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EFFECT OF FRACTIONALLY DEFATTED FLOUR OF SEEDS ON THE STRUCTURAL AND MECHANICAL PROPERTIES OF RYE DOUGH

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Abstract:
This paper offers investigation of fractionally defatted flour from seeds of walnut, pumpkin, sesame, topinambur flour and their mixes influence on the rheological properties of rye dough. The investigated raw materials provide increase of water absorption and decrease of softening of dough due to the farinograph values. The use of fractionally defatted flour and topinambur flour reduces gelatinization temperature and viscosity of suspension by amylograph indexes. Nonetheless, dough for malt rye bread with addition of certain types of fractionally defatted flour (up to 4 %) has lower viscosity that causes increase in strength of structural links in dough after kneading and its decrease after one hour of fermentation. The developed mix of fractionally defatted flour from seeds with topinambur flour led to increased rheological properties of dough and provided proper structural-mechanical properties of dough till the end of fermentation that were identical to the control samples.

Keywords: *fractionally defatted flour, topinambur flour, rye dough, rheological properties.*

1. Introduction

Malt rye bread is quite popular bread and is highly profitable for bakeries. But because of its high content in starch and its degrading products with high GI, of reduced biological value, dieticians do not recommend this bread for people suffering from carbohydrate-lipid metabolism disorder [1, 2]. In order to fortify bread with physiologically- functional components – inulin, mineral matters, high nutritional proteins and lipids, dietic fibers, - it is necessary to produce malt rye bread with addition of topinambur flour (TF) and fractionally defatted flour (FDF) from seeds of walnut, pumpkin, sesame [3-5].

Fractionally defatted flour is a product of processing of meal pellets from oil seeds that after partial oil extraction contains most part of nutritional bioactive matters [6, 7, 8]. TF and FDF include specific protein matters, hydrophilic polysaccharides, lipids and lipoids, ascarides, mineral matters, enzyme complexes, acids. Producers regularize quality of FDF by mass fat content (till 15 % to the dry matters), mass water content (till 8.0 %), and particles size. Due to the grain size this flour has similar particle sizes as rye flour T130 [9, 13].

Optimal dosage of topinambur flour for providing of 30...70 % daily intake of inulin in case of consuming 130…277 g of bread and minimum content of sugar in rye bread is 3 % [8, 9, 10]. Authors believe that increase in dosage causes worsening of taste and flavor properties of bread, decreases elasticity of crumb.

Scientists proved that the addition of fractionally defatted flour from walnut fortifies products with protein matters, polyunsaturated fatty acids, lecitin, mineral matters, and selenium [12]. But even small dosage of walnut additive decreases gas production and gas retention of dough and reduces porosity of bread and elasticity of crumb [13].

FDF from pumpkin contains more than 50 % of protein that is reached with tryptophan, valuable mineral composition. Dough with pumpkin seed products increased intensity of fermentation (gas production), shape stability, prolongation of shelf life, elastic crumb [13, 14]. But a bigger dosage leads to stickiness of crumb and flavor of pumpkin oil.

FDF in sesame fortifies bread with mineral complexes Ca, Mg and other insufficient mineral matters, monounsaturated fatty acids, dietic fibers [15]. Bread with FDF in sesame had highest quality factors of crumb, higher specific volume, but big amount of sesame product reduces gas production and gas retention of dough.

Mix of FDF made from sesame, pumpkin and walnut was determined by chemical composition of rye flour T130 and FDF by means of the program "Optima" proposed by Professor Larysa Arseniyeva [16]. It has been demonstrated that combined use of FDF with TF in amount of 10 % in relation to flour leads to the obtaining of bread with increased nutritional value and good degustation quality indexes [17]. Mix composition of TF and FDF had positive influence on the technological process and intensification of fermentation process.

So, the most important criteria of dosage of new products were their chemical composition and influence on the quality of dough. The rheological properties of dough provide quality indexes of bread; they determine choice of equipment for transporting and processing of dough [18].

The aim of the work was to investigate effect of TF and FDF made from sesame seeds, pumpkin and walnut on the structural-mechanical and rheological properties of dough from rye flour T130.

2. Matherials and methods

Ingredients

Rye flour T130 with falling number 220 c and 165 c was used.

Rye malt flour, salt, water, ready to use rye sourdough (lactic acid bacteria: *L. plantarum* 30, *L.casei* 26, *L.fermenti* 34, *L.brevis* and yeast *S. minor, S.cerevisiae)* with flour content 15 % to the general weight of flour in dough and moisture content 71,0±1,0 %, acidity - 10,0±1,0 grade.

Brewing (pregelatinized flour – 5.0 % rye flour, 5.0 % of rye malt flour with saccharification period (time of brewing) 180 min, moisture content 64.0±1.0 %.

Dough preparation included 3 steps: liquid sourdough – saccharified brewing – dough. Topinambur flour was added to dough. Moisture content of dough – 51.0±0.2 %, temperature of dough - 29 °C, last fermentation time - 60 min (3600 c)

Fractionally defatted four from walnut, pumpkin seeds and sesame (Company Richoil) had fat content 10.0…12.0 % of dry matters and Scientific-production Company "Elitphito" with fat content 10.0…15.0 % to the dry matters.

Topinambur flour "Dar"® with total fructan content 44 %, average molecular mass – 15 points of linearity, acidity 15…22 grades was used.

Structural and mechanical properties

The effect of the raw materials studied in terms of structural and mechanical properties and water absorption of rye dough have been estimated by means of farinograph (Brabender, Germany). The trial samples with general weight 300 g were prepared according to the instructions. The quantity of water for mixing the dough has been chosen experimentally in order to obtain dough with standard consistency 500 units. Rye flour T130 and flour (fractionally defatted flour from seeds and topinambur flour) were used for test samples. Registration of the changes in rheological characteristics of test samples was determined during 25 min from the start moment of mixing. This method is widely accepted to estimate the water binding as well as structural and mechanical properties of dough [19].

Viscoelastic properties

The viscoelastic properties of dough made from fractionally defatted flour were estimated by means of amylograph. (Brabender® GmbH & Co. KG, Germany) due to the ICC-Standard no. 126/1 ISO 7973 AACC Method no. 22-10 for measurement of gelatinization properties and enzyme activity of flour and whole meal [20].

Dough samples were prepared from pregelatinized flour (brewing) and rye liquid sourdough. FDF have been added in a dosage that favorizes the obtaining of bread with proper sensorial characteristics.

The viscoelastic properties of dough have been estimated after the mixing of dough and after 60 min of fermentation accordingly to the technological instruction.

Rheological characteristics

Rheological characteristics have been estimated by means of rotational viscosemeter "Rheotest-2". Test samples of dough were prepared using pregelatinized flour and liquid rye sourdough. Rheological characteristics were investigated after mixing and after 1 hour of fermentation.

3. Results and discussion

Structural and mechanical properties

Farinograms of dough with FDF and TF had a curve that is common to rye flour, without expressed section of stability dough. The results of farinograms' description of rye flour as well as its mixes with FDF and TF are shown in the table 1.

The addition of TF decreases water absorption of flour probably due to the high content of sugar [21]. Degree of dough softening also decreases due to the presence of inulin and pectin substances [22].

It was proven that the addition of TF leads to minor increase of water absorption of dough (of 0.3 – 1.7 %) and to significant decrease of dough softening (of 11 – 57 %). The dough development time with additives is in frame ± 30 c. FDF of sesame and walnut express the highest effect on reduction of degree of softening – between 40…80 points.

FDF of walnut increases elasticity of mixed dough of 5…11 %. The addition of FDF of sesame and pumpkin seeds decreases elasticity of dough, but in the case of a bigger dosage it increases elasticity of dough.

Obviously, such influence is determined by increased content of dietary fibers as well as high acidity of FDF especially FDF of walnuts.

The applying of a mix of FDF and TF causes some increase in water absorption and dough development time, but it significantly increases elasticity of dough and degree of softening.

Table 1

Effect of FDF on the farinogram parameters of dough made from rye flour T130

Sample	Dosage, % to the weight of flour	Quality indexes of dough			
		Water sorbing capacity, cm^3/100 g	Dough development time, min	Elasticity, points	Degree of softening, points
Control sample (without additives)	-	60.6…59.8	2.5	74	140
TF	3	59.8…59.0	2.5	74	100
FDF of walnut	1	60.8…60.0	3.0	77	100
	2	61.0…60.2	2.5	77	65
	4	61.0…60.2	3.5	80	60
FDF of pumpkin seeds	1	61.0…60.8	2.0	73	120
	2	61.4…60.6	2.0	73	110
	4	61.0…60.2	2.5	75	100
FDF of sesame seeds	1	60.8…60.0	2.0	73	125
	2	61.2…60.4	2.5	74	100
	4	60.8…60.0	2.0	74	95
Mix of FDF	7	60.9…60.2	2.5	80	95
Mix of FDF and TF	10	60.5…60.0	2.5	78	100

Viscoelastic properties

Due to the results of amylograms analyses of rye flour with additional raw materials (*see table 2*) TF decreases by 1 °C temperature of initial gelatinization of starch and 20 points (or 4 %) maximum viscosity of suspension.

The addition of FDF reduces the gelatinization temperature to 2…3 °C. Herewith amylograph' curves had prolonged up to 5 min section of maximum viscosity of suspension. The addition of FDF significantly reduces the maximum viscosity of water-flour suspension of rye flour – from 520 to 320…360 points (of 31….39 %).

Table 2

Effect of FTF to the carbohydrates-amylase complex of rye flour

Sample	Dosage, % to the mass of flour	Initial gelatinization temperature, °C	Maximum viscosity, Pa·c
Control sample (without additives)	-	55	520
TF	3	54	500
FDF of walnut	2	53	345
	4	53	340
FDF of pumpkin seeds	2	53	360
	4	53	355
FDF of sesame seeds	2	52	360
	4	53	345
Mix of FDF	7	53	320
Mix of TF and FDF	10	52	330

The use of FDF and TF challenges minimum viscosity of starch paste and lower initial gelatinization temperature – 51 °C. We believe that such effect may be caused by big amount of water-soluble substances in FDF that have an influence on accessibility of starch in rye flour gelatinization.

Rheological characteristics

In order to investigate the rheological characteristics of dough we installed that dynamic viscosity of un-destroyed system grows during fermentation of dough on 1.6 – 2.0 %, and dynamic viscosity of destroyed system remains unchangeable (*see table 3*). Border of capability of dough to the dynamics of destroying decreases while strength of structural links in fermented dough grows due to the capability of rye pentosans to make a sticky water solution that after oxidation turns into a strong gel. Thus, rye dough during fermentation gets more sticky, elastic and slows stretching.

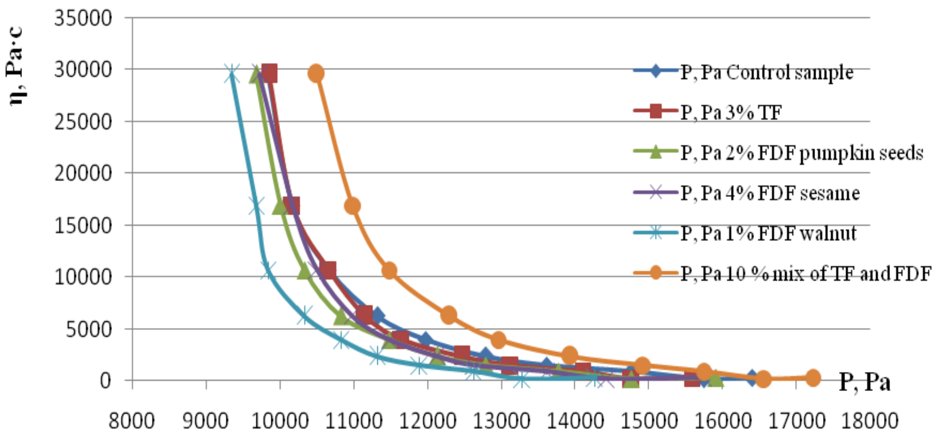
The addition of TF has minor effect on the viscosity parameters of dough after mixing but during the fermentation process, the dynamic viscosity together with the strength of structural network decrease (see *fig. 1*, *2*).

The results of table 3 and fig. 1, 2 show that FDF effects change the rheological parameters of dough during fermentation.

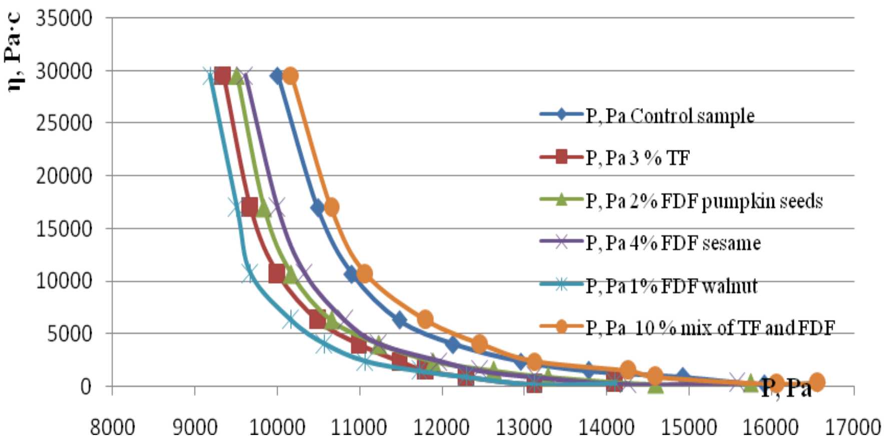
Table 3

Effect of FDF on the rheological characteristics of dough from rye flour T130

Sample	Dynamic viscosity of uncrushed structure, η_0, Pa·c*10³	Dynamic viscosity of crushed structure, η_0, Pa·c*10³	Anomaly of viscosity, $\eta_0-\eta_m$, Pa·c*10³	Character of created sysytem $P_{\kappa 1}$, Pa*10³	Dynamic limit of flowing sytem capacity, $P_{\kappa 2}$, Pa*10³	Strength of structural network, P_m, Pa*10³	Strength of structural links $P_{\kappa 1}/P_{\kappa 2}$, Pa	Stress range, $P_m/P_{\kappa 1}$, Pa
Dough after mixing								
Control sample	29.55	0.34	29.21	9.84	13.00	14.90	0.76	1.51
3 % TF	29.55	0.32	29.23	9.85	12.50	14.00	0.78	1.42
1% FDF walnut	28.07	0.29	27.78	9.35	11.00	12.50	0.85	1.34
2% FDF pumpkin seeds	29.06	0.33	28.73	9.68	11.50	13.00	084	1.34
4% FDF sesame	29.05	0.32	28.73	9.72	11.20	12.70	087	1.30
10 % mix of TF and FDF	31.52	0.35	31.16	10.50	12.30	15.00	085	1.43
Dough after fermentation								
Control sample	30.04	0.34	29.70	10.00	12.50	14.80	080	1.48
3 % TF	28.07	0.29	27.78	9.35	11.00	11.80	085	1.26
1% FDF walnut	27.58	0.29	27.29	9.18	11.10	11.75	0.83	1.28
2% FDF pumpkin seeds	28.58	0.32	28.24	9.51	11.70	12.70	0.81	1.33
4% FDF sesame	28.56	0.32	28.24	9.61	11.60	12.40	0.82	1.29
10 % mix of TF and FDF	30.53	0.34	30.19	10.17	12.20	14.26	0.83	1.40

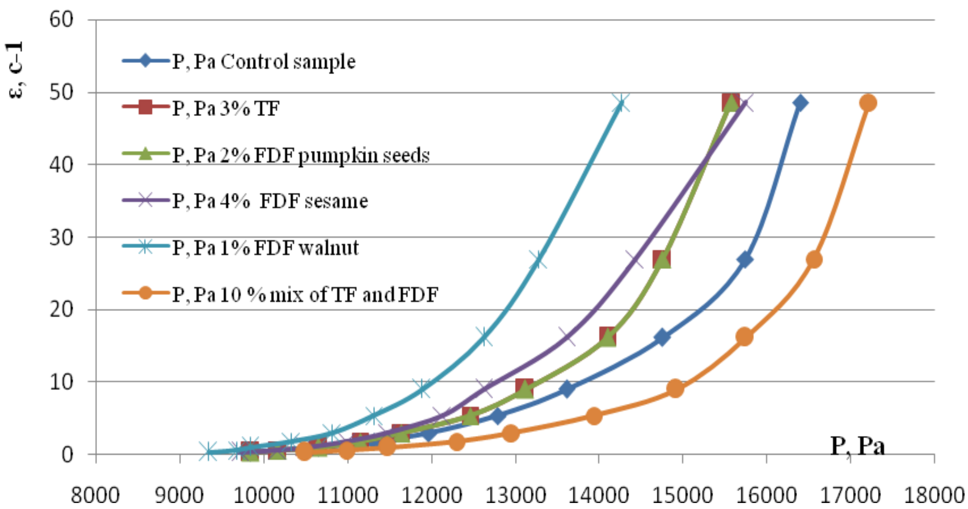


a – dough after preparation

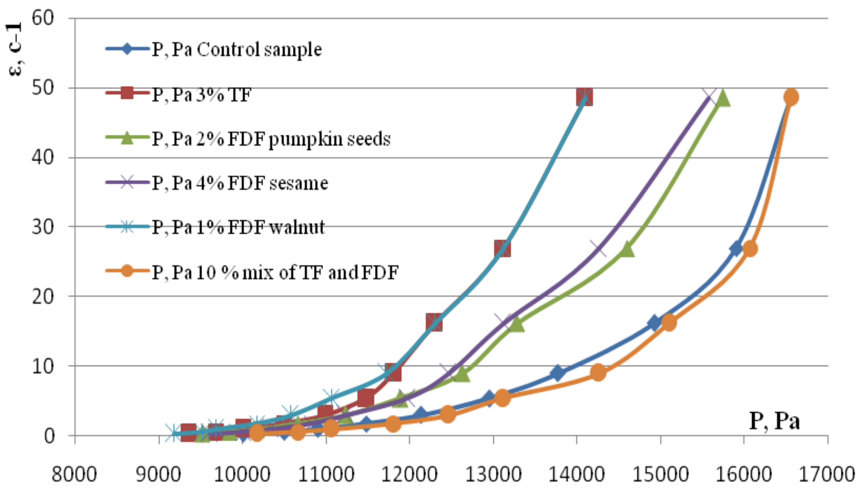


b – dough after 60 min of fermentation

Fig. 1. Influence of TF and FDF on viscosity curves



a – dough after preparation



b – dough after 60 min of fermentation

Fig. 2. Influence of TF and FDF on flow curves

Dosage of some types of FDF in amount from 1 % to 4 % decreases the dynamic characteristics of dough at the beginning and at the end of fermentation process as well when compared with the control sample. Viscosity curves of rye dough samples prove that the addition of FDF decreases values of maximum and minimum viscosity (η_0, $\eta_{m,}$) that refers to un-destroyed and practically destroyed systems of dough after mixing (*table 3, fig. 1*). But in fermented dough the effect of FDF is less evident. The lowest viscosity values have been obtained for dough samples with addition of 1 % of FDF of walnut (28072,1 Pa·c – after mixing of dough and 27579,6 Pa·c – after fermentation).

The strength of structural network of control rye dough sample almost has no changes but the strength of structural links increases (*table 3, fig. 3*). The addition of TF in dough provides an increase of structural links at the beginning of the fermentation process and at the end as well. But topinambur ingredients significantly decrease strength of structural network of dough.

FDF of seeds and mixes undergo an increase of dough strength of structural links after mixing but further its decrease during fermentation. Herewith, the addition of certain types of FDF decreases the strength of structural carcass of dough just after mixing and during fermentation.

The addition of mix of FDF with TF provides hybrid effect and increases the values of viscosity and structure strength and decreases diapasons of intentions of dough when compared to control sample. The samples of structural network and structural strength of dough with mix decrease during fermentation up to the parameters of control samples after fermentation. Such effect may be explained by the addition of high amount of dietic fibers, proteins and bioactive substances of FDF. It caused strengthening of structural links of dough after mixing, at the beginning of fermentation and decreasing of rheological parameters of dough at the end of fermentation.

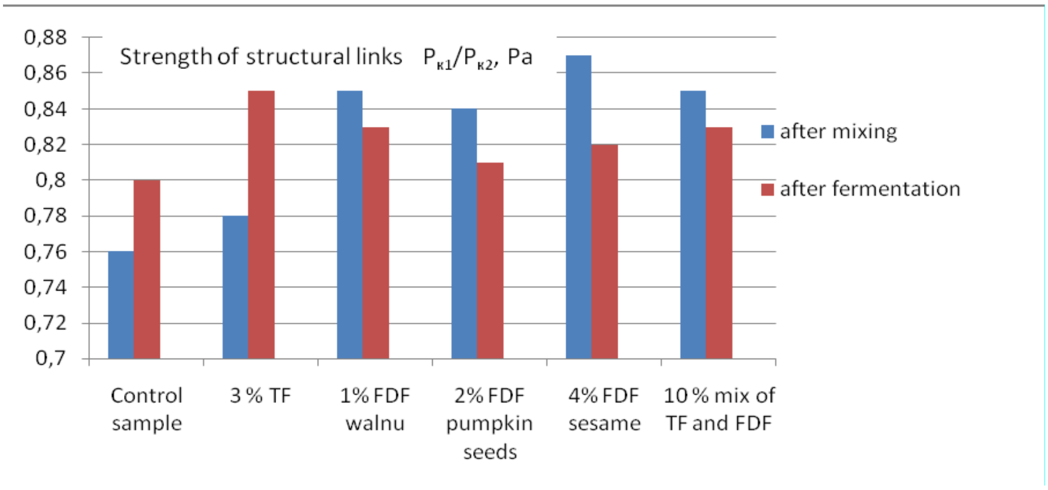


Fig. 3. Influence of TF and FDF on strength of structural links

Thus, the quality of dough with developed mix is identical to the control sample at the end of fermentation. It allows recommending the production of rye bread with addition of mix of FDF and TF by means of production line without technological adjustments of dough shaping and transporting equipment.

4. Conclusion

Investigation of structural and mechanical properties of dough showed increase in water absorption and decrease in the degree of softening of 15…80 pharinograph points due to the addition of fractionally defatted flour from walnut, pumpkin seeds and sesame.

FDF and TF provide decrease in gelatinization temperature and suspension viscosity of rye flour by amilograph values. The maximum viscosity of rye flour suspension decreases by 160…200 points and gelatinization temperature is of – 3…4 °C.

The addition of certain type FDF up to 4 % causes increase in strength links after mixing of dough in brewing and sourdough both with decrease in the structural dough network after one hour of fermentation.

The addition of mix FDF of walnut, pumpkin seeds, sesame and topinambur flour has positive influence on dough preparation – it allows to fortify dough with functional ingredients and increases rheological properties of dough for rye malt bread. This mix of FDF and TF increases viscosity of dough and strength of structural links relative to the reference dough sample and lowers these rheological properties after the fermentation process, close to the control sample. Such influence of mix is explained by the formation of carbohydate complexes between FDF and TP that borrow water in rye flour and determine changes of rheological properties.

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