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Effect of different ratios of ginger solution concentrations on the quality of millet-based Kunun-Zaki

Abstract

This study evaluates the effect of Ginger solution concentrations (GSCs) on the quality of Millet-based Kunun-Zaki (MKZ). Six (6) samples of MKZ were prepared using millet, Ginger solution concentrate and sugar syrup and they were coded, 200 (KZ preserved with 0% GSC), 201 (KZ preserved with 5% GSC), 202 (KZ preserved with 10% GSC), 222 (KZ preserved with 15% GSC), 232 (KZ preserved with 20% GSC) and 242 (KZ preserved with 25% GSC). The findings of this study suggested that the pH values observed and recorded from the day 3 indicated that the samples 200, 201 and 202 were slightly acidic ranging from 3.13 to 3.40, and the level of acidity of 3.32 increased more in sample of KZ coded 200 (the control sample); while on the day 1 and day 2 stable pH values of about 4.9 to 5.0 were recorded from samples 222, 232 and 242, respectively. This study suggest that the GSC ratio of 15%, 20% and 25% controlled the pH of the MKZ effectively for about 72 hrs, while ratio of 5% and 10% showed a drop in pH within the 48 hrs of production of MKZ, while the control (0% GSC) showed a drop in pH within 24 hrs of the production of MKZ. Also, the results of the sensory analysis conducted on the samples of MKZ indicate that the sensory properties of MKZ were stable for 48-72 hrs without any adverse change. This study concludes that this standard operating procedure (SOP) established from this study can be adopted for the commercial production of MKZ.

Keywords: millet-based Kunun-Zaki, ginger solution concentrations, ph value, sensory quality

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Introduction

The consumption of 'Kunun-zaki' (KZ) originated from the Northern Nigeria, but it is becoming popular among Nigerians in respective of class, age and geographical location.[1–4] KZ is a cereal-based beverage which is prepared either from the slurry of Millet, Sorghum, Rice, and Maize.[5] KZ is rich in carbohydrates, vitamins, and minerals but low in protein.[2,6] KZ is locally made by milling grains steeped over-night with spices, such as black pepper, clove, and ginger and sweet potatoes.[2,7] For the purpose of this study Millet-based Kunun-Zaki (MKZ) was prepared. The need to produce sensory stable and commercially viable KZ by adding a suitable ratio of Ginger solution concentration prompted this study. This is because the sensory attributes of Kunu zaki last for 12-24 hrs only making it highly perishable beverage drink.[1,3,4]

This research is aimed at evaluating the significance of spicing MKZ using a suitable ratio of Ginger concentrations solution for the purpose of monitoring its sensory attributes, pH value and the establishment of standard operating procedure (SOP) for commercial KZ production. Hence the need for the utilization of local raw materials, such as the Millet (i.e. *Pennisetum typhoides*) and Ginger (*Zingiber Officinate*), and the requirement for the adoption of a suitable ratio of Ginger solution concentration for the production of quality and safe traditional beverage known as Kunun-zaki (KZ) in Nigeria prompted this research.

Introduction to Kunu-Zaki (KZ)

Several studies have established and reported that KZ is a product of lactic acid fermentation.[4,8] KZ is a product of cereals and spices, such as the ginger and black pepper, and sugar; some home producers add sweet potatoes in the production of KZ to improve its taste and sweetness.[4] And it is produced at cottage level by most house wives to support the income of the family, and it is commonly consumed among the people domiciling in the northern parts of Nigeria. KZ is usually sold at schools and markets.[4] Also, an attempt to package and commercialize KZ has been in progress,[25] and packaging of KZ can be successfully accomplished if it is properly prepared. The objective of this study is to produce safe and quality KZ prepared from the slurry of Millet, sweetened with inverted sugar syrup and spiced with suitable ratio of Ginger solution concentration.

Methods Used for KZ production

KZ is produced by different methods as reported by various studies.[1,2,4,7–11]

Production of KZ by pre-fermentation

Millet are sorted, washed and steeped in water together with spices (ginger, dried potatoes, black pepper) for about 5 hours in-order to aid fermentation, it was later wet-milled and the paste was divided into two equal portions in which hot water was poured on one portion and allowed to cool before mixing it together with the other remaining portion, it was sieved and Sugar was added to a desire taste.[7] Another method for the production of KZ is the post-fermentation process as described by a study of Efiuvwevwere & Akoma.[7]

Production of KZ by post-fermentation

Millet is steeped in water for 24 hours, wet millet and sieved. The sediment obtained is divided into two unequal portions; one portion

is cooked and then mixed with uncooked portion (being the source of inoculum) and allowed to ferment for 8-10 hours.[7] Another method for the production of KZ is the malting process as described by a study of Awogbenga & Ahmadu.[9]

Production of KZ by malting

Malting process is achieved by weighing 150g of sorghum which will be washed with tap water and steeped in 250ml of tap water for 12 hours and then drained. The drained grain was couched by covering them with moist cloth for 3-4 days at ambient temperature (25-30°C) to germinate. This dried malted sorghum was ground and packed in cellophane bags. The malted Sorghum is then dried, grind and mixed with the uncooked portion. The mixture is then added to the cooked portion and stirred vigorously and allowed to ferment.[9] KZ can be produced by the use multiple cereals including millet, maize and sorghum by a study published by Steinkraus.[12]

Production of KZ from millet, maize and sorghum

Millet, maize and sorghum were cleaned and steeped in a tap water for 24 hours, mixed spices (ginger, black pepper and clove) and washed in fresh tap water before wet milling. The resulting slurry was sieved in excess tap water. Following sedimentation, both the cooked and uncooked paste (at 45°C) were mixed in an unequal ratio of (1:3), following dilution with 3 volume water. The mixture was allowed to ferment for 8-10 hrs at a temperature of 37°C to 40°C, and then sweetened with sugar to taste.[2,12]

Nutritional quality and probiotic properties of KZ produced by several methods

KZ produced from various cereals and by different methods has been reported by several studies to have excellent nutrients and lower glycemic effect.[9,11,13] Several studies have shown that hydrolytic enzyme (amylase) in the malted grain aids in digesting the thick slurry thereby converting the complex carbohydrate to simple sugars. The final product is usually taste sweet without the addition of any sweetening agent.[13] Also another study on glycemic effect of KZ on the blood glucose in non-diabetic person shows that KZ has similar response but lower glycemic index as compared with those of high energy drinks (glucose) suggesting that KZ would be beneficial to diabetic patient.[9] This could be attributed to the availability of simple sugars such as the Fructose in the KZ which has the ability to lower the blood Glucose in the body.[14] In addition, KZ is an excellent source of micronutrients and macronutrients including sugars (sucrose), calcium, phosphorus, protein and iron.[1,2,4] On the average, KZ contains 86.3% moisture, 3.83% protein, 0.16% ash, and 15 mg/100ml vitamin C.[11]

But with the already established nutritional known quality of KZ highlighted above, several studies have reported the probiotic properties of KZ due to presence of lactic acid bacteria such as *Lactobacillus brevis*, *Streptococcus lutetensis*, *Weissella confusa*, *Streptococcus gallolyticus* and *Bifidobacterium species*.[15] Probiotic bacteria ease digestive distress, lower cholesterol level, slow down ageing process, boost energy and improve immunity.[11,15,16] In addition, lactic acid bacteria activate the synthesis and assimilation of vitamin C and minerals in the body.[11,16]

Spices such as the ginger, clove and black pepper are used in the production of KZ in order to improve its taste, and ginger is widely used for culinary purposes in baked products.[4]

Botanical characteristic of ginger plant

Ginger (*Zingiber Officinate Roscoe*) is a monocotyledon belonging to the family of *zingiberaceae* which are aromatic, and some of the species of the Ginger are non-aromatic.[4] Ginger is obtained from the perennial plant *Zingiber officinate* which grows up to 2ft in height. The edible stem, used in sweet manufacturing is an underground root like scaly leaves and buds. Successful cultivation of Ginger requires frequent application of manure, a sufficiently, high rainfall and a high air temperature.

Safety and quality issues associated with KZ

One of the major quality problems associated with KZ is that it is produced under poor sanitary conditions; poor handling of raw materials and ingredients resulting in short shelf life.[17] This could be attributed to poor Good Manufacturing Practice (GMP) and poor Good Hygiene Practice (GHP) during processing of traditional beverages, such as KZ.[18] One of the safety issues that require attention and addressing is the use of already used polyethylene terephthalate (PET) packages in packaging sweet beverages in Nigeria. Home-based producers of TBs including KZ use old PET bottles to package. Sometimes plastic bottles and/or Polyethylene-based packages are used for packaging and presenting KZ to consumers. Research work has shown the risks associated with plastic polymers produced from synthetic materials.[19] These plastics are used repeatedly by home producers of KZ to sell their products without knowing the implications of their action. The consumers continue to buy and consume KZ packaged in old PET containers due to illiteracy coupled with poverty.[4]

Traditional beverage including KZ has poor keeping quality due to unguided processing methods and poor storage.[20] It is also known to be prone to microbial contamination.[17] There are several microbial contaminants associated with KZ including *Aspergillus* and *Penicillium* species.[20] They are both toxigenic fungi including the *Fusarium* specie.[21] Fusarium is commonly isolated from cereals, and it is the most prevalent toxin-producing fungi.[22] In developing nations such as Nigeria, it has been noted that Fuminosins and Aflotoxins are likely to be of significance, and they are produced by three species of *Aspergillus* namely *A. flavus*, *A. parasiticus* and *A. nomius* .[21–23] Aflotoxins are group of mycotoxins of most concern because they are having both hepatotoxins and carcinogens.[22]

Also, Ochratoxin A (OTA) has been reported in foodstuffs especially the cereals and their products, for example OTA (50 mg/kg) has been identified in the cereal (millet) used for the production of KZ.[17] Therefore, the important foodborne mycotoxins (FMT) formation due to *Aspergillus niger* contamination include Aflotoxins, Ochratoxins, Fuminosins and Malformins.[4,22,23] The sensory and keeping quality of KZ might improve by the addition of ginger solution concentrates in a certain proportion so that shelf life and storage optimization can be improved.[16]

Materials and methods

Materials required for the production of Millet-based Kunun-zaki (MKZ) and Ginger concentration solution (GCS) include, Millet, Ginger (fresh), granulated sugar and potable water.

Sources of materials

The millet, ginger (fresh) and granulated sugar were purchased in Kaura-Namoda Central market, Kaura-Namoda. Other materials

used were sourced from the Federal Polytechnic, Kaura-Namoda, department of Food Technology, Food Processing workshop, for the production of MKZ and GCS are weighing balance, potable water, pressure cooker, stove, muslin cloth (0.0025mm), stainless pot, bowl (plastic), stirrer and thermometer.

Methodology for production of GCS

One method was adopted in the extraction of Ginger solution concentrates was a boiling method.[24,25]

Boiling method for the production of Ginger solution concentrates

5g of weighed ginger was peeled and sliced into small pieces, it was then ground with pestle and mortar in order to lose the tissues for easy penetration of water, then 95ml of potable water was added and it was brought to boil at 100°C for 5 minutes and allowed to cool to about 40°C and filtered with the clean muslin cloth of sieve size 0.0025mm. Other concentrations solutions of Ginger were prepared in the same manner as demonstrated in Table 1 and Figure 1.[24,26,27]

Methods for production of Millet-based Kunun-zaki

There are several methods employed in the production of MKZ. Methods such as the pre-fermentation, post-fermentation, and malting are always used in the preparation of MKZ.[7,9] For the purpose of this study the post-fermentation method was adopted and used for this study.

Production of millet-based Kunun-zaki by post fermentation process

250g of millet was sorted, cleaned and steeped in a potable water before it was wet-milled, the resulting slurry was divided into two portions (i.e. 250g and 50g), boiled water was poured on one slurry (250g) and allowed to cool before it was mixed vigorously with uncooked slurry (50g), the mixture was allowed to ferment for 14 hours at 40^{0}C,then sieved with clean muslin- cloth (0.0025mm) and was sweetened with sugar syrup (Figure 1).[7]

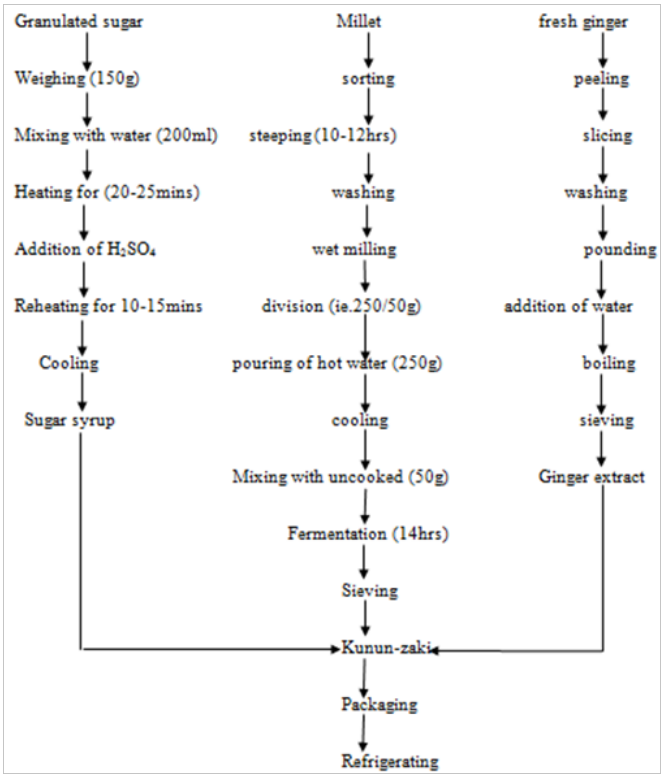

Figure 1 Process flow diagram for the production of KZ using ginger extract and sugar syrup.

Sources:[7,28]

Table 1 Preparation of Ginger solutions of various concentrations by boiling method

Sample	Weight of ginger (g)	Time (min)	Temperature (°C)	GCS (%)	Water (ml)
201	5	5	100	5	95
212	10	10	100	10	90
222	15	15	100	15	85
232	20	20	100	20	80
242	25	25	100	25	75

Procedure for the production of inverted sugar syrup

150g granulated sugar was weighed into a plastic bowl, mixed with 200ml of potable water and then heated for 25 minutes at 100°C, a drop of concentrated Sulphuric acid (H_2SO_4) was added and re-heated for 10-15minutes at 100°C, it was allowed to cool to form sugar syrup (Figure 1). The inversion of sucrose is the hydrolysis (i.e. breakdown) of Sucrose into monosaccharide Glucose and Fructose. Hydrolysis reactions are promoted by the presence of acid, enzyme or high temperature if this occurs in a beverage during storage, sweetness increases because Fructose is generated by the reaction. In addition, some of the factors that promote sucrose inversion are low storage, pH which means high acidity and high storage temperature. In some products, inversion is desirable and is created by the action of enzyme, inverters or by action of an acidulant.[28]

Addition of ginger Solution concentrations at different ratios in MKZ

Ginger concentration solutions (GCS) was added into the different samples of Millet-based Kunun-zaki (MKZ) as itemized in Table 2 below.

The Table 3 above is an illustration of how Ginger solution concentrates were added into Millet Kunun-zaki (MKZ) at different ratios and was subjected to pH determination for three days.

Procedure for pH determination

The determination of pH was carried out in triplicates. The pH was determined using reference pH Meter (Model 291 MK2PYE UNICAM, England). The electrode was fixed on a pH meter and was

calibrated using screw and potable water at 7.2, then 10ml of MKZ was taken from each sample into six cleaned beakers, the pH metre was dipped into each sample for three times and the reading were all recorded. This was done for 72hours (i.e. 3 consecutive days).[13]

Table 2 A summary of ratios of GCS added into MKZ

Sample	MKZ (ml)	GCS (%)	GCS (ml) ratio
200	100	0	0
201	95	5	5
212	90	10	10
222	85	15	15
232	80	20	20
242	75	25	25

Table 3 Results of pH values of MKZ Samples for 24 hrs (day 1)

Serial no.	Sample code	pH
1	200	5.2±0.20^{b}
2	201	5.0±0.26^{b}
3	212	5.1±0.10^{a}
4	222	5.0±0.10^{a}
5	232	4.9±0.16^{c}
6	242	4.9±0.15^{c}

[1]Each value is the mean standard error (±) of triplicate determinations.
[2]Different letters within the same column with each test are significantly different ($p<0.05$).

Sensory evaluation

The sensory attribute (taste) of processed kunu-zaki was evaluated for three days consecutively by the same 10 panelists comprising of students of various departments from Federal Polytechnic Kaura-Namoda. The method used for this sensory analysis is ranking method.[29,30]

Ranking method

Six samples that were coded 200 (KZ preserved with 0% GEC), 201 (KZ preserved with 5% GEC), 202 (KZ having 10% GEC), 222 (KZ having 15% GEC), 232 (KZ preserved with 20% GEC) and 242 (KZ preserved with 25% GEC) were presented along with score sheet (questionnaire) to 10 sensory panelists and they were asked to rank the samples based on mouth-feel only.[29,30]

During this ranking, the panelists are not allowed to have ties, thus the method will be forces choice.[31,32] The sample were ranked from most liked to least liked using the following numbers 5-1, where 5=least liked and 1=most liked, the ranking was done for every 24hrs for three days to actually detect the effect of ginger extract concentration on the sensory quality of processed KZ.

Results

Results of pH values of KZ samples

This part of the study presents and discusses the results of the pH values conducted on the samples of Kunun-Zaki (KZ) stored and observed for 72 hrs (i.e. 3 days, consecutively). The pH value of a food is a direct function of the free hydrogen ions present which are released into the food, which give foods that acidity and their distinct sour flavour.[33] This implies that if a food has a pH value of 3, then the concentration of hydrogen ions present in that food is equal to 10^{-3} (0.001) Moles/litre.[33]

Discussion

The results from pH of the day 1 analysis (Table 4) shows that the MKZ is acidic as a result of fermentation that took place during the production of MKZ which resulted to breaking down of carbohydrate-like substances by microorganisms, and the standard deviations indicated how closely the level of acidity in each sample is to each other ($p<0.05$).[29] The results of day 1 are agreement with the results reported by Obulunde & Ogunkoya;[34] Agarry & Nkama;[35] Maji & James;[1] Edward & Oheagbu.[36]

Table 4 Results of pH values of MKZ Samples for 48 hrs (day 2)

Serial no.	Sample code	pH
1	200	5.1±0.10^{a}
2	201	5.2±0.10^{a}
3	212	4.9±0.05^{b}
4	222	5.0±0.05^{b}
5	232	5.0±0.05^{b}
6	242	4.9±0.02^{c}

[1]Each value is the mean standard error (±) of triplicate determinations.
[2]Different letters within the same column with each test are significantly different ($p<0.05$).

Results of the pH values (Table 4) showed that there is no much difference in pH values of day 2 and that of day 1 probably because of the effect of GSC and cold storage condition (4-5°C for 24-48 hrs) that the samples of MKZ were preserved with GSC of various concentrations and stored in the refrigerator during the 2 days of study which as a result of that likely inhibits further fermentation of the samples. Also, the results of day 2 are in agreement with the results of Obulunde & Ogunkoya;[34] Agarry & Nkama;[35] Maji & James;[1] Edward & Oheagbu.[36]

Results of the pH values (Table 5) showed that the level of acidity has increased because of the pH values dropped from 5.1 to the ranges of 3.2 to 3.4 suggesting that there was further lactic fermentation during storage possibly due to the activities of lactic acid bacteria (LAB) as a result of the accelerated growth of the LAB making the samples of the MKZ more acidic.[12,37,38]

Table 5 Results of pH values of MKZ samples for 72hrs (day 3)

Serial no.	Sample code	pH
1	200	3.32±0.02^{c}
2	201	3.16±0.15^{b}
3	212	3.30±0.1^{a}
4	222	3.13±0.15^{b}
5	232	3.40±0.1^{a}
6	242	3.40±0.1^{a}

[1]Each value is the mean standard error (±) of triplicate determinations.
[2]Different letters within the same column with each test are significantly different ($p<0.05$).

Also, the results of day 3 are in close agreement with the results of Obulunde & Ogunkoya;[34] Agarry et al.;[35] and Edward & Oheagbu.[36]

Also, the drop in pH may be as a result of greater microbial activities since this decrease was more observed in the control samples having 0% GSC. The high rate of change in pH with storage days could be due to the decomposition of fermentable substrates and sugars by microorganisms especially *Lactobacillus* species, a lactic acid bacteria, which could comfortably ferment carbohydrates to produce energy and lactic acid.[12,36]

Results of Sensory analysis of samples of KZ stored and observed for 3 days

This part of the study presents and discusses the results of the sensory evaluation conducted on the samples of ZD stored and observed for 3 days (Table 6–10).

Table 6 Results of sensory evaluation (ANOVA) conducted for day1 6

Sources of variation	Df	Ss	Ms	F. cal	F. tab
Samples	5	6.020	1.20	4.4	4.03
Judges	9	2.43	0.27		
Error	45	34.18	0.76		
Total	59				

Table 7 Summary of ranked results of sensory evaluation conducted for day1

Samples	T. cal	T. tab	Remark
200 – 212	-0.57	1.18	SD
200 – 201	0.32	1.18	SD
201 – 222	0.65	1.18	SD
201 – 232	0.40	1.18	SD
212 – 242	-0.07	1.18	SD
242 – 200	0.26	1.18	SD

Table 8 Results of sensory evaluation (ANOVA) conducted for day 2

Sources of variation	Df	Ss	Ms	F. cal	F. tab
Samples	5	26.42	5.28	18.21	4.03
Judges	9	2.59	0.29		
Error	45	13.52	0.30		
Total	59				

Table 9 Summary of ranked results of sensory evaluation conducted for day 2

Samples	F. cal	F. tab	Remark
232 – 242	0.92	0.72	NSD
222 – 242	0.92	0.72	NSD
200 – 212	-0.55	0.72	SD
200 – 232	-0.01	0.72	SD
242 – 212	0.38	0.72	SD
242 – 232	0.92	0.72	NSD

Results of the sensory evaluation of samples of KZ (Table 7) on day 1 showed that there is significant different (P<0.05) on the taste of each sample ranked by the sensory panelists because calculated values (T. cal) are greater that the tabulated values (T. tab).[29,30]

The summary of sensory analysis (Table 8) showed that the calculated value is 18.21, and is greater that the tabulated value (4.03); therefore, there is significant different (P<0.05). [29,30] Results in Table 9 indicated that Kunu zaki (KZ) preserved with ginger extract concentrate (GEC) samples 222 (KZ preserved with 15% GEC), 232 (KZ preserved with 20% GEC) and 242 (KZ preserved with 25% GEC) are significantly having better taste than samples 200 (KZ preserved with 0% GEC), 201 (KZ preserved with 5% GEC) and 212 (KZ preserved with 10% GEC) probably due to the concentrations of GEC added into the KZ and storage condition (4-5°C) the KZ was stored at for 2 days and immediately after production (P<0.05).[29,30]

Table 10 Results of sensory evaluation (ANOVA) conducted for day 3

Sources of variation	Df	Ss	Ms	F. cal	F. tab
Samples	5	6.43	1.29	4.96	4.03
Judges	9	2.36	0.26		
Error	45	34.68	0.77		
Total	59				

The summary of sensory analysis (Table 10) showed that the calculated value is 4.96 is greater that the tabulated value (4.03) therefore, there is significant different (P<0.05).[29,30]

Results presented in Table 11 indicated that there is significant different (P<0.05) on the taste of all the samples of KZ ranked by the sensory panelists on day 3 because the tabulated value (1.18) is greater that all the calculated values (T. cal).[29,30]

Table 11 Summary of ranked results of sensory evaluation conducted for day 3

Samples	T. cal	T. tab	Remark
200 – 222	1.00	1.18	SD
200 – 201	0.78	1.18	SD
212 – 232	0.51	1.18	SD
232 – 200	-0.42	1.18	SD
222 – 200	1.00	1.18	SD
242 – 232	0.13	1.18	SD

Discussion

Sensory evaluation results imply that MKZ organoleptic qualities including aroma, colour, taste (mouth feel) and overall acceptability remain accepted by the sensory panelist for 72 hrs especially by the samples of MKZ that have 15%, 20% and 25% Ginger concentrations in them; while the sample with 0% (control), 5% and 10% samples were less accepted by sensory judges in terms of all the attributes listed (P<0.05).

Also, this study submits that the use of inverted sugar syrup, a honey-like sugar product, in sweetening the MKZ can serve as a means of making available simple sugars including Fructose and Glucose in free form for consumers; the glycemic index of Fructose is 19 compared to that of Glucose which is 100.[14] Inverted sugar syrup contains high amounts of Fructose; and several studies have shown that the anti-diabetic and hypoglacaemic effect of honey resulted from the Fructose component; owing to the fact that Fructose increase the uptake of hepatic Glucose as well as storage and synthesis of glycogen.[14,39,40–42] It has been recently reported that Fructose has the ability to lower the blood Glucose in animals' models of diabetes; and the mechanisms involved in this process include prolongation of gastric emptying time and reduced rate of intestinal absorption, stimulation of glucokinase in the hypatocytes which plays an

important role in the uptake and storage of Glucose as glycogen by the liver under the adipose tissues of the body.[14]

Although, there are some studies that reported contrary opinions regarding the use of honey in the control and management of diabetes mellitus diseases, other several research findings favourably discuss and opined that honey with high amounts of Fructose can be used to manage and control Type 2 diabetes. Hence, the need for larger sample sized; multi-centre clinical controlled studies so that better and reliable conclusion can be drawn.[14] In essence, the use of inverted sugar syrup to improve the taste of MKZ in this study can conveniently suggest that this developed MKZ can be consumed in moderation by an individual suffering Type 2 diabetes because the major component of this processed sugar product is Fructose.

Based on the results in this study, the pH values of samples of Millet-based Kunu Zaki (MKZ) were stable for 2 days, but dropped in day 3 due to the breakdown of complex sugars in the KZ by the action of micro-organisms and enzymes' activities leading to the increase in the acid level of MKZ samples within 72 hrs of MKZ production. And the results of sensory evaluation revealed that ginger extract concentrate (GEC) added into the processed Kunu zaki (KZ) enhanced the shelf-life of samples 222 (KZ preserved with 15% GEC), 232 (KZ preserved with 20% GEC) and 242 (KZ preserved with 25% GEC) for 48-72 hr. This is because these samples (222, 232 and 242) of KZ were preferred ($P<0.05$) by the sensory judges during day 1 and day 2, respectively.

Conclusion

In conclusion, the pH of MKZ can be controlled for 2 to 3 days by the addition of 15%, 20% and 25% of GSC, respectively and subsequent storing at 4-5°C ($P<0.05$). This study indicates that this process could serve as the standard operating procedure (SOP) for the commercial production of MKZ for a willing entrepreneur.

Acknowledgments

None.

Conflicts of interest

Author declares that there is none of the conflicts.

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