Full Length Research Paper

Effects of experimental variables on the malting quality of Nigerian yellow maize (*zea Mays)*, farz 27 variety

Iwouno, J. O.[1] and Ojukwu M.[1]

Department of Food Science and Technology, Federal University of Technology, P.M.B, 1526, Owerri, Imo State

In advance to the search for a reliable standard substitute for barley as a principal carbohydrate raw material for beer production. Yellow maize (Farz 27) variety was malted using varying steeping time (30hours, 36hours, 42hours).Germination time (3days, 4days, 5days) and kilning temperature (50^0c, 55^0c, 60^0c). Steeping time, Germination time and kilning temperature had significant effect on response variables; Diastatic power (DP), the Cold Water Extract (CWE), Hot Water Extract (HWE). The CWE and HWE improved progressively with increasing steeping time and Germination time. Steeping time of 42h, 5days of germination and kilning at 55^0c were good for the development of Diastatic power. DP, CWE, and HWE. However, kilning at 50^0c gave the best result of 39.05 ± 4.22% CWE, 220.00 ± 71.39%/kg HWE, and 26.73 ± 2.87^{0}L of Diastatic power

Keywords: Malting, steeping, germination, kilning.

INTRODUTION

Beer has been brewed using barley as the classical raw material. Because barley does not grow in the tropics, its importation has caused tropical countries much, eating deep, into their foreign reserves. In spite of the numerous advantages of barley over other cereals, researchers are making frantic efforts to achieve success in the usage of tropical cereals for beer production, even when large scale commercial trials have been hampered by short comings such as low diastatic power, low FAN (Free amino nitrogen) etc.

As part of these efforts, (Aniche, 2003) assessed the malting qualities of rice (a popular staple food in the tropics). Basically, tropical cereals such as sorghum, millet, maize and rice have all been malted for beer production. Among these, sorghum has been much studied as a replacement for barley, at experimental and industrial levels 2(Okafor and Aniche, 1980).

However, maize has been used since time immemorial as part of the carbohydrate material in beer brewing, but mainly as an adjunct prepared in different forms such as flakes, grits and flour. Malting of maize for use as a major source of hydrolytic enzymes required for brewing purposes has received less attention (Eneje et al., 2004).

Malting reduces the paste viscosity of slurries from cereal flours and thereby raises the caloric density of the slurry which is highly desired in weaning food formulations (Malleshi et al., 1985). Moreover it is controlled germination process, which produces a complement of enzymes, which are able to convert cereal starch to fermentable sugar to secure adequate supply of amino acids and other nutrients for yeast, and to modify the quality of the microelements (Ikujenola et al., 2007).

Despite the establishment of definite malting conditions for proper enzyme development in barley, there are over three thousand (3,000) experiments on barley and so, if a fraction of the number of such experiments are carried out on tropical cereals, which are easily grown in the tropics, it will be a great discovery and will give a relief on our foreign exchange.

As part of this contribution, this work intends to determine the effects of experimental variables (steeping time, germination period and kilning temperature) on the malting qualities of Nigerian yellow maize (FARZ 27) variety, with a view of establishing the appropriate malting conditions for maize, for proper enzyme development, suitable for use in brewing instead of barley.

*Corresponding Author E-mail: macmosesforall@yahoo.com

MATERIALS AND METHODS

Maize varieties used in these studies

The maize variety used in these studies was obtained from the National Crop Research Institute (NCRI) Amakama, Umuahia in Abia State. The variety is Farz-27 (yellow) whose production date is 2006.

Determination of properties of the maize grain

Because the properties of the unmalted grain and the malting conditions influence the malt quality, several procedures were used for assessing the unmalted grain. Most of these methods were created originally for barley and are based on the Recommended Methods of Analysis of institute of Brewing (ANON, 1970), American Society of Brewing Chemist (A.S.B.C) (ANON, 1958).

Determination of maize sample purity

100g of maize grains were wide spread on a sheet of white cloth. Impurities were separated out into different categories namely Inert matter (stones, etc.) weed seeds; other cereal kernels. The total weight grains; chaffs and broken and the weight of the individual types of impurities were determined as a percentage of the original maize weight.

Determination of one thousand corn weight of maize

Determination of the quality of grain is aided by this weight as used by barley maltsters. This weight may be found relevant should maize malt become a satisfactory means of brewing.

500g of each of the maize variety was weighed out. The maize variety was weighed out and reduced using a divider into two portions of about 20g. Also removed were foreign matter and half corns. Each sample was weighed in beakers.

The number of maize grains in each portion was counted (Recommended Methods of Analysis of the institute of Brewing (ANON, 1982).

The weight of one thousand grains of dry maize grains (G) is determined by

$$G = \frac{W \times 1000 \times DM}{N \times 100}$$

Where W = total weight of maize taken
DM = Dry matter percentage of maize
N = total number of grains counted

Determination of presence of mould

Mouldy grains poor produce malting qualities and could introduce toxic mycotoxins. Grains normally carry a flora of moulds and bacteria. Moulds, in the same vein, do not constitute a problem until they grow heavily. The presence or absence of mould growth from the maize grains was determined by visual inspection, since signs of fungal contamination can easily be seen. Mouldy grains were removed by picking.

Determination of the moisture content of maize grain

About 20g sample of maize was ground finely according to the Recommended Methods of Analysis, Institute of Brewing. About 5g of the sample, which was thoroughly mixed, was immediately placed in a moisture dish. Cooling was effected and the weight of the dish taken immediately with the sample. The cover was removed and the dish placed in a preheated oven for exactly 3 hours at 105°c. The lid was replaced and the dish allowed to cool in a desiccators for at least 20 minutes to room temperature. The dish was reweighed to 0.001g. The moisture percentage (M) of the maize samples was determined by the expression

$$M = \frac{W_1 - W_2}{W_1} \times 100$$

Where W_1 = weight of sample before drying
W_2 = weight of sample after drying
The average value was written as percentage moisture content of sample.

Determination of germinative capacity of maize

The aim of this assay is to determine the percentage of living corns in the sample. This gives an index of the amount of maize grains that will germinate during malting. Grains for malting should have at least 95% of corns capable of germination (Bishop, 1936) 200 maize kernels were steeped for 2 days in a 200ml fresh H_2O_2 at 18^{0}c – 21^{0}c. The steep liquor was strained off and germinated corns were counted after separation. The Germinative capacity in percentage ($H_2^{0}{}_2$) was found by the formular

Germinative capacity (G.C) (%) $= \frac{200-n}{2}$

Where n= Number of corns which did not germinate.

Determination of germination energy

100 kernels were placed in 15cm test tube and at 28^{0}c,

covered with distilled water, filling the tube within 20mm of the lid. Floating kernels were forced below the surface of the water repeatedly. The water was drained off after one day and replaced with fresh H_2O. After 2 days of steeping, the water was drained again. Then, a sheet of Watman No 1 filter paper was moistened by dipping it in distilled water for 5s and then allowed to drain for a few further seconds. The moistened filter paper was placed on a glass sheet and the steeped grain distributed in a compact single layer of kernels in the center of one half of the filter paper, the other half of the filter paper was pressed down firmly on the layer of the maize kernels and this was placed in a desiccators containing H_2O in order to maintain the humidity near saturation. The desiccators were kept on a bench at a temperature of 20^0c. After 72 hours, the germinating maize grains were examined, and those kernels with sprouts were removed. The percentage of sprouted kernel was reported as Germinative Energy percent (ASBC, 1958).

Determination of water sensitivity

Two filter papers were placed in the bottom of a petridish and 8mls of water was added. 100kernels of maize were placed on filter papers in each of the petridishes, so that each makes good contact, ensuring that only the ventral side touched the paper to avoid drowning of the embryo. Each dish was covered with its lid. The dishes were incubated for 72 hours at room temperature. Then percentage of grain germinated was reported as water sensitivity percent (Recommended method of analysis of the institute of brewing (ANON, 1982).

Determination of nitrogen and protein of maize

1.00g of maize ground finely was placed into a kjedhal digestion flask. 25ml of concentrated tetraozosulphate (VI) acid (H_2SO_4) was added together with 0.7g of Mecuric oxide (HgO), and 10g of powdered potassium sulphate (K_2SO_4). The flask was placed in an inclined position on a digestion rack and it was heated to boiling until the content of the flask was clear. The kjedhal digestion flask and its content were well mixed. The mixture was cooled to 24^0c, and 25ml of $NA_2S_2O_3$ (aq) was added to precipitate the mercury. 70ml of 0.1 NaOH was then introduced to the digestion flask by carefully pouring it down the side of the neck of the flask so that it underlay the acid solution but did not mix with it. The flask was connected to a condenser by the bulb trap and the contents were heated until all the ammonia had distilled into a standard acid (0.1m H_2SO_4) in the receiver. The excess acid in the receiver was titrated with 0.1N NaOH using methyl red as indicator. The percentage nitrogen was calculated thus % Nitrogen = (ml of 0.1N H_2SO_4 - ml 0.1N NaOH) × 0.0014 × 100

Weight of maize grain sample
   Percent protein 'as in' obtained by multiplying Nitrogen percentage by 6.25, thus:
ml of 0.1N H_2SO_4 - ml 0.1N NaOH)   × 0.0014 × 6.25 × 100
Weight of maize grain sample
Percent protein 'drying' =
Percent protein ('as in') × 100
100 – Percent moisture content of maize grain

Malting procedure for maize

Cleaning

The maize grains (white variety) were washed in running tap water until they were cleaned.

Steeping

Steeping was carried out in room temperature. The steep water temperatures fluctuate between 22^0c and 28^0c depending on the time of the day. Water was drained after every eight hours and the rains given thirty minutes air-rest throughout the steeping period of 30h, 36h and 40 hours for different samples.

Couching

After steeping appropriately, the grains were heaped on jute bug and covered with same. The aim of doing this is to generate heat of germination.

Germination

The cast grains were spread out on some white cloth and reasonable quantities of grains were removed from the samples for kiln-drying after 24hours of germination up to the fifth day of germination. The grains were turned after every eight hours and clean water sprinkled on the grains to compensate for surface dehydration of sample.

Kilning

The green malts were collected after every one day and kiln-drying was affected at 50^0c, 55^0c and 60^0c for every 24hours in and oven. After dehydration, shoots and roots were shrubbed off by rubbing.

Analysis of maize malt

The following assays were carried out on the maize malt.

Determination of cold water extract

10.05g of ground malt was digested with 200ml of distilled H_2O containing 12ml of 0.1N NH_3 for 3hours at 20 ± 0.02^0c stirring at 30min intervals. The solution was filtered and the relative density of the filtrate measured at 15.5^0c. The cold water extract percentage was assessed as follows:

Cold Water Extract % (C.W.E) $= \dfrac{G - 100}{3.86} \times 20$

Where G = the excess degrees of gravity of the filtrate taking water at 15.5^0c as 1000 i.e.

G = 1000 (S.G – 1)

Determination of diastatic power of maize malt (lintner value)

Firstly, a malt infusion method was prepared as done in Cold Water Extract. The extract was not filtered but allowed to settle. 3ml aliquot of the supernatant liquid was removed using pipette into 100ml of 2% buffered starch solution kept at a temperature of 25^0c and contained in a 200ml flask. The flask was shaken and left at this temperature for an hour exactly. The reaction was inhibited by the addition of 0.1N NaOH and the volume made up to 200ml at 20^0c with distilled H_2O.

5mls of mixed Fehling's solution was pipette into a 15ml narrow-necked boiling flask from a burette and the flask content was mixed and was boiled with moderate heat for 2min. The boiling and addition of starch solution was continued for another 2 minutes until the blue colour of Fehling's solution was bleached. Three drops of Methylene blue indicator were added and the titration completed. The end point was indicated by the decolourization of the Methylene blue indicator and the reacting liquid, just become red.

The Diastatic power (D.P) expressed in degree I.O.B was calculated from the expression:

D.P $= \dfrac{2000}{XY} - \dfrac{200}{SX}$

Where X = number of ml of malt extract used to digest starch

Y = number of ml of converted starch to reduce 5ml of Fehlings solution

S = titre of starch blank.

Determination of Blank Titre for Starch

The undiluted 2% starch solution was titrated against a mixture of 1ml of mixed Fehlings solution A and B, using the above described technique. The titre was taken as S. The correction to be subtracted from the probable diastatic power of the malt is 200/sx, where x is the number of ml of malt extract for the conversion. The blank is usually neglected if it is less than 3% of the

measured diastatic power of the malt.

Determination of hot water extract (i.e. I.O.B) method of pale malt extracts determination

Hot Water Extract (H.W.E) is an analytical measure of the quantity of soluble solids in sweet wort, prepared form malt or other materials by a small scale mashing process.

50g ± 0.5g of ground maize malt was put in a 1000ml beaker. The beaker was then placed in a heated water bath (at temp. of 65^0c) and preheated for 10 – 15 minutes. 360ml of distilled H_2O was added into the beaker at a temperature not greater than 68^0c into the beaker ensuring and initial mash mix of 65^0c. Stirring was vigorously and done well to ensure the removal of all lumps in the mash was kept at 6.5 ± 0.2^0c for exactly an hour after the initial mix. The beaker was the n immersed at least to the level of the level of mash surface and the mash stirred at 10min intervals. After an hour, the mash was removed from the water bath and quickly cooled to 20^0c. The mash was transferred to a 515ml at 20 ± 0.2^0c. The contents of the flask were thoroughly mixed by vigorous shaking for 5 minutes. Thereafter the volume of the prepared mash was adjusted to 515ml at 20^0c as described above.

The entire mash was filtered with the first 50ml of filtrate returned to the filter and the filtrate collected for 30min. The relative density of the filtrate was determined at 15.5^0c within an hour of collection.

The Hot Water Extract (HWE) was calculated thus:

Extract 'as in' = G × 10.13 lintel degrees/kg.

Where G = excess degrees of Gravity of the filtrate taking water at 15.5^0c as 1000.i.e. G = 1000 (S.G. -1).

RESULTS AND DISCUSSIONS

Properties of the farz 27 yellow maize varieties

The physical and chemical properties of the yellow grain are given in Table 1a and table 1b as well as the proximate composition of barley, rice and Guinea millet.

Analysis of (farz 27) yellow maize malt

Effect of steeping on the malting quantity of yellow maize variety

As the steeping time progresses from 30hours to 42hours, there was a progressive increase in the rootlets of the steeped grains. Maize steeped for 30hours and 36hours respectively. This agrees with the findings of (Aniche, 2003) for some Sorghum varieties.

The values for the Cold Water Extract (CWE). Hot Water Extract (HWE) and the Diastatic power (DP) for

Table1a. Properties of Maize Grains (farz 27)

Properties	Yellow maize farz 27
One thousand corn weight	295.04
Moisture content %	12.26
Germinative energy %	95
Germinative capacity %	95
Water sensitivity %	84
Protein (N × 6.25)%	10.5
Foreign matter and broken kernels %	1.38
Oil (Ether extract) %	4.49

Table 1b. Proximate Composition of Cereal Grains

Parameters	Barley	Rice	Maize
Moisture content %	11.12	11.0	10.87
Protein (n × 6.25)%	8.20	12.51	9.02
Oil (Ether extract) %	1.00	0.14	4.99

Table1c. Effect of Period of Steeping and Temperature on the CWE(%), HWE(%/kg) and DP (0L) of samples. (Germination Time = 5 days)

Periods of Steeping Chans	kilning temperature (^{0}c)								
	50			55			60		
	CWE	HWE	DP	CWE	HWE	DP	CWE	HWE	DP
30	35.02	226.67	25.34	35.05	221.67	24.30	35.15	230.00	23.81
36	39.10	260.00	29.01	39.26	266.67	29.32	39.35	270.00	29.04

Each table is the average of values from 3 replicate samples

Table 2. Effect of Period of Steeping and Temperature on the CWE(%), HWE(%/kg) and DP(^{0}L) of Samples. (Steeping = Time 42hrs)

Periods of Germination Days	kilning temperature (^{0}c)								
	50			55			60		
	CWE	HWE	DP	CWE	HWE	DP	CWE	HWE	DP
3	34.20	123.33	23.12	34.23	126.67	23.10	34.20	133.33	23.32
4	39.09	235.00	26.92	38.42	233.33	26.77	38.38	243.33	26.71
5	43.51	298.33	30.16	444.51	300.00	30.21	48.48	306.67	30.82

Table 3. Effect of Period of Steeping and Germination on CWE (%), HWE(%/kg) and DP(0L) of samples. (Temperature= 50%)

Periods of Steeping	Germinative period(5 days)								
	50			55			60		
	CWE	HWE	DP	CWE	HWE	DP	CWE	HWE	DP
30	29.63	126.67	19.22	30.56	111.67	23.45	35.02	226.67	22.45
36	33.84	148.33	23.12	37.71	186.67	28.13	39.10	260.00	28.34
42	43.20	123.33	28.13	38.09	235.00	26.25	43.51	300.00	30.15

Table 4. Effect of Germination time and Kilning Temperature on the Cold Water Extract (CWE)(%) at steeping time of 42hours

Kilning Temperature	Days of germination				
	Day 3	Day 4	Day 5	Total	mean
50	34.20	38.09	43.51	115.80	38.60a
55	34.23	38.42	44.51	117.16	39.05a
60	34.20	38.38	43.48	116.06	38.69a
Total	102.63	114.89	131.50	349.02	
Mean	34.21[a]	38.30[b]	43.83[c]		

Table 5. Effect of germination time and kilning temperature on the Hot Water Extract (HWE)(%/kg) at steeping time of 42hours

Kilning Temperature	Days of germination				
	Day 3	Day 4	Day 5	Total	mean
50	123.33	235.00	298.33	656.66	218.89[a]
55	126.67	233.33	300.00	660.00	220.00[a]
60	133.33	243.33	306.67	683.33	227.78[a]
Total	383.33	711.66	905.00	1999.99	
Mean	127.78[a]	237.22[b]	301.67[c]		

grains steeped for 42hours shows improved values. This agrees with the opinion of (Chukwurah, 2003) that proper steeping hydrates the aleurone layer resulting in enzyme production and its subsequent migration through the multicellular complex of the endosperm.

Effects of germination time on the malting quality of yellow maize

Table 3, 5 and 6 shows the effect of germination time on the Cold Water Extract (CWE), Hot Water Extract (HWE)

Table 6. Effect of Germination time and kilning temperature on the Diastatic power (DP) (^{0}L) at steeping time of 42hours

Kilning Temperature	Germination days				
	Day 3	Day 4	Day 5	Total	mean
50	23.12	26.92	30.15	0.19	26.73[a]
55	23.10	26.78	30.22	80.10	26.70[a]
60	23.32	26.71	30.09	80.12	26.71[a]
Total	69.54	80.41	90.46	240.41	
Mean	23.16[a]	26.80[b]	30.15[c]		

Table 7. The Mean Values of the effect of kilning temperature on the Cold Water Extract, (CWE) (%), Hot Water Extract (HWE)(%/kg) and Diastatic Power (DP)(^{0}L)

Kilning Temperature	CWE	HWE	DP
50	38.60 ± 3.82[a]	218.89 ± 72.35[a]	26.73 ± 2.87[a]
55	39.05 ± 4.22[a]	220.00 ± 71.39[a]	26.71 ± 2.91[a]
60	38.69 ± 3.79[a]	227. 78 ± 71.62[b]	26.71 ± 2.76[a]

Table 8. The mean Values of the effect of kilning temperature on the Cold Water Extract, (CWE), hot Water Extract (HWE) and Diastatic Power (DP)

Germination time	CWE	HWE	DP
3	34.21 ± 0.01[a]	127.78 ± 4.16[a]	23.18 ± 0.10[a]
4	38.30 ± 0.15[a]	237.22 ± 4.37[a]	26.80 ± 0.09[a]
5	43.83 ± 0.48[a]	301.67 ± 3.60[b]	26.71 ± 0.05[a]

a, b, c means, within the same column with different superscripts vary significantly (P > 0.05)

and the Diastatic Power of the yellow maize malts. Table 8 shows the mean values of the effect of germination time. For the CWE, HWE and DP. Germination time had significant effect (p=0.05). This could be as a result of the increased absorption by the scutellum of deploymerized starch and protein reserves in the starchy endosperm as reported by (Robert et al., 1998) and also agrees with the findings of (Gothard et al., 1980) for Barley varieties whose malting qualities improve according to the germination period. The yellow maize malt showed low diastatic power when compared with barley malt as reported by (Okafor and Aniche, 1980).

Effects of kilning temperature on the malting quality of yellow maize malts

Table 8 shows the effect of the kilning temperature on the malting quality of yellow maize malt as shown by the mean values.

For the CWE, the variations in kilning temperature had no significant effect (P = 0.05) on the malts. Conversely, the kilning temperature caused slight significant variation on the Hot Water Extract (HWE) of the malts, especially at 600c. This agrees with Aniche (2004) findings which suggest that kilning temperatures exceeding 550c denature enzymes in the grains such as sorghum.

For the Diastatic power, the kilning temperature had no significant effect (P = 0.05) but maize malt kilned at 550c and 600c respectively. This contradicts findings which suggest that maize malts kilned at 550c has higher diastatic power.

CONCLUSION AND RECOMMENDATION

The overall result revealed that yellow maize (Farz 27) variety malted at the conditions: 42 hours of steeping, 5 days of germination and 500c kilning temperature gives

the best maize malt, though less when compared with that of sorghum and barley. Therefore due to poor enzyme (most especially amylase_ development, during maize malting, brewing with maize malt might require the use of industrial enzymes and not necessary malted barley.

REFERENCES

Aniche GN (2003). Physiological Aspects of malting cereals in Fundamentals of Brewing Science and Technology; Colour Communicadtion Publishers, Enugu. 52-61

Aniche GN (2003). Physiological aspects of malting cereals, In: Fundamentals of Brewing science and Technology.Colour Communication publishers, Enugu: 52-61

ANON (1958). The President magazine, October edition

ANON (1970). European Brewing Convention, Analysis committee. Journal of Institute of Brewing 76:571

ANON (1982). Recommended Methods of Analysis. Institute of Brewing.

ASBC (1958). Annual meetings of Executive Committee 5:15-16

Chukwurah EN (2003). Malting System and methods in:

Eneje LO, Ogu EO, Aloh CU, Agu RC, Palmer GH (2004). Effects of Steeping and Germination on Malting Performance of Nigerian White and yellow Maize Varieties. Process Biochemistry 39:1013-1016

Fundamentals of Brewing Science and Technology. Colours communications publisher, Enugu: 44-51

Gothard PG, Clark MI, Girdon AC (1980).The effect of modification period upon the ability of micro malting procedure of selected Baleys for malting quality.J. Institute of brewing, 3:15-16

Ikujenola AV, Adetuyi FO, Ibrahim T(2007). Effects of Malting period on the chemical compositions of Acha(*Digitaria exilis*) and Sorghum .Proceedings of the 31st NIFST Annual Conference/General Meeting: 62-63

Malleshi NG, Desikachar HSR (1985). Studies on the Comparative Malting Characteristics of some tropical cereals and Millet. J. Institute of Brewing 92:174-176

Okafor N, Aniche GN (1980). Brewing Lager Beer from Nigerian Sorghum. Brewing and Distilling International, 10:32-33,35

Robert LHM, Burton R, Fincher R (1998). Biochemistry and Molecular Biology of Arabinoxylan Metabolism in Germinated Barley. (www.regionalrog)lau/abts/1999//ee.html. Accessed 12-02-07