ORIGINAL PAPER

PHYSICO-CHEMICAL INVESTIGATIONS OF BISCUITS SUPPLEMENTED WITH RYE FLOUR

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Manuscript received: 11.09.2019; Accepted paper: 07.11.2019;
Published online: 30.12.2019.

Abstract. *The chemical composition of rye flour can be a good indicator of the bread quality. In this study, the rye flour was mixed with wheat flour in ratios of 10%, 25% and 50%. The chemical parameters (moisture, ash, fat contents and alkalinity) and the physical parameters (diameter, thickness, weight and spread factor) of the biscuits have been analysed. The results of the chemical analysis showed variable results, such as the increase of the fat and ash contents, and the decrease of the moisture content and of the alkalinity. In terms of physical characteristics, the samples generally presented some differences. The Pearson coefficient showed that there is a strong correlation between the width of the biscuits and the proportion of added rye flour, and a weak correlation between the spread ratio and the amount of rye flour that is used.*

Keywords: *biscuits, rye flour, wheat flour, physical-chemical characterization*

1. INTRODUCTION

Biscuits are sweet products with a long shelf-life. They are obtained through baking of the dough from flour and different ingredients enriching their nutritive value. The permanent development of the types of biscuits, together with the progress in manufacturing technology requires the use of flour with differentiated physico-chemical and technological properties [1]. The raw and auxiliary materials used at the production of biscuits define the sensorial properties of the products; the physical-chemical modifications of the raw and auxiliary materials which appear during the technological process also contribute to the improvement of the final characteristics of the product [2, 3].

The flour, the main raw material, plays an important role in the production of final quality products. The quality requirements for the flour differ based on its type, the baking process and the preferences of the customer. There have been several attempts to incorporate flour from various sources into cereal products as a high source of proteins and fibres. Lately, the use of wheat and other cereals has gained importance in the formulation of various food products [4-8]. The flour used for the production of biscuits comes generally from white wheat, with a minimum content of 27% gluten. The biscuits need flour with medium gluten content. Since the gluten plays a limited role in the definition of biscuits processability and quality, it may be integrated with an alternative flour, in different combinations [9].

The chemical composition of the rye flour may be a good indicator for the quality of the bakery. The functional properties of the main components of the rye- starch, proteins and pentosanes- influence the bakery properties of the rye flour. The interaction between the gelatinisation properties of the starch and the activity of the α-amylase is considered a special

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factor for the bakery properties. In this study, wheat flour was supplemented with rye flour in biscuits in percentages of 10%, 25% and 50% and the effects on the physical and chemical characteristics of biscuits due to wheat flour supplementation have been analysed.

2. MATERIALS AND METHODS

2.1. MATERIALS

Wheat flour, rye flour and biscuit ingredients were purchased from a local market. The substituted flour was obtained by supplementing the wheat flour with rye flour in different proportions of 10 % (S1), 25% (S2) and 50% (S3).

2.2. METHODS

Preparation of biscuits

Composite flour was prepared from wheat flour supplemented with rye flour at different levels (10%, 25 % and 50%) and the biscuits were prepared using a standard method with slight modifications (Table 1) [10]. The ingredients were mixed using a laboratory dough mixer. The biscuits were cut with a biscuit cutter in round shapes with diameter of approximatively 4.5 cm. The baking was performed at 200 ºC for 10 minutes in the banking oven. The biscuits were put aside to cool at room temperature for 8-10 minutes and then have been sealed in polyethylene bags in order to evaluate the quality. The biscuit samples produced from 100% wheat flour served as control (C).

Table. 1. Weight of ingredients used for biscuits preparation

Ingredients	Weight [g]			
	C	**S1**	**S2**	**S3**
flour	500	450	375	250
sugar	150	150	150	150
fat	125	125	125	125
milk powder	25	25	25	25
salt	5	5	5	5
baking powder (ammonium bicarbonate)	5	5	5	5

Physical and Chemical Analysis

The proximate analysis of the composite flours was determined using the methods described by AOAC [11]. The moisture, alkalinity, fat, ash content of biscuits were determined according to STAS 1227-3/1990.

The physical characteristics of biscuits, such as diameter (width), thickness, weight and spread factor were determined using the standard method [12]. The diameter was measured by placing 6 biscuits edge-to-edge to obtain the average value in millimetres. The thickness was measured by stacking 6 biscuits on top of each other to get the average value in

millimetres. The weight of biscuits was measured with the help of the weighing balance. 6 pieces of biscuits were weighted and the arithmetic mean was calculated. The spread ratio of biscuits was calculated by dividing the diameter by the thickness of the biscuits.

All analytical determinations were performed two times in triplicates and the mean values ± standard error were reported. Pearson correlation was applied in order to assess the relationships between obtained data.

3. RESULTS AND DISCUSSION

3.1. RESULTS

The mean values of the analysed raw materials are presented in Table 2. The moisture content of wheat flour and rye flour was 8.4 and 11.62%, respectively. The moisture content of the blended flours was below 10%, thereby rendering the flours a longer shelf-life. Moisture is an important parameter in the storage of flours and levels superior to 12% allow for microbial growth [13]. The fat content of the flour samples ranged from 0.96% to 1.92%, being lowest for wheat flour and highest for rye flour. The ash content of flour samples ranged from 0.47-0.69 %. Among the raw materials, rye flour raw and mixture flours had significant higher ash contents as compared to wheat flour.

Table 2. Chemical composition of raw materials

	Moisture* [%]	**Ash* [%]**	**Fat* [%]**	**Acidity* [degree]**
Wheat flour	8.40	0.47	0.96	3.1
Rye flour	11.62	0.69	1.92	4.2
Mixture flour				
10%	9.32	0.54	1.03	3.3
25%	9.56	1.57	1.26	3.4
50%	9.89	0.62	1.42	3.7

**The values represent the means of the three replications ± the standard deviation*

Physical properties are important and helpful to judge consumer acceptability [14]. The average value of physical characteristics of biscuits such as the diameter, thickness and spread ration are presented in Table 3. Wheat flour supplementation produced a significant change ($p<0.05$) in the quality properties of the biscuits.

Table 3. Physical parameters of biscuits samples

Level of flour supplementation, [%]	**Weight* [g]**	**Diameter* [cm]**	**Thickness* [cm]**	**Spread ratio* (D/T)**
0	16.41	5.66	0.55	10.21
10	15.12	5.50	0.53	10.38
30	14.29	5.38	0.51	10.59
50	13.55	5.22	0.48	10.81

**The values represent the means of the three replications ± the standard deviation*

3.2. DISCUSSION

The widening of the biscuits during baking is expressed in percentages as the difference between the final and initial value of the diameter, reported to the initial diameter of the products. The biscuits prepared with different rye flour proportions behaved differently during the baking process. Initially, all samples had the same sizes, 4.5 m diameter and 0.3 cm height. Upon the increase of rye flour proportion, the wideness of the products at baking is reduced. The biscuits prepared with wheat flour had a wideness of 25.8%, while the supplementation with 50% rye flour led to a widening of only 16.1 %. If we statistically analyse the results, we could notice a very good correlation between the wideness of the biscuits and the flour proportion that was used, the linear regression coefficient having a positive value, (r=0.8275).

The supplementation of the wheat flour with different quantities of rye flour led to a decrease in the weight of the biscuits. Thus, the biscuits prepared from wheat flour had an average mass of 16.4 grams while the products with 50% rye flour had an initial average mass of 13.55 g.

This shows that the rye floor had a higher hydration capacity as compared to wheat flour, consequently, it led to an initially higher humidity content of the dough and to a higher water loss during the baking of the biscuits.

Spread ratio (D/T). In order to characterise the baking products from a geometrical point of view, another parameter is used, the diameter / thickness ratio. For biscuits, this indicator is important since it also describes how the products develop during baking-vertically, horizontally or both ways [15]. With the increase of rye flour proportion, the diameter/thickness ratio of the sample increases as well. The significant difference of the D/T ratio between samples may be due to the reduced content of gluten proteins in the rye flour. The values obtained indicate that during baking, the doughs with a higher wheat flour proportion tend to widen more. Although a constant increase of D/T ratio is noticed along with the increase of rye flour proportion in the biscuits dough, the correlation is very weak, the linear regression coefficients have low values (r=0.3548). This indicates a very small variability; actually, preservation of the proportions, of the shape of products is noticed, although a clear widening, between 16 and 29%, is observed. The almost unchanged diameter/thickness ratio indicates that the sample with a higher wideness suffered an adequate increase in height.

Fig.1 show the values of the moisture content of the biscuit samples. It indicates that there was a gradual decrease in the moisture content of biscuits from the control sample (wheat flour) to products with 50% rye flour.

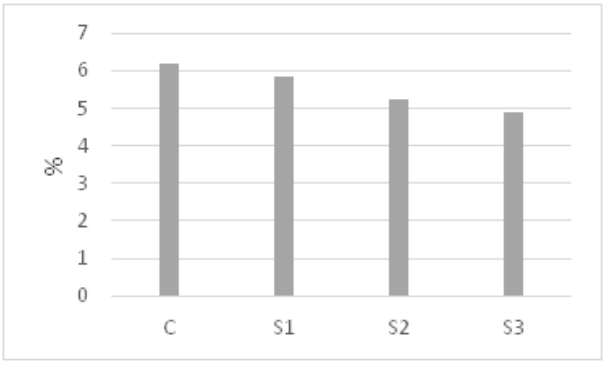

Figure 1. Effects of the blending flour on the moisture of biscuits.

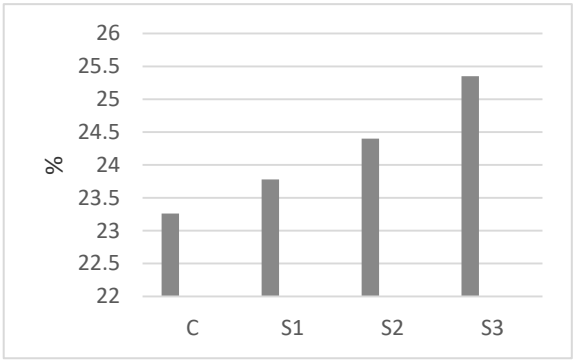

Figure 2. Effects of the blending flours on the fat content of biscuits.

The moisture content of biscuit samples decreased as the inclusion levels of rye flour increased. This may be attributed to the low water-binding capacity of rye flour that retained low moisture content in the final product. Our results for moisture content were similar to the results obtained by Srivastava et al. (2012), who incorporated taro flour in the preparation of the biscuits [16]. The concentration of fat in the biscuits ranged between 23.26% and 25.36%, and the highest concentration of fat was detected in biscuits with a higher content of rye flour (Fig. 2).

Although the rye flour had a higher fat content, the total fat content does not appear to vary much. The variations observed in the fat contents of the biscuit sample despite the same quantity of the fat used in the recipe may be due to variations in the moisture contents or baking procedure, when some of the fat could be reduced. The fat content in biscuits sample was similar to those reported by other researchers, who used composite flours for the production of biscuits [17]. Similar to the wheat flour, the rye flour presents dependency between the content of mineral substances and the direct extraction degree. The rye flour of small extraction has a higher content of mineral substances as compared to the wheat flour and is standardised based on the same criteria applied for wheat flour. Ash is an indication of the mineral content in foods and Alabi and Anuonye (2007) presented it as high in soy supplemented cereal meals [18]. The ash content of biscuits increased significantly from the control samples (wheat flour) to products with 50% rye flour (0.88% to 1.73%) due to higher ash content in the rye flour and due to externally added fat during the preparation of biscuits (Fig. 3). The increase in ash content could be attributed to the increased supplementation of rye flour in the flour blend. This may be because the ash content of rye flour is high, as compared to wheat flour. Gamal et al. (2012) found ash content in supplemented biscuits in the range of 0.56 – 1.26%, according to the results observed in this study [19, 20].

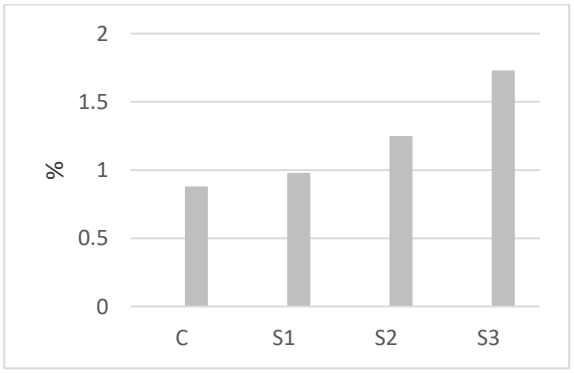

Figure 3. Effect of blending flours on the ash content of biscuits.

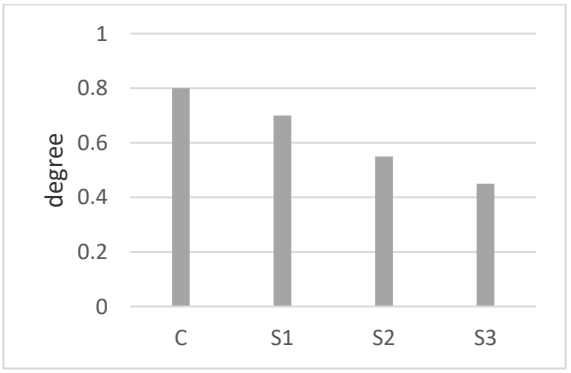

Figure 4. Effect of blending flours on the alkalinity of biscuits.

The biscuits dough is known as having higher **alkalinity**, following the ammonium content, resulting from the decomposition of baking powder. This characteristic of the dough decreased towards the end of the baking, following the evaporation of a big part of the ammonium. The data obtained at the determination of the **alkalinity** showed a slight decrease in the alkalinity, along with the increase of rye flour quantity (Fig. 4).

The rye flour has a higher **acidity** as compared to the wheat flour. The main explanation of this is the content of phytin, content that increased with the extraction degree of the flour. By enzymatic hydrolysis of phytin and phytic acid, phosphates and phosphoric acid are formed. Thus, with the increase of the rye flour content, the biscuits alkalinity decreases. The rye flours contain essential amino acids, mineral substances, vitamins, enzymes and all these together contribute to the intensification of the fermentation process and the accumulation of acidity in the dough.

4. CONCLUSION

This study shows that the addition of the rye flour to wheat flour affects the physical and chemical characteristics of the biscuits. The physical characteristics of biscuits resulting from the supplementation with rye flour revealed variable results. The spread ratio of the biscuits increased while the width and thickness factors decreased. The substitution with rye flour significantly influenced the proximate composition of the biscuits based on wheat flour. Thus, the fat and ash contents increased whereas moisture content and alkalinity decreased. The results could be valuable for local industries to partially or completely substitute wheat in the production of snacks.

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