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Performance of Malted Maize Flour as Composite of Wheat in the Production of Cake

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Abstract

The aim of this study was to evaluate the performance of malted maize flour as composite of wheat in the production of cake. Maize was subjected to malting and then processed into flour while unmalted maize was also processed into flour. Eight flour blends were formulated from unmalted maize, malted maize and wheat; these include substitutions of malted and unmalted maize flours in the percentages of 5, 10, 15 and 20 each in wheat flour. Composite cakes were then produced from each flour blend, including whole wheat flour, and their antinutritional factors, proximate analysis and sensory evaluation were determined. Trypsin inhibitor ranged from 0.31 to 0.72 mg/100g in cake samples produced from wheat-malted maize flour (WMMF) blends while a range of 0.93 and 1.26 mg/100g was obtained for wheat-unmalted maize (WUMF) samples. Lower phytic acid contents were observed in cakes made from WMMF than their WUMF counterparts. A range of 0 to 0.01 U/g was obtained as α-amylase inhibitor in cakes from WMMF and 0 to 0.03 from WUMF samples. Protein contents were lower (8.76 to 9.45%) in cakes from WMMF compared to WUMF (10.16 to 10.44%). Crude fiber and ash contents were also higher in cakes from WMMF than WUMF SAMPLES. Result of sensory evaluation indicates that the WMMF samples recorded higher mean scores than WUMF in the attributes of aroma, texture, appearance and acceptability. It was concluded that malting led to enhanced nutritional and sensory qualities in the cake samples produced from flour blends of wheat and malted maize. Malting also reduced antinutritional factors in the cake samples.

1. Introduction

The major source of flour for baked products such as cakes, bread, biscuit and chin-chin is wheat flour. Wheat flour as the major ingredient for bakery products has dominated other potential sources of flour for bakery products. However, the high cost of wheat flour has led to a rise in the cost of bakery products in Nigeria and indeed other countries in Sub-Sahara Africa (Ikpeme et al. 2012). This has necessitated research efforts towards development of composite flours involving partial substitution of wheat flour with those from locally available vegetable crops in developing countries, especially Nigeria (Olaoye et al. 2006; Olaoye and Onilude 2008; Olaoye and Ade-Omowaye 2011).

Composite flours are mixtures of different vegetable flours rich in starch, protein, and/or other nutrients with or without wheat flour. Several institutions, including the

Food and Agriculture Organization (FAO), have been involved in research designed to find ways of partially substituting wheat flour with those from other sources or replacing wheat altogether. The technology of composite flours represents an interesting option for the management of costs associated with importation of wheat flour in developing countries where wheat is not cultivated for climatic reasons (Olaoye et al. 2006). With the constant increase in the consumption of cake and other baked products in many developing countries, coupled with ever-growing urban populations, the composite flour/baked product technology could be very useful (Olaoye and Ade-Omowaye 2011). It has been reported that replacing wheat with 20% non-wheat flour for the manufacture of bakery products would result in an estimated savings of $320 million annually (FAO 1982).At 30% substitution, the savings would be $480 million annually.

Malting process is a way to promote changes in the biochemical, sensorial and nutritional characteristics of cereal grains. Food processing technologies can contribute to the alleviation of micronutrient deficiencies; one technique is malting which is widely used in legumes and cereals to increase their palatability and nutritional value, particularly through the breakdown of certain antinutrients such as phytate and protease inhibitors (Afify et al. 2012). Process operations that reduce the level of antinutritional factors and that minimize the losses of micronutrients are of interest to food processors; biological processes such as malting have the potential to improve the nutrient availability in foods.

Research on the use of vegetable flours as partial substitutes for wheat in the production of baked products has been attributed to efforts being made at promoting cost effectiveness and utilization of local crops as a result of huge foreign exchange that is associated with wheat importation (Olaoye et al. 2006). This has resulted in the need to source for locally available and underutilized crops such as maize (*Zea mays*) in the production of flours to be used as partial substitutes for wheat in bakery manufacturing. This would help drive down cost, enhance affordability by low-income populations and improve the nutritive value of baked products.

The present finding was therefore aimed at investigating the influence of malting on the anti-nutritional factors in maize flour and evaluating the organoleptic attributes of cake produced from flour blends of maize and wheat. This was with a view to promoting further utilization of the vegetable crop in the production of baked products in developing countries such as Nigeria.

2. Materials and Methods

2.1. Source of Material

The maize grains used in this study were obtained from National Stored Products Research Institute (NSPRI), Port Harcourt, Rivers State, Nigeria. Wheat flour and other ingredients for cake production were purchased from a local market in Umuahia Township in Abia State, Nigeria

2.2. Production of Malted Maize Flour

The flow charts used in the production of unmalted and malted maize flour are represented in Figures 1 and 2 respectively. Whole maize grains were sorted to remove dirt and other extraneous materials, and then washed in clean water. Grains were soaked in water for 1 h and then drained. They were spread on jute bags, moistened and left to germinate for 48-72 h. The germinated grains were dried in air drying oven (Gallenkamp, USA) at 65^{o}C for 24-36 h after which radicules and plumules were removed by winnowing. They were then milled using hammer mill machine (tiger-extruda 6.5 hp, UK) and sieved to obtain malted maize flour. Unmalted maize grains were also processed into flour for comparison. The flour samples were packaged in polyvinyl chloride bag and stored at room temperature until use.

2.3. Production of Composite Cakes

The various flour formulations used in the production of cake samples are shown in Table 1. Other ingredients used along with the flour blends were fat, sugar, baking powder, salt, eggs, milk powder, nutmeg and water. The method of cake preparation described by Onuegbu et al. (2013) was adapted with little modification. Mixing of ingredients was done using a manually operated hand mixer (Philip Sc. 450, UK) while baking took place in a preset oven at 181^{o}C for about 1 h 15 min.

2.4. Determination of Antinutritional Factors in Flour Blends and Composite Cakes

Phytic acid contents of the flour blends and composite cakes were determined using the method described by Wheeler and Ferrel (1971).

Polyphenols were determined according to the Prussian blue spectrophotometric method (Price and Bulter, 1977) with some modification. Sixty milligrams (60 mg) of flour sample was shaken manually for 1 min in 3.0 ml methanol. The mixture was filtered (Whatman No. 1). The filtrate was mixed with 50 ml distilled water and analyzed at 50 min. About 3.0 ml of 0.1 M $FeCl_3$ in 0.1 M HCl was added to 1.0 ml filtrate, followed by addition of 3.0 ml freshly prepared $K_3Fe\ (CN)_6$ and shaken. After 3 min, the absorbance was monitored on a spectrophotometer (PyeUnicam SP6-550 UV, London, UK) at 720 nm. A standard curve was obtained, expressing the result as tannic acid equivalents - the amount of tannic acid (mg/100 g) that gives a color intensity equivalent to that given by polyphenols after correction by blank sample.

Trypsin inhibitor, lectin and α-amylase activities were determined according to the methods of AOAC (2005).

2.5. Proximate Analysis

Proximate analysis of moisture, ash, fat, and protein contents of composite cakes were determined using the methods of Association of Official Analytical Chemists (AOAC 2005). Carbohydrate was determined by difference.

2.6. Sensory Evaluation of Composite Cakes

The cake samples produced from the different flour blends were subjected to sensory evaluation for the attributes of taste, appearance, texture, aroma and acceptability. A semi trained twenty member panel was used and scores were allocated to the attributes based on a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The data collected were subsequently subjected to statistical analysis to determine possible differences among samples.

2.7. Statistical Analysis

Data which depended on different percentages of malted and unmalted maize flour incorporation into wheat were analyzed according to a completely randomized design with three replicates. Data were subjected to variance analyses and differences between means were evaluated by Duncan's multiple range test using SPSS statistic programme, version 10.01 (SPSS 1999). Significant differences were expressed at $p<0.05$.

3. Results and Discussion

Trypsin inhibitor, phytic acid and polyphenol contents of flour blends of malted maize and wheat were lower than those recorded in blends of unmalted maize (Table 2). Highest values of 3.7, 38.3 and 2.85 were recorded for trypsin inhibitors, phytic acids and polyphenols respectively in the flour blend containing 20% unmalted maize flour while lowest values of the antinutritional factors were recorded in whole wheat flour. This indicates that malting produced reduction in antinutritional factors in malted maize flour. This observation is in support of the findings of Sokrab et al. (2012) who reported reduction in the phytic acid contents of maize flour after malting. However, the authors noted that malting did not produce significant reduction in the polyphenol contents, and this is in contrast with the finding of this present study. The reason may be attributed to differences in genetic variations in the maize varieties as well as malting conditions used (Sokrab et al. 2012). Interestingly, Luo et al. (2013) reported reduction in the in the polyphenol contents of faba beans after subjection to germination. This corroborates the reduction caused by malting in the study being currently reported. Reduction in the phytic acids and trypsin inhibitors could be of significance as a result of the ability of these anti-nutritional factors to bind with certain constituents of foods, thereby making them unavailable for assimilation when such foods are consumed. According to Olaoye et al. (2015), phytic acids usually form insoluble salts with mineral elements such as zinc, calcium and iron to prevent their utilization in the body. Furthermore, Luo et al. (2013) reported that phytic acid binds minerals that are necessary as cofactors, thus interfering with several essential metabolic processes, especially the utilization of protein. The ability of polyphenols to form complex with protein and minerals thereby making them nutritionally unavailable has also been reported (Nadeem et al. 2010; Luo et al. 2013). Hence, the reduction recorded in antinutritional factors in the flour blends of malted maize and wheat could be of nutritional advantage. Production of enzymes has been noted to occur during malting and this may have catabolic effect on some of the antinutritional factors in cereals, thereby bringing about their reduction (Nadeen et al. 2010). It was observed in our present finding that malting did not produce reduction in α-amylase inhibitor and lectin contents of the flour blends. Ejigui et al. (2005) noted the same observation in their finding and reported that for reduction of α-amylase inhibitor to be achieved, the process of fermentation by microorganisms, especially lactic acid bacteria, has to be used to complement malting.

Evaluation of the antinutritional factors in the cakes produced from flour blends of malted and unmalted maize with wheat indicates that there was significant reduction of the factors in the product (Table 3). The reduction could obviously be attributed to the effect of heat during the baking process. This suggests that application of heat during processing of flour blends of maize and wheat may bring respite to consumers who may entertain concerns over the presence of antinutritional factors in maize. However, it is worth mentioning that such heal application should preferably be at elevated temperature capable of destroying these antinutritional factors, and such temperature should not have any significant adverse effect on nutrients. Although, there was reduction in the antinutritional factors in the composite cakes, it was noted that concentrations were higher in samples containing unmalted maize flour than malted maize. Therefore, it may be necessary to adopt malting as pretreatment in the processing of maize into value added products, as this would guarantee enhanced reduction in antinutritional factors (Luoet al. 2013). Reduction in antinutritional factors in the composite cakes is in agreement with the finding of Ikpeme et al. (2012) who produced composite bread and cakes from flour blends of beniseed and wheat. According to the authors, antinutritional factors were found in the baked products, but contents were lower than in raw flours. This indicates that application of heat may not completely remove the antinutritional factors, but would reduce them significantly to safe level.

Proximate analysis of the composite cakes shows that cakes from whole wheat flour had the highest protein content of 10.50 while the lowest was recorded for sample containing 20% malted maize flour (Table 4). Significant differences ($p<0.05$) were recorded in protein contents of cake samples produced from whole wheat flour and their counterparts containing malted maize flour. Protein contents were higher in cake samples produced from unmalted maize than their malted maize counterparts, showing that malting led to reduction of protein in maize. This result is in support of many research findings carried out on the effect of malting on protein in cereals. For example, Afify et al. (2012) reported that germination produced reduction in the protein contents of three sorghum varieties' Dorado', 'Shandaweel-6' and 'Giza-15'. A similar finding was reported by Raimi *et al.*

(2012) on another sorghum variety. The reduction of protein contents in germinated cereals has been attributed to possible leaching of soluble nitrogen and conversion of protein into amino acids during malting processes (Afify et al. 2012).

Crude fiber contents of the cake samples ranged between 1.27 and 1.47, with the whole wheat having the lowest value while the highest was recorded for sample produced from 20% unmalted maize flour. The unmalted maize cake samples generally have higher crude fiber contents than their malted maize counterparts. Reduction of crude fiber in malted cereals has been reported by Afify et al. (2012). Crude fat were slightly higher in unmalted maize samples than in malted maize and ranged from 12.44 to 12.82; the highest was recorded in the sample containing 20% unmalted maize. The result suggests that malting brought about reduction in fat contents, and this observation was also made by Raimi et al. (2012) and Afify et al. (2012) who carried out studies on the effect of germination on fat contents of some sorghum varieties. The reduction may be due to the biochemical and physiological changes that occur during germination, including utilization of fat in the production of energy required for sprouting (Raimi et al. 2012).

Ash content of the cake sample produced from whole wheat flour was highest (2.0%) among others. It is interesting to note that ash contents increased in samples produced from malted maize than unmalted maize. This shows that malting produced increase in ash contents of the cake samples and this is in agreement with previous findings (Raimi et al. 2012; Afify et al. 2012).

Results of sensory evaluation of the composite cakes indicate that samples containing 15 and 20% malted maize had mean scores of 7.30 and 7.10 respectively in the attribute of aroma; these were higher than the values recorded for others. Similar observation was made in the attribute of texture where mean scores of 7.10 and 7.30 were recorded for cake samples produced from 15 and 20% malted maize respectively. The cake samples produced from 15 and 20% malted maize also recorded higher mean score of 7.45 each than others in the attribute of appearance. Moreover, the mean scores of the attribute of acceptability were higher in cake samples produced from 15 and 20% malted maize than others, and values of 7.60 and 7.35 were recorded for the respective samples. This indicates that the cake samples produced from 15 and 20% malted maize were preferred to others in the sensory attributes of aroma, texture, appearance and acceptability. Furthermore, the attribute of taste recorded higher mean score of 7.50 for cake sample from 15% malted maize than others. Malting of maize therefore contributed significantly to the sensory quality of the composite cakes.

It was concluded that malting contributed to increased quality attributes of the composite cakes, especially in terms of sensory and nutritional qualities. Malting also produced reduction in the antinutritional factors of phytic acid, trypsin inhibitor and polyphenols. It is therefore recommended that malting of cereals be encouraged, among producers and researchers, when their flours are to be used as composite of wheat for production baked products. This is because of the inherent nutritional benefits and ability to reduce antinutritional factors.

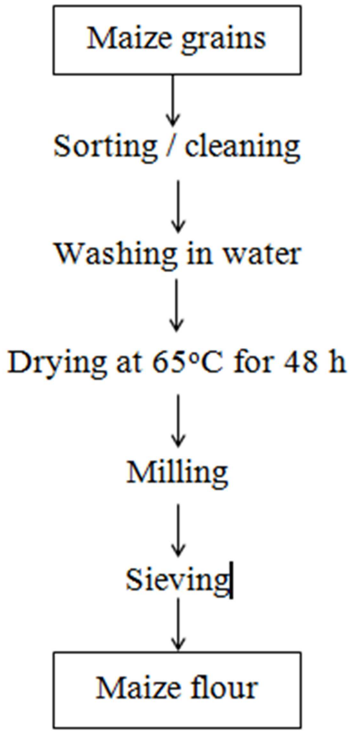

Figure 1. *Flow diagram for the production of maize flour*

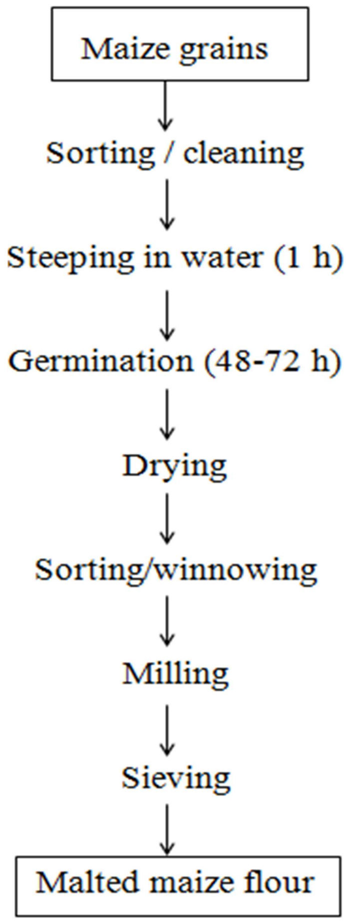

Figure 2. *Flow diagram for the production of malted maize flour.*

Table 1. *Formulation of flour blends used for cake production.*

Code	Flours (%)		
	Wheat flour	**Malted maize flour**	**Unmalted maize flour**
WW100	100	-	-
MM5WW95	95	5	-
MM10WW90	90	10	-
MM15WW85	85	15	-
MM20WW80	80	20	-
UM5WW95	95	-	5
UM10WW90	90	-	10
UM15WW85	85	-	15
UM20WW80	80	-	20

Table 2. *Antinutritional factors in the blends of wheat-maize flour*

Flour blends	Anti-nutritional factors				
	Tryp Inhibitor (mg/100g)	**Phytic acid (%)**	**α –amylase inhibitor (U/g)**	**Lectins (HU/g)**	**Polyphenols (mg/g)**
WW100	$1.4^{c}\pm0.11$	$6.5^{f}\pm1.02$	$0.35^{a}\pm0.02$	$412.52^{a}\pm0.01$	$0.82^{e}\pm0.02$
MM5WW95	$1.7^{b}\pm0.01$	$8.2^{e}\pm0.97$	$0.24^{b}\pm0.04$	$409.57^{a}\pm0.01$	$1.02^{d}\pm0.04$
MM10WW90	$1.81^{b}\pm0.21$	$13.8^{d}\pm2.19$	$0.18^{c}\pm0.09$	$396.82^{a}\pm0.03$	$1.25^{c}\pm0.10$
MM15WW85	$1.99^{b}\pm0.01$	$17.1^{c}\pm2.19$	$0.13^{e}\pm0.01$	$372.63^{b}\pm0.01$	$1.32^{c,b}\pm0.16$
MM20WW80	$2.08^{b}\pm0.13$	$19.3^{c}\pm1.24$	$0.09^{f}\pm0.00$	$318.56^{h}\pm0.02$	$1.45^{b}\pm0.09$
UM5WW95	$1.9^{b}\pm0.42$	$19.3^{c}\pm3.23$	$0.29^{b}\pm0.02$	$403.87^{a,c}\pm0.01$	$1.83^{c}\pm0.17$
UM10WW90	$2.3^{b,a}\pm0.33$	$25.7^{b}\pm1.72$	$0.21^{c}\pm0.05$	$385.62^{b}\pm0.01$	$2.31^{b}\pm0.07$
UM15WW85	$2.9^{a}\pm0.03$	$27.8^{b}\pm2.84$	$0.15^{c}\pm0.09$	$345.71^{c}\pm0.01$	$2.76^{a}\pm0.21$
UM20WW80	$3.7^{a}\pm0.01$	$38.3^{a}\pm1.26$	$0.12^{e,c}\pm0.01$	$294.78^{d}\pm0.01$	$2.85^{a}\pm0.14$

Values are mean scores of three replicated samples. Values with different superscript letters are not significantly different ($p<0.05$).
WW100, whole wheat flour; MM5WW95, 5% malted maize and 95% wheat flour; MM10WW90, 10% malted maize and 90% wheat flour ; MM15WW85, 15% malted maize and 85% wheat flour; MM20WW80, 20% malted maize and 80% wheat flour; UM5WW95, 5% unmalted maize and 95% wheat flour; UM10WW90, 10% unmalted maize and 90% wheat flour; UM15WW85, 15% unmalted maize and 85% wheat flour; UM20WW80, 20% unmalted maize and 80% wheat flour.

Table 3. *Antinutritional factors in the composite cake samples*

Flour blends	Anti-nutritional factors				
	Tryp Inhibitor (mg/100g)	**Phytic acid (%)**	**α –amylase inhibitor (U/g)**	**Lectins (HU/g)**	**Polyphenols (mg/g)**
WW100	$0.24^{c}\pm0.11$	$1.50^{f}\pm1.02$	$0.03^{a}\pm0.02$	$32.34^{a}\pm0.01$	$0.00^{e}\pm0.00$
MM5WW95	$0.31^{b}\pm0.01$	$1.89^{e}\pm0.97$	$0.01^{b}\pm0.04$	$27.22^{a}\pm0.01$	$0.02^{d}\pm0.00$
MM10WW90	$0.47^{b}\pm0.21$	$2.96^{d}\pm2.19$	$0.01^{c}\pm0.09$	$21.84^{a}\pm0.03$	$0.04^{c}\pm0.00$
MM15WW85	$0.51^{b}\pm0.01$	$3.78^{c}\pm2.19$	$0.00^{e}\pm0.01$	$15.05^{b}\pm0.01$	$0.04^{c,b}\pm0.00$
MM20WW80	$0.72^{b}\pm0.13$	$4.21^{c}\pm1.24$	$0.00^{f}\pm0.00$	$12.57^{h}\pm0.02$	$0.05^{b}\pm0.00$
UM5WW95	$0.93^{b}\pm0.42$	$4.73^{c}\pm3.23$	$0.03^{b}\pm0.02$	$41.03^{a,c}\pm0.01$	$0.01^{c}\pm0.00$
UM10WW90	$0.97^{b,a}\pm0.33$	$5.71^{b}\pm1.72$	$0.02^{c}\pm0.05$	$38.52^{b}\pm0.01$	$0.02^{b}\pm0.00$
UM15WW85	$1.04^{a}\pm0.03$	$6.73^{b}\pm2.84$	$0.01^{c}\pm0.09$	$23.75^{c}\pm0.01$	$0.03^{a}\pm0.21$
UM20WW80	$1.26^{a}\pm0.01$	$6.72^{a}\pm1.26$	$0.00^{e,c}\pm0.01$	$19.42^{d}\pm0.01$	$0.04^{a}\pm0.14$

Values are mean scores of three replicated samples. Values with different superscript letters are not significantly different ($p<0.05$).
HU, haemagglutinating units; WW100, whole wheat flour; MM5WW95, 5% malted maize and 95% wheat flour; MM10WW90, 10% malted maize and 90% wheat flour ; MM15WW85, 15% malted maize and 85% wheat flour; MM20WW80, 20% malted maize and 80% wheat flour; UM5WW95, 5% unmalted maize and 95% wheat flour; UM10WW90, 10% unmalted maize and 90% wheat flour; UM15WW85, 15% unmalted maize and 85% wheat flour; UM20WW80, 20% unmalted maize and 80% wheat flour.

Table 4. *Proximate analysis of the composite cake samples*

Cake	Proximate parameters (%)					
	Moisture	Ash	Crude Fiber	Crude Fat	Protein	Carbohydrate
WW100	$24.10^{b}\pm0.14$	$2.00^{a}\pm0.00$	$1.27^{d}\pm0.02$	$12.44^{c}\pm0.01$	$10.50^{a}\pm0.03$	$51.44^{c}\pm0.18$b
MM5WW95	$23.50^{c}\pm0.14$	$2.00^{a}\pm0.00$	$1.28^{d}\pm0.03$	$12.46^{c}\pm0.04$	$9.45^{c}\pm0.01$	$51.61^{a,b}\pm0.24$
MM10WW90	$22.90^{d}\pm0.14$	$1.70^{b}\pm0.14$	$1.34^{c}\pm0.00$	$12.44^{c}\pm0.04$	$9.39^{c}\pm0.01$	$52.24^{a}\pm0.33$
MM15WW85	$23.30^{c,d}\pm0.14$	$1.70^{b}\pm0.14$	$1.36^{c}\pm0.01$	$12.73^{b}\pm0.01$	$9.16^{c}\pm0.04$	$51.47^{abc}\pm0.31$
MM20WW80	$23.60^{c}\pm0.28$	$1.70^{b}\pm0.14$	$1.41^{b}\pm0.01$	$12.48^{c}\pm0.04$	$8.76^{d}\pm0.01$	$50.67^{c}\pm0.47$
UM5WW95	$23.15^{c,d}\pm0.21$	$1.70^{b}\pm0.14$	$1.41^{b}\pm0.01$	$12.77^{ab}\pm0.14$	$10.44^{a}\pm0.01$	$50.75^{c}\pm0.41$
UM10WW90	$24.10^{b}\pm0.14$	$1.60^{b}\pm0.00$	$1.41^{b}\pm0.01$	$12.79^{a}\pm0.14$	10.28a±0.04	$49.83^{d}\pm0.21$
UM15WW85	$22.90^{d}\pm0.14$	$1.70^{b}\pm0.14$	$1.46^{a}\pm0.03$	$12.81^{a}\pm0.02$	$10.22^{a}\pm0.03$	$50.70^{c}\pm0.35$
UM20WW80	$24.60^{a}\pm0.28$	$1.60^{b}\pm0.00$	$1.47^{a}\pm0.01$	$12.82^{a}\pm0.03$	$10.16^{b}\pm0.02$	$49.01^{e}\pm0.35$

Values are mean scores of three replicated samples. Values with different superscript letters are not significantly different ($p<0.05$).
WW100, whole wheat flour; MM5WW95, 5% malted maize and 95% wheat flour; MM10WW90, 10% malted maize and 90% wheat flour ; MM15WW85, 15% malted maize and 85% wheat flour; MM20WW80, 20% malted maize and 80% wheat flour; UM5WW95, 5% unmalted maize and 95% wheat flour; UM10WW90, 10% unmalted maize and 90% wheat flour; UM15WW85, 15% unmalted maize and 85% wheat flour; UM20WW80, 20% unmalted maize and 80% wheat flour.

Table 5. *Mean scores of sensory evaluation of the composite cakes*

Cakes	Sensory attributes				
	Taste	Aroma	Texture	Appearance	Acceptability
WW100	$6.95^{a}\pm1.23$	$6.85^{a}\pm1.46$	$6.70^{a}\pm0.98$	$7.10^{a,b}\pm1.12$	$7.10^{a,b}\pm1.02$
MM5WW95	$6.80^{a}\pm1.11$	$6.95^{a}\pm1.05$	$6.85^{a}\pm1.09$	$7.30^{a,b}\pm1.08$	$7.00^{a,b}\pm0.73$
MM10WW90	$6.85^{a}\pm1.18$	$6.95^{a}\pm1.28$	$6.80^{a}\pm1.11$	$6.50^{b}\pm1.57$	$6.85^{a,b}\pm1.09$
MM15WW85	$7.50^{a}\pm1.28$	$7.30^{a}\pm1.03$	$7.10^{a}\pm1.12$	$7.45^{a}\pm0.95$	$7.60^{a}\pm0.94$
MM20WW80	$7.05^{a}\pm1.10$	$7.10^{a}\pm1.21$	$7.30^{a}\pm1.08$	$7.45^{a}\pm1.15$	$7.35^{a,b}\pm0.86$
UM5WW95	$6.85^{a}\pm1.60$	$6.95^{a}\pm1.19$	$6.70^{a}\pm1.34$	$7.10^{a,b}\pm1.15$	$7.05^{a,b}\pm1.19$
UM10WW90	$7.35^{a}\pm1.27$	$6.35^{a}\pm0.99$	$7.00^{a}\pm1.26$	$7.15^{a,b}\pm1.23$	$7.30^{a,b}\pm0.86$
UM15WW85	$7.10^{a}\pm1.21$	$6.65^{a}\pm1.23$	$6.65^{a}\pm1.57$	$7.20^{a,b}\pm1.54$	$7.05^{a,b}\pm1.28$
UM20WW80	$7.05^{a}\pm1.15$	$6.80^{a}\pm1.24$	$6.55^{a}\pm1.50$	$6.80^{a,b}\pm1.47$	$6.70^{b}\pm1.34$

Values are mean scores of three replicated samples. Values with different superscript letters are not significantly different ($p<0.05$).
WW100, whole wheat flour; MM5WW95, 5% malted maize and 95% wheat flour; MM10WW90, 10% malted maize and 90% wheat flour ; MM15WW85, 15% malted maize and 85% wheat flour; MM20WW80, 20% malted maize and 80% wheat flour; UM5WW95, 5% unmalted maize and 95% wheat flour; UM10WW90, 10% unmalted maize and 90% wheat flour; UM15WW85, 15% unmalted maize and 85% wheat flour; UM20WW80, 20% unmalted maize and 80% wheat flour.

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