International Journal of Basic Science and Technology
August 2018, Volume 4, Number 2, Pages 53- 59

ISSN 2488-8648
http://www.ijbst.com/

Effect of Germination Time, During Malting, on Sugar content of Some Sorghum (Sorghum bicolor {L} Moench) Types

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Article Information
Article # 1008
Received date: 12th April, 201
1st Revision 16rd July, 2018
2nd Revision: 28th July, 2018
Acceptance: 25th July, 2018
Published: 1st August, 2018

Key Words
Germination time,
Malting, Sorghum types,
Sugar content

Abstract

Effect of germination time, during malting on the sugar content of some sorghum was investigated. The study was carried out at Food science laboratory, Modibbo Adama University of Technology, Yola Nigeria. The locally improved and hybrid sorghum used for this study subjected to malting while the sugar content were progressively monitored and evaluated during germination over 48 and 96h respectively. Spectrophotometric procedure was used to determine the different sugars at different wavelength using standard sugar for each sugar sample. The data obtained from the study were analyzed using ANOVA while the means were separated by Duncan Multiple Range Test. The results showed progressive increased in the various sugars as germination time increases. The maltose content varied from 0.4% to 1.50%, sucrose varied from 0.45% to 1.44% while fructose varied from 2.11 to 2.22% at the onset of germination (0h) while barley which serves as control had a higher value (4.23%) for maltose and fructose (2.87%). The study showed that there were no significant differences ($p > 0.05$) in the maltose, sucrose, glucose and fructose content of the dry grain (unmalted) and the sorghum samples at the onset of germination at (0h). Hybrid sorghum type was observed to have higher maltose contents but lower sucrose content when compared to other sorghum types. This inferred that the hybrid sorghum showed a better potential than the other sorghum, and had good potential for malting and will be suitable in the brewing industry and in the production of many of sorghum processed products.

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Introduction

The mechanism of the malting process of sorghum has been a subject of detailed research. In recent times, there has been an increased utilization of sorghum and maize as adjunct of barley malt in Nigerian breweries for the production of brewing extract (Chukwurah, 1988).The grains can be processed into many products, one of which is malt.Malt is the major raw material used in the brewing industry. Barley is traditionally the cereal chosen for malting in order to develop enzymes(Kuntz and Bamforth, 2007).In Nigeria, where attempts to cultivate barley have met with little success , the high cost of improving barley malt, in conjuction with the rising demand for European-type lager , has forced the use of local cereals particularly sorghum, as a malting and brewing grain

Malts are cereals that have been steeped, germinated and kilned under controlled condition. Barley is traditionally the cereal chosen for malting. However, barley cultivation in tropical areas has not been successful. Thus, the production of beer (opaque and lager) and malted foods require the importation of barley malt from temperate regions or utilization of tropical cereals for germination and malting. Sorghum displays a unique adaptability in terms of the need for more food (Taylor and Belton, 2002).Traditionally; Nigeria has employed sorghum in both malted and unmated form in a wide variety of food products. In recent times, there has been an increased utilization of sorghum and maize as adjunct of barley malt in Nigerian breweries for the production of brewing extract (Taylor and Dewar, 2001).Generally,a lot of enzymes are either synthesized or are set free during germination. Malting significantly reduce some of the antinutrients in sorghum particularly phytic acid and tannin while

it improves enzymic activity (Mamudu, 2005). The primary aim of malting is to develop hydrolytic enzymes and activate the enzymes to degrade insoluble reserved foods. Starchy endosperm is degraded to sugars, amino acids and compounds which need to impact a maltry taste and aroma after the kilning process. Studies showed that germinated sorghum grains develop Alpha –glucosidase, Alpha and Beta amylase, Carboxypeptidases and proteinases (endopeptidases) (Kanauchi and Bamforth, 2008) As a result malted grains are very important and could be used as brewer malt, distillers 'malt, malt sugars, and malt flour which are used in the preparation of beer, breakfast cereal, bakery products, pharmaceutical, infant foods, weaning foods and as enzyme rich flours The activities of these enzymes are terminated by drying (kilning) the young plant (green malt) such that the endosperms are not completely depleted through respiration of the embryo and its growth. Activation of amylases that occur during malting results in an increase in the concentration of total soluble sugars, both reducing and non-reducing sugars in malted sorghum. The various sugars obtained from sorghum grain may be one of the factors imparting taste and flavor to the food products and may play a significant role in determining the end use. The most frequently studied sugar cereal grains are glucose, fructose, maltose and sucrose Hence, there is the need to evaluate the quantities of these sugar.

Therefore, the objective of this study was to determine the suitability of different sorghum types for the production of glucose, fructose, sucrose and maltose.

Materials and Methods

Sources of Materials

Three sorghum types were used for this study. Local sorghum (Pelipeli, Kwaya,Kilburi and Telleri) were obtained from Adamawa Agricultural Development Agency, Yola Adamawa State. Improved sorghum (Samsong 17, Samsong 41,FF Katsina and White Kaura) were sourced from Institute of Agricultural Research (IAR) A. B.U Zaria, Kaduna state. The hybrids samples coded (A, B, Cand D) were sourced from Lake Gerio research farm of River Basin Development Authority (RBDA), Yola: The barley (control sample) was obtained from Lake Chad Research Institute, Maiduguri Bornu State. All samples were stored in a dry environment in different polyethylene bags in the laboratory at room temperature of 32 ± 1^0C and 65% RH until required. Chemicals and reagents were obtained from recognized distributors and were of analytical grade.

Malting of Sorghum Grains

Experimental samples (300 g) of sorghum and barley were taken and the malting process follows the procedure of Palmer (1989). The cleaned grains were steeped in thrice quantity of water for 12h with 1h air rest after 6h of steeping. For each air rest, the steeping water was changed. After steeping, the grains were sterilized by soaking in a solution of 1% sodium hypochlorite for 5min before it was drained prior to germination at (0h) just after steepout moisture to determine the sugar content (maltose, sucrose,glucose and fructose).The steeped grains were spread on wet jute bags and covered with moist cotton cloth and left to sprout at room temperature (32 ± 3^0C) for 48h, and 96h germination periods while the sugar contents were monitored as described by Obizoba and Atii (1994).

After germination, the grains were dried in Gallenkamp oven (BS model OV-160, England) at 50^0C for 24h. Rootlets and shoots of the grains were separated from the kernels by rubbing the grain in a sieve (Endecotts Ltd, London, England) of 0.6mm mesh size. The sieve allowed the rootlets and shoots to pass through but retained the kernels (Morall *et al.*, 1986)

The unmalted and malted sorghum and barley samples were milled into flour with a hammer mill(Gibbons Electric, Essex, UK) to pass through- 1mm mesh size screen into fine flour for determination of various sugars. The samples were then stored at room temperature (32 ± 2^0C) for subsequent analysis

Determination of Sugars

Sample (3 g) each was extracted in 25 ml distilled water at 65^0C for 30min with stirring every 10min **(**Gotherd *et al.,* 1980) cooled and filtered using Whatman filter paper. From the filtrate, 2 ml was taken into 10 ml volumetric flask and made up to volume with distilled water. The absorbancies were read at 280 nm on a UNICAM UV2 QYUARTZ system spectrophotometer for maltose and fructose, 370 nm for sucrose and 390 nm for glucose. The standard for each sugar was prepared using the same procedure as for the samples. The sugar concentration was calculated as contained in the formula below. The sugar concentrations were calculated using the formula below.

$$Sugar\ concentration\ (mg) = \frac{Absorbance\ of\ sample\ \times\ concentration\ of\ standard}{Absorbance\ of\ standard}$$

Statistical Analysis

The general linear model (GLM) of SPSS statistical package (version 16) was used for the statistical analysis of results. All the results obtained for the statistical analysis were subjected to analysis of variance (ANOVA) to determine differences within the samples (Snedecor and Cochran, 1987) and Duncan Multiple Range Test (Duncan, 1955) was used to determine the differences within the variation at 95% confidence level ($p \leq 0.05$)

Results and Discussion

Maltose Content of Some Sorghum Types, During Malting as Influenced By Germination

Effect of germination time, during malting, on maltose content of unmalted and malted sorghum types is presented in Table 1. The various sugars obtained from sorghum grain may be one of the factors imparting taste and flavor to the food products and may play a significant role in determining the end use. The maltose content of the (dry grain) unmalted and malted sorghum types at 48h and 96h showed that there were significant differences ($p<0.05$) observed in the maltose content of the sorghum types at the different levels of germination time. No significant difference was observed at ($p \leq 0.05$) in the maltose content between (dry grain) unmalted grain and the grain prior to germination at (0h) just after steepout moisture.However, the maltose content increases significantly from 0h to 96h germination time. Aychew *et al*. (2012) reported that germination at 48h and 96h were the optimum and peak germination time in his study as it was used in this study. The maltose content of sorghum types varied from 0.40-1.50% prior to germination at 0h just after steep out moisture, 0.89-2.69% and 1.32-4.37% for malted sorghum at 48h and 96h of germination time respectively. No significant difference ($p\leq 0.05$) was observed in barley which serves as control as germination time increases.
Hybrid sorghum samples were observed to have higher maltose contents and closer to that of barley than most of the other sorghum types while the maltose content for barley remained the highest at the different levels of germination time. Hybrid sorghum (Hybrid A) recorded the highest maltose content after 96h of germination time while Local sorghum (Telleri) recorded the lowest value (1.32%) The maltose contents of most of the sorghum types were within the range (0.92-4.0%) as reported by many workers. Maltose is the main sugar of brewer's wort. Cultivars with high maltose content are most desired for malt drink production. Therefore, if selection of the grains for malt drink production were to be based on maltose content, hybrids have better potential.

Sucrose Content of Some Sorghum Types during Malting as Influenced by Germination

Effect of germination time, during malting, on sucrose content of unmalted and malted sorghum types is presented in Table 1.There were significant differences ($p<0.05$) observed in the sucrose content of the sorghum types and barley at the different level of germination time. No significant difference was observed at ($p \leq 0.05$) in the sucrose content between the dry grain (unmalted grain) and grain prior to germination at (0h) just after steepout moisture. However, the sucrose content of the sorghum types increases significantly from 0h to 96h germination time. This could be as a result of hydrolytic enzymes, which are synthesized during malting and thus increase as germination time progresses. Aychew *et al*. (2012) reported that germination at 48h and 96h were the optimum and peak germination time in his study as it was used in this study. The values ranged from 0.45-1.44% prior to germination at 0h just after steepout moisture, 1.32-2.31% and 1.55-3.42% for malted sorghum at 48h and 96h of germination time respectively. The sucrose content of the hybrids were found to be lower compared to other sorghum types but higher than that of barley at the different levels of germination time. The sucrose content for the unmalted sorghum samples fell within the range reported many workers. High sucrose in malt instead of maltose is undesirable. (Bravo *et al*. (2013) This inferred that the hybrid sorghum type showed a better potential than the other sorghum types.

Glucose Content of Some Sorghum Types, during Malting as Influenced by Germination

Effect of germination time, during malting, on glucose content of unmalted and malted sorghum types is presented in Table 2. The results showed that the glucose contents of the unmalted and malted sorghum types were very low. As the results indicate, there were significant differences ($p<0.05$) observed in glucose content at the different levels of germination time. No significant difference was observed at ($p \leq 0.05$) in the glucose content between the dry grain (unmalted grain) and the grain prior to germination at (0h) just after steepout moisture. However, the glucose content of the sorghum types increases significantly from 0h to 96h germination time. The glucose contents of most of the hybrids were observed to be higher than that of the other

sorghum types. It varied from 0.04-0.17%, 0.15-0.31%, and 0.21-0.45% in the (dry grain) unmalted sorghum and malted sorghum at 48h and 96h of germination time respectively. Glucose is one of the products of enzymic activity when starch is hydrolyzed to sugar and was found to be generally low at all the different levels of germination time. This could be attributed to low level of β- amylase activity (Mamudu *et al*., 2005) while sugar content of barley was the lowest at the different levels of germination time. Glucose is a monosaccharide sugar, from the hydrolysis of maltose. It is therefore a desired sugar in malt production.

Fructose Content of Some Sorghum Types, during Malting as Influenced by Germination

Effect of germination time, during malting, on fructose content of unmalted and malted sorghum types is presented in Table 2.It showed that there were significant differences ($p<0.05$) observed in the fructose content for barley and the sorghum types at the different levels of germination time. No significant difference was observed at ($p \leq 0.05$) in the fructose content between the dry grain (unmalted grain) and the grain prior to germination at (0h) just after steepout moisture. The fructose content varied from 2.11-2.22% prior to germination at (0h) just after steepout moisture, 2.35-2.79%, 2.89-3.20%for the malted grain at 48h and 96h respectively. However, the fructose content of the sorghum types increases significantly from 0h to 96h germination time.

However as the results indicate, no significant difference ($p<0.05$) was observed between the hybrids and the other sorghum types in the fructose contents after 48h of germination time. . The values for the fructose content obtained for barley were observed to be higher than those of the sorghum types.

Mamudu *et al.* (2005) reported that sorghum malt does not contain β- amylase activity and if it does is in a very low amount. It was reported that since β-amylase activities is the key enzyme in starch hydrolysis to produce sugars, the low levels of these sugars at the different levels of germination time could be attributed to this enzyme activity.

The value for the sugar content obtained for the barley agrees with the values reported by Deklan *et al.* (2005). Most of the maltose, sucrose glucose and fructose contents in the malted samples might be produced by activities of starch degrading enzymes. The amylases could produce these products to nourish the embryo- seedling before the photosynthetic systems are developed for enough sugars to support the plant. However, before the young seedlings utilize an appreciable quantity of these products, the development of the seedlings is halted by drying but not by temperature which will completely inactivate the enzymes in the grains. Kanauchi and Bamforth (2008) indicated that starch in the endosperm is degraded slowly during malting and the sugar levels are developed according to degradation of starch. Rise in reducing sugars may be due to mobilization and hydrolysis of seed polysaccharides. Also, rapid amylolysis yields significant amount of maltose, a reducing sugar (Kunz and Bamforth, 2007). It was reported that dextrin, maltose and glucose increased during malting.

Conclusion

Malting of different sorghum types (local, improved and hybrids and the control sample (barley)) showed the effect of germination time during malting on the sugar content of different sorghum type. The sugar levels vary among the sorghum types but barley had higher sugar content than the sorghum types. However, if selection of grains for malting is to be based on sugar levels, Hybrid sorghum cultivars had good potential for malting at different levels of germination time and therefore will be more suitable in the brewing industry and in the production of many of the sorghum processed products.

International Journal of Basic Science and Technology
August 2018, Volume 4, Number 2, Pages 53- 59
ISSN 2488-8648
http://www.ijbst.com/

Table 1: Effect of germination time, during malting, on maltose and sucrose of some sorghum types

Samples	Maltose Germination Time (Hours)				Sucrose Germination Time (Hours)			
	unmalted	0	48	96	Unmalted	0	48	96
Local								
Pelipeli	0.45±0.02^{ix}	0.51±0.01^{ix}	1.18±0.01^{gy}	1.58±0.09^{hz}	1.38±0.01^{ax}	1.44±0.03^{ax}	2.31±0.11^{ay}	3.42±0.01^{az}
Kwanya	0.87±0.03^{efx}	0.92±0.04^{efx}	1.50±0.06^{fy}	2.35±0.03^{gz}	1.31±0.01^{bx}	1.36±0.05^{bx}	2.17±0.01^{by}	3.35±0.01^{az}
Kilburi	0.67±0.01^{gx}	0.75±0.02^{gx}	1.23±0.01^{dey}	1.68±0.03^{hz}	0.89±0.02^{ex}	0.96±0.01^{ex}	1.85±0.02^{cy}	2.80±0.01^{bz}
Tellerri	0.33±0.04^{jx}	0.40±0.01^{jx}	0.89±0.03^{hy}	1.32±0.01^{iz}	1.06±0.02^{dx}	1.12±0.04^{dx}	1.95±0.01^{cy}	2.46±0.02^{cdz}
Improved								
Samsorg 17 (SK5912)	0.75±0.02^{fgx}	0.83±0.04^{fgx}	1.82±0.01^{dey}	3.11±0.05^{efz}	0.83±0.01^{fx}	0.88±0.02^{fx}	1.65±0.01^{dy}	2.75±0.21^{bz}
Samsorg 41 (1CSV400)	1.08±0.04^{ex}	1.14±0.06^{ex}	1.48±0.03^{fy}	3.51±0.08^{ez}	1.33±0.01^{bx}	1.39±0.06^{bx}	2.18±0.02^{by}	3.23±0.02^{az}
White Kaura (SV20043)	0.51±0.02^{hx}	0.59±0.03^{hx}	1.96±0.01^{dy}	2.48±0.03^{fz}	0.72±0.03^{gx}	0.80±0.04^{gx}	1.36±0.01^{efy}	2.37±0.02^{dz}
FF kastina (SSV20050)	0.81±0.06^{fx}	0.88±0.02^{fx}	1.78±0.05^{ey}	3.05±0.01^{fgz}	1.15±0.02^{cx}	1.23±0.03^{cx}	2.11±0.01^{by}	2.28±0.02^{dez}
Hybrids								
Hybrid A	1.15±0.06^{dx}	1.24±0.04^{dx}	2.69±0.01^{by}	4.37±0.03^{bz}	0.65±0.02^{hx}	0.67±0.01^{hx}	1.43±0.01^{ey}	1.55±0.01^{efz}
Hybrid B	1.32±0.04^{cx}	1.40±0.01^{cx}	2.58±0.05^{aby}	4.21±0.05^{cz}	0.42±0.02^{jx}	0.45±0.03^{jx}	1.63±0.01^{dy}	1.81±0.02^{ez}
Hybrid C	1.45±0.03^{bx}	1.50±0.04^{bx}	2.38±0.04^{cdy}	4.11±0.03^{bcz}	0.85±0.02^{gy}	ND	1.49±0.01^{efz}	1.69±0.02^{efz}
Hybrid D	1.38±0.05^{bcx}	1.46±0.05^{bcx}	2.44±0.03^{cy}	4.01±0.06^{dz}	0.54±0.03^{ix}	0.62±0.06^{ix}	1.32±0.02^{efy}	1.95±0.02^{ez}
Barley (Control)	4.15±0.01^{ax}	4.23±0.06^{ax}	4.32±0.04^{ax}	4.85±0.04^{ax}	0.15±0.01^{kx}	ND	0.27±0.01^{hy}	0.40±0.01^{gz}

Values are means ±standard deviation of three determinations. Values with different superscripts in a column/row are significantly different at ($p \leq 0.05$)
0 hour is the time at the onset of germination, ND not detected.

ISSN 2488-8648
http://www.ijbst.com/

Table 2: Effect of germination time, during malting, on Glucose and Fructose of some sorghum types

Samples	Glucose Germination Time (Hours)				Fructose Germination Time (Hours)			
	Unmalted	0	48	96	Unmalted	0	48	96
Local								
Pelipeli	0.15±0.01^{bcx}	ND	0.25±0.01^{cdy}	0.27±0.0^{efz}	2.05±0.05^{cdx}	2.11±0.06^{cdx}	2.35±0.08^{by}	2.89±0.02^{cdz}
Kwanya	0.11±0.01^{dex}	ND	0.18±0.04^{dey}	0.28±0.01^{ez}	2.10±0.02^{bcx}	2.15±0.01^{bcx}	2.65±0.13^{by}	3.18±0.14^{bz}
Kilburi	0.04±0.01^{fx}	ND	0.18±0.04^{dey}	0.31±0.02^{dz}	2.03±0.02^{dx}	2.11±0.03^{dx}	2.79±0.10^{by}	3.14±0.03^{bz}
Tellerri	0.08±0.02^{ex}	ND	0.26±0.02^{cy}	0.32±0.02^{dz}	2.08±0.03^{cdx}	2.15±0.05^{cdx}	2.54±0.04^{by}	2.96±0.03^{bcz}
Improved								
Samsorg 17 (SK5912)	0.14±0.02^{cx}	ND	0.18±0.04^{dey}	0.25±0.02^{fz}	2.11±0.03^{bx}	2.17±0.01^{bx}	2.60±0.32^{by}	3.12±0.09^{cz}
Samsorg 41 (1CSV400)	0.16±0.02^{bx}	ND	0.21±0.02^{dy}	0.32±0.03^{dz}	2.15±0.05^{abx}	2.21±0.07^{abx}	2.73±0.16^{by}	3.20±0.02^{abz}
White Kaura (SV20043)	0.10±0.02^{dex}	ND	0.15±0.01^{ey}	0.21±0.03^{hz}	2.04±0.01^{dx}	2.12±0.03^{dx}	2.52±0.15^{by}	3.02±0.03^{abcz}
FF kastina (SSV20050)	0.13±0.01^{dx}	ND	0.16±0.01^{ey}	0.23±0.02^{gz}	2.16±0.03^{abx}	2.21±0.02^{abx}	2.61±0.15^{by}	3.15±0.02^{abz}
Hybrids								
Hybrid A	0.17±0.04^{abx}	ND	0.27±0.02^{aby}	0.36±0.02^{cdz}	2.15±0.03^{abx}	2.22±0.05^{abx}	2.73±0.14^{by}	3.08±0.05^{cz}
Hybrid B	0.16±0.01^{bx}	ND	0.31±0.02^{ay}	0.38±0.05^{cz}	2.11±0.06^{bx}	2.17±0.03^{bx}	2.69±0.07^{by}	3.12±0.03^{c}
Hybrid C	0.10±0.02^{dex}	ND	0.28±0.01^{by}	0.45±0.11^{bz}	2.06±0.03^{cdx}	2.11±0.01^{cdx}	2.45±0.03^{by}	2.75±0.03^{dz}
Hybrid D	0.15±0.01^{bcx}	ND	0.21±0.02^{dy}	0.36±0.01^{cdz}	2.08±0.03^{cdx}	2.13±0.03^{cdx}	2.55±0.03^{by}	2.89±0.02^{cdz}
Barley (Control)	0.22±0.01^{ax}	ND	0.32±0.04^{ay}	0.56±0.01^{az}	2.81±0.02^{ax}	2.87±0.01^{ax}	3.05±0.03^{ax}	3.62±0.01^{ay}

Values are means ±standard deviation of three determinations. Values with different superscripts in a column/row are significantly different at ($p \leq 0.05$)
0 hour is the time at the onset of germination, ND not detected.

ISSN 2488-8648
http://www.ijbst.com/

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