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Physical and Sensory Qualities of Hydrocolloid Treated 80:20 Wheat-Cassava Composite Breads

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Abstract

The objective of this study was to determine the physical and sensory qualities of hydrocolloid treated 80:20 wheat-cassava composite bread. The study was limited to the use of various ratios of these hydrocolloids; carboxymethyl cellulose (CMC), gelatin and egg white. The dough samples from the various wheat-cassava composite flour, treated with egg white, gelatin and CMC respectively and in combination were baked using the straight dough method. The physical parameters- loaf weight were carried out 20 mins after baking using laboratory scale and the readings recorded in grams, then the loaf volumes were determined using seed displacement methods and the loaf samples weighed in a laboratory balance. Sensory evaluations were conducted using forty member trained panelists who were drawn from usual bread consumers to evaluate the quality attributes of the loaves for crumb texture, taste, color, appearance and overall acceptance. All analyses were carried out in triplicate and the results were subjected to statistical analysis using analysis of variance (ANOVA). Regression analyses of the data were conducted. Significance differences among the means were established at 5% level of using Duncan's multiple range tests. The results obtained showed significant differences ($P<0.05$) among some of the parameters analyzed; loaf weights, loaf volumes and sensory attributes. Thus, 80:20 wheat cassava composite flour bread samples treated singly with egg white, gelatin and carboxymethyl cellulose or their combinations as hydrocolloids had different degrees of acceptability. The 80:20 wheat-cassava composite flour treated with a combination of egg white, gelatin and carboxymethyl cellulose (EGC_m) in respective ratio of 1:2:1 or 1:1:2, yielded breads with similar volumes (4.17-5.27cm^3/g) as reference 90:10 (W-C) and control (100% wheat) flour.

Keywords: *Wheat, cassava, hydrocolloids, flour, bread*

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1. Introduction

Bread is an important staple food in the tropics, but the product is relatively expensive as a result of its production from imported wheat that is not cultivated in the tropics for climatic reasons (Ederma *et al*, 2004,). Production of bread is a common practice in many countries of the tropics and increase in its consumption has been recorded due to expansion in population density; this is especially true in Nigeria where increase in consumption of the product has been observed (Olaoye *et al*., 2006). Efforts have been made to promote the use of composite flours from local raw materials in the production of bread, thereby decreasing the demand for imported wheat (Giami *et al*., 2004). Addition of hydrocolloids to the composite flour will help produce bread with well vesticulated crumb and good loaf volume.

Food hydrocolloids are group of improvers commonly used as additives in food industry. These compounds commonly named gums are capable of affecting both the rheology and texture of aqueous systems, stabilization of emulsion, suspensions and foams (Dziezak, 1991). Food hydrocolloids are high-molecular weight hydrophilic biopolymers used as stabilizers functional ingredients in foods. They include gums which are used for retarding staling and for improving the quality of freshly baked products. These hydrocolloids help to improve dough stability during proofing of the bread loaves (Zlatica *et al*., 2009).

Hydrocolloids have been used in gluten free breads to improve their texture (Mollakhalili *et al.*, 2015). In the baking industry researches have shown that hydrocolloids such as carboxymethyl cellulose (CMC), hydroxylpropyl methylcellulose (HPMC), methylcellulose (MC), guar gum, Arabic gum, xanthan gum and others can be used as gluten substitutes in the formation of gluten free bread (Toufeli *et al*., 1994; and Lazaridou *et al*., 2006).

Studies on the use of wheat-cassava composite flour in bread making showed that cassava flour can replace wheat flour up to 10 % level for the production of satisfactory products (Akobundu *et al*., 2005. Ukpong *et al.* (2017) said that incorporation of 0.5% of the leguminous seed flours into both the wheat and cassava recipe resulted in improved loaves and specific volumes of the breads and also improved the crumb moisture contents of the loaves. Bread produced from wheat-cassava composite flour with 20 % or more cassava flour is inferior in quality to 100 % wheat flour bread (Giami *et al*., 2004). Such breads are heavy, lack desirable volume, do not have well vesiculated crumb, and have inferior organoleptic properties. These defects from composite containing more than 10 % cassava flour can be minimized by the use of appropriate hydrocolloids. The aim of this work is to investigate the effects of hydrocolloids on the physical and sensory qualities of the 80:20 wheat-cassava composite bread.

2. Materials and Method

2.1 Sources of materials

Freshly harvested six months old sweet cassava (*Manihot esculenta*) tubers were obtained from the Root Crop Research Institute, Umudike Umuahia; Abia State and brought to Imo State Polytechnic Cassava Processing Mill the same day where it was processed into cassava flour. The hydrocolloids, xanthan gum, guar gum, carboxymethyl cellulose and gelatin were procured from a chemical store in Onitsha in Anambra state, and eggs from a poultry farm in Owerri, Imo State. Wheat flour (Golden Penny Prime)**,** and other baking ingredients such as fat, yeast, sugar, and salt were purchased from bakery shops in Owerri. A variety of sweet cassava (*Manihot esculenta*) tubers were used to prepare cassava flour.

2.2 Cassava Flour Production

The processing of cassava flour (CF) was carried out according to the method described by Onabola and Bokanga (1998) and Sanful and Darko (2010). Freshly harvested tubers of cassava were sorted and the bad ones removed. The sorted cassava tubers were peeled manually using knives then washed and grated using mechanical grater. The grated pulp was tied in sack- bag and dewatered using hydraulic press. It was then pulverized and oven dried at 60 ^{0}C using hot air oven (Model D25, Genlab Widnes Inc). The dried samples were milled finely and sieved using sieve of 0.5 mm mesh size. The cassava flour was packaged in polypropylene bag, from which samples were withdrawn for blending with wheat flour.

2.3 Baking process

The dough samples from the various wheat-cassava composite flour, treated with egg white, gelatin and CMC respectively and in combination were baked using the straight dough method of Chauhan *et al.* (1992). All the ingredients were thoroughly mixed in a z-blade mixer to form dough followed by cutting. The cut dough were placed in, a baking pan greased with baking fats accordingly. The formed doughs were covered with greased bread wrapper. The doughs were fermented for 90 min at room temperature (28 ^{0}C + 1^{0}C), proofed at 35 – 40 ^{0}C for 90 min, and baked in an oven maintained at 230^{0}C – 250 ^{0}C for 30 min. After cooling, the bread samples were packaged in low density polyethylene bags at room temperature until they were used for analysis.

2.4 Physical and sensory Analysis

Physical and sensory analyses were carried out in triplicates using the method described by AOAC (2005).

2.5 Data Analysis

The values were subjected to statistical analysis using analysis of variance (ANOVA). Regression analyses of the data were carried out as described by Agbekun and Akubor, (2013). The standard deviations of the results from the means were also calculated. Significant differences among the means were established at 5% level using Duncan's multiple range tests (DMR) using Statistical Package for the Social Sciences Version 15 Software (SPSS Inc, Chicago,II., U.S,A.).

3. Results and discussion

Table 1 shows the physical properties of bread loaves produced from hydrocolloid treated 80:20 wheat-cassava bread loaves. The hydrocolloids/ improvers; egg white, gelatin, carboxymethyl cellulose (CMC) were prepared and used singly, double and in synergies to produce the loaves.

Table 1: Physical Properties of Bread Loaves Produced from Hydrocolloids-treated 80:20 Wheat-cassava Composite Flour.

Flour samples	Dough weight (g)	Loaf weight (g)	Loaf volume (cm^3)	Specific volume (cm^3/g)
WC-E	200	174.9^{def}	676.7^{e}	3.87^{de}
WC-G	200	178.9^{abc}	580.3^{f}	3.24^{e}
WC-C$_m$	200	174.8^{def}	632.0^{ef}	3.62^{e}
WC-EG	200	177.7^{abc}	771.7^{c}	4.34^{cd}
WC-EC$_m$	200	177.1^{bcde}	695.0^{de}	3.92^{de}
WC-C $_m$G	200	178.1^{abcd}	888.3^{ab}	4.99^{abc}
WC-EGC$_m$ (1:1:1)	200	173.4^{ef}	780.0^{c}	4.50^{bc}
WC-EGC$_m$(2:1:1)	200	175.6^{cde}	601.7^{f}	3.42^{e}
WC-EGC$_m$(1:2:1)	200	181.4^{a}	911.7^{ab}	5.03^{ab}
WC-EGC$_m$(1:1:2)	200	180.6^{ab}	850.0^{b}	4.71^{abc}
90:10 (W-C)(Ref.)	200	177.2^{bcde}	882.3^{ab}	4.98^{abc}
100:0 (W-C) (Cont.)	200	175.4^{cde}	925.0^{a}	5.27^{a}
LSD (P<0.05)	-	3.89	63.88	0.68

Values are means ± standard deviations from the means. Means with different superscript letters in the same column are significantly different (p<0.05)

Key:
LSD= Least Significant Difference
WC= Wheat-cassava composite flour
E= egg white,
G= gelatin,
C$_m$= carboxymethyl cellulose (CMC),
90:10 (W-C) (Ref.) = 90% wheat + 10% cassava composite flour (reference sample)
100:0 (W-C) (Cont.) = 100% wheat flour or control flour sample.
WC-E=Wheat-cassava composite flour treated with egg white (singly)
WC-G= Wheat- cassava composite flour treated with gelatin (singly)
WC-C$_m$=Wheat- cassava composite flour treated with carboxymethyl cellulose (singly)
WC-EG= Wheat-cassava composite flour treated with egg white and gelatin (double improver)
WC-EC$_m$= Wheat-cassava composite flour treated with egg white and carboxymethyl cellulose (double improver)
WC-C$_m$ G=Wheat-cassava composite flour treated with carboxymethyl cellulose and gelatin (double improver)
WC-EGC$_m$ = Wheat-cassava composite flours treated with egg white, gelatin and carboxymethyl cellulose at ratios of 1:1:1, 2:1:1, 1:2:1, 1:1:2 (synergy improver).

3.1 The Physical Properties of Bread Loaf Samples Produced from Hydrocolloids-treated 80:20 Wheat-cassava Composite Flour

The bread loaf weights were not equal even though some had similar weights. Although, the loaves were baked from doughs of equal weights, they had different loaf weights. The differences could have been due to relative loss of moisture caused by the kind of hydrocolloids or combination of hydrocolloids added to the composite flours. Some of the hydrocolloids could have restricted escape of moisture from the interiors of some of the bread loaves.

The volumes of bread loaves from the flour samples WC-CmG, WCEGC (1:2:1) and 90:10 (W-C) (reference sample) were 883.3 cm3, 911.7 cm3 and 882.3 cm ^{3} respectively and these volumes were not significantly different (p<0.05) from that of the bread loaf baked with control (100 % wheat) flour sample. Volume is an important attribute for measuring the physical quality characteristic of bread loaves. It is related to the specific volume or inverse density of bread loaves. Specific volume however is a more important measurement than volume as it encompasses both the volume and weight of the bread loaf. Specific volume however is a more important measurement than volume as it encompasses both the volume and weight of the bread loaf. Specific volume is related to rising power of a bread loaf during baking. It is a measure of the ability of flour dough to retain gas (CO2) during fermentation.

A bread may have very high volume and at the same time very low specific density. Over risen bread loaf often has very low specific volume. The specific volume of the bread loaf from the control or 100 % wheat flour (5.27cm3/g) was similar to the specific volumes of the bread loaves from the samples WCCmG (4.99 cm3/g), WC-EGCm (1:2:1) (5.03 cm3/g), WC-EGCm (1:1:2) (4.71 cm3/g) and 90:10 (W-C) (reference flour sample) (4.98 cm3/g). These four bread samples that had similar specific volumes with the control sample or 100 % wheat bread had good physical quality and good crumb texture or crumb grain. Also, the bread loaves produced from 80:20 wheat-cassava composite flour treated singly with any of the three hydrocolloids (egg white, gelatin or carboxymethyl cellulose) were inferior to the bread loaf from the control flour sample 100:0 (W-C) in terms of volume and specific volume. Wheat flour is unique for bread making because it allows aerated structure to form. Wheat flour contains gluten protein which is lacking in cassava flour. The gluten proteins when mixed with water form a viscoelastic network that is able to retain gas during loaf rising without premature rupturing (Debraszczyk *et al.,* 2005*).* The gluten in the wheat of the 80:20 wheat-cassava flour was diluted by the substitution with 20 % cassava flour; that was why the bread loaf from 80:20 wheat-cassava composite flour had low volume and low specific volume probably due to premature rupture of the viscoelastic network of gluten and that consequently led to its (dough) inability to retain enough gas in course of fermentation. Treatment of 80:20 wheat-cassava composite flour with the combination of carboxymethyl cellulose and gelatin or combination of egg white, gelatin and carboxymethyl cellulose either at the ratio of 1:2:1 or 1:1:2 probably prevented premature rupture of the viscoelastic structure or network of diluted gluten, thus leading to retention of gases in the three loaves.

Egg has been reported to have a binding action on other ingredients, emulsifying effect and leavening effect as well as contributing to the bread dough rising higher than non-egg yeast bread (Takashi, 2011). The protein in the egg white helps to strengthen the gluten structure which might allow for more open crumb (Scott *et al*., 2001). Gelatin is largely composed of the amino acids, glycine and proline and it produces gel effect in foods (Mason, 2011)). It has many functions such as elasticity, water binding capacity, emulsifying ability and adhesive property (Rouille *et al*., 2005) as well as aerating properties that make it to increase the volume of the mixture of the ingredients by a considerable proportion, provided the mixture contains water (Takashi, 2011).

Carboxymethyl cellulose is a gum and it is a cellulose derivative with the carboxymethyl group bound to some of the hydroxyl groups of glucopyranose monomers that make up the cellulose background (Selomulyo and Zhou, 2007)). It is used in foods as viscosity modifier or thickener, and it is also used to stabilize emulsions in various products (Deshmuk, 2007)). Therefore, the aggregate properties of carboxymethyl cellulose and gelatin combined and those of egg white, gelatin and carboxymethyl cellulose combined in the ratios of 1:2:1 or 1:1:2 in 80:20 (W-C) flour could have contributed in no small measures to the production of bread loaves of volumes and specific volumes similar to those of 100 % wheat (control) flour bread. They contributed to good dough volume and specific volume by making the dough to knead well and become firm, thereby allowing the escape of gas (CO2) produced during fermentation.

Table 2 shows the sensory properties of bread loaves produced from hydrocolloid treated 80:20 wheat-cassava bread loaves. The hydrocolloids/ improvers; egg white, gelatin, carboxymethyl cellulose (CMC) were prepared and used singly, double and in synergies to produce the loaves.

Table 2: Mean Scores of Sensory Properties of Bread Loaves Produced from hydrocolloid-treated 80:20 Wheat-cassava Composite Flour

Bread Sample	Crust Color	Aroma	Taste	Crumb Texture	Overall Acceptability
WC-E	8.30 ± 1.10^{a}	8.28 ± 1.22^{a}	8.40 ± 1.31^{ab}	6.63 ± 1.19^{cd}	7.91 ± 1.56^{ab}
WC-G	6.90 ± 1.17^{b}	7.80 ± 1.39^{ab}	7.97 ± 0.78^{abcde}	7.10 ± 0.87^{c}	7.33 ± 1.13^{c}
WC-C$_{m}$	8.11 ± 0.87^{b}	7.80 ± 1.17^{ab}	7.70 ± 1.07^{def}	6.90 ± 0.70^{c}	7.90 ± 0.67^{ab}
WC-EG	6.90 ± 1.10^{b}	7.00 ± 1.05^{cd}	7.50 ± 1.05^{ef}	6.80 ± 1.05^{c}	7.40 ± 1.05^{bc}
WC-EC$_{m}$	8.12 ± 0.70^{a}	8.00 ± 0.97^{ab}	6.80 ± 1.22^{g}	6.00 ± 1.03^{e}	6.40 ± 0.99^{d}
WC-C $_{m}$G	7.20 ± 1.87^{b}	7.50 ± 1.17^{bc}	7.80 ± 0.99^{cdef}	8.00 ± 1.08^{ab}	7.86 ± 0.48^{abc}
WC-EGC$_{m}$(1:1:1)	7.20 ± 1.13^{b}	7.00 ± 1.49^{d}	7.20 ± 1.42^{fg}	7.00 ± 1.17^{c}	7.40 ± 2.02^{bc}
WC-EGC$_{m}$2:1:1)	7.20 ± 1.31^{b}	6.80 ± 1.03^{d}	8.15 ± 1.41^{abcd}	6.20 ± 1.07^{de}	6.10 ± 2.00^{de}
WC-EGC$_{m}$(1:2:1)	8.12 ± 1.13^{a}	7.20 ± 1.39^{cd}	7.90 ± 1.15^{bcde}	7.90 ± 1.19^{b}	7.94 ± 1.22^{a}
WC-EGC$_{m}$(1:1:2)	8.13 ± 0.63^{a}	8.00 ± 1.19^{ab}	8.30 ± 1.19^{abc}	7.90 ± 1.42^{b}	7.90 ± 1.56^{ab}
90:10 (W-C) (Ref)	8.10 ± 0.56^{a}	7.60 ± 0.84^{bc}	8.10 ± 0.63^{abcd}	7.90 ± 0.63^{b}	7.97 ± 0.91^{a}
100:0(W-C) (Cont)	8.40 ± 0.63^{a}	8.30 ± 0.70^{a}	8.50 ± 0.70^{a}	8.50 ± 0.70^{a}	8.02 ± 0.31^{a}
LSD ($p \leq 0.05$)	0.48	0.52	0.55	0.51	0.53

Values are means ± standard deviations from the means. Means with different superscript letter(s) in the same column are significantly different ($p<0.05$)

Key.
LSD= Least Significant Difference
WC= Wheat-cassava composite flour
E= egg white,
G= gelatin,
C$_{m}$= carboxymethyl cellulose (CMC),
90:10 (W-C) (Ref.) = 90% wheat + 10% cassava composite flour (reference sample)
100:0 (W-C) (Cont.) = 100% wheat flour or control flour sample.
WC-E=Wheat-cassava composite flour treated with egg white (singly)
WC-G= Wheat- cassava composite flour treated with gelatin (singly)
WC-C$_{m}$=Wheat- cassava composite flour treated with carboxymethyl cellulose (singly)
WC-EG= Wheat-cassava composite flour treated with egg white and gelatin (double improver)
WC-EC$_{m}$= Wheat-cassava composite flour treated with egg white and carboxymethyl cellulose (double improver)
WC-C$_{m}$ G=Wheat-cassava composite flour treated with carboxymethyl cellulose and gelatin (double improver)
WC-EGC$_{m}$ = Wheat-cassava composite flour samples treated with egg white, gelatin and carboxymethyl cellulose at ratios of 1:1:1, 2:1:1, 1:2:1, 1:1:2 (synergy improver).

3.2 The Sensory Properties of Bread Loaf Samples Produced from Hydrocolloids- treated 80:20 Wheat-cassava Composite Flour

The bread loaves from the 80:20 wheat-cassava composite flour samples, WC-E, WC-EC_m, WC-EGC_m (1:2:1) and WC-EGC_m (1:1:2) had the same crust colour or appearance with bread loaves from the control and reference flour samples. With the exception of bread loaf produced from sample WC-EG which had a score of 6.9 (moderately liked) for crust colour, all the bread loaves produced from the composite flour treated with hydrocolloids containing egg white alone or egg white in combination with the other hydrocolloids had scores above 8.0 (very much liked) for appearance. The reason for their good crust colours was as a result of reaction between egg white protein and carbohydrate of the composite flour (mailard reaction). It had been reported that egg white hydrocolloids the colour of baked products (Elkhanifa and El-Tinay, 2002). The product appearance or colour is a very important quality attribute that influences the choice of foods.

The aroma of the bread loaf from the 80:20 wheat-cassava flour sample, WC-E was liked equally (score ≈ 8.3) with that of bread loaf from control (100 % wheat) flour. Also, the aroma of the bread loaves from the 80:20 wheat-cassava flour samples WC-G, WC-C_m, WC-EC_m and WC-EGC_m (1:1:2) were not significantly different from ($p<0.05$) that of the control (100% wheat flour bread). Aroma is the perceivable smell of foods or spices. It is worth noting that the above five bread loaves from the 80:20 wheat-cassava composite flour which had similar aroma rating with the 100 % wheat bread were treated with some levels of one or combination of the hydrocolloids. This showed that the hydrocolloids (egg white, gelatin or carboxymethyl cellulose) had no adverse effect on the aroma of bread loaf. Egg is used to enhance flavour of baked products (Mine and Icy, 2008). Addition of carboxymethyl cellulose to bread and cake formulations has been reported to enhance their aromas by Gimeno *et al*. (2004).

The taste of bread from the control flour (100 % wheat flour) was similar to the tastes of the bread loaves produced from the samples; WC-E, WC-G, WC-EGC_m (2:1:1), WC-EGC_m (1:1:2) and 90:10 (W-C). Taste is the sensation of flavor in the mouth and throat on contact with a substance. This finding showed that the treatment of 80:20 wheat-cassava composite flour with egg white, gelatin, combination of egg white , gelatin and carboxymethyl cellulose at ratio of (2:1:1 or 1:1:2) did not affect the taste of bread loaves produced from the flour, adversely. The bread loaf from the sample WC-C_mG (i.e. 80:20 wheat-cassava composite flour treated with combination of carboxymethyl cellulose and gelatin) had a crumb texture which was not significantly different ($p<0.05$) from the crumb texture or crumb grain of the bread loaf from the control flour or 100 % wheat flour bread. Heino *et al*. (2016) reported that effects of particle size are different in different processes and particle size reduction being beneficial in expanded snacks and eventually in biscuit baking, whereas in bread making it is often not.

Carboxymethyl cellulose and gelatin respectively have the ability to form gel when their solution is heated (Sanderson, 1996). Gelatin produces gel affects in foods (Takashi, 2011) and it has many functions, some of which are elasticity, adhesiveness and water binding capacity. Carboxymethyl cellulose is a gum and it is used in foods as viscosity modifier or thickener. Thus, when carboxymethyl cellulose and gelatin are combined, they synergize to produce an effect which could have made it possible for the 80:20 wheat-cassava flour dough to knead well and become firm. This in turn would have led to gas (CO_2) retention in the dough during fermentation thereby leading to the production of a bread loaf with good specific volume and crumb texture.

Bread loaves produced from the reference flour sample (90:10 wheat-cassava composite flour) have been reported by Giami *et al*. (2004) to have some quality comparable with that of a bread produced from 100 % wheat (control) flour. The bread loaves from samples WC-EGC_m (1:2:1) and WC-EGC_m (1:1:2) (i.e. 80:20 wheat-cassava) composite flour treated with combination of egg white, gelatin and carboxymethyl cellulose either at the ratio of (1:2:1 or 1:1:2) were rated as similar (score ≈8) to the bread loaf from the reference flour by the panelist.

Egg has been reported to have binding action on other ingredients together with emulsifying and leavening effects. Therefore egg white combination with gelatin and carboxymethyl cellulose in the ratios of 1:2:1 or 1:1:2 as hydrocolloids in the 80:20 wheat-cassava composite flour could have also helped their doughs to rise properly and produce bread loaves with good crumb textures. Some of the hydrocolloids-treated 80:20 wheat-cassava composite flour bread loaves such as the ones produced with the flour samples WC-E, WC-C_m, WC-C_mG, WC-EGC_m (1:2:1) and WC-EGC_m (1:1:2) had overall acceptability scores (7.86 - 7.94) which were not significantly different from those of bread loaves from the control (8.02) and reference flour bread samples (7.97). This showed that acceptable bread loaves can be produced with 80:20 wheat-cassava composite flours treated with either the egg white or carboxymethyl cellulose alone, or combined carboxymethyl cellulose and gelatin, or combination of egg white, gelatin and carboxymethyl cellulose at the ratio of 1:2:1 or 1:1:2.

4. Conclusion

Thus, 80:20 wheat-cassava composite flour bread samples treated singly with egg white, gelatin and carboxymethyl cellulose or their combinations as hydrocolloids had different degrees of acceptability. The 80:20 wheat-cassava composite flour treated with a combination of egg white, gelatin and carboxymethyl cellulose (EGC_m) in respective ratio of 1:2:1 or 1:1:2, yielded bread loaves with similar specific volumes (4.71-5.27cm^3/g) as the reference 90:10 (W-C) and control (100% wheat) flour. It did not matter whether egg white alone or carboxymethyl cellulose alone or a combination of gelatin and carboxymethyl cellulose, or the combination of egg white, gelatin and carboxymethyl cellulose were used to hydrocolloids the 80:20 wheat-cassava; bread loaves with the same acceptability rating (very much acceptable, score ≈ 8) as the reference flour 90:10 (W-C), and the control flour (100 % wheat) were realized thus, the decision of which to use depends on choice, availability and cost or economy.

Declarations

Competing Interest
The authors declare no competing interest.

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