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Research on the influence of the addition of sunflower seed flour on rheological properties of the dough

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Abstract

Sunflower is an important oilseed crop native to South America and currently cultivated through out the world. Generally, the sunflower is considered important based on its nutritional and medicinal value. Due to its beneficial health effects, sunflower has been recognized as functional foods or nutraceutical, although not yet fully harnessed.

1. Introduction

Sunflower *(Helianthus annuus* L.) is one of the three most cultivated oil crops in the world. The main by-product of the oil extraction process, which can constitute up to 36% of the mass of the processed seeds, is the so-called sunflower meal or cake. This by-product has a high protein content (40–50%) and is used primarily in ruminant feed. The production of sunflower oil results in a byproduct called sunflower meal or cake, which can represent up to 36% of the mass of the processed seeds (Yegorov et al., 2019). Is the fourth crop in the world for oil production after palm, soybean and rapeseed oil, with 15.8 million tonnes produced in 2014 (FAO, 2018).

The growth of this culture in the world is to a great extent linked to the adopstion of systems that make complete use of the seed, since this results in environmental gains as well as promoting the amplification and sustainability of the culture. Thus, the total and effective use of the byproducts results in the economic valorization of the whole productive chain (Pedroche, 2015).

Sunflower seeds are a good source of plant protein, providing 6 grams or 12 percent of the Daily Value per ounce. Vitamin E is an antioxidant that may protect against heart disease by getting rid of harmful molecules called free radicals that can lead to atherosclerosis. Sunflower seeds are the best whole food source of vitamin E (Srivastava &Verma, 2014).

Just one ounce of sunflower seeds provides 76 percent of the Recommended Dietary Allowance for vitamin E. Selenium works with vitamin E as an antioxidant and protects cells from damage that may lead to cancer, heart disease, and other health problems (Eman et al., 2012). 100g sunflower seeds contains moisture-5.5 g, protein-19.8 g, fat-52.1 g, minerals-3.7 g, fibre- 1.0 g, carbohydrate-17.9 g, energy- 620 kcal, calcium- 280 mg, phosphorus670 mg, iron- 5 mg (Gopalan et al., 2007).

On the other hand, some limitations include a high insoluble fibre content, the residue solvents used for oil extraction in the cakeand the presence of anti-nutrients such as protease inhibitors, saponins and arginase inhibitor (Wanjari & Waghmare, 2015).

The high protein content and small particle size of DSSF, make it different from other fruit and vegetable by-products and for these reasons the use of DSSF in baked goods is particularly interesting. A previous study utilising sunflower meal protein isolate to replace wheat flour in breadfound that only 1% inclusion was acceptable whereas higher levels led to reduced bread volume and increased hardness. However, bread requires a high level of "*strong*" wheat flour (higher in wheat gluten proteins) in order to form an elastic structure that can lead to control gas release and high loaf volume (Mohammed et al., 2018).

Consequently, the concept of enrichment of cereal-based products with oil seeds is not new. It was reported that sensorially acceptable and nutritionally improved bread can be made with as much as 16% of sunflower seed on flour basis (Škrbić, & Filipčev, 2008).

The potential of the oil extraction residue includes: an elevated protein content (40e50 g/100 g), the fact that it is not genetically modified organism (GMO) and is rarely allergenic. All these factors indicate sunflower bran as a raw material for human consumption (González-Pérez, &Vereijken, 2007).

2. Materials and Methods

2.1. Materials

The wheat flour analyzed in this study was a refined one (harvest 2019) provided by S.C. MOPAN S.A. (Suceava, Romania). The partial defattedsunflower(SSF) was provided by Marbacher Ölmühle GmbH (Germany). The flours were analyzed according to international and national standards as fallowing: moisture content (ICC methods 110/1), ash content (ICC 104/1), proteincontent (ICC 105/2). The wheat flour was also analyzed for the fallowing parameters according to international and national standards: falling number (ICC 107/1), gluten deformation index (SR 90:2007) and wet gluten (SR 90:2007).

2.2. Methods

In order to underline the sunflower floureffect addition in wheat flour from the technological point of view, the dough rheological properties was analyed during mixing, pasting and extension for samples in which deffated sunflower flour was incorporated in wheat flour to a level of 2,5%, 5%, 7,5%, 10%, 15% and 20% .

2.2.1. Rheological properties of composite flours dough during extension

In order to evaluate the extension properties, the Glutograph and Extensograph devices (Brabender OGH, Duisburg, Germany) were used. For Extensograph analysis the dough was previously prepared to Farinograph. To Glutograph, the values determined were stretching and relaxation whereas to Extensograph the fallowing values were analyzed: resistance to extension (R50), energy (E), extensibility (Ext), maximum resistance to extension (Rmax) and ratio number (R/E) at a proving time of 135 according to ICC method 115/1.

2.2.2. Rheological properties of composite flours dough during pasting

In order to evaluate the pasting properties, the Falling Number (FN 1900 model, Perten, Sweden) and Extensograph devices (Brabender OGH, Duisburg, Germany) were used. The parameters analyzed according to ICC 107/1 and ICC 126/1 was as fallowing: falling number index value (FN), temperature at peak viscosity (T_{max}), peak viscosity (PV_{max}) and gelatinization temperature (T_g).

2.2.3. Statistical analysis

Data were evaluated by analysis of variance (ANOVA), and general linear models of the Statistica 7.1 statistical software (StatSoft Inc., Tulsa, Oklahoma). Means were compared using the Tukey's test at the 0.05 level of probability. Data are expressed as means ± SD of three independent determinations.

3. Results and Discussion

3.1. Materials characterization

The wheat flour used as base for the composite flours was a refined one, with the fallowing characteristics: 0.65% ash content, 12.67% protein content, 14.0% moisture content, 30% wet gluten content, 6 mm gluten deformation index, 1.5% fat content and 442 s Falling Number value. According to the obtained data the wheat flour is a white one, of a very good quality for bread making and a low alpha amylase activity (Codină et al., 2019). The defatted sunflower flour of a golden variety, presented the fallowing characteristics: 58,58% protein content, 7,27% moisture content, 7,42% ash content, 11,28 % fat content.

3.2. Mixing values for the composite flours dough samples

The data obtained for Farinograph samples are shown in Table 1. As it may be seen, the addition of deffated sunflower flour in different levels in wheat flour lead to significant changes to Farinograph values.

Table 1. Farinograph parameters of sunflower -wheat flour blends

Sample SSF	WA (%)	DT (min)	ST (min)	DS (UB)
SSF0 (0%)	59,0±0,1^{a}	1,9±0,1^{a}	2,3±0.2^{a}	76±0,3^{d}
SSF2.5 (2.5%)	59,4±0,1^{a}	2,2±0,1^{b}	2,4±0.1^{a}	74±0,1^{cd}
SSF5 (5%)	60,0±0,2^{a}	6,3±0,1^{e}	6,9±0.2^{d}	38±0,2^{a}
SSF7.5 (7.5%)	60,2±0,1^{a}	5,7±0,2^{d}	6,0±0.1^{c}	60±0,2^{b}
SSF10 (10%)	62,7±0,2^{b}	5,3±0,1^{c}	4,6±0.1^{b}	71±0,4^{c}

Farinograph parameters: WA, water absorption (%), DT, dough development time (min), ST, dough stability (min), DS, degree of softening at 10 min (BU), a,b,c,d Different superscripts within the same column represent significant differences between the results ($p < 0.05$), according to Tukey's test.

The results obtained on samples of flour with added sunflower seed meal are noted by increasing the hydration capacity, the development time of the dough, the stability of the dough and a decrease in softening of the dough.

The hydration capacity of the mix is likely to increase due to the higher protein content in the mix. The moisturizing capacity of the dough depends on the hydration of protein substances and starch the main role of the protein substances.

The higher the protein content of the flour, the more water it absorbs when the dough is formed. The hydration capacity value shows significant differences ($p<1$) only when the high addition of SSF to the dough recipe. For low doses (SSF2.5-SSF7.5) no significant differences ($p<0,05$) for the WA parameter were recorded.

Compared to the blank, the sample with 10 % sunflower seed meal resulted in a WA 6,27 % higher, while the dough stability increased 2,78 times. The highest dough stability (ST) was recorded for the 5 % sunflower seed flour added flour sample, for which the value was 3 times higher than the blank. There are significant differences ($p<0,05$) between the blank and the samples with the addition of 5-10 % sunflower seed meal. In terms of development time(DT) there are significant differences $p<0,05$ for all samples with added sunflower seed flour, compared to the control with o% addition. The degree of softening (DS) shall have values whose significant differences ($p<0,05$) are found between the blank (SSF0) and the SSF7, SSF7.5 and SSF10 samples. There are no differences between the blank and the sample with the addition of 2.5% sunflower seed meal ($p<0,05$)

3.3. Extension values for the composite flours dough samples

The elasticity and viscosity of gluten obtained for wheat flour with the addition of different percentages of sunflower seed meal are given in Table 2.

The values of the elasticity parameter have increased from 167 UB for the blank to 354 UB, is the highest value for an addition of 10% sunflower seed meal. Significant differences are recorded between the control sample with the addition of 0 % sunflower-seed meal and samples with different additions from 2,5 % to 20 % ($p<0,05$).

From the data given in Table 4.1 it is noted that the expandability index value increases with respect to the blank sample (652 UB to 800 UB) on all added samples taken in the study, and is not influenced by the addition of sunflower seed flour nor by time. Practically there are no significant differences $p<0,05$ between the control and 6 samples with different add on rates.

Table 2. Assessment of the quality of gluten obtained from wheat flour supplemented with different doses of sunflower seed meal

Sample SSF	Parameters			
	Elasticity		Extensibility	
	sec	UB	sec	UB
SSF0 (0%)	60±0,0	167±1,3[a]	125±0,0[g]	652±1,2[a]
SSF2.5 (2.5%)	60±0,0	329±1,8[f]	49±0,2[e]	800±0,0[b]
SSF 5 (5%)	60±0,0	208±1,6[c]	13±0,4[b]	800±0,0[b]
SSF 7.5 (7.5%)	60±0,0	222±1,1[d]	37±0,1[d]	800±0,0[b]
SSF 10 (10%)	60±0,0	354±2,3[g]	8±0,1[a]	800±0,0[b]
SSF 15 (15%)	60±0,0	292±1,6[e]	17±0,2[c]	800±0,0[b]
SSF 20 (20%)	60±0,0	174±1,5[b]	75±0,1[f]	800±0,0[b]

The values represent the mean standard deviation for three samples performed
.a.g. the values for a characteristic on the same column, accompanied by the same letter, are not significantly different (p=95%)

3.4. Influence of the addition of sunflower-seed meal on the fundamental reological properties of the dough

Multiple food matrices have a reological behavior that classifies them between liquid and solid States, which means that their properties materialize in both viscous and elastic behaviors. This behavior - Vascoelasticity - is caused by the composition of the foodstuffs. This category also includes bread dough.

The reology of the dough used to make bread gives an idea of how it behaves in different stages of the techonogical process and characteristics of finished product can be expected.

Any addition in the technological process influences the reological properties of the dough. In our case, sunflower seed meal that has a high content of vegetable protein and fiber

[The dough's reological properties are affected by processing parameters (kneading time, kneading energy, temperature), the composition of the flour (by low or high content of protein, starch, fiber, etc.) and other ingredients (water, salt, yeast, lipids, emulsifiers, emulators, other additions).

The elastic module (G’) and viscosity module (G’) values were measured at frequency sweep (Figure 1) and temperature sweep (Figure 2).

Upon changing the frequency, the elastic (G’) and storage (G’’) module has increased continuously; it is noted that for all samples, G’ is greater than G’, which demonstrates their predominant robustness.

The following order for G’ has been obtained throughout the frequency sweep: SSF10% > SSF2.5% > SSF7.5% >SSF0%. SSF5% and for G” the order was: SSF2.5% > SSF7.5% > SSF10%. Also SSF5% > SSF0% (Figure 1).

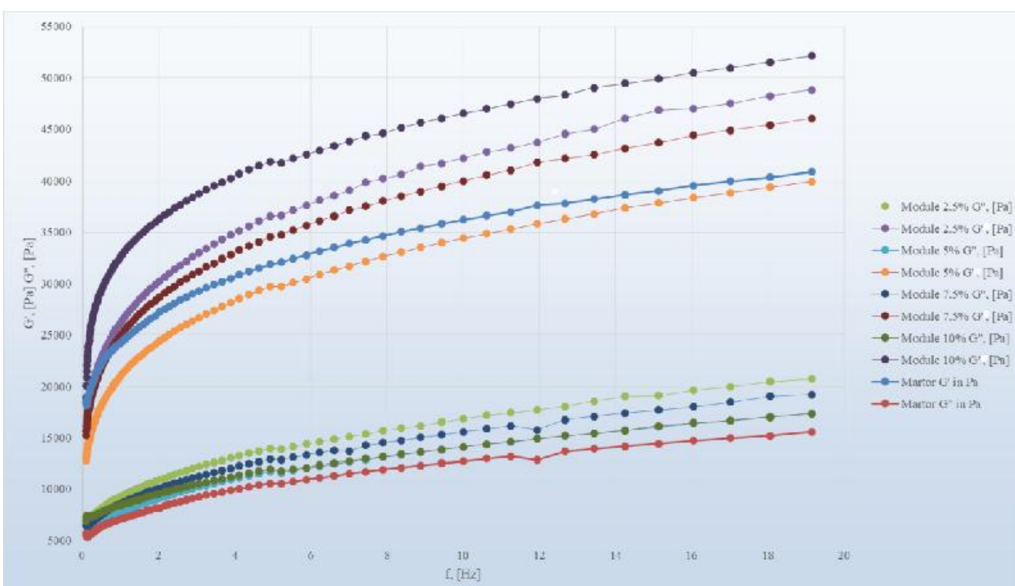

Fig. 1. Storage (elasticity G’) and loss (viscosity G'') at frequency, when the wheat flour is supplemented by sunflower seed flour in the dough

An increase in the elastic (G') and viscosity (G') module with the amount of sunflower seed flour added was also observed (Figure 2). The highest increase was observed for the 10% sunflower seed meal added to the dough.

Figure 2 shows the development of the elastic module (G') and the viscous module (G') for dough made from unadded flour only (blank sample) and samples with different concentrations of sunflower seed meal. Three distinct regions of G' curves can be observed: A relatively constant region with only a slight decrease at temperatures up to 55 °C; a region with a sharp rise in G' values at temperatures of 55 to 65 °C indicating the start of starch gelatinization and the course of this process; and a final region where G in the original portion usually decreases suddenly or slowly.

The start temperatures of the starch gelatinisation, determined as the first point of curvature of the G' curves, were very close for the samples analyzed. The slow growth of G' after the start of starch gelatinisation indicates the development of a single structural shape. Also observe a similar behavior of the samples analyzed at temperature rise in the range of 20-75 ^{o}C.

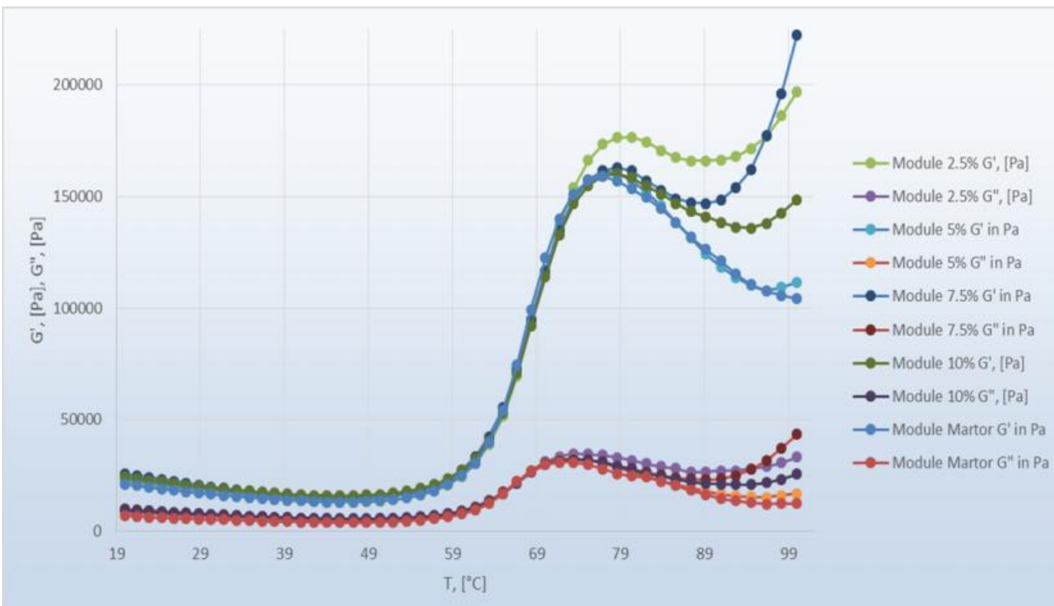

Fig. 2. Effect of changing temperature and supplementing wheat flour with flax seed flour in dough on storage module (elasticity G ') and loss module (viscosity G')

Conclusions

The addition of sunflower seed flour has significantly changed the reological properties of the dough. The values for the gluten elasticity parameter showed significant increases (p<0,05) in particular to the addition of 10% sunflower seed flour.

In terms of the values obtained on the farinograph, the addition of SSF has led to an increase in the moisturizing capacity of the dough, development time, stability and a decrease in softening.

The maximum of stability and development time was recorded for the SSF5 sample, which indicates that the 5% SSF added dough is the strongest for bread. The lowest degree of softening of the dough was also recorded for this sample.

In terms of the data obtained at the Extensigraph, there is a decrease in the strength of the dough and expandability especially at high doses of SSF incorporated in the manufacturing recipe.

Compared to the blank, the maximum viscosity of the dough, the maximum viscosity temperature and the gelatinisation temperature increased for SSF-added samples in the manufacturing recipe. However, the value of the drop index decreased.

At the reoffer counter the total volume of evolved gases shall be the maximum for the SSF5 sample and the maximum retention coefficient for the SSF10 sample.

In general, SSF-added samples have higher modulus of elasticity and viscosity depending on frequency and temperature compared to the blank test.

From the results obtained it can be concluded that the SSF5 sample has the best reological behavior with the highest values for stability development time, the total volume of gas released which recommends it for use in bread making.

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