Original Research Article

COMPARATIVE STUDIES OF WORT PROPERTIES OF YELLOW MAIZE AND RED SORGHUM VARIETIES

ABSTRACT

The malting properties of maize and sorghum were analyzed according to the method of the institute of Brewing (1.0.B) 1977. Germination was done for 5 days at 30^{o}c. The parameters evaluated included a thousand corn weight (30g and 20g) for both yellow maize and red sorghum respectively), moisture content (9% and 6% for both yellow maize and red sorghum respectively), germinative energy (96% and 88% for yellow maize and red sorghum respectively), water sensitivity (86% and 92% for yellow maize and red sorghum respectively), presence of tannin (34% and 92%) for yellow maize and red sorghum respectively), germinative capacity (96% and 88%) for yellow maize and red sorghum respectively), cold water extract (41. 5^{o1}/kg and 51.2^{oL}/kg for yellow maize and red sorghum respectively), hot water extract (200.94^{oL}/kg and 129.63^{oL}/kg for yellow maize and red sorghum respectively), result observed where however satisfactory due to the fact that the maize and sorghum could be used as a substitute for barley in commercial brewing.

Keywords: Maize, Sorghum, Yellow, Red, Barley

INTRODUCTION

Sorghum has been, for centuries, one of the most important staple foods for millions of poor rural people in the semiarid tropics of Asia and Africa. For some impoverished regions of the world, sorghum remains a principal source of energy, protein, vitamin and materials sorghum grows in harsh environments where impoverished region of the world. It is usually grown without application of any fertilizers or other inputs by a multitude of small-holder farmers in many countries.

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 (8.0million metric tons), USA (9.8million metric tons), India (8.0million metric tons) and Mexico (6.3million metric tons) [18]. Grain sorghum is the third most important cereal crop grown in the United States and the fifth most important cereal crop grown in the world. In 2010, Nigeria was the world's largest producer of grain sorghum, followed by the United States and India. In developed countries, and increasing in developing countries such as India, the predominant use of sorghum is as fodders for poultry and cattle leading exporter's exports in 2010 were the United States, Australia and Argentina, Mexico was the largest importer of sorghum. 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 vitamin B-complex (β-carotene), but its quantity also varies with the environment in which the sorghum was grown [15, 16].

An international effort is under way to improve sorghum farming. The international crops research institute for the semi-arid tropics [11] has improved sorghum using traditional genetic improvement and integrated genetic and natural resources management practices. A new variety of sorghum from (ICRISAT) has now resulted in India producing of tons per hectares. Sorghum is used primarily as poultry feed, ad secondarily as cattle feed and in brewing applications.

Sorghum is a potential substitute for barley which can be used as an alternate substrate and also raise economic benefits [13].

Most culturated varieties of sorghum can be tracke84+d back to Africa, where they grow on savanna lands. During the Muslim Agricultural Revolution, sorghum was planted extensively in parts of the Middle East, North Africa and Europe. According to Goldhammer,2006, 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. The name sorghum comes from Italian "sergo" in turn from *latin syricum (granum*) meaning "grain of Syria".

Maize known in some English speaking countries as corn is a large grain plant domesticated by indigenous peoples in mesomeri prehistoric times. The leafy stake produces ears, which contain the grain, which are seeds called kernels. Maize kernel is often used in cooking as a starch. The six major types of maize are dent, flint, pod, popcorn, flour, and sweet. Maize spread to the rest of the world because of its ability to grow in diverse climates. Sugar rich varieties called sweet corn are usually grown for human consumption as kernels, while field corn varieties are used for annual feed, various corn-based human food uses (including grinding into cornmeal or maize, pressing into corn oil, and fermentation and distillation into alcoholic beverages like bourbon whiskey, and as chemical feedstock's.

Maize is the most widely grown gain crop throughout the Americas, with 332 million metric tons grown annually in the United States alone. Approximately 40% of the crop- 130 million tons – is used for corn ethanol. The aim of this work is to compare the wort properties of Red Sorghum and yellow maize.

MATERIALS AND METHODS

Materials

The yellow maize and red sorghum samples used in this study were obtained from a local market Eke-Awka, Awka, Anambra State. All analysis and laboratory work were carried out in the research laboratory. All reagents used were of analytical grade.

Reagents Used

- Formaldehyde solution (M & B)
- Ammonia Solution (Hegkin & Wilhour Ltd)
- Acetic acid (MDH)
- Benedict solution (M & B)
- Ethanol (BDH)
- Sodium Carbonate (Griftin George)
- Hydrogen Peroxide (BDH)
- Sodium Hypochlorite Solution (hypo)
- Laboratory Distilled Water

- Laboratory Dionized Water
- DNS
- Soluble Starch (BDH)

Apparatus

- Hot air oven (gen lab model)
- Electronic incubator (model DNP)
- Gallamkamp Shaker (Stuart Model)
- Centrifuge (Searchtech model
- Spectrophotometer – (Jensway 640uv/vis)
- Waterbath (memmert)
- Electric blender (Q –link)
- Tripple beam balance (Fury)
- Sheaker (HY-2A model)
- pH water (Hanna HI9llolo)
- Weighing balance (Labtech BL 7501)
- Colorimeter (Minalta brand)
- Dark carbinet
- Filter paper (Whatman no 1)
- Refrigerator (thermocool)

Methods

The grains sorghum and maize were sorted. This was done by removing foreign and other unwanted materials such as stones, metals and the weathered or broken grains.

Grains Analysis

Determination of Germinative Energy/Water Sensitivity

This was determined according to the recommended methods of analysis of the Institute of Brewing (10B), 1977.

Two filter papers were placed in the bottom of the Petri dish and either 4ml or 8ml of water were accurately added. 100 corns were counted from the sample, obtained with the divider, and placed on the paper so that each grain made good contact.

In the 8ml test, the ventral side of each grain only was allowed to touch the paper to avoid drowning the grain, embryo. The Petri dishes were covered with their lids ensuring good seals. The dishes were incubated in the cabinet and chatted grains were removed at 24h, 48h and 72h from the beginning of steeping.

The percentage corns chatted as the germinative energy or water sensitivity was calculated.

Germinative energy = G, E, (4ml) %

Water Sensitivity = W.S. (8ml) %

Moisture Content Determination

Duplicate crucibles were used, 5g of milled sample were placed in the moisture dish, after the dishes were weighed, and then weighed again within the sample in it. The oven was at temperated for 1hr then the content of the crucibles were dried without the lid for 3hrs at 105^0C after which the lid wort replaced and cooled, then weighed again for comparison.

% weight of dry matter = $\frac{W_3 - W_1}{W_2} \times 100$

Where W_1 = weight of the empty dish + lid

W_2 = weight of the grinded sample

W_3 = weight of the dry sample + lid

Moisture content = 100 - % weight of the dry matter

Determination of Thousand (1000) kernel weight

(According to the recommended methods of analysis of the institute of Brewing (10B), 1977)

The whole sample was weighed out (W). A sample was weighed out (preferably 500g) and reduced using a sample divided into two portions of about 20g. The grains were sorted to remove obvious foreign materials (soil, other seeds, stones etc) and weighed in tarred beakers (e.g. 50 ml capacity) to the third decimal place. The corns in each sample were counted

Divide the total weight taken by the total count of both samples and report the calculated weight of 1000 corns to one place of decimals.

i.e. the weight of 1000 corns of dry grains in grams

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

Where W = total weight of sample taken

DM = dry matter percentage of sample

N = total number of corns counted

Determination of Germinative Capacity

This was determined according to the recommended methods of analysis of the institute of brewing (10B), 1977- Hydrogen peroxide and feeling referrer. The lots of steeped 100 grains were obtained using a sample divider. Each of 100 grains was steeped for two (2) days in 200ml fresh hydrogen peroxide solution at 18-21^{0}C. The step liquor was strained off and replaced with 200ml of fresh hydrogen peroxide solution at 18-21^{0}C for one (1) day. The steep liquor was strained off and the corns which have not develop both root and acrospires growth were counted and separated. The outer layers of the embryos (husk for barley) were peeled from the corns which have not developed rooty and acrospires growth. The tip of a dissecting needle was inserted under the cover at the ride of the germ and swept around to allow the piece of covering over.

Determination of the Presence of Tannins

100 grains were counted into the beakers and the bleaching agent was to cover the grains surface and was incubated for 20 minutes at room temperature and swirled every 5 minutes. The content was emptied into the strainer and rinsed with tap water and blot dry, placed on a white paper and counted.

Malt Analysis

Determination of Cold Water Extract (CWE)

(According to the recommended methods of analysis of the Institute of Brewing (108), 1977). About 10g of ground alt was suspended in 200ml of distilled water containing 12ml of 0.1m ammonia solution.

The mixture was incubated at 20^{0}C for 3h with mixing at 30min interval. The mixture was their filtered through a Whatman No.1 filter paper.

The cold water extract in percent is calculated as;

% CWE = $\frac{G}{3.86}$ x 20,

Where G = the excess degrees of gravity of the filtrate taking water at 200c as 1000. i.e. G = 1000 (S.G-1)

Or C.W.E = $\frac{S.G - 1000}{3.86}$ x 20

Where S.G. = the excess specific gravity of filtrate over 1000

Determination of Hot Water Extract (H.W.E)

This was carried out according to the decantation method of Etokakpan (1992). About 2.5g of homogenized sample flour was extracted by shaking with 22.5ml of 0.5 % Nacl for 1 h at room temperature. This was allowed to stand for 15 min and the cloudy supernatant decanted into another flask and the residue was boiled for 10 min and cooled to 50-55^{0}C for 1 h with striving every 1.5min. This was allowed to cool to 25^{0}C, then transferred a mashing flask and made up to 27.75ml with 0.5 % solution and centrifuged.

The specific gravity of the supernatant was measured using a 10ml.

Specific gravity bottle

The hot water extractives calculated as;

H.W.E. = G x 10.13

Where G = 1000 (S.G.-1)

S.G. = Specific Gravity Supernatant

WORT ANALYSIS

Mashing Process

Mashing is the hot water soaking process that provides the right condition for enzymes to convert the grains starches into fermentable sugar.

Estimation of Reducing Sugars

This was done using the method, 1 ml of 3,5 – Dinitrosalicyclic acid (DNS) is added to 1ml of supernatant of wort (sample) in a test tube and the mixture heated in boiling water for 10 mins. The test tube is cooled rapidly in tap water and the volume adjusted to 12 ml with distilled water. A blank containing 1ml of distilled water and 1ml of DNS is also prepared. The optical density (OD) of sample is read against the blank in a spectrophotometer at 540 nm absorbance. The concentration of sugar is estimated from a glucose standard curve.

RESULTS

In the grain analysis, the result of this analysis of grain shows that moisture content (%), Germinative Energy(%), and Germinative Capacity (%) and 1000 kernel weight (g) in yellow maize is higher than red sorghum while the presence of tannins (%) cold water extract (kg/%), Hot water (6g/^{0}L) and protein content in red sorghum is higher than yellow maize values.

Table 1.0: Grain Analysis

Parameters	Samples	
	Yellow maize	**Sorghum (red varieties)**
Moisture Content (%)	9	6
Germinative Energy (%)	98	81
Germinative Capacity (%)	96	88
Water Sensitivity (%)	86	92
Presence of tannins (%)	34	92
Cold water Extract (kg/^{0}L)	41.5	51.2
Hot Water Extract (kg/^{0}L)	200.94	129.63
1000 Kernel weight (g)	30	20
Protein/Nitrogen Content (%)	5.2	8.4

In malt analysis, the result of this analysis shows that moisture content (%), cold water Extract (kg/^{0}L) and Hot water Extract (kg/^{0}L) in yellow maize is higher than sorghum.
While protein/Nitrogen content (%) in sorghum is higher than that of the maize.

Table 2.0: Malt Analysis

Parameters	Samples	
	Yellow maize	**Sorghum (red varieties)**
Moisture Content (%)	9.4	7
Cold water Extract (kg/^{0}L)	147.3	108.7
Hot Water Extract (kg/^{0}L)	200.3	191.8
Protein/Nitrogen Content (%)	3.2	5.4

Wort Analysis, the result of this analysis shows that sorghum reducing sugar; colour, pH, and protein/Nitrogen content (%) in sorghum are higher than yellow maize.

Table 3.0: Wort Analysis

Parameters	Samples	
	Yellow maize	**Sorghum (red varieties)**
Reducing sugar	0.48	1.81
Colour	6.0	8.2
Ph	5.7	5.2
Protein/Nitrogen Content (%)	0.08	1.54

DISCUSSION

The result of this study for yellow maize and red sorghum grains are shown in tables 1, 2 and 3. The moisture content of the yellow maize is (9.4%) and red sorghum (9.1%) which was determined and according to [10] method, which shows that yellow maize has a higher moisture content than that of red sorghum grain .The moisture content of 9 was lower than the values reported for maize Farz 23 yellow at 12.8% and Farz 34 at 13.2% in Iwouno *et al* [12], but higher in finger millet at 7.67% Banusha (2013) [5].This result of moisture content local red sorghum varieties has similarities to that of sweet sorghum varieties and sorghum varieties. Thus, the moisture of maize is acceptable for long term storage.The study of Agbo *et al* (2020) [2] shows higher values for moisture content, water sensitivity and protein content with the same values for germinative energy while germinative capacity has a little lower the value for the yellow maize oba super 2 variety.

The germinative properties are useful in selecting grains used for malting. The germinative energy values indicate the percentage of corn capable of germinating under the time and condition of test and to ensure good germination of grains to be malted. Its significance is that it helps in measuring the percentage of grains which is accepted to germinate fully. The values obtained are 98% and 81% for yellow maize and red sorghum respectively. The values obtained were higher than those obtained from Nigeria maize varieties which have the range between 60–98% and lower that the germinative energy reported for barley which ranged between 97-100%.This work shows the germination capacity and energy to be within the range of 96-98% and in the work of Iwouno and Odibo (2015) [12] to be 96% for Farz white 34 and 92% for Farz 23 yellow. The high values indicates the good quality for malting. The sorghum variety CSR-02 in Orji-Udezuka *et al* (2020) [15, 16] falls within the range of the germinative capacity of the red locally produced sorghum varieties.

Moreover, hot water extract measure the soluble materials obtainable from the malt when some hydrogen enzymes have added optimally.The grain size affects the hot water extract quality as bigger grains have less husk and higher carbohydrates compared to the smaller grains. The value is higher than those other works of Iken and John, (2002) [9] , 200.94 ^{o}L/kg and 129.63 $^{o}_{L}$/kg for yellow maize and red sorghum respectively but low than that of barley 248.4^{oL}/kg. The work of Owuama (2019) [17] shows the hot water extract(HWE) range to be within 8.8-17.5% and the HWE increased with total sugars in wort and this could be attributed to temperature of extraction for HWE which encouraged enzymic activities and consequently the hydrolysis of more malt starch and protein [3].

The cold water extract (CWE) which measures the readily available materials obtained from the malt is also good measure of enzyme modification of the grain and CWE increases with longer periods of steeping and germination time. However, the value obtained was 41. 5$^{o}_{L}$/kg and 51.2 for yellow maize and red sorghum respectively. The CWE measures only water extract including,sugars and amino acids, by preventing enzyme action with dilute ammonia solution Ghasemi *et al* (2012) [7]. The CWE range of the sweet sorghum varieties and sorghum varieties and local red sorghum varieties are favorable. The sweet sorghum varieties (SSV) have the potential to produce quality malts compared to sorghum varieties (SV) and the local red sorghum varieties. The protein content of maize in Iwouno *et al* (2015) [12] is higher than the generally accepted figure for cereals about 7.5% Adair (1972) [1] but in Table 1 the value for red sorghum varieties is above it while yellow maize in table 2 and 3 falls within the accepted figure.

The result of water sensitivity is similar to that of Owuama, (2019) [17] as the SSV, SV and locally produced red sorghum varieties have high water sensitivity. Water sensitivity proved higher in red sorghum varieties with 92% than the yellow maize which had a lower value compared to the work of Archibong *et al* (2015) [4] which had 98 and 93% water sensitivity for sorghum SSV98001 and SSV98002 respectively. According to Orji Udezuka *et al* [15, 16] research work all sorghum used had good malting properties but the CSR-02 was found to have higher and better malting quality and can be used in the brewing industry as a substitute for barley. The study shows that the wort properties include reducing sugar, color, pH and protein/ nitrogen content of red sorghum are higher than those of the yellow maize analyzed and would yield more extract.

CONCLUSION

The effect of the physio-chemical property of maize showed that cold water extract and hot water extract are significant characteristics of cereals with good brewing potential.

From analysis of the maize malt it could be said that maize has suitable malting properties essential for brew. Although so many varieties of sorghum have been studied in relation to their brewing potentials, very few have been discovered to have possible excellent brewing potentials. Some sorghum varieties are suitable and have good quality malts for brewing. Those found to have excellent brewing potentials normally possess large proportion of mealy endosperm [14]. However, more studies are required to understand the strange malting loss of maize before it could be recommended as a cereal with suitable brewing potential and further work is still required to establish more varieties of sorghum with better malting and brewing qualities. This study shows that some maize and sorghum varieties can serve effectively in brewing and local farmers should be encouraged to produce them for use in the country and cut back on barely which is not common or easily gotten and has to be imported for use, giving rise to economic growth and improvement.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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