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Rheological characteristics of dough from wheat-defatted flaxseed composite flours

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Abstract

In this study, dough rheological characteristics were analyzed for composite flours obtained through different blends between refined wheat flour and defatted flaxseed one. The flaxseed flour was incorporated in wheat flour to a substitution level of 0%, 5%, 10%, 15% and 20%. The dough rheological characteristics were analyzed through different Brabender devices such as Glutograph, Farinograph, Extensograph and Amylograph. Also, for the mix samples the falling number values were determined in order to evaluate the alpha amylase activity. According to the obtained data it may be noticed that in general, flaxseed addition increased Farinograph values such as water absorption, dough stability, dough development time and decreased the degree of softening at 10 min. During extension, flaxseed flour decreased dough strength and extensibility. From the pasting point of view, compared to the control sample, the samples in which flaxseed were incorporated in wheat flour presented a lower falling number value and a higher peak viscosity one.

Keywords: flaxseed-wheat flours, mixing, extension, pasting

1. Introduction

Bakery products play an important role in the human nutrition all over the world. These products presents a high energy source due to its high amount content in starch, and also a high nutritional value due to its dietary fiber or other comonents which may be added in the bread receipe [1]. A such of ingredient which may increase the bakery products nutritional quality is flaxseed [2], a rich source of omega-3 fatty acids [3]. Due to it content, flaxseed (*Linum usitatissimum*) may be considered a functional food ingredient. It presents a high content of polyunsaturated fatty acids (73% of total fatty acids), a moderate one of monounsaturated fatty acids (18%), and a low one of saturated fatty acids (9%). From the fatty acids content, the linoleic acid constitutes in about 16% of them, and a-linolenic acid (ALA) about 57% [4].

Nowdays, flaxseed is cultivated in many parts of world for oil, fiber as well as for medicinal purposes and also as a nutritional ingredient product [5]. It seems that due to the consumer awareness for it nutritional benefits the demand for flaxseed has been increased [2].

Different studies have been reported that flaxseed addition decrease the postprandial glucose absorption, improves the glucose tolerance and serum cholesterol levels. [6]. Traditionally, flaxseed has been processed into oil and meal and is not dehulled before oil extraction. This may led to a deterioration of the oil quality due to gum residue from the oil fraction [7]. In bakery products flaxseed is used as raw and roasted ground flaxseed flour, before or after oil extraction [8]. Through it addition the bread nutritional quality is improved. According to Marpelle *et al.*, 2015 the protein digestibility of the bread samples enriched with roasted flaxseed flour increased [9].

However, according to this study it seems that flaxseed flour addition in a roasted form decreased the bread physical properties and the textural ones such as crumb softness. According to other studies, the polyphenols content from bakery products with defatted flaxseed addition increased fact that reflect a high antioxidant activity of flaxseed [10, 11].

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Furthermore, the bioactivities of the flax protein isolates can be increased through enzymatic hydrolysis in order to produce bioactive peptides [11]. Nowdays, it has been trying to develop food products in which flaxseed are incorporated such as bakery, dairy, snacks, extruded, fermented products, traditional products and to evaluate the effect of flaxseed addition on the nutritional, physico-chemical, and sensory properties of these products [12]. It has been incorporated to the industrial levels in products such as bread and pasta [13]. It addition affect the bakery products technological process which may be clearly noticed to the laboratory level from the dough rheological properties point of view. In order to underline the flaxseed effect 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 flaxseed flour was incorporated in wheat flour to a level of 5%, 10%, 15% and 20%.

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 defatted flaxseed flour (FDS) 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), protein content (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

2.2.2. 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.

2.2.3. 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).

2.2.4. Statistical analysis: Statistical analysis was performed with XLSTAT (Version 2019.14.1, free trial; Addinsfot's Corporation, USA). Results are presented as means±standard deviation.

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 [14]. The defatted flaxseed flour of a golden variety, presented the fallowing characteristics: 32.03% protein content, 7.78% moisture content, 7.57% ash content, 3.07 % 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 flaxseed flour in different levels in wheat flour lead to significant changes to Farinograph values. It signficant increased of water absorption values, these results being in agreement with those reported by Pourabedin *et al.*, 2017; Marpalle *et al.*, 2014; Xu *et al.*, 2014; Koca and Anil, 2007 [15, 16, 17, 18] and in disagreement with those reported by Codină *et al.*, 2019; Codină and Mironeasa, 2016; Roozegar *et. al.*, 2015 [14, 19, 20].

Also, different researchers reported no significant difference of this parameter value with the increase of flaxseed addition level [21]. It seems that the variation of this parameter values depends to the flaxseed particle size, namely the lower it is the higher the water absorption value is [19]. The defatted flaxseed flour used in this study is one made and recommended to be used by the producer in bread making. It is a very fine one and that way it probably produced such a significant increase of water absorption value.

Table 1. Farinograph parameters of golden flaxseed-wheat flour blends

Sample	Parameters			
	WA (%)	**DT (min)**	**ST (min)**	**DS (BU)**
FSF0	59.0±0.1	1.9±0.1	2.3±0.1	76±1.2
FSF5	62.2±0.1	2.0±0.1	6.1±0.2	42±1.5
FSF10	64.8±0.1	2.4±0.1	7.7±0.2	34±0.9
FSF15	67.5±0.2	6.3±0.2	6.7±0.1	32±0.8
FSF20	69.3±0.1	5.5±0.3	4.9±0.1	44±1.2

Farinograph parameters: WA, water absorption (%), DT, dough development time (min), ST, dough stability (min), DS, degree of softening at 10 min (BU)
The values are means±standard deviations of two replicates.

From the dough development time point of view, it may be seen higher values for this parameter for the samples in which FDS was incorporated in wheat flour compared to the control one. This increased may be correlated to the water absorption value by the fact that dough requires longer mixing time because it absorbs more water. However, it may be seen a decrease of the DT value for the sample with the highest FSF addition level probably due to the fact that dough become less strength as a decrease of the amount of gluten from it system. From the stability (ST) and degree of softening at 10 min (DS) point of view, it may be seen that FSF addition exert a strength effect on wheat flour dough, with higher values for ST and lower for DS for the samples in which is incorporated compared to the control one. This behavior is in agreement with those reported by Meral and Dogan, 2013; Roozegar *et al.*, 2015 [22, 20] and may be attributed to the gum content from flaxseed which causes a denser and uniform dough [19]. However, at high levels of FSF addition the dough tendency is to beacome weaker probably due to the gluten dilution from the dough system.

3.3. Extension values for the composite flours dough samples

The extension values for the composite flours samples determined to Glutograph and Extensograph are shown in Table 2 and Figures 1-5.

As it may be seen from Table 2, the FSF addition lead to values lower for dough strength and higher for relaxation as it may be seen from the Glutograph data.

Table 2. Glutograph parameters of golden flaxseed-wheat flour blends

Sample	Parameters	
	Stretching (s)	**Relaxation (BU)**
FSF0	125±0.0	652±0.8
FSF5	125±0.0	687±1.4
FSF10	125±0.0	725±1.2
FSF15	8±0.1	800±0.0
FSF20	27±0.1	800±0.0

The values are means±standard deviations of two replicates.

In creep measurements to the Glutograph device, the gluten with FSF addition needs higher shear time to reach 800 BU facts that indicates that gluten become more viscous. To Extensograph, the extensibility (Ext) of the samples decreases as FFS addition increase. This data was similar with those reported by Koca and Anil, 2007; Pourabedin *et al.*, 2017; Codină *et al.*, 2017 [18, 15, 23].

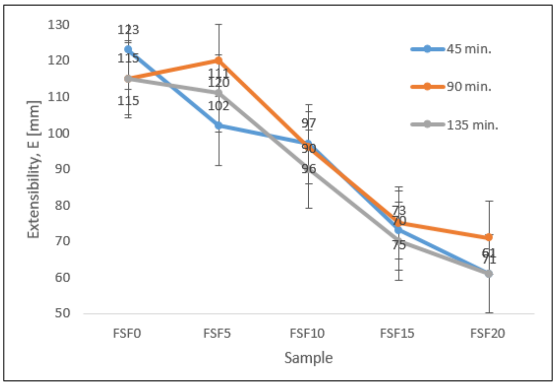

Figure 1. Extensograph extensibility, (E) parameter of flaxseed-wheat flour blends

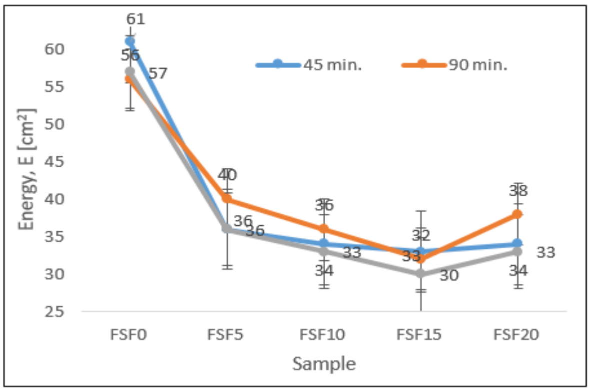

Figure 2. Extensograph energy (E) parameter of flaxseed-wheat flour blends

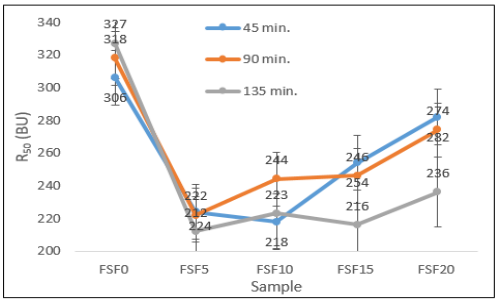

Figure 3. Extensograph resistance to extension, (R_{50}) parameter of flaxseed-wheat flour blends

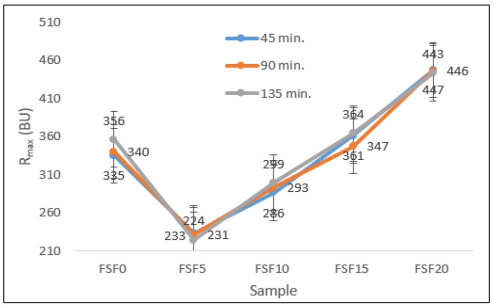

Figure 4. Extensograph maximum resistance to extension, (R_{max}) parameter of flaxseed-wheat flour blends

The dough energy (E), resistance to extension (R50) and maximum resistance to extension (R_{max}) decreased when low levels level of FFS are incorporated in wheat flour as it may be seen from the figures 2-4. However, at high levels of FSF addition it may be seen a slightly increased of this values.

According to Pourabedin *et al.*, 2017 the increase of the resistance to extension when high levels of FSF are incorporated in wheat flour are due to the interaction between FSF and wheat flour gluten. They associated this behavior with the negative effect of insoluble fiber addition on the gluten network formation due to the gluten dilution [15].

3.4. Pasting values for the composite flours dough samples

Table 3. Amylograph and Falling Number parameters of flaxseed-wheat flour blends

Sample	Parameters			
	Tg (^{0}C)	PV_{max} (BU)	T_{max} (^{0}C)	FN (s)
FSF0	62.3±0.11	1181±3.3	88.4±0.14	442±2.0
FSF5	61.9±0.07	1259±2.4	89.5±0.21	410±1.3
FSF10	59.3±0.10	1513±3.5	90.1.±0.15	420±0.9
FSF15	59.0±0.06	1547±2.7	90.3±0.08	432±1.2
FSF20	59.3±0.12	1484±3.2	91.4±0.13	437±1.0

Pasting parameters: Tg, gelatinization temperature, PV_{max}, peak viscosity (BU), T_{max}, temperature at peak viscosity, FN, falling number.
The values are means±standard deviations of two replicates

As it may be seen from Table 3, the falling number values did not vary in a significant way compared to the control sample. The flaxseed flour did not contain any amylases in it system, this variation being rather due to the starch gelatinization process from the dough system. It seems that peak viscosity increases when FSF is incorporated in wheat flour. This behavior is due to starch gelatinization and protein water absorption. According to Liu *et al.*, 2020 the increase of viscosity is probably due to the aggregation of amylose molecules [24]. This increase may be also attributed to the mucilage system from the flaxseed addition [25]. However, when high levels of FSF are added in wheat flour (20% addition), peak viscosity begin to decrease. This may be due to the mucilage water from flaxseed that led to gelation. As a consequence, starch granules were insufficiently gelatinized and slowly expanded, leading to a decrease of the peak viscosity value. Regarding the gelatinization temperature (Tg) and temperature at peak viscosity (T_{max}) values it seems that FSF decreases T_g and increases T_{max} values. FSF also compete with water for gluten or other wheat flour components. According to Farinograph data, more water is incorporated in dough system by FSF addition which seems to be available to the starch when FSF is incorporated in dough recipe.

4. Conclusions

This study wanted to be as complete as possible taking into account the FSF effect on mixing, extension and pasting properties of dough obtained from wheat-FSF composite flours. According to the obtained data, it seems that defatted flaxseed flour addition influences in a significant way all the dough rheological parameters analyzed. To Farinograph, FSF addition increases the water absorption, stability and dough development time values and decreases the degree of softening at 10 minutes. According to the extension data it seems that in general, FSF decreases dough extensibility, dough energy and dough resistance to extension. The pasting values indicates that FSF did not affect in a significant way the falling number value but it influences in a more evident way the Amylograph parameters by increasing peak viscosity, temperature at peak viscosity and by decreases the gelatinization temperature value.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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