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ASSESSMENT OF THREE NIGERIA SORGHUM VARIETIES FOR THEIR BREWING QUALITIES.

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Abstract

Barley malt which is the major raw material for beer production is usually imported from Europe with its very high import value by the Nigeria Government. It is therefore imperative that grains of similar agronomical values to barley are developed in Nigeria in other to sustain the brewing industry and this lead to research on Sorghum. The major reasons for this research were to evaluate Selected Nigerian Sorghum Malt Extract quality for their chemical composition for beer production. The selected Nigerian sorghum samples were obtained from Research Institute Ahmadu Bello University, Zaria, Nigeria and analyzed according to Standard methods of the Association of Official Analytical Chemist. The proximate analytical results for the raw grains reviewed protein from 9.31-10.90 %, carbohydrate from 74.48-76.78 %, Moisture content from 9.03-9.16 %, crude fiber from 1.13-1.37 %, crude fat from 2.68-3.33 % and ash content from 0.85-0.92 %. Steeping and sprouting/germinatio n at different temperature (15-18°C, 25-28°Cand 37°C) (17h and 39h) were observed to be optimal at temperature 25-28°C for the varieties. Preliminary investigation depicted the presence

KEYWORDS:
Barley, sorghum malt, Beer

of microorganisms which were inhibited using 0.1% formaldehyde. Proximate result on the malted grains reviewed protein ranged from 1.28-1.65 %, carbohydrate 85.21-89.88 %, Moisture content 6.44-10.94 %, crude fiber 12.70-20.40 %, crude fat from 0.90-1.40 % and ash content ranged from1.10-1.50 %. Results were represented using tables, ANOVA, and chart and it showed that CSR-10 and CSR-02 exhibited good quality malt but CSR-02 and Barley has almost or approximate mean effect on each other than others.

INTRODUCTION

Sorghum is an important food crop particularly in arid and semi arid tropics. In 2013, the Food and Agricultural Organization of the United Nations reported that Mexico was the top producer of sorghum with a net harvest of 6,969 metric tons. The next four major producers of sorghum, in decreasing quantities were Nigeria, USA, India and Argentina. The other major sorghum producing countries in the world, by harvested quantities were; Ethiopia, Australian, Brazil, China, Burkina Faso, Mali, Cameroun and Egypt. Production levels according to ICRISAT, (1996) for leading sorghum producers are; Africa (16%), Asia (36%), Central and South America (21%), and USA (20%). Leading producers around the world are USA (9.8million metric tons), India (8.0million metric tons), Nigeria (8.0million metric tons), and Mexico (6.3million metric tons), (USGC, 2005). Sorghum is an important food crop particularly in arid and semi arid tropics. It is a dual purpose crop providing staple food for human consumption (35%) and the rest as a fodder for livestock, alcohol production as well as preparation of industrial products (Awika and Rooney,2004). The brewing industry depends to a great extent on agricultural products in which barley predominates as the chief raw material. In line with the development of the beer industry, these are insufficient resources. Sorghum is a potential substitute for barley which can be used as an alternate substrate and also raise economic benefits (Ogu *et al*., 2006). Nutritionally, sorghum has high carbohydrate content in form of starch. The protein content is significant and comparable to that of wheat and maize but its digestion is an obstacle to its nutritive value. It has a high fat content than wheat or rice, but, it is lower than that of maize. Some varieties of sorghum

have high dietary fiber content. Unfortunately this tends to have adverse effect on the availability of some nutrients. Sorghum is also known to be a rich source of B-complex (β-carotene), but its quantity also varies with the environment in which the sorghum was grown.

Leaf diseases can be problems in areas with high rainfall and humidity, planting disease-free seed are all methods which can be used to minimize losses from disease. Grain sorghum is resistant to corn rootworms, but may be attacked by corn earworms, aphids, and greenbugs which can affect the malt quality for beer production. According to Goldammer, (2008), the purpose of malting is to develop enzymes in sorghum grains to break down the complex starch and protein; it converts insoluble starch to soluble starch, reducing complex protein generating nutrients for yeast development and the development of enzymes. Sorghum is a potential substitute for barley which can be used as an alternate substrate and also raise economic benefits (Ogu *et al*., 2006). Sorghum is the closest to barley and stands as one of the reasons why various attempts were carried out in the past for barley replacement and through this current research it discovered that two selected sorghum varieties exhibited barley malt quality and this discovery gave room for this research. The study of the Evaluation of Selected Nigerian Sorghum Malt Extract Quality as an Alternative to Barley in Beer Industries aims at monitoring the germination behavior of the three Nigerian sorghum varieties at different temperature regime and timing as well as evaluates the malting qualities of selected Nigerian Sorghum varieties.

Material and Method

Source of Grain Samples

Three Nigerian sorghum varieties (SAMSORGH-17, CSR-01 and CSR-02), were obtained from the Institute of Agricultural Research, Ahmadu Bello University, Zaria, Kaduna Nigeria. The grains were sorted and screened by hand to remove broken or damaged kernels and foreign materials and all the analyses and laboratory work were carried out in the research laboratory. All reagents used were of analytical grades.

Sample preparation

The three varieties of sorghum obtained were properly sorted to remove foreign materials as well as broken and shrunken seeds.

Proximate Analysis

The proximate analysis comprising of six parameters; moisture content, crude protein, crude fat, crude fiber, ash content, and carbohydrate (by difference), were carried out each in triplicate for the raw grain and the malted grain as well. The methods used for the proximate analysis were those of the American Association of Cereal Chemist (AACC, 2000).

Moisture Content Determination for Raw Sorghum Grains

Twenty grams of sorghum grains were finely grinded using laboratory mill and thoroughly mixed. Five grammes of the grinded sample was added into a moisture content dish of a known weight and reweighed with the lid covered. The cover was removed from the dish and placed in a pre-heated oven for exactly 3hours at 105 degrees centigrade. After 3hours, the lid was replaced; the sample removed from the oven and allowed to cool in desiccators for 20minutes. The dish was reweighed and the change in weight noted.

The percentage moisture content was calculated as thus:

The moisture content formula = $W2 - W1 \times 100$

$W1$ 1

Where, W1= Weight of sample before drying.

W2= Weight of sample after drying.

Moisture Content Determination for Steeped Sorghum Grain

A revised method by American Association of Cereal Chemist (AACC, 2000) was used. 20g of the raw three Nigerian sorghum grains each steeped at 17h and 22h were finely grinded separately using laboratory mill and thoroughly mixed. 5grams of the grinded sample was added into a moisture content disc of a known weight and reweighed with the lid covered. Knowing that the moisture content is above 17%, it becomes necessary to determine the grain moisture content as follows; with the cover removed, the grinded grain in the moisture content dish was preheated at 50°C for 3h and the percentage moisture lost calculated using equation-1 above. The moisture content of the pre-dried sample was determined as in the case of unmalted sorghum grain, the moisture percentage of the raw grain can be calculated as follows:

$$MC = X_a + \frac{X_b\ [X_a \times X_b]}{100}$$

Where, MC = Moisture Content.

X_a = percentage of moisture lost by pre-drying.

Determination of Crude Protein

Twenty grammas of sorghum samples were grinded for the determination of the Nitrogen content. The sample was transferred to a stopper bottle and thoroughly mixed. 1.5g of the grinded sample was weighed accurately from the 20g in the stopper bottle, and then transferred quantitatively into a completely dry kjieldahl flask. 10g of powdered catalyst mixture was added to the grinded sorghum grain. About 20mls of sulfuric acid was added, the flask gently swirled to mix and wet the contents of the flask thoroughly. The content was digested at low temperature until frothing ceases. The digest was boiled briskly until the brown color has disappeared and the heating continued strongly for 20 to 30minutes. The digest was allowed to cool afterwards.250mls of distilled water was used to dilute the digest, anti-bumping agent added, and then 70ml of NaOH was added slowly to form two distinct layers. Without disturbing the layers, the trap was fixed and connected to the condenser unit whose tube dips below the surface of the boric acid solution. The content of the flask was swirled to ensure rapid mixing and heat was applied fully. The ammonia was distilled into an excess 2% boric acid solution (about 25ml) containing 0.5ml of screened indicator. 180ml of the distillate was collected and the ammonia titrated with the standard acid (0.1Normal (N) sulfuric acid) to the grey end point. A blank estimation was made on the reagents.

The percentage nitrogen (N) in dry sorghum was calculated thus:

$$\frac{X \times 14}{W \times DM}$$

Where, X = ml of 0.1N acid required to neutralize the ammonia after subtracting
reagent blanks.

W = grams of sample taken.

DM = percentage dry matter.

The results were expressed as percentage of nitrogen on dry weight and corrected to two decimal places.
Conversion of the result to percentage protein on dry weight was done by multiplying the Nitrogen by 6.25. The precision of the method was about ±0.07%

Determination of Crude Fat
The sorghum samples were dried to constant weight in the laboratory forced-air oven at 100degrees centigrade (Manufacturer's Laboratory Thermal Equipment Ltd.), crude fat was then extracted from the dried sample using petroleum ether (B.P 40 to 60degrees centigrade) in a soxhlet extraction unit.

Determination of Crude Fiber
The fat free residue from the fat extraction was dried to constant weight at 100degrees centigrade in a forced-air oven. The fiber was then digested for 30minutes with dilute sodium hydroxide (NaOH). The residue was washed successively with alcohol and ether and then dried at 100degrees centigrade to constant weight. It was then ashed at 600degrees centigrade. The difference between the dried residue and the ash was taken as the crude fiber content.

Determination of Ash Content
The samples were first ignited in silica dishes over a Bunsen burner. They were then ashed at 55degrees centigrade to constant weight using a Gallenkamp muffle furnace.

Determination Carbohydrate Content by Difference
The carbohydrate content was determined by difference (subtracting the total percentage of the rest proximate analysis from 100).

Malting of Raw sorghum
The malting process consists of three stages; steeping, germination and kilning.
Steeping : Five hundred grams (500g) of each of the sorted grains were weighed out and washed twice in distilled water to remove dust then

steeped in 1000mls of water at different temperature (15-18^{oC}, 25-28^{oC}and 37^{oC}). A 17h steeping regime was used followed by 39h re-steeping of the raw grain at three different temperatures; 4h air-rest and steeped water were assessed microbiologically and 0.1% of Formaldehyde was added to the steep water to reduce microbial load on the grains at different temperature**.**

Germination and Kilning Germination was carried out at (15-18^{o}$_{C}$, 25-28^{oC} and 37^{oC}) for four (4) days with twelve (12) hourly spray of 10ml water to prevent drying out. Germinated root lengths were collected everyday for kilning and subsequent measurement. Germinated grains were kilned in an oven at 50°C for 24h (USDA, 2009). Total malting Loss Percentage was determined and expressed on a wet weight basis using the formula:

$$\frac{\text{Initial grain weight - polished malt weight}}{\text{Initial grain weight}} \times 100 \quad (1)$$

Determination of Germination behavior/ capacity

This was determined according to the Recommended Methods of Analysis of the Institute of Brewing (IOB), (1991). Briefly, two lots of sorted 200 corns were obtained using a sample divider. Each lot of 200 sorghum variety was steeped for two (2) days in 200ml fresh Hydrogen Peroxide solution. The steep liquor was strained off and replaced with 200ml of fresh Hydrogen Peroxide solution for one (1) day. The steep liquor was strained off and the sorghum varieties which have not developed both root and acrospires growth were counted and separated. The outer covers of the embryos sorghum were peeled from the sorghum which have not developed root and acrospires growth. The tip of a dissecting needle was inserted under the cover at the side of the germ and swept around to allow the piece of covering over the germ to be peeled back and off. The skin covering the germ was removed by rubbing with the finger to expose the pure white germ. The peeled were incubated on a moist filter paper or moist sand contained in a closed petri dish for 1 day. The grains showing either root or acrospires growths were counted (d).The grains which do not show root or acrospires growth were noted (n).

$$\text{Germination Capacity Percentage (Hydrogen Peroxide)} = \frac{200 - n\ (\%)}{} \quad (2)$$

Kilning: The germinated grains were kilned in an attemperated oven at 500^{oC} for 24 hours.

De-culming: After kilning, the malts were detached from the rootlets and stored for use.

Results

Figure 1: Steeping and 4hour air-rest of the selected sorghum varieties

Figure 1 reviewed the steeping and air resting stage of the selected raw sorghums as shown above. During this stage which is the first stage of malting, water was absorbed by the cereal kernels and the grains became mealy (soft). The rate of water uptake by the grains was noted by checking the moisture contents.

CSR-01 **CSR-02** **SAMSORGH-17**

Figure 2: Sprouting Behavior of the selected sorghum varieties.

Figure 2 above reviewed the sprouting behavior of the selected sorghum grains. Looking at the figure above, it has shown a higher sprouting ability for CSR-01 and CSR-02 than in Samsorgh-17 and this has proven that the other two varieties produced a quality malt than samsorgh-17 because quality steeping and sprouting gives rise to quality malt.

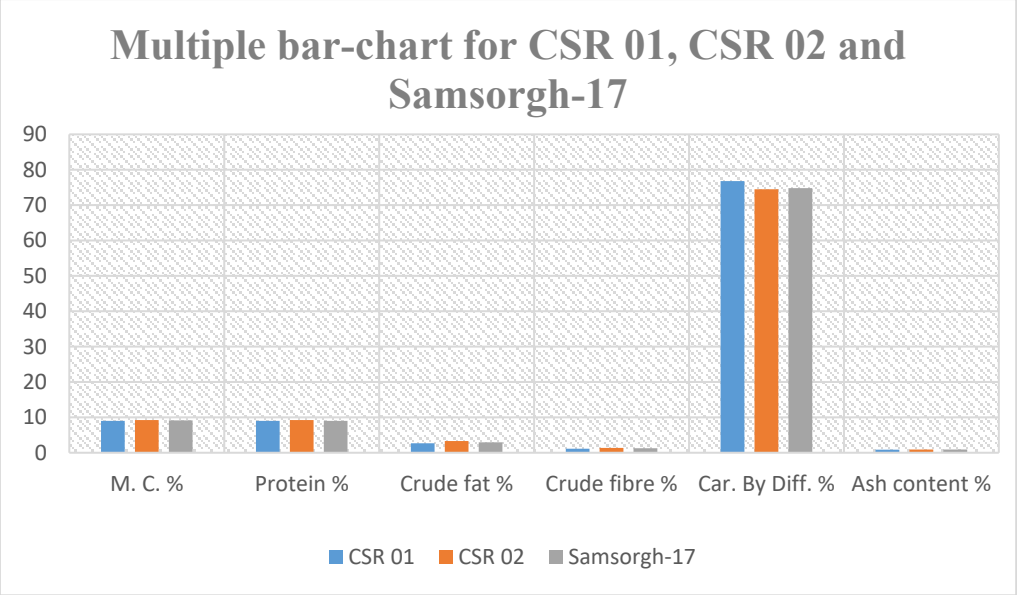

Figure 3: Multiple bar-charts for raw Nigerian sorghum varieties.

Figure 3 represents proximate composition of raw Nigerian sorghum varieties which reviewed moisture content ranged from 9.03 - 9.25%, the bar chart reviewed that the protein content was very high ranged from 9.53 - 10.90% this was as a result of the un-malted state of the grains. Fat content ranged from 2.68 - 3.33%, fiber content ranged from 1.13 - 1.37%, ash content ranged from 0.85 - 0.92%, and carbohydrate by difference ranged from 74.48 - 76.78%. All the varieties exhibited good compositions but was shown to be best in CSR-01 and CSR-02.

Table 1: Descriptive analysis on the raw three Nigerian sorghum varieties.

CSR- 01	
Mean	16.5783
Standard deviation	29.7249
Standard error	12.1351
Median	5.84
Sample variance	883.5689
Skewness	2.3651
Range	75.93
CSR- 02	
Mean	16.43
Standard deviation	28.6781

Standard error	11.7079
Median	6.28
Sample variance	822.4337
Skewness	2.3591
Range	73.56

SAMSORGH-17	
Mean	16.3517
Standard deviation	28.8638
Standard error	11.7836
Median	5.985
Sample variance	833.1192
Skewness	2.3616
Range	73.88

Table 1 represents Descriptive analysis output it can be seen that in the column that the p-value is 1.00 which depicts perfectness of the test, but the analysis was run setting alpha value (α=0.05). In comparison it can be seen that the p-value is more than the α-value (1.000>0.05)

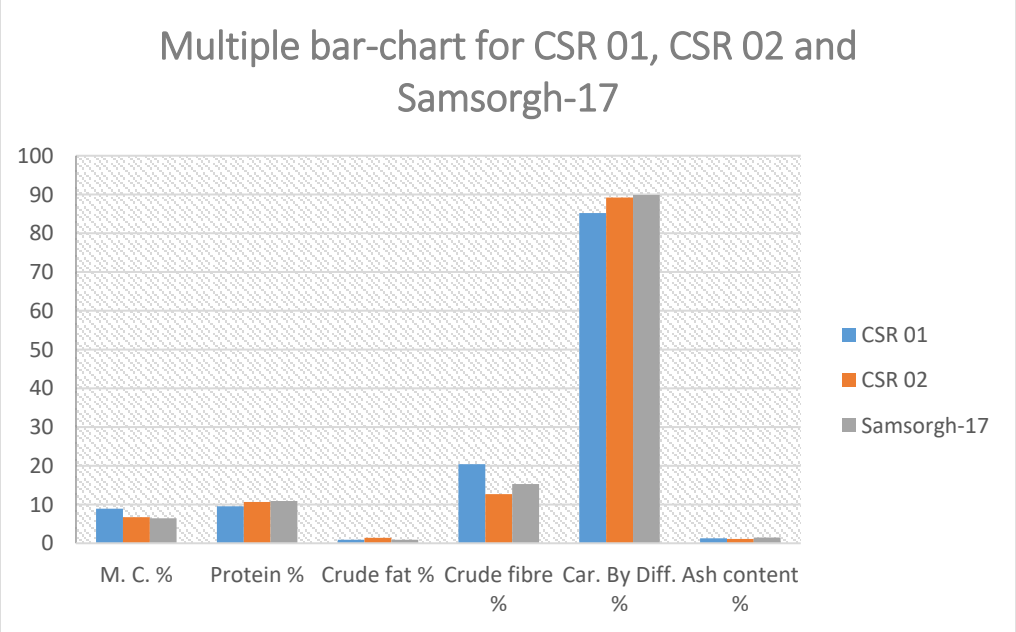

Figure 4: Multiple bar-chart for the proximate Analytical result of malted three Nigerian sorghum varieties.

Figure 4 represents the proximate compositions of the malted sorghum grains, the bar chart reviewed that the protein content decreased during

malting from the range of 9.53 - 10.90% to a range of 1.28 - 1.65% while the carbohydrate by difference increased from a range of 74.79 - 76.79% to a range of 85.21 - 89.88% when compared to that of the raw sorghum grains which entails that enzymes were release production of quality malt; The fiber, ash and fat content are usually neglected in brewing.

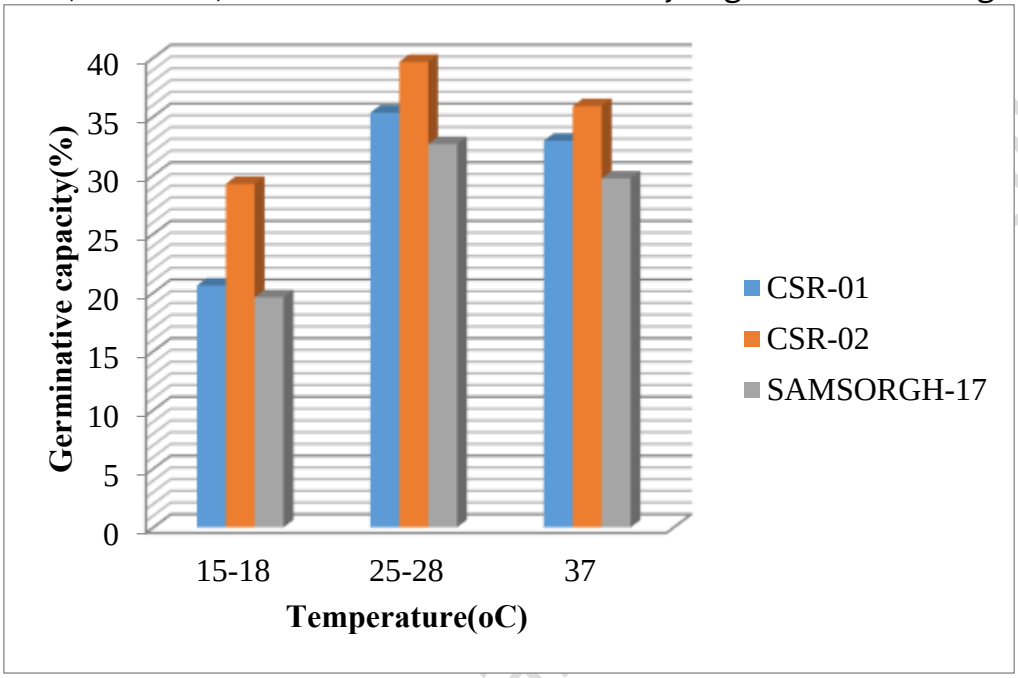

Figure 5: Germination/Sprouting behavior of the raw sorghum varieties.

Figure 5 represents the sprouting/germination behavior of three Nigerian sorghum varieties at different temperatures for four days at different temperature shown above. Highest sprouting/germination behavior was seen in CSR-01 and CSR-02 at 25 - 28°C when compared to the third variety. The results showed that 25 - 28°C is the best temperature for sorghum germination.

Table 2: One way ANOVA and post hoc. Test for selected sorghum malts and Barley malt.

ANOVA					
	Sum of Squares	difference	Mean Square	F	Sig.
Between Groups	453682.529	3	151227.510	.014	.998
Within Groups	418080477.176	38	11002117.820		
Total	418534159.705	41			

Multiple Comparisons						
LSD						
(I) types_of_var	(J) types_of_var	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

Barley	CSR 01	248.513636364	1490.855480834	.868	-2769.56549827	3266.59277100
	CSR 02	261.527818182	1490.855480834	.862	-2756.55131645	3279.60695282
	Samsorgh-17	248.819272727	1490.855480834	.868	-2769.25986191	3266.89840736
CSR 01	Barley	-248.513636364	1490.855480834	.868	-3266.59277100	2769.56549827
	CSR 02	13.014181818	1414.349694474	.993	-2850.18708541	2876.21544904
	Samsorgh-17	.305636364	1414.349694474	1.000	-2862.89563086	2863.50690359
CSR 02	Barley	-261.527818182	1490.855480834	.862	-3279.60695282	2756.55131645
	CSR 01	-13.014181818	1414.349694474	.993	-2876.21544904	2850.18708541
	Samsorgh-17	-12.708545455	1414.349694474	.993	-2875.90981268	2850.49272177
Samsorgh-17	Barley	-248.819272727	1490.855480834	.868	-3266.89840736	2769.25986191
	CSR 01	-.305636364	1414.349694474	1.000	-2863.50690359	2862.89563086
	CSR 02	12.708545455	1414.349694474	.993	-2850.49272177	2875.90981268

Table 2 represent ANOVA results and it can be seen that CSR-02 and Barley had the highest lower and upper mean interval of (-4.097099, 66.633766) and (-9.358464, 71.341798) respectively. while the CSR-02 has a mean , standard deviation, and standard error as 31.268333, 33.6994774, 13.7577540 respectively and Barley 30.991667, 38.4493622, 15.6968864 with their respective count as 6 (six). This simply implied that CSR-02 and Barley has almost or approximate mean effect on each other than others

Discussion

Sorghum generally like other grains (cereals) is very important in the production of alcoholic beverages. One of the species native to Africa is

Sorghum bicolor which has different varieties (CSR-01, CSR-02 and SAMSORGH-17) and these varieties were used in this work. Malting plays an important role before beer is actually produced through processes and these processes involve three technological steps that include: steeping, germination and kilning. During steeping water is absorbed by the cereal kernel and germination begins, in the process, and the grain becomes mealy (soft). Germination, which began in a steep tank, continues in the compartment where barley kernel undergoes modification. Modification refers to the breakdown of the protein and carbohydrate, and the resulting opening up of the seed's starch reserves. Kilning, which is the last step is more of a complex process involving biochemistry, chemistry and physics to produce malt with acceptable flavour and quality.This research project was part of effort to aid local malting and brewing industries in the effective selection of sorghum varieties with good malting qualities. Most importantly, varietal characteristics such as grain shape and size have been identified to affect rate of water absorption during steeping and germination behavior (Kunze, 2004). Small kernels take up water much more quickly than large ones (Kunze, 2004). Additionally, endosperm texture and intrinsic enzymes' activities play dominant roles in the rate of endosperm hydration and modification during steeping and germination (Kunze, 2004) and by implication malt quality. Steeping should not only give optimal germination; it should equally cause optimal hydration of the starchy endosperm thereby encouraging enzyme formation and metabolic transformations of its food reserves (Kunze, 2004). Figure 1 and 2 and 3 reviewed the proximate composition of both raw sorghum. However, there is a direct relationship between steeping time and out-of-steep moisture with sorghum malt quality. The proximate analysis of the raw three Nigerian sorghum varieties were reported in figure 3, the moisture content ranges from 9.03-9.23%, fat from 2.68-2.96%, fibre from 1.13-1.28%, Ash from 0.85-0.92% and carbohydrate by difference from 74.48-76.78% while figure 4 reviewed proximate composition of malted sorghum. These value correlate with the values reported by other workers (Okolo and Ezeogu, 1996, Okorie and Oke, 2003). After 39h of steeping, there was a rapid increase of moisture uptake and sprouting behaviors of the three Nigerian sorghum varieties at different

temperature range which lead to production of quality malt. The degree of steeping (DS) of the three sorghum varieties was consistent with the results reported by Ogbonna *et al.* (2003). However, there is a direct relationship between steeping time and out-of-steep moisture with sorghum malt quality. Germination behavior of each varieties of sorghum at different temperatures and at different days can be seen in figure 5. The results obtained for germination capacity ranged from 78 - 90% and germination observed revealed that the optimal temperature best for sorghum grains was room temperature (25-28°C). The value was exactly 90% for CSR-02 which is consistent with that reported by Archibong, *et al.,* (2009) and when compared with Barley which was our control (see figure 5), CSR-01 and CSR-02 exhibited good germination capacity unlike SAMSORGH-17 whose values are less than 90%. The statistical representation of this research work such as descriptive result revealed that CSR-02 and Barley had the highest lower and upper mean interval of (4.097099,66.633766) and (-9.358464,71.341798)respectively.CSR-02 had a mean, standard deviation, and standard error as 31.268333, 33.6994774, 13.7577540 respectively and Barley 30.991667, 38.4493622, 15.6968864 and other two varieties. The ANOVA Analysis output revealed that the p-value is 1.00 and alpha value (α=0.05). In comparison it can be seen that the p-value is more than the α-value (1.000>0. The implication is that there is no statistically significant difference in the mean of the sorghum variety and barley.

Conclusion

The study revealed that the sorghum varieties CSR-02 out of the three sorghum varieties was suitable for the production of good quality malts for brewing. With respect to the results obtained from the analyses, it showed that the three sorghum varieties (CSR-01, CSR-02 and SAMSORGH-17) were studied considering their moisture content uptake during steeping at different temperature and their proximate compositions. This study revealed that the sorghum variety CSR-02 out of the three sorghum varieties was suitable for the production of good quality malts for brewing. This was shown by its agreeable characteristics after screening such as high water uptake, high sprouting yield. Although so many varieties of sorghum have been studied in

relation to their brewing potentials, very few have been discovered to have posse's excellent brewing potentials. Those found to have excellent brewing potentials normally possess large proportion of mealy endosperm (Okolo and Ezeogu, 1996). In this study they all had good malting potentials but CSR-02 was found to have higher and better malting quality and can be use in the brewing industries as a substitute for barley. Further work is still required to establish more varieties with better malting and brewing qualities.

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