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Effect of Experimental Variables on the Malting Performance of Nigerian Maize Oba Super 2 Variety

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Authors' contributions

This work was carried out in collaboration among all authors. Authors FJCO and AOA designed the work, wrote the first protocol and the first draft of the manuscript. Authors AOA and AEM managed the literature searches, analysis of the study and wrote the final manuscript. Authors AEM and AOA performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Background: The Nigerian cultivar, Oba Super 2 (OS2) maize is inexpensive but under- utilized owing to poor development of malting technology for brewing.
Aim: To study the effects of experimental variables on the malting performance of Nigerian maize Oba Super 2 variety.
Study Design: Exploratory.
Place and Duration of Study: Department of Applied Microbiology and Brewing, Nnamdi Azikiwe University, Nigeria, between March, 2018 to September, 2019.
Methodology: Certified Oba Super 2 maize variety was obtained from Premier Seed Limited, Zaria. The grain sample was malted at varying steeping (S) period (S30, S36 and S42 hours), different germination (G) period (0, 1, 2, 3, 4 and 5 days) and varying kilning (K) temperatures (45, 50 and 55°C) to determine the malting performance. The properties of the un-malted and malted maize were determined using standard methods. Data were analysed using analysis of variance (ANOVA) at $P < 0.05$.
Results: The malting loss (ML) was significantly higher ($P < 0.05$) at different steeping period, on the fifth day of germination (G5). The cold water extract (CWE) was significantly higher ($P < 0.05$)

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on the fourth day of germination (G4) kilned at K50. The values for hot water extract (HWE) were significantly higher ($P < 0.05$) on the G4 at K45, K55 and K50, respectively, while free alpha amino nitrogen (FAN) values were significantly higher ($P < 0.05$) on the G4, all kilned at K50. The values for diastatic power (DP) were significantly higher ($P < 0.05$) on the G5, kilned at K50, while the cold water soluble protein (CWS-P) was significantly higher ($P < 0.05$) on the G3 kilned at K50.
Conclusion: The results indicated that longer steeping and germination periods as well as moderate kilning temperature contributed maximally in improving the malting properties and high extract yields.

Keywords: Malting; steeping; germination; kilning; Oba Super 2 maize variety.

1. INTRODUCTION

Maize (*Zea mays* L.) grains play significant roles in food security, economy and as major staple food crop consumed either whole or as processed products in many countries of the world including Nigeria [1,2]. In Nigeria and sub-Sahara Africa (SSA), it ranks first next to millets and sorghum and third most important grain standing next to wheat and rice in global production [2,3]. Maize is used for animal feed and industrial purposes including brewing, production of bioethanol, biogas (biofuels) and enzymes [4].

The main raw material for brewing is barley due to wide array of hydrolytic enzymes (cytolytic, amylolytic and proteolytic) development during malting, low starch gelatinization temperature, high diastatic power (DP), among others [5]. However, in the tropics, the use of other cereals; sorghum [6], millets [7], maize [8] etc., as a replacement for barley malt have been effective due to economic considerations, government policy on high import duty and local availabilities [9]. The enormous growth of grain bioethanol and biofuels production based predominantly on maize, the brain behind developments in commercial enzyme technology [10] and the gluten-free maize [11,12] have contributed maximally to less patronage on barley.

Over the years, there are many varieties of maize (Oba Super 2, Oba Super 6, Sammaz) produced in Nigeria showing differing desirable characteristics and more new cultivars are developed through plants breeding research [13]. Among these varieties are those that possess salient malt qualities for brewing, such as good diastatic power, free alpha amino nitrogen and high extract recovery. Oba Super 2 maize for instance is an improved hybrid variety. It is an annual herbaceous plant, earlier maturing, drought tolerant variety, resistance to Strigahermonthica and other foliar diseases and insects [14]. It is also a high quality protein maize (QPM), having about 70% higher in essential amino acids- lysine and tryptophan [15], and higher polyunsaturated essential fatty acids, reported to have been in suboptimal amount in normal maize varieties [16]. In brewing, cereal grains are malted (germination in moist air under controlled conditions) and a number of hydrolytic enzymes developed to degrade the reserve nutrients of the endosperm. Since proper enzyme development ultimately leads to complete saccharification and high extract yield, amylases and proteases are of critical importance as they initiate the breakdown of starch granules and protein during germination and thus hydrolyse starches to fermentable sugars and protein to peptide bond and amino acids [17].

Since some tropical cereal grains had been conditioned through the malting process to bring up their properties to that of malted barley [18], poor development of malting technology has contributed to paucity of information especially on these local varieties. It is against this background that this local variety of maize, Oba Super 2 capable of high malting yield was selected. The aim of this work was to study the effects of experimental variables on the malting performance of Nigerian maize (*Zea mays* L.), Oba Super 2 variety.

2. MATERIALS AND METHODS

2.1 Sample Collection and Reagents

Certified Oba Super 2 maize was obtained from Premier Seed Nigeria Limited, Zaria, Kaduna-State, Nigeria. All the reagents and chemicals used were of analytical grades.

2.2 Grain Malting

Six hundred (600) grammes of the grain sample was cleaned to remove broken kernels, foreign matter and washed several times in tap. The

sample was surface sterilized by immersion for 40 minutes in sodium hypochlorite (NaOCl) solution having 1% (v/v) available chlorine to check microbial contamination and washed several times in tap water [19].

2.3 Steeping

Cleaned sample was divided into two hundred (200) grammes each and steeped at a temperature of 30°C for different periods; 30, 36, and 42 hours in a ratio of 1:2 (w/v) grains to water in a plastic container as described by Bryce et al. [20]. The steep cycle involved alternating 12 hours wet steep with one (1) hour air-rest period. The steep water was changed at every cycle to prevent fermentation and microbial growth after which the grains were drained and subjected to germination using the method of Ayernor and Ocloo [21].

2.4 Couching

Steeped samples were couched (heaped) on jute bag previously sterilized with dry heat to generate enough heat required for germination to commence.

2.5 Germination

Samples were germinated at fluctuating temperature of 25 - 30°C for five (5) days in dark germination chambers with twelve (12) hourly spray of 10ml of water to prevent drying out. From the zero day of germination to the fifth day (0, 1, 2, 3, 4, 5), samples were removed for kilning and subsequent analysis.

2.6 Kilning

Germinated grains were kilned at different temperatures of 45, 50, and 55°C for 30 hours using hot air oven. Kilned samples were manually de-rooted and the malt stored for analyses.

2.7 Grain Analysis

2.7.1 Determination of thousand (1000) corn weight

This was done according to the recommended methods of analysis of the Institute of Brewing (IOB) [22].

2.7.2 Moisture content

The moisture content was determined according to the Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC) [23].

2.7.3 Germinative capacity

The Approved Methods of Analysis of the American Association of Cereal Chemists (AACC) [24] - 0.75% (v/v) hydrogen peroxide (H_20_2) reference method.

2.7.4 Germination energy and water sensitivity

The Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC) [23] was used. Germination energy; G.E (4ml) % and water sensitivity; W.S (8 ml) %.

2.7.5 Determination of crude protein

The estimation of crude protein was done by micro-Kjeldahl method as described by the Official Methods of Analysis of the AOAC [23]. The percentage (%) protein on dry weight basis = N x 25.

2.7.6 Fat content

The fat content of the maize was determined by Rose-Gottlieb method as described by Pearson [25].

2.8 Malt Analyses

2.8.1 Malting loss

Malting loss (M.L) % was determined using the Institute of Brewing method of Analysis as described by Nnamchi et al. [26].

2.8.2 Specific gravity (S.G)

This was done according to the Association of Official Analytical Chemists [23].

2.8.3 Cold water extract (CWE)

The CWE of the malt was done according to Institute of Brewing as described by Nnamchi et al. [26]

2.8.4 Hot water extract (HWE)

The HWE was determined according to the recommended methods of the IOB as described by Nnamchi et al. [26].

2.8.5 Free alpha (α-) amino nitrogen (FAN) (ninhydrin method)

The FAN was determined using ninhydrin as described by AOAC [23].

2.8.6 Diastatic power (D.P) (°Lintner)

The D.P was determined using Fehling's solution according to the Recommended Method of Analysis of the Institute of Brewing as described by Eneje et al. [7] and diastatic power reported as degree Lintner (°L).

2.8.7 Cold water soluble protein (CWS-P)

The soluble protein in the cold water extract was measured using the Biuret reagent expressed as: mg CWS- Protein % dry matter [27].

2.8.8 Total non-protein nitrogen (TNPN)

The TNPN content of the malt was determined using supernatants from malt FAN analysis. The TNPN in the extract was measured using the semi-micro Kjeldahl distillation method as reported by Pearson [25].

2.9 Statistical Analysis

The data obtained in this study were subjected to statistical analyses using IBM SPSS statistics 22 software. Results are presented as mean of duplicates ± standard error of mean (SEM), n = 2 and significant level was defined at $P< 0.05$. Analysis of variance was performed by one-way ANOVA procedures. Comparisons between the mean values were determined by the least significant difference (LSD) and Duncan's multiple range test (DMRT).

3. RESULTS

3.1 Determination of the Properties of the Maize Grain

Table 1 shows the results of some properties of the un-malted maize variety. The results showed that the un-malted Oba Super 2 (OS2) variety had large 1000 corn weight, low moisture content, high germination energy, germination capacity and water sensitivity as well as low broken kernel, protein content and fat (ether extract).

Table 2 shows the effects of different steeping period (hours) and germination period (days) on malting loss (%) of the grain sample. It was observed that the malting loss increased progressively with longer days of germination period at different steeping cycles. The malting losses were slightly higher for the 42 hour steep cycle but the increase in all the cycles were consistent. At 30 hour steeping, the ML (%) obtained at germination period (days) of G0 to G5 were in increasing order. Similar order of increase was recorded at 36 hour and 42 hour, respectively.

3.2 Cold Water Extract (CWE) (%) of the Malt

The CWE values increased with longer period of steeping (hour) and germination (days). This parameter reached its maximum value after 4th day of germination, 42 hours of steeping and kilned at 50^{o}C (Table 3). The result of analysis of variance (ANOVA) of the cold water extract (CWE) values indicated significant difference ($P < 0.05$) among the parameters; steeping period (hours), germination period (days) and kilning temperature (°C)] on Oba Super 2 (OS2) maize malt.

However, the least significant difference (LSD) and Duncan multiple range test (DMRT) revealed that, there was no significant difference ($P > 0.05$) among germination period at zero day (G0) to fifth day (G5), kilning temperatures of 45 - 55^{o}C at steeping hour 30 (S30).

At steeping period of 36 hour, there was significant increase ($P < 0.05$) between the kilning temperatures 45 - 55°C at germination day zero, while at first to fifth day of germination (G1 - G5), no significant difference was observed.

3.3 Hot Water Extract (HWE) (%) of the Malt

Table 4 showed increasing trends in HWE values with longer period of steeping and germination, thus reaching maximum, also on the 4th day of germination and decline. Also, the highest HWE development was noticed on sample steeped for 42 hours, 4th day of germination and kilned at 50°C.

3.4 Free Alpha Amino Nitrogen (FAN) (mg/l) of the Malt

The FAN levels increased with longer period of steeping and germination, reaching its maximum at 4th day of germination (Table 5). The highest FAN level was noticed on sample steeped for 42 hours, 4th day of germination and kilned at 50°C.

Table 1. Properties of the un-malted Oba Super 2 (OS2) maize variety

Properties	OS2
Thousand corn weight (g)	280
Moisture (%)	11.5
Germination energy (%)	94
Germinative capacity (%)	96
Water sensitivity (%)	87
Broken kernel (%)	0.82
Protein (N X 6.25) %	9.06
Fat (ether extract) %	4.20

Table 2. Effects of different steeping (S) period (hours) and germination (G) period (days) on malting loss (%)

Germination Period	S_{30}	S_{36}	S_{42}
	Malting Loss (%)		
G0	7.10±0.00[a]	8.10±0.00[a]	8.90±0.10[a]
G1	10.25±0.15[a]	10.05±0.05[a]	10.50±0.10[a]
G2	14.22±0.10[a]	14.80±0.20[a]	14.40±0.10[a]
G3	16.68±0.03[a]	16.70±0.30[a]	17.80±020[a]
G4	19.58±0.08[a]	20.12±0.12[a]	21.90±0.10[b]
G5	20.12±1.02[a]	21.10±0.05[a]	23.00±1.00[b]

Key: S30, S36, S42 = Steeping period of 30, 36 and 42 hours; G0, G1, G2, G3, G4 and G5 = Germination period (days); of day zero (0), 1, 2, 3, 4 and 5, respectively. Results are presented as mean ± standard error of mean (SEM) of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping to compare the means, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

Table 3. Cold water extract (CWE) (%) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	26.99±0.01[b]	26.08±0.02[a]	26.37±0.04[a]
K50	28.58±0.08[b]	29.75±0.05[a]	28.50±0.10[a]
K55	27.19±0.11[b]	28.84±0.15[a]	28.18±0.05[a]
G1K45	37.53±0.05[b]	36.86±0.06[b]	37.56±0.05[a]
K50	36.69±0.02[b]	36.07±0.03[b]	38.63±0.03[b]
K55	37.45±0.15[b]	36.88±0.35[b]	38.70±0.10[b]
G2K45	40.90±0.05[b]	36.50±0.10[b]	43.40±0.10[a]
K50	41.85±0.05[b]	38.80±0.10[b]	46.61±0.01[b]
K55	41.65±0.05[b]	38.98±0.02[b]	42.08±0.03[a]
G3K45	41.45±0.15[b]	40.52±0.09[b]	47.81±0.01[b]
K50	42.50±0.20[b]	43.14±1.06[b]	47.80±0.10[b]
K55	42.19±0.30[b]	43.35±0.15[b]	46.67±0.03[b]
G4K45	41.8±50.08[b]	43.51±0.12[b]	49.93±0.04[a]
K50	43.25±1.84[b]	44.56±0.03[b]	51.87±0.04[a]
K55	43.03±0.75[b]	44.42±0.06[b]	50.85±0.05[a]
G5K45	42.37±0.17[b]	41.32±0.03[b]	50.57±0.04[a]
K50	41.95±0.50[b]	41.82±0.01[b]	49.61±0.11[a]
K55	43.14±0.84[b]	41.17±0.03[b]	49.26±0.04[a]

Key: S30, S36, S42 = Steeping period of 30, 36 and 42 hours; G0, G1, G2, G3, G4 and G5 = Germination period (days) of day zero (0), 1, 2, 3, 4 and 5, respectively; K45, K50 and K55 = Kilning temperature (^{o}C) of 45, 50 and 55, respectively. Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

3.5 Diastatic Power (DP) in Degree Lintner (°L)

The DP of the maize malt increased equally with longer period of steeping and germination sequences (Table 6). Also, sample kilned at 50°C gave the highest percentage DP values in all the steep cycles. The peak values for DP at 33.40 and 33.55 were significantly higher ($P<$ 0.05) on the G5, kilned at K50.

Table 4. Hot water extract (HWE) (L°/kg) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	100.61±0.41^a	110.40±0.40^a	112.30±0.30^b
K50	106.50±0.50^a	108.60±0.40^a	109.50±0.50^a
K55	111.51±0.49^a	114.25±0.05^a	110.03±0.00^a
G1K45	128.40±0.40^b	124.45±0.35^a	143.95±0.05^a
K50	149.85±0.15^a	127.01±0.10^b	159.85±0.15^a
K55	111.10±0.10^b	116.51±0.49^a	163.45±0.45^a
G2K45	138.30±0.10^a	131.90±0.10^a	211.20±0.00^b
K50	219.53±0.47^a	117.45±0.45^a	211.80±0.10^a
K55	138.40±0.20^a	138.90±0.10^a	218.15±0.06^a
G3K45	230.50±0.50^a	182.40±0.40^a	224.16±0.05^a
K50	230.00±0.00^a	205.05±0.05^a	222.06±0.06^a
K55	164.50±0.10^b	223.50±0.10^a	224.45±0.35^b
G4K45	243.25±0.55^a	229.00±1.00^a	240.16±0.04^a
K50	242.20±0.40^a	237.40±0.20^a	250.05±0.05^a
K55	221.40±0.20^a	238.60±0.00^b	230.30±0.10^a
G5K45	260.70±0.30^a	214.60±0.00^a	224.56±0.56^a
K50	239.50±0.50^a	227.40±0.20^a	219.84±0.67^a
K55	210.45±0.36^a	228.50±0.10^a	216.69±1.52^a

Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

Table 5. Free alpha (α-) amino nitrogen (FAN) (Mg/l) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	29.25±0.02^b	28.01±0.01^b	30.45±0.45^b
K50	30.49±0.05^b	29.53±0.07^b	31.45±0.45^b
K55	28.81±0.09^b	28.75±0.15^b	29.45±0.55^a
G1K45	32.15±0.55^b	30.54±0.54^b	32.75±0.25^b
K50	35.14±0.01^a	32.05±0.55^b	34.30±0.20^a
K55	32.86±0.14^b	31.37±0.47^b	32.32±0.09^b
G2K45	40.89±0.31^b	38.03±0.03^b	40.35±0.55^a
K50	42.89±0.02^b	41.77±1.03^b	45.55±0.45^a
K55	40.72±0.01^b	38.50±0.40^b	41.80±0.20^b
G3K45	41.78±0.02^b	41.10±0.10^b	42.71±0.10^b
K50	43.75±0.25^b	43.85±0.05^a	43.02±0.02^b
K55	41.90±0.10^b	41.50±0.50^b	41.65±0.45^b
G4K45	48.25±0.25^b	45.61±0.51^a	48.95±0.05^b
K50	49.50±0.20^b	49.75±0.15^a	53.55±0.55^a
K55	48.60±0.40^b	47.05±0.05^a	48.91±0.01^b
G5K45	32.33±0.53^b	32.61±0.47^b	31.03±0.01^b
K50	31.58±0.52^b	34.02±0.02^a	32.55±0.25^b
K55	31.30±0.50^b	32.36±0.46^b	31.08±0.08^b

Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

Table 6. Diastatic power (DP) measured in degree lintner (°L) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	25.29±0.29^{b}	24.65±0.15^{b}	26.60±0.00^{b}
K50	25.10±0.00^{b}	25.18±0.03^{a}	25.30±0.05^{b}
K55	25.20±0.00^{b}	26.25±0.25^{b}	25.25±0.15^{a}
G1K45	26.75±0.05^{b}	22.30±0.20^{a}	33.20±0.60^{b}
K50	26.55±0.05^{b}	26.30±0.00^{b}	33.10±0.10^{b}
K55	25.55±0.05^{b}	26.15±0.05^{b}	32.45±0.35^{a}
G2K45	27.38±0.02^{b}	25.50±0.00^{b}	34.15±0.15^{b}
K50	25.70±0.10^{b}	26.68±0.08^{b}	34.10±0.10^{b}
K55	26.50±0.10^{b}	26.72±0.08^{b}	34.21±0.10^{b}
G3K45	27.48±0.18^{b}	26.75±0.05^{b}	34.30±0.00^{b}
K50	32.63±0.03^{a}	34.85±0.05^{a}	36.35±0.25^{b}
K55	26.85±0.05^{b}	26.18±0.03^{b}	35.79±0.12^{b}
G4K45	28.95±0.05^{b}	27.85±0.05^{a}	35.75±0.25^{b}
K50	34.85±0.05^{b}	35.50±0.10^{a}	37.10±0.10^{b}
K55	27.35±0.05^{b}	24.85±0.05^{b}	34.77±0.03^{b}
G5K45	30.70±0.10^{b}	26.37±0.02^{b}	36.70±0.10^{b}
K50	33.40±0.40^{a}	33.55±0.05^{a}	38.08±0.08^{b}
K55	28.09±0.09^{a}	25.55±0.05^{b}	35.73±0.08^{b}

Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping in comparing the means, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

3.6 Determination of Cold Water Soluble Protein (CWS-P) (%) of the Malt

The CWS-P measured in mg/ml is depicted in Table 7. It showed gradual increase as days of germination progressed, and thus peaked on the 3rd day of germination in all the steep cycles kilned at 50°C. The CWS-P values of 48.83, 47.65 and 49.55% were significantly higher (P < 0.05) on the G3 kilned at K50.

Table 7. Cold water soluble protein (CWS-P) (%) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	20.75±0.25^{b}	19.62±0.39^{b}	21.16±0.95^{b}
K50	20.56±0.46^{b}	20.13±0.08^{b}	20.11±0.11^{b}
K55	20.70±0.10^{b}	20.00±0.05^{b}	21.33±0.28^{b}
G1K45	22.93±0.33^{b}	21.50±0.50^{b}	26.37±0.14^{b}
K50	24.65±0.40^{b}	23.78±0.22^{b}	23.35±0.25^{b}
K55	23.34±0.23^{b}	22.00±0.40^{b}	22.05±0.55^{b}
G2K45	25.10±0.03^{b}	23.55±0.05^{b}	26.62±0.39^{b}
K50	27.95±0.05^{b}	21.95±0.05^{b}	26.16±0.06^{b}
K55	26.50±0.50^{a}	22.01±0.23^{b}	26.60±0.40^{b}
G3K45	45.95±0.17^{b}	44.79±0.51^{b}	47.85±0.65^{b}
K50	48.83±0.23^{a}	47.65±0.65^{a}	49.55±0.65^{a}
K55	46.34±0.27^{b}	44.55±0.35^{b}	46.85±0.15^{b}
G4K45	30.09±0.02^{b}	30.50±0.25^{b}	31.45±0.45^{b}
K50	30.13±0.02^{b}	30.85±0.15^{b}	32.10±0.10^{b}
K55	29.58±0.58^{b}	30.58±0.33^{b}	30.83±0.68^{b}
G5K45	26.61±0.41^{b}	23.58±0.32^{b}	23.13±0.13^{b}
K50	25.93±0.58^{b}	26.13±0.13^{a}	24.80±0.20^{b}
K55	25.00±0.30^{b}	22.96±0.05^{b}	23.50±0.50^{b}

Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping to compare the means, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

Table 8. Total non-protein nitrogen (TNPN) (%) of the malt

	S_{30}	S_{36}	S_{42}
G0K45	18.15±0.05^b	17.70±0.10^b	18.45±0.15^b
K50	18.50±0.10^b	18.10±0.10^b	18.70±0.30^b
K55	18.20±0.20^b	17.22±0.02^b	17.90±0.10^b
G1K45	20.30±0.10^b	19.55±0.05^b	19.50±0.10^b
K50	21.98±0.03^a	20.95±0.85^a	22.45±0.25^b
K55	20.70±0.10^b	19.50±0.35^b	21.64±0.04^b
G2K45	23.65±0.25^b	22.30±0.20^b	24.40±0.20^b
K50	24.15±0.05^b	24.55±0.35^b	26.08±0.03^a
K55	23.40±0.40^b	21.95±0.05^b	25.10±0.10^b
G3K45	23.30±0.20^b	23.70±0.10^a	28.38±0.03^b
K50	25.40±0.30^a	24.95±0.05^b	32.10±0.10^a
K55	23.85±0.05^b	22.50±0.10^b	29.24±0.19^b
G4K45	32.11±0.12^b	30.59±0.27^b	34.50±0.10^b
K50	38.68±0.08^b	32.33±0.33^a	38.50±0.10^a
K55	31.50±0.10^a	30.08±0.03^b	34.83±0.18^b
G5K45	29.50±0.40^b	28.05±0.05^b	28.15±0.15^b
K50	28.83±0.40^b	29.50±0.30^b	28.34±0.94^b
K55	27.90±0.90^a	28.23±0.13^b	28.63±0.53^b

Results are presented as mean ± SEM of two replicates. Using least significant difference (LSD) and Duncan multiple range test (DMRT) grouping to compare the means, values followed by the letter "a" are significantly different at P< 0.05, while values followed by the letter "b" are not different significantly at P< 0.05

3.7 Determination of Total Non-protein Nitrogen (TNPN) (%) of the Malt

The result of TNPN showed increasing trend as germination progressed up to a maximum on the 4th day and marginally declined (Table 8). The TNPN values of 38.68, 32.33, and 38.50% were significantly higher (P< 0.05) on the G4 kilned, also at K50.

4. DISCUSSION

The results in Table 1 show some properties of the un-malted maize grain. It gave much information which is relevant for determining the suitability of the grain for malting and brewing. The 1000 corn weight of 280 g obtained in this study was good. In barley, the 1000 kernel weight is a measure of the size of the grains and therefore a reflection of their extract potential [28]. Hence, the OS2 maize variety had larger 1000-corn value than Farz 23 yellow maize reported elsewhere [8], while sorghum SK5912 had correspondingly lower value [29].

The moisture content of 11.5% obtained in this study was lower than the value reported for maize Farz 23 yellow at 12.8% and Farz 34 white at 13.2% [8], but higher than in Finger millet at 7.67% [30]. However, sorghum SSV98001 gave correspondingly higher value of 14.4% [29] when compared with OS2 maize cultivar used in this study.

The germinative properties are useful in selecting grains for malting. It is necessary to evaluate the viability of the grain and if germination falls below 65%, the grain is not viable enough to malt, because diastatic enzymes are activated only during germination [31]. Germination energy enables maltsters to detect dormancy in barley and it was adopted for the study of maize to detect any sign of dormancy. The germination energy and capacity recorded in this study fell within the range at 94% and 98%, respectively and were about the same as several varieties of sorghum studied by Abiodun [28]. These values are at variance with the findings of Iwouno and Odibo [8] for maize, Farz 23 yellow at 92% and Farz 34 white at 96%, however, Iwuagwu and Izuagbe [32] recorded 97% for millet. The high values achieved here are indication of good malting quality. Maltsters avoid water sensitive grains or have to adjust the steeping regime to overcome the condition. The value obtained for water sensitivity indicates that this variety is not water sensitive with about 87% achieved. Similar observation was noted by Eneche [33] for maize grain. However, Archibong et al. [29] achieved 98 and 93% water sensitivity for sorghum SSV98001 and SSV98002, respectively. Germination increased the water absorption capacity of the sample, which was in line with the work of Gernah et al. [34]. The increase in water absorption capacity of the sample observed in this study may be as a result of the production of compounds having

good water holding capacity such as soluble sugars.

The broken kernel value (0.82%) obtained in this study is comparable to that reported by Iwouno and Odibo [8] for two Nigerian maize varieties (Farz 23 yellow and Farz 34 white). The values obtained in this study were an indication that it contains tolerable levels of broken kernels. Broken kernels are major sources of microbial infection during malting of grain and should be avoided by maltsters.

The fat content (ether extract) of 4.20% obtained in this study is in line with the one reported elsewhere [8], while the result contrasts with 1.42% obtained for Finger millet [30]. Information about fat content is very vital in brewing. The low fat value of the grain was good because high level of lipid can destroy foaming potentials of beer. They can accelerate staling. Since this grain variety has comparatively low fats value, it lends itself as promising candidate for use in producing brewer's grits.

The protein content of the grain studied was comparable with the values reported elsewhere for Farz 23 yellow and Farz 34 white [8]. The protein content of the grain was higher compared with the general accepted value for cereals; about 7.5% [35] and the findings of Iwuagwu and Izuagbe [32] for Nigeria millet, *Pennisetum typhoideum* which was about 8.40%. Grains with high protein contents are not recommended due to problem of haze. It may be inferred that this variety has been specially bred for high protein content since it is used for food. Oba super 2 used in this study is a high quality protein maize (QPM), having about 70% higher in essential amino acids - lysine and tryptophan [36,37], and higher polyunsaturated essential fatty acids, reported to have been in suboptimal amount in normal maize varieties [16].

Steeping the grain increases the water content of kernel and also activates enzymes stored in the endosperm [38], thus prompting these enzymes for action. Germination facilitates the conversion of endosperm and enzymes synthesis in the grain for proper modification [39]. The Findings in this study indicate that the ML through the roots and shoots growths increased progressively with longer steeping hours and germination days (Table 2). The malting losses (ML) % was slightly higher in the 42 hour steep cycle but the increase in all the cycles was consistent (Table 2). Malting loss is a key aspect of malting and should be minimized for economic viability of the malt [17]. We can infer that longer steeping and germination periods contributed significantly ($P< 0.05$) to the increase on malting loss and high extract yields, thus an indication of malt quality.

The CWE measures only water extract including, sugars and amino acids, by preventing enzyme action with dilute ammonia solution [18]. It was observed that the CWE values increased with longer period of steeping and germination periods. The high CWE shows high rate of production of starch degrading enzymes and the values fell within the range as previously reported by Ogu et al. [40] for sorghum varieties. However, our findings (Table 3) are higher than the established and accepted CWE value of 17-20% for barley [18]. The increase in the values could be attributed to proper manipulation of the malting parameters; different steeping sequences, air rest, good watering regime and kilning temperatures employed in the course of this work.

The increase in HWE values in this study is an indication of the progress of modification (breakdown of the endosperm reserves, predominantly by amylase and protease enzymes) of the malt during germination and this finding was supported by Aloh and Agu [41]. HWE values of maize and other tropical cereals are lower than that of barley due to a lower diastatic power. The HWE values were significantly higher ($P< 0.05$) at steeping cycles of 30, 36 and 42 kilned at 45, 50 and 55°C, on 4th day of germination (G4) (Table 4). These values were lower than those other varieties reported elsewhere [8]. Our findings, however, are much higher than sorghum varieties reported by Nnamchi et al. [26] which could be as a result of smaller grain size. Comparatively, higher HWE values obtained in this study suggests that grain size influences HWE quality, a reinforcement of the fact that bigger grains contain proportionately less husk and therefore a higher carbohydrate content than smaller ones [28].

Research had shown that un-germinated cereals do not have enough diastatic power (DP) [42]. The DP measured in Lintner degree (^oL) is not meaningful when malt is rich in β-amylase, but tropical cereal malts are however low in β-amylase when compared with barley malt. Germination medium moisture gave high DP value than with high and low watering regime [43]. The present report of 42 hours steeping regime which gave highest DP and protease activity values as compared with 36 and 30 hours (Table 6) agrees with the work of Evan

and Monday [44]. The maximum DP values recorded on 5th day, kilned at 50^{o}C showed enhanced development of hydrolytic enzymes (amylase and proteases) resulting from proper modification of the malt that are more nutritious than the un-malted grain. Akoma et al. [45] had reported hydrolytic enzymes (amylase and proteases) enhancement, resulting in products more nutritious than the un-malted grain. However, high watering regime and different steeping cycles employed in this work had contributed maximally in the increase of malt produced in terms of brewing quality characteristics such as DP (amylase activity) and free amino nitrogen (free amino acids and short peptides).

The progressive increase in CWS-P on the third day of germination at various steeping schedule, kilned at 50°C (Table 7), was in agreement with the findings of Osman et al. [46] and Cizakova et al. [47], who reported that as modification progressed, the CWS-P increases due to breakdown of water insoluble hordein component of the reserve protein and release of bound protein which contribute in the formation and stability of beer foam. The general increase in TNPN value recorded on the 4th day of germination (Table 8) may be as a result of translocation of the products of storage protein degradation, while the decrease thereafter at kilning temperatures (°C); 55 and 45, respectively may reflect the synthesis of the non-protein nitrogen into protein during seed germination.

5. CONCLUSION

This study had shown that a Nigerian maize variety, Oba Super 2 (OS2) exhibited excellent malting properties. Proper manipulations of experimental variables (independent) during malting enhanced extracts development, since the CWE, HWE, FAN, DP, CWS-P (all malt quality parameters) increased significantly with increasing steeping and germination periods ($P < 0.05$) at moderate kilning temperature schedules. The results obtained from this study indicated that maize malt can serve as an attractive alternative for barley malt, hitherto adjudged the main raw material for brewing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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