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Effect of *Aframomum danielli* Extract on the Quality of Non Alcoholic Malt Beverage Produced from Quality Protein Maize (QPM) at Storage

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Abstract Non alcoholic malt beverage from maize and other cereals has a short shelf life. The aim of this study was to evaluate the effect of *Aframomum danielli* extract on the shelf life of non alcoholic quality protein maize (QPM) malt beverage stored at ambient and refrigerated conditions. The stored malt samples were assessed for physical observation, physicochemical characteristics, microbial properties and sensory qualities. The results showed that non *Aframomum danielli* treated sample at ambient temperature was spoilt by day 3. *Aframomum danielli* treated sample at refrigerated condition was wholesome till day 28. The pH reduced with days of storage in all the malt beverage samples. Non *A. danielli* treated sample at refrigerated condition had the highest °Brix. Total viable count was least in *A. danielli* treated malt sample at refrigerated condition (day 28). *A. danielli* treated malt sample at refrigerated condition was acceptable throughout the storage period for sensory attributes. Malt beverage could be produced from quality protein maize (a maize variety with twice lysine content than in ordinary maize). QPM malt beverage treated with *A. danielli* could keep for 7 days at ambient temperature and 28 days at refrigerated condition. With the shelf-life findings in this study, QPM malt beverage could be produced, consumed and sold at household and small scale levels.

Keywords: *QPM malt beverage, Aframomum danielli, ambient, refrigerated, preservation*

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1. Introduction

Malt beverage is a non alcoholic, energy providing and satisfying food drink. Beverages are usually produced from a wide variety of raw materials including fruits, vegetables and cereal grains. They provide the body with energy, proteins, vitamins and minerals [1]. During production of malt beverage, cereals are first subjected to malting. Malting is a process of initiating growth in moistened cereals. During malting, the grains are modified physically, chemically and biologically [2] during which desirable changes of starch and protein hydrolysis take place.

Maize (*Zea mays* L.) serves as the major source of dietary protein for weaning children, sick adults and children in Nigeria. It is also consumed during lean crop production cycles since it has a biological nutritional value of 40% of that of milk. Quality protein maize is an improved maize variety which was found to contain about twice the levels of lysine and tryptophan and 10% higher grain yield than the most modern varieties of tropical maize. A high level of these two amino acids not only enhances the manufacture of complete proteins in the body, but also offers 90% of the nutritional value of skim milk, thereby alleviating malnutrition [3,4]. The nutritive value of QPM both as human food, especially for women and children and as animal feed for pigs, poultry and other livestock have been reported [4,5,6].

At present, there is a global concern with the use of chemical preservatives in foods due to carcinogenic and mutagenic related problems. The use of spices with antioxidant and antimicrobial properties has been found useful in providing health benefits and preservation qualities in foods. Examples of such spices include ginger (*Zingiber officinale*), garlic (*Allium sativum*), black pepper (*Xylopia aethiopica*), cloves (*Eugenia aromatica*) and alligator pepper (*Aframomum danielli*). Essential oil of *A. danielli* was found to contain cineole, pinene and terpinene as major constituents [7]. The natural spice, *A. danielli* is known to possess preservative properties [8]. It is rich in nutrients and antioxidants, its potential as antibacterial agent in food preservation has been reported [9]. The preservative effect of the powder of *A. danielli* has been associated with phytochemical components tentatively identified as alkaloids [7].

A number of fruit drinks manufactured from fruit juice and other natural ingredients are popular and are sold

worldwide [10]. Non alcohlolic beverages have been made from maize, millet and sorghum [11]. Production of non alcoholic beverage from QPM may yield beverage of better protein quality. Furthermore, non alcoholic malt beverages have short shelf – life of one to two days at ambient temperature [12]. The study therefore aimed at utilizing this nutritious crop to process non alcoholic beverage and extending its shelf life using natural spice *A. danielli* as preservative.

2. Materials and Methods

2.1. Source of Materials

Quality protein maize (SW1) was obtained from the seed store of Institute of Agricultural Research and Training, Ibadan, Nigeria. Spice, *Aframomum danielli* was purchased from Oja Oba market, Ibadan, Nigeria and characterized at the Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria.

2.2. Malting of the Maize Grains

Malting of the grain maize was done using the modified method of [13]. Quality protein maize grains (1.5 kg) were soaked in 1000 ml of water at ambient temperature for 18 hr. After which the grains were drained and spread on a tray lined with moistened cotton wool. The wet grains were placed in dark room. Water (200 ml) was sprinkled twice daily on the maize at regular intervals to keep the grains moist and active and prevent mould growth. The grains were left in the dark room for 4 days during which the grains germinated. After germination, the grains were dried in an oven (Apex B35E, London) at 50°C for 18 hr and the vegetative parts were removed by rubbing grains between the palms. The dried malted grains were then roasted in an open frying pan for 10 mins with intermittent stirring. The roasted grains were cooled, milled into grits and packaged in high density polyethylene bags.

2.3. Preparation of Cold Extraction of *Aframomum danielli* Spice

Extraction of *Aframomun danielli* spice was carried out using the method described by [7] with slight modification. *Aframomum danielli* seeds were sorted, cleaned and oven-dried at 40°C for 24 hr. The dried seeds were pulverized into powder using blender (Margic blender pentunjik penggunaam, Nikai, Japan). *A. danielli* extract, 5% (w/v) was prepared by weighing 5 g of the spice crude powder in 100 mL of distilled water. The suspensions were kept in the refrigerator for 5 days followed by centrifugation at 1118 x g for 30 min. Supernatant was collected as crude extract of the spice, the extract was pasteurized at 75°C for 30 minutes, kept in previously sterilized bottles and cooled at ambient temperature before storing in a refrigerator (4°C) until used.

2.4. Preparation of the Malt Beverage

Malt beverage was prepared according to the method described by [13] with slight modification. Roasted malted QPM grit (500 g) was placed in cooking pot, 2000 ml of water was added (1:4). This was allowed to steam for about 50 min to form mash. Sugar (50g) was added to the mash. The mash was allowed to stand for 10 mins to allow for sedimentation before it was filtered using muslin cloth. Preliminary sensory evaluation was carried out on the malt beverage using various concentration of *A. danielli* extract of between 1 to 10 % concentrations. *Aframomum danielli* extract (5% concentration) was added to the malt beverage in ratio 95:5 i.e 95 ml of malt beverage and 5 ml of 5% *A. danielli* extract. The formulated malt beverage was then pasteurized at 75°C for 10 mins. After pasteurization, the beverage was allowed to cool and dispensed in clean plastic pet bottles. The bottled malt beverages were pasteurized again at 65°C for 30 mins. The bottles were laid on their side to cool. The cooled beverages were then stored as appropriate (ambient and refrigeration conditions) for between 0 and 35 days

2.5. Physical Observation of the QPM Malt Beverage at Storage

The plain malt beverage and *Aframomum danielli* treated malt beverage samples at ambient and refrigerated conditions were physically observed using visual appearance for colour, foaming, whey separation and smell characteristics.

2.6. Determination of pH, Titratable Acidity and °Brix in the Malt Beverage Samples

The pH of the malt beverage was measured using a pH meter (ATC, Model HI-8915) and °Brix was measured using a hand-held refractometer (MASTER-53α, Japan) [14]. The titratable acidity was determined using titrimetric method described by [15] in which the beverage sample was titrated against NaOH (0.1N) using phenolphthalein as indicator to a faint pink end point and total acidity expressed as percent of malic acid equivalent.

2.7. Microbial Determination of the Malt Samples

Microbial count of the malt beverage samples was determined using pour plate method described by [16]. Sample (1ml) of the appropriate dilution was plated out in triplicates on Nutrient agar (NA), Potato dextrose agar (PDA) and Mannitol salt agar to enumerate the total viable count, fungi count (Yeast and mould) and Staphylococcus count, respectively. The NA and mannitol salt plates were incubated at 35 °C for 24 hr while potato dextrose agar plates were incubated at 28 °C for 48 hr after which colony forming unit per ml sample (cfu/ml) was estimated.

2.8. Sensory Evaluation of the Malt Beverage Samples

Freshly prepared and stored malt beverage samples (Plain and *Aframomum* treated samples) were coded and presented to 20 semi trained panel of judges who are familiar with non alcoholic malt beverages. The malt beverage samples were compared with the commercial malt beverage (Hi malt). The panelists were asked to score

the samples for colour, flavour, taste, after taste and overall acceptability using 9 point Hedonic scale, where 9 = like extremely and 1= dislike extremely [17]

2.9. Statistical Analysis

All determinations were carried out in duplicates. Means, standard error and 95% confidence interval were determined. The results were subjected to one way ANOVA using descriptive and inferential statistics (SPSS version 17). Means were separated by Duncan multiple range Test. Significance was accepted at 5% level.

3. Results and Discussion

3.1. Physical Observation of the Malt Beverage Samples at Storage

The result of the physical observation of the QPM malt beverage samples are shown in Table 1. Sample A (plain malt at ambient temperature) was wholesome till day 3. On day 7, foaming and separation of liquid whey was observed and the sample smelled spoilt. Warm condition of the ambient temperature must have favored the growth of spoilage microorganisms which must have produced gas that caused the foaming. Sample B (malt beverage + *Aframomum danielli* at ambient temperature) was wholesome till day 7. Thereafter, colour change, foaming, separation of whey and spoilt odor were observed after day 7. This is an indication that the preservation power of the spice had positive effect on the spoilage microorganism at ambient till day 7. Sample C (plain malt beverage at refrigerated temperature) was wholesome till day 14. Slight colour change and reduced flavour were observed after day 14. Foaming and whey separation and disagreeable odor were observed from day 21. Sample D (malt beverage + *A. danielli* at refrigeration condition) was wholesome till day 28. Slight changes in colour and odour were observed after day 28 (Table 1).

Pasteurization must have assisted the keeping quality of the malt beverages both at ambient and refrigerated conditions while pasteurization and addition of *A. danielli* must have improved the keeping quality of the *A. danielli* preserved sample.

3.2. pH, Titratable Acidity and °Brix

The result of the pH, titratable acidity (TTA) and the percentage sugar (°Brix) of the malt beverage samples are shown in Table 2. The pH reduced with days of storage in all the malt beverage samples. *Aframomum danielli* treated sample had higher pH value over the plain malt sample at day 0. There was no significant difference ($p > 0.05$) in the pH of plain malt and *A. danielli* treated sample stored at ambient temperature on day 3. The reduction in pH was more prevalent at ambient temperature storage and this could be due to elevated microbial activities resulting in production of organic acids from the sugars present in the samples while at refrigeration condition, microbial activities were reduced. [18] similarly reported that decreased in pH of kununzaki preserved with different preservatives was due to microbial activities resulting in production of organic acids from carbohydrate substrates. The result is also similar to the report on preservation of warankashi with *A. danielli* [9]. The pH values of all the malt beverage samples are close to pH value of between 5.0 and 5.21 reported by [13] and the pH values of between 3.5 and 5.0 suggested for malt beverages. Decreases in pH with storage could be attributed to growth of microorganisms which produced acids. Similar trend was reported on the use of *A. danielli* for preservation of soymilk based juice [19]. The titratable acidity (TTA) increased with storage period which corresponded to decrease in pH of the malt beverage samples (Table 2). There was no significant difference ($p > 0.05$) in the TTA of samples C and D on the day 28. The °Brix decreased with days of storage in the malt beverage samples. The values ranged between 7.9 and 10.0 with sample B having the highest °Brix value. Non alcoholic beverage should have a value not less than 8 °Brix [20]. The values of °Brix reported in this study are within the range specified by Ghana Standard Authority (GSA). Low values recorded on days 21 to 35 is an indication that most of the sugars in the beverage samples could have been utilized at this stage due to microbial activities. However *A.danielli* treated sample at refrigerated condition had higher values of sugar than the non *A.danielli* treated samples, an indication that microbial activities that could lead to depletion of the sugar was reduced by the action of *A.danielli* in the beverage and subsequently the spoilage.

3.3. Microbial Evaluation of the Malt Beverage Samples during Storage

The results of the microbial evaluation of the QPM malt beverage during storage are presented in Table 3. Total viable count (TVC) increased with storage days in plain malt (A) at ambient temperature. It increased from 7.29 cfu/mL on day 0 to 8.64 cfu/mL on day 3 and the count became too numerous to count (TNTC) from day 7 hence the TVC was not determined again after day 7 in Sample A. The result of the TVC agreed with the result of the physical observation of the malt beverage in this study, which showed that plain malt beverage at ambient temperature without addition of *A. danielli* was spoilt by day 7 of storage. Total viable count (TVC) decreased from 7.23 cfu/mL on day 0 to 7.11 cfu/mL on day 14, after which the count increased to 8.37 cfu/mL on day 21 and too numerous to count (TNC) on day 28 in Sample B. Yeast count increased with days of storage in the malt samples stored at ambient temperature. The yeast count increased from 4.10 cfu/mL on day 3 to 5.0 cfu/mL on day 7 in Sample A while it increased from 3.65 cfu/mL on day 3 to 4.70 cfu/mL on day 14 in Sample B. Total viable count (TVC) reduced with days of storage in plain malt (C) at refrigeration condition till day 7 of storage after which it increased on day 14 and to too numerous to count (TNTC) on days 21 and 28. TVC decreased till day 28 in *Aframomum* treated sample (D) at refrigeration condition, similar to the report obtained for *Kunun-zaki* stored under various preservative regimes [21]. There was no significant difference ($p > 0.05$) in the total viable count of sample C and D on day 14, but TVC was significantly different ($p < 0.05$) on days 21 to 35. There was no yeast,

mould and Staphylococus growth in refrigerated malt beverage samples. Similar observation of no yeast and mould growth in *kununzaki* preserved and stored under refrigerated condition was reported [22]. There was no mould growth in any of the malt beverage samples at storage. This might probably be due to the liquid nature of the samples. There was also no Staphylococcus count in any of the malt beverage samples.

3.4. Sensory Evaluation of the Malt Beverage Samples at Storage

The results of the sensory evaluation of the malt beverage samples at storage are shown in Table 4a and Table 4b. On day 0, the plain malt (A) and *Aframomum danielli* treated sample (B) were evaluated with the commercial malt (Z). There was no significant difference ($p>0.05$) in the colour, flavor, taste and overall acceptability of sample A and B. The commercial malt (Z) had the highest scores in all the sensory attributes evaluated (Table 4). On day 3, both ambient and refrigerated malt samples were evaluated and compared with the commercial malt drink. There was no significant difference ($p>0.05$) in the colour of non *A. danielli* treated sample at refrigerated condition (C) and *A. danielli* treated sample at refrigerated condition (D) There was also no significant difference ($p>0.05$) in the taste of B and C. Sample Z was the most preferred in all the attributes tested (Table 4a and Table 4b). On day 7, plain malt at ambient temperature (A) was not evaluated because it was spoilt. Samples B, C and D were evaluated and compared with Z. There was no significant difference ($p<0.05$) in the colour of C and D. Sample Z had the highest acceptability followed by sample D. On day 14, samples C and D were evaluated and compared with the commercial malt (Z). Sample C had the least score in all the sensory attributes evaluated but it was still accepted. Only Sample D was compared with the commercial malt beverage on days 21 and 28. Although sample Z had the higher score in the sensory attributes tested, sample D was accepted.

The malt beverage samples were stored for 35 days but were not evaluated for sensory after 28 days because the physical observations (Table 1) already showed that the samples were not wholesome after 28 days.

Table 1. Physical observation of the QPM malt beverages during storage

Sample	D0	D3	D7	D14	D21	D28	D35
				Colour			
A	OK	OK	Not OK	Spoilt	Spoilt	Spoilt	Spoilt
B	OK	OK	OK	Not OK	Not OK	Spoilt	Spoilt
C	OK	OK	OK	OK	Not OK	Spoilt	Spoilt
D	OK	OK	OK	OK	OK	OK	Not OK
				Foaming and Separation of liquid whey			
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	OK	OK	Not OK	Spoilt	Spoilt	Spoilt	Spoilt
B	OK	OK	OK	Not OK	Not OK	Spoilt	Spoilt
C	OK	OK	OK	OK	Not OK	Spoilt	Spoilt
D	OK	OK	OK	OK	OK	OK	Not OK
				Smell			
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	OK	OK	Not OK	Spoilt	Spoilt	Spoilt	Spoilt
B	OK	OK	OK	Not OK	Not OK	Spoilt	Spoilt
C	OK	OK	OK	OK	Not OK	Spoilt	Spoilt
D	OK	OK	OK	OK	OK	OK	Not OK

KEY: A = Plain QPM malt beverage at ambient temperature, B= QPM malt beverage + *Aframomum danielli* at ambient temperature, C = Plain QPM malt beverage at refrigeration temperature, D = QPM malt beverage + *Aframomum danielli* at refrigeration temperature, OK= wholesome.

Table 2. pH, Titratable acidity (TTA) and °Brix of the QPM malt beverages during storage

Sample	D0	D3	D7	D14	D21	D28	D35
				pH			
A	5.56± 0.11^{b}	5.30±0.07^{c}	ND	ND	ND	ND	ND
B	5.62±0.07^{a}	5.30±0.09^{c}	4.67±0.11^{c}	ND	ND	ND	ND
C	ND	5.48±0.09^{b}	5.45±0.07^{b}	5.33±0.07^{b}	5.25±0.08^{b}	5.21 ±0.10^{b}	5.20±0.11^{b}
D	ND	5.65±0.07^{a}	5.61±0.0^{a}	5.55±0.11^{a}	5.32±0.10^{a}	5.29 ±0.10^{a}	5.25±0.11^{a}
				TTA			
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	0.07±0.00^{b}	0.09±0.01^{a}	ND	ND	ND	ND	ND
B	0.09±0.01^{a}	0.11±0.07^{a}	0.12±0.00^{a}	ND	ND	ND	ND
C	ND	0.09±0.01^{a}	0.11±0.01^{a}	0.13±0.01^{a}	0.18±0.01^{a}	0.21±0.01^{a}	0.25±0.09 ^{a}
D	ND	0.05±0.00^{b}	0.07±0.00^{b}	0.07±0.00^{b}	0.10±0.00^{b}	0.11±0.01^{b}	0.17±0.10^{b}
				°Brix			
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	9.80±0.09^{b}	9.60±0.11^{b}	ND	ND	ND	ND	ND
B	10.0±0.11^{a}	9.90±0.07^{a}	9.80±0.11^{a}	ND	ND	ND	ND
C	ND	9.00±0.11^{c}	9.00±0.07^{c}	8.90±0.11^{b}	8.80 ±0.10^{a}	8.00 ±0.11^{b}	7.90 ± 0.08^{a}
D	ND	9.50±0.11^{b}	9.40±0.11^{b}	9.20±0.09^{a}	8.9±0.08^{a}	8.20±0.08^{a}	7.90 ± 0.08^{a}

Means followed by the same superscript within a column are not significantly different ($p<0.05$)
A = Plain QPM malt beverage at ambient temperature, B= QPM malt beverage + *Aframomum danielli* at ambient temperature, C = Plain QPM malt beverage at refrigeration temperature, D = QPM malt beverage + *A. danielli* at refrigeration temperature, ND = Not determined.

Table 3. Microbial count of the QPM malt beverages during storage

Sample	Total viable count (log cfu/ml)						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	7.29± 0.01[a]	8.64± 0.01[a]	TNTC	TNTC	ND	ND	ND
B	7.23± 0.02[b]	7.21± 0.03[c]	7.18± 0.01[a]	7.11± 0.02[b]	8.37±0.01[a]	TNTC	ND
C	ND	7.25± 0.02[b]	6.25± 0.01[c]	7.21± 0.01[a]	TNTC	TNTC	ND
D	ND	7.21±0.02[c]	7.19± 0.02[b]	7.18± 0.01[a]	6.72±0.01[b]	6.22±0.01	7.88±0.02
	Staphylococcus count (log cfu/ml)						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	NIL	NIL	NIL	ND	ND	ND	ND
B	NIL	NIL	NIL	NIL	NIL	ND	ND
C	ND	NIL	NIL	NIL	NIL	NIL	NIL
D	ND	NIL	NIL	NIL	NIL	NIL	NIL
	Fungi (yeast and mould) count (log cfu/ml)						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	NIL	4.10± 0.02[a]	5.00± 0.01[a]	ND	ND	ND	ND
B	NIL	3.65± 0.03[b]	3.30± 0.01[b]	4.70± 0.01	ND	ND	ND
C	ND	NIL	NIL	NIL	NIL	NIL	NIL
D	ND	NIL	NIL	NIL	NIL	NIL	NIL

Means followed by the same superscript within a column are not significantly different ($p<0.05$)
A = Plain QPM malt beverage at ambient temperature, B= QPM malt beverage + *Aframomum danielli* at ambient temperature, C = Plain QPM malt beverage at refrigeration temperature, D = QPM malt beverage + *Aframomum danielli* at refrigeration temperature, ND = Not determined, NIL = No growth, TNTC = Too numerous to count.

Table 4. Sensory evaluation of the QPM malt beverages during storage

Sample	Colour						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	6.2 ± 0.12[b]	5.2 ± 0.12[d]	ND	ND	ND	ND	ND
B	6.0 ± 0.08[b]	5.7 ± 0.02[c]	5.6 ± 0.08[c]	ND	ND	ND	ND
C	ND	6.1± 0.12[b]	5.9 ± 0.02[b]	5.5 ± 0.05[c]	ND	ND	ND
D	ND	6.2 ± 0.12[b]	6.1± 0.06[b]	5.9 ± 0.08[b]	5.8 ± 0.02[b]	5.5 ± 0.02[b]	ND
Z	8.1 ± 0.02[a]	7.9± 0.05[a]	7.9± 0.12[a]	7.9 ± 0.10[a]	7.9 ± 0.08[a]	7.9 ± 0.02[a]	ND
	Flavour						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	7.5 ± 0.08[b]	5.4 ± 0.05[e]	ND	ND	ND	ND	ND
B	8.2 ± 0.01[b]	6.7 ± 0.08[d]	6.5 ± 0.05[c]	ND	ND	ND	ND
C	ND	7.0 ± 0.12[c]	6.9± 0.05[c]	6.1 ± 0.05[c]	ND	ND	ND
D	ND	7.7± 0.08[b]	7.5± 0.08[b]	6.8 ± 0.05[b]	6.7± 0.02[b]	6.1± 0.08[b]	ND
Z	8.6 ± 0.02[a]	8.6 ± 0.05[a]	8.2 ± 0.05[a]	8.2 ± 0.02[a]	8.1 ± 0.05[a]	7.9 ± 0.02[a]	ND
	Taste						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	8.0 ± 0.12[b]	6.6 ± 0.12[d]	ND	ND	ND	ND	ND
B	8.1 ± 0.02[b]	7.2 ± 0.02[c]	6.2 ± 0.08[d]	ND	ND	ND	ND
C	ND	6.8 ± 0.12[c]	5.5 ± 0.02[c]	5.2 ± 0.05[c]	ND	ND	ND
D	ND	7.6 ± 0.02[b]	7.0± 0.12[b]	6.8 ± 0.02[b]	6.5± 0.08[b]	6.1 ± 0.02[b]	ND
Z	8.6 ± 0.05[a]	8.5 ± 0.08[a]	8.2 ± 0.02[a]	8.2 ± 0.10[a]	8.2± 0.05[a]	7.9 ± 0.02[a]	ND
	Aftertaste						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	7.6 ± 0.02[b]	5.2 ± 0.05[d]	ND	ND	ND	ND	ND
B	7.1 ± 0.02[b]	6.6± 0.05[b]	6.2 ± 0.05[c]	ND	ND	ND	ND
C	ND	6.2 ± 0.02[c]	5.7 ± 0.04[d]	5.7± 0.08[c]	ND	ND	ND
D	ND	6.6 ± 0.02[b]	6.5 ± 0.05[b]	6.1 ± 0.02[b]	5.9 ± 0.05[b]	5.9 ± 0.12[b]	ND
Z	8. 2 ± 0.02[a]	8.1 ± 0.05[a]	8.1 ± 0.03[a]	8.1± 0.08[a]	8.0 ± 0.02[a]	7.8 ± 0.08[a]	ND
	Overall acceptability						
	D0	**D3**	**D7**	**D14**	**D21**	**D28**	**D35**
A	7.0 ± 0.02[b]	6.1 ± 0.12[d]	ND	ND	ND	ND	ND
B	6.8 ± 0.12[b]	6.6± 0.05[d]	6.1 ± 0.08[d]	ND	ND	ND	ND
C	ND	7.0 ± 0.02[c]	6.6 ± 0.12[c]	5.6 ± 0.08[c]	ND	ND	ND
D	ND	6.9± 0.02[b]	6.9 ± 0.02[b]	6.7± 0.10[b]	6.6 ± 0.02[b]	6.1± 0.02[b]	ND
Z	8.4 ± 0.08[a]	8.4 ± 0.08[a]	8.2 ± 0.02[a]	8.2 ± 0.10[a]	8.2± 0.01[a]	8.1 ± 0.02[a]	ND

Means followed by the same superscript within a column are not significantly different ($p<0.05$). A = Plain QPM malt beverage at ambient temperature, B= QPM malt beverage + *Aframomum danielli* at ambient temperature, C = Plain QPM malt beverage at refrigeration temperature, D = QPM malt beverage + *Aframomum danielli* at refrigeration temperature, Z = Commercial malt beverage (Hi malt), ND = Not determined.

4. Conclusions

The study concluded that extract of *Aframomum danielli* spice has preservative effect on the keeping quality of malt beverage produced from quality protein maize (QPM). QPM malt beverage without addition of *A. danielli* as preservative could keep at ambient temperature for 3 days and at refrigeration temperature for 14 days while QPM malt beverage with addition of *Aframomum danielli* as preservative could keep at ambient temperature for 7days and at refrigeration temperature for 28 days. QPM malt beverage could be produced, consumed and sold at household and small scale levels. Further work should be carried out on the extension of the shelf life of *Aframomum danielli* preserved malt beverage beyond 4 weeks for scaling up the commercialization of the product.

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