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Evaluation of biscuits obtained from novel composite flour containing Maiorca malt flour

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PAPER

Abstract

The aim of this study was to investigate a novel composite flour containing one of the old Sicilian wheat landraces called Maiorca and the resultant biscuits. In this study, the effect of replacing soft wheat flour with Maiorca malt flour and commercial malt flour at different percentages (5, 10, and 15%) on the color intensity, formation of acrylamide, and descriptive sensory analysis was evaluated. Sensory analysis revealed that the biscuit sample containing 5% Maiorca malt flour was most appreciated by panelists. Eventually, data analysis revealed that Maiorca malt flour had great potential to be used as a part of biscuit ingredients.

Keywords: acrylamide; biscuit; composite flour; Maiorca malt flour; sensory evaluation

Introduction

Biscuit is a flour-based baked product and one of the most popular snack foods worldwide. Prolonged shelf life, a wide range of tastes, low price, and easy accessibility are the reasons why biscuits are popular around the world (Agrahar-Murugkar *et al.*, 2015). Flour is one of the major ingredients in bakery products. Replacement of a part of wheat flour with other flours is mainly due to a lack of essential amino acids, such as lysine and tryptophan, in wheat flour and to enhance the nutritional value and functional properties of wheat flour-based baked products. On the other hand, the study conducted by the Food and Agriculture Organization (FAO) in 1982 showed that substitution of wheat flour with 20 and 30% non-wheat flour for the production of bakery items leads to possible savings of 320 and 480 million dollars annually, respectively.

In recent years, many studies have been conducted to determine the possible effects of the replacement of wheat flour with various cereal flours, including maize flour (Jauharah *et al.*, 2014; Pourmohammadi *et al.*, 2019), rice flour (Chandra *et al.*, 2015), barley flour (Aly *et al.*, 2021; Drakos *et al.*, 2019; Verardo *et al.*, 2011; Vujić *et al.*, 2015), millet flour (Jayawardana *et al.*, 2022; Shimray *et al.*, 2012), oat flour (Vujić *et al.*, 2015), and rye flour (Drakos *et al.*, 2019). Moreover, researchers claimed that malted cereals have recently acquired popularity as a bakery ingredient due to their high polyphenol content, antioxidant activity, and structure-improving properties (Adebiyi *et al.*, 2017; Chauhan *et al.*, 2015).

Khalil *et al.* (2000) reported how the addition of 1% malt improved the stability of the dough, flour strength, and dough weakening of composite flours. Agrahar-Murugkar *et al.* (2015) reported that the biscuits obtained from composite flours were preferable to biscuits obtained with soft wheat flour in terms of texture, physical, nutritional, and sensory attributes. Furthermore, they had higher organoleptic acceptability on the 9-point hedonic scale. In addition, Yang *et al.* (2020) highlighted how the addition of wheat malt flour improved the texture of cookies.

According to Dendy (1994), three elements are important for the selection of raw materials: availability, compatibility, and reasonable cost. Nowadays, Sicilian landrace flour varieties such as Maiorca, Russello, Timilia, Perciasacchi, or ancient varieties like Cappelli and Margherito, are now commercially accessible in Sicily (Visioli, 2021). In recent years, many products have been prepared from Maiorca wheat, such as white bread, biscuits, breadsticks, and wafers. Therefore, we undertook a study to investigate the impact of the partial replacement of soft wheat flour with landrace Maiorca malt flour on the characteristics of the dough and on consumer acceptability.

Materials and Methods

Materials

Maiorca wheat was supplied by a commercial cereal farm in Valledolmo (province of Palermo, Sicily). It was subsequently malted in an automatic malting system (PHOENIX BIOSYSTEMS Automatic Micromalting System). This malt was ground through a Cyclotec type 120 mill (Perten, Huddinge, Sweden) with a sieve of 500 μm to obtain flour. The other ingredients, such as soft wheat flour, malt flour, leavening agents, water, and sunflower oil were bought from the local market.

Methods

Malting process conditions

The malting process on Maiorca wheat was performed in triplicate in an automatic malting system (PHOENIX BIOSYSTEMS Automatic Micromalting System) at the University of Palermo (Italy). It was carried out according to the conditions proposed by Alfeo *et al.* (2018). The germinated samples were dried and kilned for 34.5 h in the following conditions: 3 h at 55°C, 12 h at 60°C, 10 h at 65°C, 5 h at 70°C, and 4.5 h at 75°C. After malting all the samples of Maiorca malt, a moisture content of 4.82% was attained.

Proximate composition analysis

The moisture content was measured following the European Biochar Certificate (EBC) analytical method (4.2) in an oven at 105°C for 3 h. The ether extraction method was applied to determine the lipid content. Total protein and fiber contents were analyzed according to the Kjeldahl method (N × 6.25) and AOAC (2012), respectively. Ash content was determined in accordance with AOAC (1990), in a muffle furnace at 550°C. The total carbohydrate content was obtained by subtracting the total of crude protein, lipid, fiber, moisture, and ash contents from 100.

The Megazyme assay kit (Megazyme International, Ireland) was used for total starch content (db%) determination following the AOAC Method 996.11 (2005).

A malt amylase assay kit (Megazyme International) was used to quantify α and β amylases in malt flours. The enzyme activities were measured by reading the assay absorbance using a Varian Cary n100 UV–vis spectrophotometer (Palo Alto, California, United States) and reported as units per gram of dry matter (U g^{1}). One unit of activity is defined as the amount of enzyme required to release one micromole of p-nitrophenol from BPNPG7 in 1 min under the defined assay conditions.

Malt diastatic power was determined using the EBC analytical method 4.12.1 by spectrophotometry.

Formulation of composite flour

The composite flour was prepared by replacing soft wheat flour with Maiorca malt and commercial malt flour, as shown in Table 1; and the control sample was composed of 100% soft wheat flour and labelled as CT.

Production of biscuits

The essential ingredients for the production of biscuits and their various proportions are shown in Table 1.

Baking powder, sunflower oil, and water were the same for all the proportions. After weighing the ingredients, they were transferred to a mixer and mixed at room temperature for 5 min. The dough was sheeted to a thickness of 6 mm with a roller and a wooden frame of standard height, and then cut with a 50-mm diameter mold and baked at 190°C for 14 min, and finally were cooled at room temperature.

Color of biscuits

The color of the biscuit surface was determined using a Minolta Chroma Meter CR-300 (Minolta, Osaka, Japan), based on three color coordinates according to the CIE L*a*b* system (CIE, 1986); L* is lightness and varies from black (L* = 0) to white (L* = 100), the value of redness (a*) from green (−a*) to red (+a*), and yellowness (b*) from blue (−b*) to yellow (+b*). The calibration of the Chroma Meter was performed using a Minolta calibration plate (No. 11333090; Y = 92.9, x = 0.3159; y = 0.3322). The color determination was made only on the upper surface of the biscuits, in a total of six replications per sample.

Table 1. Replacement of soft wheat flour with Maiorca malt and commercial malt flour at different percentages.

Sample code	Soft wheat flour (g)	Maiorca malt flour (g)	Commercial malt flour (g)	Baking Powder (g)	Sunflower oil (g)	Water (g)
CT	100	0	0	0.5	28	34
MF_5	95	5	0	0.5	28	34
MF_{10}	90	10	0	0.5	28	34
MF_{15}	85	15	0	0.5	28	34
CF_5	95	0	5	0.5	28	34
CF_{10}	90	0	10	0.5	28	34
CF_{15}	85	0	15	0.5	28	34

MF, Maiorca flour; CF, commercial flour.

Acrylamide content of biscuits

The acrylamide content of biscuit samples was evaluated according to the method described by Galluzzo *et al*. (2021). One gram of biscuit samples were weighted and transferred into a tube (50 mL) with 25 µL of acrylamide-d3 solution (1 mg/kg) as an internal standard. Thereafter, 10 mL of acetonitrile and 5 mL of water were added to the mixture, and then it was vortexed for 1 min. To the solution were added the contents of a Supel QuE Citrate extraction tube 55227-U (Sigma, Darmstadt, Germany), then mixed vigorously by vortex for 1 min and centrifuged for 5 min at 3500 rpm. A 0.45-µm filter was used to filter the supernatant, and LC-MS/MS analysis was carried out on 1 mL of filtrate. Thermo Fisher UHPLC system (Thermo Fisher Scientific, California, U.S.A.) was used for the LC analysis. In this experience, an Ascentis Express C18 column was employed for chromatographic separation. The flow rate and column temperature were 0.3 mL min^{-1} and 30°C, respectively. The injection volume was 25 µL with a partial loop of 10 µL.

Sensory evaluation

In this study, at first 30 students of agri-food science and technology, University of Palermo, aged between 19 and 26 were employed. They were asked to identify basic taste such as salty, sweet, sour, bitter with water solutions of sodium chloride, sucrose, citric acid and caffeine, respectively. Out of 30 panelists, 19 were able to correctly identify basic taste. In the next step, those who had correctly identified were asked to rank different concentration levels of basic tastes from the weakest to the strongest. In this regard, samples were prepared in 15 mL of aqueous solution in different concentrations: sweet (5, 10, 25, and 50% sucrose in water, w/v); salty (0.5, 1, 1.5, and 5% NaCl in water, w/v); sour (0.25, 0.5, 1, and 1.5% citric acid in water, w/v); bitter (0.3, 0.6, 1.3, and 2.6% caffeine in water, w/v). Finally, 11 panelists, who correctly ranked all the samples, were selected to carry out the descriptive test. Seven biscuit samples, coded with a three-digit number, were presented to each panelist for descriptive sensory analysis.

Statistics analysis

Data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). One-way ANOVA was performed on the experimental data, and Duncan's post hoc test was used when a statistically significant effect ($p < 0.05$) was observed. Pearson correlation analysis was used to determine the correlation between parameters.

Results and Discussion

Flour analysis

Proximate compositions

Chemical characteristics of three types of flour, including soft wheat flour (SWF), Maiorca flour (MF) and commercial flour (CF) were evaluated and summarized in Table 2.

Results showed that the protein, carbohydrate, and lipid contents of MF (12.06, 72.16, 2.72%, respectively) are slightly higher than those of SWF and CF. Moisture content was the lowest in MF (4.82%) in comparison with SWF and CF; the main reason could be found in the malting process. The moisture content plays a crucial role in the preservation, transportation, and packaging (Man *et al*., 2021). The moisture levels in this research were within the optimal range for preventing fungal growth during storage. The fiber content of CF (9.74%) was significantly ($p < 0.05$) higher than that of other flours. It should be noted that the macronutrient value of Maiorca malt flour is quite close to that of commercial malt flour. Therefore, Maiorca malt flour, which is not usually used in bakery products, has great potential to be used as an alternative in the production of various bakery products.

Moreover, given that biscuits contain approximately 20–25% lipid and are sensitive to oxidation during storage, MF may has a positive effect on shelf life due to its potential antioxidant activity.

Table 2. Proximate composition of flours.

Type of flour	Protein (%)	Carbohydrate (%)	Lipid (%)	Fiber (%)	Moisture (%)	Ash (%)
SWF	10.93 ± 0.22	71.01 ± 1.40	1.73 ± 0.03	3.21 ± 0.04[c]	11.93 ± 0.26[a]	1.31 ± 0.02
MF	12.06 ± 0.24	72.16 ± 1.52	2.72 ± 0.05	6.53 ± 0.07[b]	4.82 ± 0.12[c]	1.71 ± 0.03
CF	11.04 ± 0.24	69.91 ± 1.49	1.82 ± 0.05	9.74 ± 0.12[a]	6.22 ± 0.18[b]	1.44 ± 0.02

SWF, soft wheat flour; MF, Maiorca malt flour; CF, commercial malt flour.
[a,b,c]Values in the same column with different superscripts differ significantly (P < 0.05).

Malt flour analysis

For malt flours, α-amylase, β-amylase, total starch, and diastatic power were measured, as shown in Table 3. As expected, there were significant positive correlations between these parameters ($r = 0.73$ and $p < 0.05$).

Starch is mainly hydrolyzed by α-amylase and β-amylase in malt and barley. Regarding the content of amylolytic enzymes, Maiorca malt showed a significantly (<0.0001) higher α-amylase content than commercial malt, while no significant difference was observed in the β-amylase value. These results are consistent with those of Alfeo *et al.* (2021) who analyzed several old wheat landraces, including Maiorca. It is interesting to note this significant difference in the content of α-amylase, which unlike β-amylase is synthesized during the germination process in the aleurone cells. Total starch and diastatic power showed a significant difference ($p < 0.05$) in different malt flour samples; in both parameters, MF displayed significantly ($p < 0.05$) higher amount than CF. Evans *et al.* (2009) revealed that malt's diastatic power is determined by the combined activities of β-amylase, α-amylase, α-glucosidase, and limit dextrinase. According to Bera *et al.* (2018), genotype, malting process, and preparation method of malt determine the diastatic property variation.

Color of biscuits

Color plays a principal role in the consumer's initial perception of the product. The results obtained from colorimeter data are shown in Figure 1.

Based on the findings, different compositions in the flour significantly ($p < 0.05$) affected the biscuit's color. The CT sample showed significantly ($p < 0.05$) the highest lightness ($L^* = 105.14$) and the lowest redness ($a^* = 4.25$) and yellowness ($b^* = 42.85$) indexes compared to the other samples. The sample with 10 and 15% of Maiorca malt flour demonstrated the lowest lightness index due to the increase in carbohydrate content. The Maillard's reaction during cooking could be the reason. This finding is in agreement with Jukic *et al.* (2022); they also claimed that due to the biscuit's low moisture content, sucrose hydrolysis is limited, but yet it is sufficient to lead to color development. During baking, sucrose is hydrolyzed into fructose and glucose, which can participate in browning of biscuits and Maillard reactions (Struck *et al.*, 2014). Moreover, Van Der Sman (2021) reported that biscuit color is influenced by the thermal dextrinization of starch as well.

By adding Maiorca malt flour, L^* value significantly ($p < 0.05$) decreased, while a^* value significantly ($p < 0.05$) increased. It is notable that no significant differences were found in all the color indexes (L^*, a^* and b^*) by increasing the CF level.

Accordingly, the L^* value was reduced with the following order: CT > CF > MF; In addition to the amount of carbohydrates, there are probably two other reasons: (1) The protein content: as mentioned before, MF (12.06%) has a higher protein content than CF (11.04%); Chevallier *et al.* (2000) reported that there was a negative correlation between the lightness of the biscuit and the protein content. In this experience, a negative significant correlation ($r = -0.63$, $p < 0.05$) between the amount of protein and lightness was observed. (2) The moisture content of SWF, CF, and MF showed moisture level of 11.9, 6.2, and 4.8%, respectively. According to Pérez *et al.* (2013),

Table 3. Characteristics of malt flour.

Sample	Total starch (%db)	α-amylase (CU/g malt)	β-amylase (BU/g malt)	Diastatic power (WK)
MF	62.60 ± 1.25[a]	148.96 ± 2.65[a]	31.39 ± 0.59	380.61 ± 7.61[a]
CF	57.39 ± 1.15[b]	60.61 ± 1.19[b]	27.99 ± 0.57	375.73 ± 7.52[b]

MF, Maiorca malt flour; CF, commercial malt flour.
[a,b,c]Values in the same column with different superscripts differ significantly (P < 0.05).

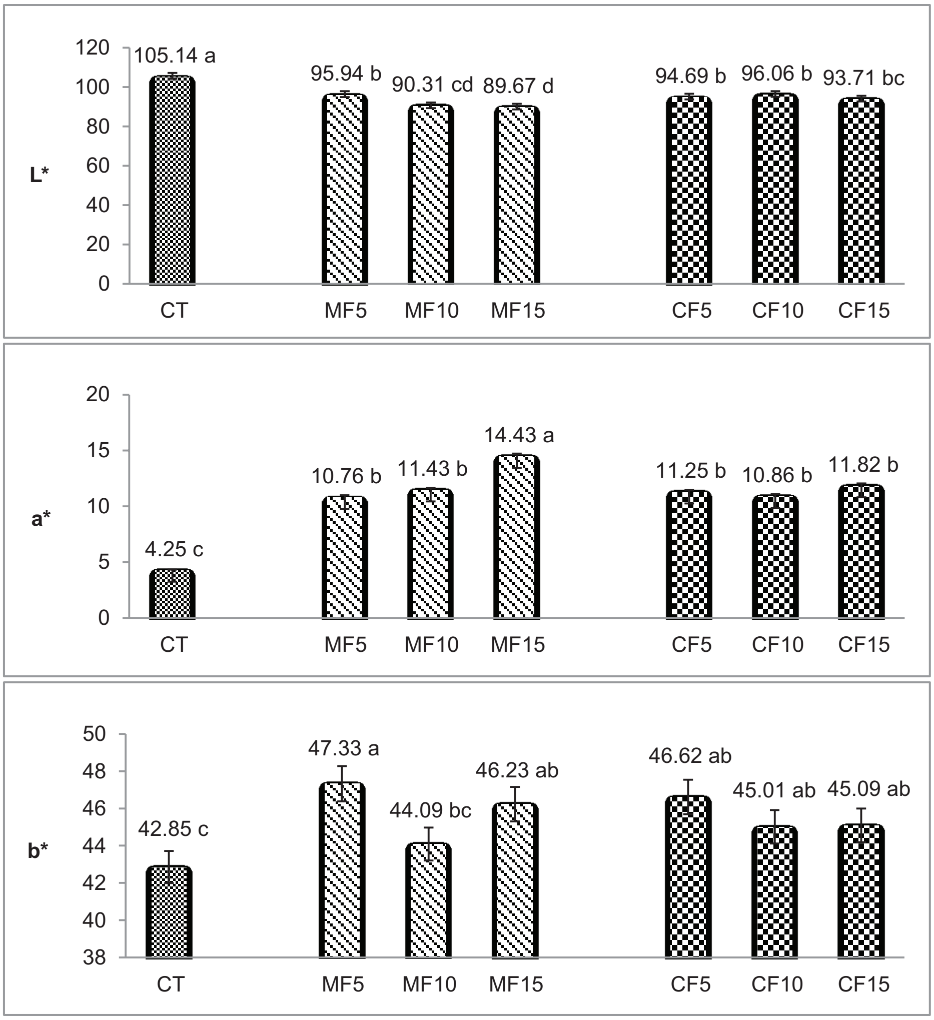

Figure 1. The effect of different ingredients on the biscuit color. L*: Lightness; a*: Redness; b*: Yellowness. a,b,c,d Values on the column differ significantly (P < 0.05).

having a higher water content means the surface temperature of the cookie takes longer to reach its browning temperature.

Acrylamide level in biscuits

The results obtained from LC-MS/MS are shown in Table 4.

The Maillard reaction is responsible for the formation of acrylamides during high-temperature and low-moisture processes in a number of food categories, including bakery products (Schouten *et al.*, 2022).

The range of acrylamide in this study was between 2 and 13.90 μg/kg that are below the value specified by Regulation (EU) 2017/2158, that is, of 350 μg/kg. Many factors affect the formation of acrylamide in bakery products, including food composition, ingredients, pH, temperature, water activity, and the process of baking (Claus *et al.*, 2008).

Table 4. Acrylamide levels of biscuit samples.

Sample	Acrylamide content (μg/kg)
CT	5.39 ± 0.11^{c}
MF_5	8.29 ± 0.17^{b}
MF_{10}	13.90 ± 0.28^{a}
MF_{15}	9.02 ± 0.18^{b}
CF_5	12.72 ± 0.25^{a}
CF_{10}	7.87 ± 0.16^{b}
CF_{15}	2.00 ± 0.04^{d}

^{a,b,c,d} Values with different superscripts differ significantly (P < 0.05).

Sensory evaluation

The sensory evaluations of biscuits and the panelist's scores are summarized in Figure 2.

Color and hardness attributes showed a significant difference ($p < 0.05$) between the samples. CF_{15} displayed the

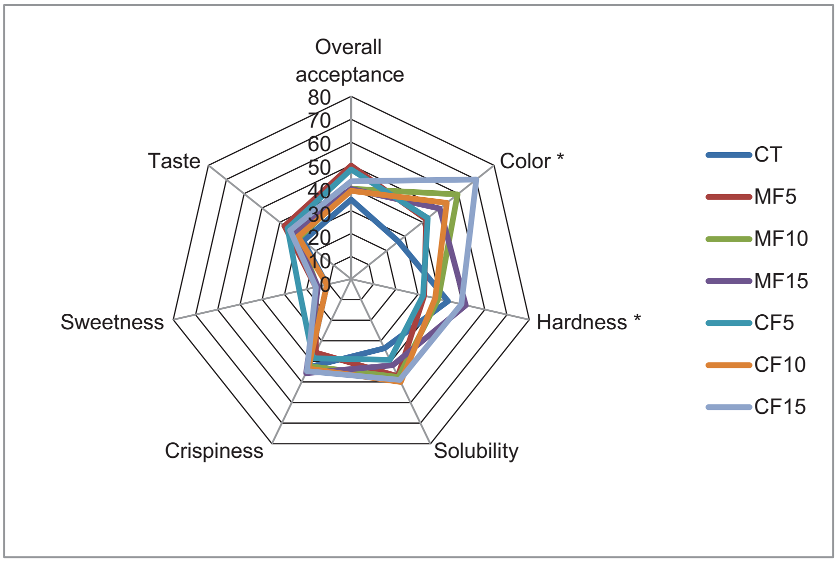

Figure 2. Mean value of descriptive sensory analysis of biscuit samples.

highest hardness and color intensity among all products. Color value was increased by adding both commercial and Maiorca malt flour; these findings confirmed the results obtained with the colorimeter.

Finally, no significant differences were found in taste and overall acceptance of all products, but sample containing 5% MF was the most popular with the highest score among all biscuits; this means Maiorca malt flour might be an excellent flour alternative in bakery products. In general, one of the main reasons for low score of taste and overall acceptance could be due to the absence of sugar in the formulation.

Conclusion

The results of the experiments showed that we can apply old landrace wheat with a reasonable assurance to bakery products as it is used in other products such as beer, as previous studies have shown. In this study, positive results were obtained based on parameters such as color, acrylamide content, and consumer acceptance. It has been observed that replacing more Maiorca malt flour led to darker biscuits, while maintaining the same time and temperature during baking. In fact, these darker colors are not correlated with harmful compounds such as acrylamide, based on the observed values, which were far below the reported value of European regulation. Moreover, the biscuit samples prepared with Maiorca malt flour were well received by the panelists, and the sample with 5% MF was the most popular sample among all products. There is sparse evidence about the effects of adding Maiorca malt flour to samples of bakery products; therefore, these results already represent a viable starting point for reintroducing the ancient varieties of wheat that have been abandoned; however, there are many other aspects to be explored in this regard.

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