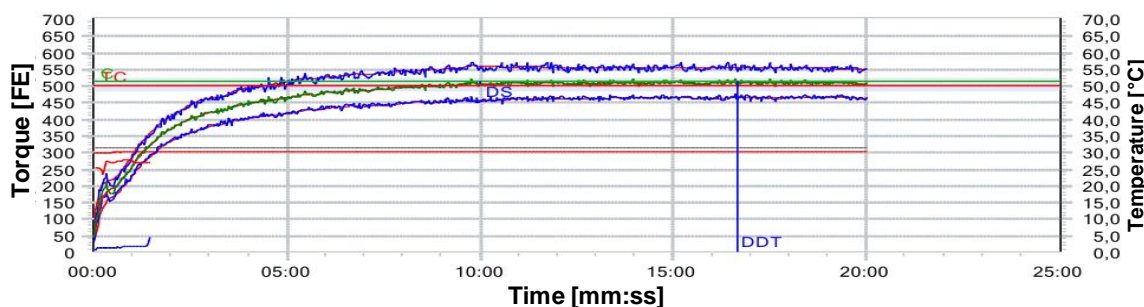


Fig. 2. Farinograms with replacing of 20 % wheat flour of premium class to the DWG

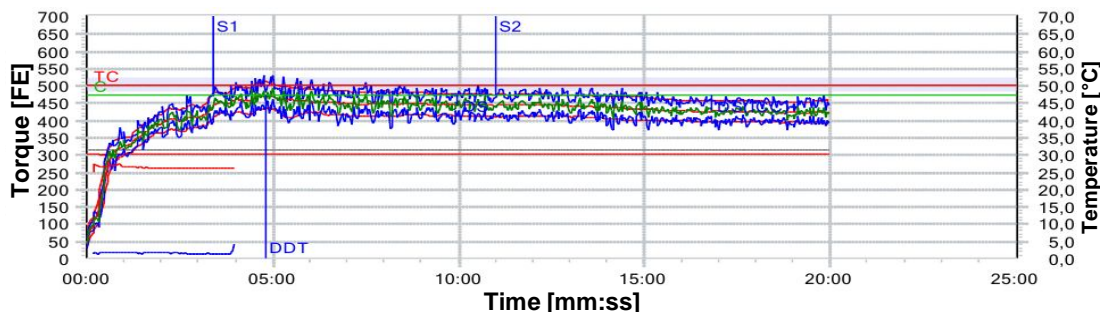


Fig. 3. Farinograms with replacing of 20 % wheat flour of premium class to the ISP

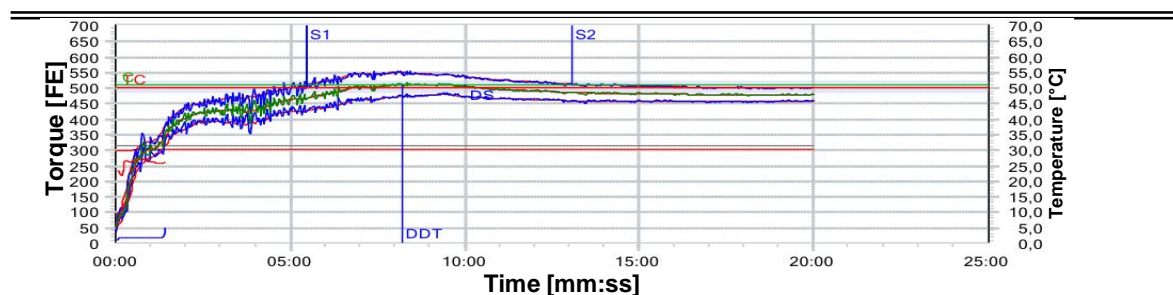


Fig. 4. Farinograms with replacing of 20 % wheat flour of premium class to the IPP

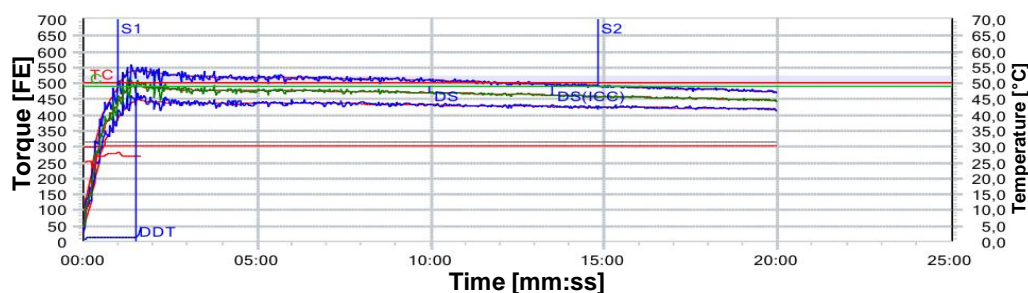


Fig. 5. Farinograms with replacing of 20 % wheat flour of premium class to IRP

Numerical data of farinogram decryption is presented in the table 1.

Table 1

Data of farinograms with addition of high-protein plant raw materials

Index	Control sample (without additives)	With replacement of 20 % wheat flour in:			
		DWG	ISP	IPP	IRP
Water absorption, %	61.8	73.3	94.2	78.1	66.5
Dough development time, min.	2.1	16.4	4.5	8.1	1.3
Dough stability, min.	12.6	25	7.4	7.4	13.5
Degree of softening	18	6	29	6	21

The addition of HPRM has effects on dough stability. The sample with rice protein isolate is similar to the control sample, whereas that with addition of 20 % of SPI – is 1.5 times less.

The degree of softening increases in samples with addition of IRP and ISP by 3 and 11 % in accordance with the control sample too, though sample the with IPP has this index 3 times lower than that in the control sample. Such behavior of different samples may be explained firstly due to the redistribution of water between high-protein plant raw material and components of wheat flour that has negative effect on the swelling of colloidal substances of flour and decreases the

forming of dough structure. The development of protein-protein complexes between wheat gluten and protein of added raw materials may take place.

On the ground of obtained data it is possible to make further recommendations in order to correct the duration of dough kneading. All the types of added high-protein raw materials, excepting rice protein isolate, require prolonged duration of kneading, especially those made from dry wheat gluten.

And it is necessary to increase the quantity of water to be added in the dough. It depends on the type and quantity of added high-protein plant raw materials. Since the industrial production of bread requires

different dosages of HPRM, it may take place as well by using compositions with different proportions. Thus, the method of calculating the water absorption coefficient of dough with HPRM was proposed.

Due to farinogram data we obtained that 1 g of flour absorbs approximately 0.6 g of water. The calculating formula of the conversion coefficient required by the quantity of water for dough kneading is proposed:

$$K = \frac{WA - G_f \cdot K_f}{G_{ad}}$$

where WA – water absorption capacity of high-protein plant raw materials;

G_f – weight of flour, g;

K_f – coefficient that takes into account water absorption of control sample ($K_f = 0.6$);

G_{ad} – quantity of added HPRM, g.

According to this formula, the conversion coefficient required by the quantity of water for dough kneading with DWG is:

$$K_{DWG} = \frac{73.3 - 80 \cdot 0.6}{20} = 1.3$$

It is possible to calculate coefficients for ISP (2.3), IPP (1.5) and IRP (0.9) in the similar way.

So, replacement of 1 g of flour to the DWG will need adding of 1.3 g of water; 1g of ISP – 2.3 g of water, 1g of IPP – 1.5 g and 1 g of IRP – 0.9 g of water.

This method is used in calculations of different dosages and proportions of DWG and HPRM. For example, in the case of proportion 10 DWG:10 SPI additional quantity of water will be 36 g: addition of 10 g of DWG requires additionally 13 g of water (10×1.3), and addition of 10 g of ISP – 23 g of water (10×2.3). To verify the theoretical calculation, the analysis of the calculated dough by means of farinograph was implemented (Fig. 6). 10 % of DWG and 10 % of ISP have been replaced by 20 % of wheat flour.

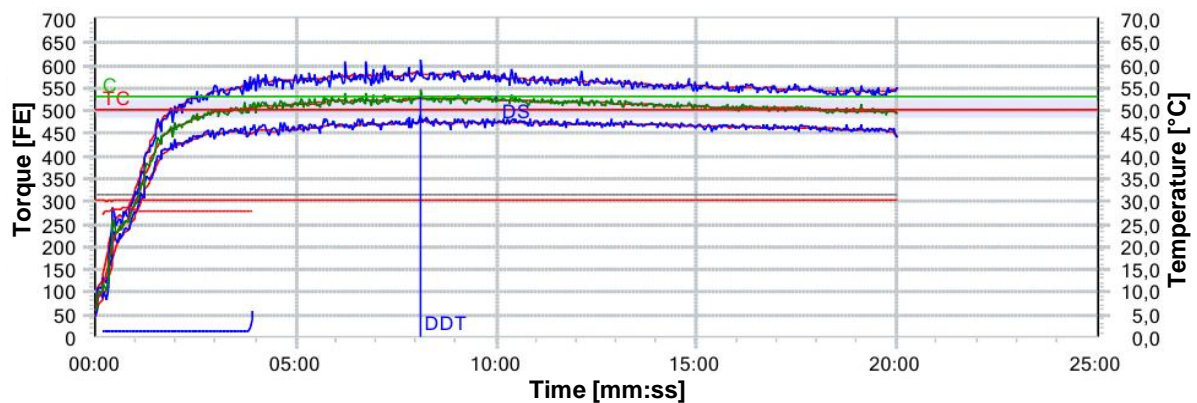


Fig. 6. Farinograms with replacing of 20 % of wheat flour to 10 % DWG and 10 % ISP.

The experimental results show that the proposed calculation method may be applied in the

obtaining of dough with necessary structural and mechanical properties.

4. Conclusion

The changes of structural and mechanical properties of wheat dough with addition of different kinds of high-protein plant raw materials have been investigated. The necessity of prolonging kneading period has been carried out by the farinogram data (excepting the addition of rice protein isolate) and addition of extra quantity of water. The coefficients that take into account the type of raw material and its

water absorption capacity have been calculated: for isolate of soya protein – 2.3, for isolate of pea protein – 1.5, for dry wheat white – 1.3, for isolate of rice protein – 0.9. The use of these coefficients in calculating the additional quantity of water in case of adding of high-protein raw materials will provide dough with necessary structural and mechanical properties.

5. References

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