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ORIGINAL PAPER

# Effect of sprouting time on dough and cookies properties

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**Abstract**

The role of sprouting in improving cereals nutritional properties is known. However its use in baked products is limited due the functional modifications occurring. In this study, the use of whole wheat flour sprouted for 24 and 48 h sprouted whole wheat flour (SWWF), and SWWF-refined flour blends (50:50) in cookies elaboration was investigated. Sprouting decreased water holding capacity and swelling volume and increased oil absorption capacity (OAC) gradually with sprouting time. For the dough, an increase in visco-elastic moduli (G′ and G″) was recorded when whole wheat flour (WWF) and SWWF were used instead refined flour. However, no significant differences were observed between SWWF, weather for 24 or 48 h, and raw WWF. Regarding cookies, both WWF and SWWF decreased spread factor and increased hardness compared to control. Cookies color parameters were also affected with a decrease in lightness (L*) and yellowness (b*) and an increase in redness (a*). Cookie color changes were more pronounced with 100% 48 h sample. Despite these changes, consumers overall acceptability was improved when both WWF and SWWF were used.

**Keywords** Whole-wheat flour · Sprouting · Flour properties · Rheology · Cookies characteristic

## Introduction

The widespread of several diseases, such as obesity, type 2 diabetes, cardiovascular diseases and cancer, raised consumers' awareness about the importance of their diet on their health. Consequently, the demand for health-oriented food products is steadily increasing in food market [1] and the use of whole grain could be suggested in this context due to its nutritional composition. Whole grains have a high level of nutrients like fibers, minerals, vitamins and phytochemicals [2]. For this reason, consumption of whole grain cereals may reduce some diet related diseases as proved by several epidemiological studies [3].

Sprouting bioprocess is known by improving cereals nutritional properties by enhancing nutrients and bioactive content amounts [4]. Bioactive compounds like carotenoids, phenols and vitamins (A, B, C & E) are newly formed during sprouting [5, 6]. Furthermore, sprouting decreases phytate content which improves minerals bioaccessibility [5, 7]. On the other hand, the evolution of storage molecules during this bioprocess improves flour digestibility thanks to starch and protein degradation [8].

Cookies are widely consumed all over the world due ready to eat and easy storage nature, long shelf life, availability of several varieties and low cost [9, 10]. Thus, they might be suggested as an effective vehicle of nutritional fortification [11].

Despite the nutritional interest of sprouted wheat flour, its use in cereal products is challenging as its functional properties are affected after starch and protein degradation. Previous studies suggested the use of sprouted wheat flour in different bakery products such as tortillas [12], breads [13, 14] and cakes [15]. However, no previous study investigated the use of sprouted whole wheat flour (SWWF) in cookies. Thus, the aim of this study is to evaluate the influence of sprouted whole wheat flour use in cookies formulation. Durum wheat (*Triticum durum*) was selected as grain to sprout since it is more cultivated in some North African areas, like Tunisia, compared to bread wheat (*Triticum aestivum*) [16]. In this way, durum wheat was sprouted for 24 and 48 h and the obtained SWWF together with their blends

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at 50% with refined flour were used in cookies elaboration. Flour hydration properties and oil absorption capacity were measured. Dough properties were assessed through visco-elastic moduli. Cookies were characterized by their physical properties (spread factor, color, texture) and consumer acceptability.

## Material and methods

### Materials

Wheat (*T. durum*) (13.91 g/100 g protein) was supplied by Harinera Villamayor (Huesca, Spain). The rest of ingredients were: refined flour (11.82 g/100 g moisture, 10.40 g/100 g protein) (Haricaman, Toledo, Spain), white sugar (AB Azucarera Iberica, Valladolid, Spain), sodium bicarbonate (Manuel Riesgo S.A., Madrid, Spain) and margarine (Argenta Crema, Puratos, Barcelona, Spain).

### Methods

#### Preparation of flours: sprouting and milling

Durum wheat seeds were sprouted as described previously [17]. Briefly, samples were disinfected with 1% (V/V) hypochlorite sodium solution during 30 min. Then, the grains were rinsed three times with distilled water to remove completely solution residues. After this step, seeds were soaked again in distilled water for 40 min and finally spread into plates with three layers of "Blotting paper". The seeds were germinated in darkness for 24 or 48 h at 25 °C at 30% R.H. Finally, sprouts were oven dried at 50 °C for 8 h and milled with a screen size of 500 µm (Ultra-Centrifugal Mill, Retsch, ZM 200, Germany). Milled samples were stored at 4 °C until further analysis.

### Flour characteristics

#### Water holding capacity (WHC) and swelling volume (SV)

WHC and SV were determined in duplicate as follows: 5 g of sample were weighed in a graduated cylinder. Then, 100 ml of distilled water were added and the samples were kept at room temperature for 24 h. After that, the water was removed and the weight and volume of swollen sample were recorded. In this way, the WHC corresponds to the amount of water retained by the sample without being subjected to any stress [18]. The SV was calculated by dividing the total volume of swollen sample by the original dry weight of the sample.

#### Oil absorption capacity (OAC)

Oil absorption capacity (OAC) was determined in triplicate according to the protocol suggested by Lin et al. [19]. Briefly, flour samples ($100 \pm 0.2$ mg) were mixed with 1 ml of sunflower oil. The content was stirred for 1 min to disperse the sample. The samples were vortexed for 30 min then centrifuged at $3000\times g$ and 4 °C for 10 min. The supernatant was removed with a pipette and tubes were inverted for 25 min. Residues were weighed. The oil absorption capacity was expressed as grams of oil bound per gram of sample on dry basis. OAC was calculated according to Eq. (1):

$$\mathrm{OAC} = \frac{\text{Residue weight}}{\text{Sample weight (g db)}} \quad (1)$$

### Cookie making

Six different flours were used for cookies formulation: 100% refined flour (Control), 100% whole wheat flour (WWF), 100% sprouted whole wheat flour (SWWF) for 24 h (100% 24 h), 100% SWWF for 48 h (100% 48 h), and 50:50 mixtures of refined flour with SWWF for 24 h (50% 24 h) and 48 h (50% 48 h). The following ingredients proportions were used (g/100 g dough basis): 42.8 flour, 19.2 margarine, 30.8 sugar, 0.9 sodium bicarbonate and 6.2 of water. Cookies were elaborated as described by Bravo-Nuñez et al. [20]. Briefly, on a first step the moisture of the flour blends was adjusted to 15 g/100 g. Then, the ingredients were mixed accordingly: The margarine was heated in the microwave (1000 watts for 1 min). The melted margarine together with the sugar were mixed in a Kitchen Aid 5KPM50 mixer (Kitchen Aid, Benton Harbor, MI, USA) using a flat beater at speed 4 for 180 s, with intermediate scraping every 60 s. The water was then added and mixed at speed 4 for 120 s, with a scraping steep at the end. Finally, the flour and the sodium bicarbonate were included and mixed at speed 2 for 120 s, with scraping every 30 s. The obtained dough was covered with plastic film and allowed to rest for 30 min at 25 °C. After the resting period, the dough was laminated with a Salva L-500-J sheeter (Salva, Lezo, Spain) using a gap of 6.00 mm and cut with a circular cookie cutter (internal diameter: 40 mm). The resulting dough pieces were baked in an electric modular oven for 14 min at 185 °C. Finally, cookies were cooled down for 60 min at room temperature before packing them in plastic bags and storing them at 24 °C. All cookies were made in duplicate.

### Dough rheology

For the rheological behaviour of doughs a controlled strain rheometer (Thermo Fisher Scientific, Schwerte, Germany) equipped with a parallel-plate geometry (60 mm diameter titanium serrated plate-PP60 Ti) and a water bath (Thermo Fisher Scientific) at 25 °C were used following the methodology suggested by Mancebo et al. [21] Circular dough pieces (3 mm height and 60 mm width) were placed in the rheometer and compressed with a gap of 3 mm. Samples were rested for 300 s before measuring. A strain sweep test in the range of 0.1–100 Pa at a constant frequency (1 Hz) was conducted to identify the strain value included in the linear viscoelastic region. This strain value was used to perform a frequency sweep test in a frequency range from 10 to 0.1 Hz. Elastic modulus (G′ [Pa]), viscous modulus (G″ [Pa]) and loss factor (tan δ) were obtained. Doughs were analyzed in duplicate.

### Physical properties of cookies

From each elaboration, the dimensions (diameter and height) of six cookies were measured with a caliper. Cookie diameter was measured twice, perpendicularly, in order to calculate an average diameter. Spread factor of cookies was determined by dividing the average diameter by the thickness.

Cookie color was measured using a Minolta CN-508i spectrophotometer (Minolta, Co. LTD, Tokyo, Japan) with the D65 standard illuminant and the 2° standard observer. Measurements were carried out at the cookie centre of the upper surface (crust) for six cookies from each elaboration. Results were expressed in the CIE L*a*b* color space.

Cookies texture was determined by a 'three-point bendinG′ test, using a TA-XT2 texture analyser (Stable Microsystems, Surrey, UK) and a sounding line HDP/3 PB with a test speed of 2.0 mm/s. The maximum force (N) to break the cookies (hardness) was measured. From each elaboration, eight cookies were used for textural analysis. All physical properties were determined 7 days after baking.

### Sensory analysis

Hedonic sensory evaluation of the cookies was conducted with 79 volunteers who were habitual cookie consumers. For sensory evaluation, samples were presented as whole pieces on white plastic dishes coded with four-digit random numbers and served in random order. A nine-point hedonic scale was used to evaluate cookies acceptability on the basis of their appearance, odor, texture, taste and overall appreciation. The scale of values ranged from "like extremely" to "dislike extremely", corresponding to the highest and lowest scores of "9" and "1" respectively.

### Statistical analysis

One way Analysis of variance (ANOVA) was performed using the Fisher test for determination of differences between means. Significance was defined at $p < 0.05$. Statistical analysis was carried out using the Minitab software (Minitab 17, Pennsylvania, USA).

## Results and discussion

### Flour properties

Flour properties are summarized on Table 1. For WHC and SV, WWF had the highest value. An increase in sprouting time decreased these two parameters as shown by 100% 24 h and 100% 48 h samples. Cornejo and Rosell [22] reported also a decreasing trend in hydration properties (WHC and SV) for germinated brown rice. The differences in hydration properties between refined flour and sprouted and/or whole wheat flour might be attributed to the ability of the bran in binding water [23]. Starch also plays a key role in hydration properties. In fact, starch holds water through hydrogen bonding between amylose and amylopectin branches and inter amylopectin helices [24]. Accordingly, the decrease in WHC and SV in sprouted samples is expected as sprouting is known by starch degradation under amylasic enzymes [25].

Regarding oil absorption capacity (OAC), WWF had higher values than refined flour since fibre of wheat bran has a high capacity to hold oil [26]. For SWWF, OAC increased gradually with sprouting time. The role of sprouting in

**Table 1** Flour functional properties

| Flour | WHC (g/g db) | SV | OAC (g/g db) |
|---|---|---|---|
| Control | $1.50 \pm 0.06^{e}$ | $2.25 \pm 0.13^{d,e}$ | $1.82 \pm 0.05^{d}$ |
| WWF | $3.73 \pm 0.31^{a}$ | $3.88 \pm 0.23^{a}$ | $1.97 \pm 0.02^{b}$ |
| 50% 24 h | $2.21 \pm 0.08^{d}$ | $2.68 \pm 0.22^{c}$ | $1.93 \pm 0.02^{bc}$ |
| 100% 24 h | $3.24 \pm 0.09^{b}$ | $3.59 \pm 0.01^{b}$ | $2.03 \pm 0.03^{b}$ |
| 50% 48 h | $2.15 \pm 0.22^{d}$ | $2.14 \pm 0.12^{e}$ | $1.87 \pm 0.04^{c,d}$ |
| 100% 48 h | $2.71 \pm 0.19^{c}$ | $2.42 \pm 0.00^{c,d}$ | $2.20 \pm 0.03^{a}$ |

Means in same column that do not share same letters are significantly different, according to Fisher's test. ($p < 0.05$)

Control: refined flour; WWF: whole wheat flour; 50% 24 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 24 h; 100% 24 h: 100% sprouted whole wheat flour for 24 h; 50% 48 h:blend containing 50% refined flour and 50% sprouted whole wheat flour for 48 h. 100% 48 h: 100% sprouted whole wheat flour for 48 h; WHC: water holding capacity; SV: swelling volume; OAC: oil absorption capacity, db: dry basis increasing OAC has been reported previously with germinated sorghum and germinated brown rice [22, 27].

This trend after sprouting might be related to the protein degradation under proteolytic enzymes which may increase lipophylic surfaces [28].

## Dough rheological properties

As shown on Table 2, for all samples, G′ is higher than G″, which confirms the elastic behavior of the dough. Refined flour had lower values of G′, G″ and G* than WWF and SWWF. In this way, the presence wheat bran increased G′, G″ and G* and consequently the rheological dough values which is in agreement with the higher water absorption capacity of WWF samples. Contrarily, refined flour had the highest value of Tan δ due to the greater rise of G′ compared to G″. Sprouting time did not induce significant ($p > 0.05$) changes in G′ and G″. Mixtures of refined and SWWF (whether for 24 or 48 h) had intermediate values. These results are not in line with previous study [29] where significant changes in viscolelastic moduli were observed after sprouting bread wheat up to 24 h. However, in this previous study the dough was only composed by wheat flour and water and, therefore, there was a great gluten network development being the responsible of the dough rheology [30]. In this way, the proteolytic activity manifested during sprouting [4] can hydrolyse the gluten network [31] and modify dough rheology. In our case, the high fat and sugar quantities hinder the gluten development and the rheological behavior is influenced not only by the flour but also by the rest of ingredients. The use of WWF induced a significant decrease in Tan δ if compared to control. Meanwhile, sprouting did not affect Tan δ. The difference between refined and WWF might be related to the composition of each as higher fiber content are detected in WWF. In fact, results of Li et al. [32] showed that an increase in aleurone-rich fraction (ALF) decreased dough Tan δ values. Such findings reflect an improvement in dough stability thanks to bran fibers [23].

## Cookies properties

### Physical properties

Compared to control, the use of WWF decreased significantly spread factor (Fig. 1). In fact, this decrease was due the increase in thickness and decrease in cookie diameter (Table 3). Sprouting did not affect this parameter as no significant differences were seen between WWF, 100% 24 h and 100% 48 h samples. The effect of WWF on decreasing cookie spread factor has been reported previously [33], just like the incorporation of wheat bran [34]. Similarly, Jan et al. [35] observed that the use of germinated chenopodium flour did not affect spread factor significantly. Evolution of spread factor highlights previous results of hydration and rheological properties. Compared to control, the use of WWF and SWWF increased hydration capacity (Table 1) and dough viscosity (as G″ increased) (Table 2). Such increase in hydration capacity and viscosity might decrease expansion

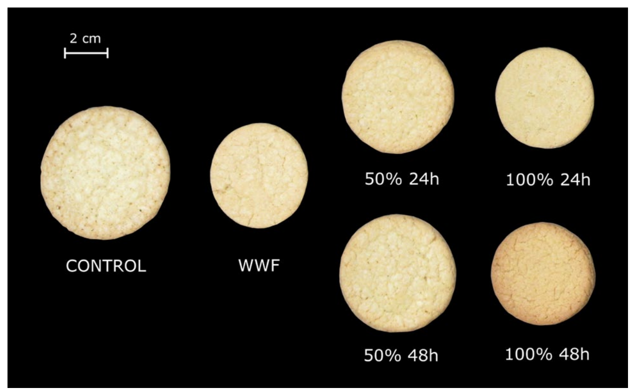


**Fig. 1** Image of cookies made with different flours: Control: refined flour; WWF: whole wheat flour; 50% 24 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 24 h; 100% 24 h: 100% sprouted whole wheat flour for 24 h; 50% 48 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 48 h. 100% 48 h:100% sprouted whole wheat flour for 48 h

**Table 2** Rheological characteristic of the dough

| Sample | G′ (Pa)* $10^5$ | G″ (Pa)*$10^5$ | G*(Pa)* $10^5$ | Tan δ |
|---|---|---|---|---|
| Control | $0.66 \pm 0.13^{d}$ | $0.24 \pm 0.05^{c}$ | $0.71 \pm 0.14^{d}$ | $0.36 \pm 0.01^{a}$ |
| WWF | $1.97 \pm 0.16^{a}$ | $0.56 \pm 0.01^{a}$ | $2.05 \pm 0.16^{a}$ | $0.29 \pm 0.03^{d}$ |
| 50% 24 h | $1.32 \pm 0.27^{b,c}$ | $0.42 \pm 0.07^{b}$ | $1.39 \pm 0.28^{b,c}$ | $0.32 \pm 0.01^{b,c}$ |
| 100% 24 h | $1.88 \pm 0.35^{a}$ | $0.55 \pm 0.09^{a}$ | $1.96 \pm 0.36^{a}$ | $0.30 \pm 0.02^{c,d}$ |
| 50% 48 h | $1.13 \pm 0.28^{c}$ | $0.37 \pm 0.08^{b}$ | $1.18 \pm 0.29^{c}$ | $0.33 \pm 0.01^{b}$ |
| 100% 48 h | $1.63 \pm 0.15^{a,b}$ | $0.46 \pm 0.03^{a,b}$ | $1.70 \pm 0.14^{a,b}$ | $0.30 \pm 0.02^{c,d}$ |

Means in same column that do not share same letters are significantly different, according to Fisher's test. ($p < 0.05$)

Control: refined flour; WWF: whole wheat flour; 50% 24 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 24 h; 100% 24 h: 100% sprouted whole wheat flour for 24 h; 50% 48 h:blend containing 50% refined flour and 50% sprouted whole wheat flour for 48 h. 100% 48 h:100% sprouted whole wheat flour for 48 h

Table 3 Cookies physical characteristic

| Flour used | Thickness (mm) | Width (mm) | Spread factor | Hardness (N) | L* | a* | b* |
|---|---|---|---|---|---|---|---|
| Control | 7.57 ± 0.4d | 61.73 ± 1.0$^{a}$ | 8.15 ± 0.4$^{a}$ | 37.18 ± 8.0$^{d}$ | 55.8 ± 7.8$^{a}$ | 4.07 ± 0.6$^{e}$ | 15.55 ± 4.9$^{b}$ |
| WWF | 10.57 ± 0.3$^{a}$ | 46.25 ± 0.8$^{d}$ | 4.37 ± 0.1$^{d}$ | 64.50 ± 8.6$^{b}$ | 59.3 ± 3.1$^{a}$ | 5.25 ± 0.18$^{c}$ | 19.14 ± 2.0$^{a}$ |
| 50% 24 h | 8.99 ± 0.4$^{c}$ | 51.41 ± 0.5$^{c}$ | 5.72 ± 0.3$^{c}$ | 43.79 ± 7.1$^{c}$ | 46.7 ± 4.9$^{c}$ | 4.34 ± 0.38$^{e}$ | 12.66 ± 3.6$^{c}$ |
| 100% 24 h | 10.27 ± 0.5$^{a,b}$ | 45.01 ± 0.4$^{e}$ | 4.38 ± 0.2$^{d}$ | 76.56 ± 10.0$^{a}$ | 50.6 ± 2.1$^{b}$ | 4.79 ± 0.37$^{d}$ | 15.61 ± 1.3$^{b}$ |
| 50% 48 h | 8.98 ± 0.6$^{c}$ | 53.94 ± 0.8$^{b}$ | 6.01 ± 0.4$^{b}$ | 42.94 ± 5.5$^{c}$ | 47.9 ± 3.8$^{b,c}$ | 5.89 ± 0.54$^{b}$ | 10.92 ± 3.0$^{c}$ |
| 100% 48 h | 10.15 ± 0.4$^{b}$ | 46.58 ± 1.0$^{d}$ | 4.59 ± 0.2$^{d}$ | 60.50 ± 8.2$^{b}$ | 46.7 ± 2.0$^{c}$ | 7.24 ± 0.49$^{a}$ | 11.04 ± 1.9$^{c}$ |

Means in same column that do not share same letters are significantly different, according to Fisher's test. ($p < 0.05$)

Control: refined flour; WWF: whole wheat flour; 50% 24 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 24 h; 100% 24 h: 100% sprouted whole wheat flour for 24 h; 50% 48 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 48 h. 100% 48 h:100% sprouted whole wheat flour for 48 h

during baking [21, 36] which decreases cookies diameter (Table 3) and consequently spread factor.

Cookies hardness is among parameters influencing consumers' acceptability. The use of WWF increased cookies hardness by 73.4% if compared to control. Similarly, using sprouted flours increased hardness while the use of blends with refined flour led to intermediate values. These results could be related to the lower spread factor of the cookies and, therefore, a more compact structure, as it has been confirmed in prior studies [37]. Previous studies also showed that the use of germinated flours (brown rice and chenopodium) did not modify cookies hardness comparatively to their raw seeds flour [35, 38]. While results of Sudha et al. [34] highlighted the role of wheat bran incorporation on increasing cookies hardness and also decreasing spread factor as shown by our results. Accordingly, the increase in hardness might be attributed to the difference in flour composition between refined and WWF. Particularly, WWF (and SWWF) might have higher fiber content than control. The contribution of insoluble fibers on increasing cookies hardness has been previously reported [34, 39]. This increase might be attributed to the contribution of fibers in increasing water absorption capacity increasing cookie hardness [40].

The use of WWF did not affect cookies lightness (L*). However, the use of SWWF decreased it gradually with sprouting time. Regarding redness (a*), both WWF and SWWF flour increased its averages significantly. The highest values were recorded when 100% 48 h SWWF was used. Such decrease in lightness (L*) and increase in redness (a*) were previously reported with germinated amaranth and germinated brown rice flours [36, 38]. Yellowness (b*) increased when WWF is used while its value decreased when sprouted whole wheat flour is used. Yaqoob et al. [15] observed the same trend in unsprouted/sprouted barley-wheat flour blend. Evolution of cookies color is related to baking and Maillard reaction. During sprouting starch is degraded under enzymatic activity [41] which may lead to a pronounced Maillard reaction.

## Sensory analysis

As shown on Table 4, the use of WWF and SWWF increased the appearance values, although there were not significant different between them. Therefore, the improvement of appearance is probably due to the use of the whole grain and its impact on cookies size and/or color, since cookies made with

Table 4 Effect of raw and sprouted whole wheat flour use on the organoleptic acceptability

| Sample | Appearance | Odor | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| Control | 5.69 ± 1.79$^{a}$ | 4.97 ± 1.68$^{a}$ | 5.11 ± 2.16$^{a}$ | 5.44 ± 1.65$^{a}$ | 5.4 ± 1.76$^{a}$ |
| WWF | 6.55 ± 1.54$^{b}$ | 5.39 ± 1.39$^{a,b}$ | 5.68 ± 1.71$^{a,b}$ | 6.33 ± 1.49$^{b}$ | 6.03 ± 1.37$^{b}$ |
| 50% 24 h | 6.45 ± 1.25$^{b}$ | 5.53 ± 1.44$^{b,c}$ | 5.93 ± 1.73$^{b}$ | 5.79 ± 1.60$^{a}$ | 6.11 ± 1.37$^{b}$ |
| 100% 24 h | 6.45 ± 1.22$^{b}$ | 5.56 ± 1.56$^{b,c}$ | 5.96 ± 1.70$^{b}$ | 5.73 ± 1.52$^{a}$ | 6.17 ± 1.41$^{b}$ |
| 50% 48 h | 6.61 ± 1.45$^{b}$ | 5.44 ± 1.49$^{a,b,c}$ | 5.57 ± 1.83$^{a,b}$ | 5.92 ± 1.62$^{a,b}$ | 5.8 ± 1.54$^{a,b}$ |
| 100% 48 h | 6.73 ± 1.51$^{b}$ | 5.91 ± 1.51$^{c}$ | 5.96 ± 1.64$^{b}$ | 5.63 ± 1.78$^{a}$ | 6.11 ± 1.37$^{b}$ |

Means in same column that do not share same letters are significantly different, according to Fisher's test. ($p < 0.05$)

Control: refined flour; WWF: whole wheat flour; 50% 24 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 24 h; 100% 24 h: 100% sprouted whole wheat flour for 24 h; 50% 48 h: blend containing 50% refined flour and 50% sprouted whole wheat flour for 48 h; 100% 48 h:100% sprouted whole wheat flour for 48 h

WWF and SWWF were smaller (spread factor, Table 3) and darker (Fig. 1). Regarding odor, this parameter was affected by the flour used. In general, the use of sprouted whole wheat flour improved cookies odor and taste versus control. This could be attributed to role of Maillard reaction in enhancing aromatic compounds, mainly because more reducing sugars are available on SWWF after starch degradation [42]. Coming to texture, cookies made with WWF got the highest mark while no significant differences were seen among all the other samples. Altogether, substitution of refined flour by WWF or SWWF improved overall acceptability.

## Conclusion

Sprouting is recognized as an effective tool to improve cereals' nutritional properties. Moreover, the sprouted flours are whole grain flours, which have also nutritional benefits. The sprouting process decreased the WHC of whole wheat flours, but it did not modify the dough rheology. The use of SWWF led to cookies with the same spread factor and similar hardness as WWF. Compared to control, cookies made with WWF and SWWF had lower spread factor and higher hardness. However, the sprouting changes (grain components hydrolysis) influenced the Maillard reactions and cookies color. The use of WWF improved the cookie acceptability, but the sprouted flour cookies had not significant differences respect to WWF cookies. Therefore, sprouted flours could be an interesting alternative to WWF due to their nutritional benefits.

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