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Vol. 15(46), pp. 2627-2636, 16 November, 2016
DOI: 10.5897/AJB2016.15581
Article Number: D7BC1BA61703
ISSN 1684-5315

http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Shelf life improvement of sorghum beer (pito) through the addition of *Moringa oleifera* and pasteurization

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Received 22 July, 2016; Accepted 7 September, 2016

Pito is a traditional alcoholic beverage that is mostly brewed in the three northern regions of Ghana. Although widely consumed and used in many festivities, poor storability limits its economic potential as an income-generating venture for most women. This study was carried out to improve the shelf-life of pito through the addition of *Moringa oleifera* leaf extract and pasteurization (75 to 80°C). Microbial enumeration, physico-chemical parameters (pH, extract (%) and alcohol) and consumer preference scores were used as quality indices of each pito treatment carried out. There was a general decline in coliform and fungi growth and in the physico-chemical (pH, extract (%) and alcohol) properties during the 56 days of storage. Microbial load, extract (%), alcohol content and pH were significantly different (P<0.05) among treatments. Pasteurized moringa pito had the least microbial load. The treated pito samples had higher values in pH, extract (%) and alcohol content than the untreated pito during storage. There was high consumer acceptability of pasteurized pito from the 0 day to the 28 days of storage, with a mean score of 4.27 ± 0.75 to 3.61 ± 1.36. However, the moringa treated pito (pasteurized moringa pito and moringa pito) was less preferred (with a mean score of 2.86 ± 1.19 to 1.87 ± 0.92) from the 0 day to the 28 days of storage. The untreated pito was also acceptable for a period of seven days. Based on the findings of this research, it can be concluded that pasteurization and/or the addition of *M. oleifera* leaf extract can improve the shelf-life of pito for four weeks, but addition of moringa extract in pito reduced consumer preference for it. Further research using other antimicrobial plants is recommended as consumers did not like pito with the *M. oleifera* leaf extract.

Key words: *Moringa*, pasteurization, pito, shelf-life, storage.

INTRODUCTION

The brewing and drinking of traditional beverages are intrinsic part of the culture of the African people. Traditional brewed beverages are characterized by good mineral composition such as calcium, magnesium,

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sodium, zinc, potassium and iron, which are necessary for regulating and building the living cells (Kolawole et al., 2007; Duodu et al., 2012) and also contain probiotic properties (Moslehi-Jenabian et al., 2010). One of such traditionally brewed beverage in Ghana is pito (sorghum beer). Pito is brewed and consumed by people of the West African sub regions (Demuyakor and Ohta, 1993). Pito brewing is usually processed at households by women and linked with the people of northern (Upper West, Upper East and Northern Region) Ghana. It is an income generating business which serves as a source of employment in areas in which they are produced. However, pito production is limited by short shelf-life; as a result, the product needs to be consumed within a day (Demuyakor, 1994).

The causes of short shelf-life of pito have been intensively studied. Microbial contamination and activity from poor pito brewing practices is mainly the cause of spoilage (Novellie, 1962; Ekundayo, 1969; Faparusi et al., 1973; Dirar, 1978; Tisekwa, 1989). These microbes include diverse array of bacteria and wild yeasts with lactic acid bacteria being the dominant spoilers (Sakamoto and Konings, 2003). Spoilage of pito is attributed to undesirable changes in sensory characteristics in terms of texture, smell, taste or appearance (Doyle, 2001) which lead to discarding the whole product. Microbial spoilage of alcoholic beverages is of critical importance hence, different methods have been adapted to reduce spoilage. Among these methods are thermal treatment (pasteurization), filtration and chemical treatment (addition of artificial preservatives) (Ellis et al., 2005; Onaghise and Izuagbe, 1989; Osseyi et al., 2011). Instances when pasteurized at 75°C for 30 min and addition of sorbic acid concentration of 5% improved the shelf-life of pito for a period of four weeks (Onaghise and Izuagbe, 1989). Some of these methods can be sophisticated and expensive for the small scale operator to adopt. Ellis et al. (2005) also improved the shelf-life of filtered pito for eight weeks by pasteurization (60 to 70°C for 15 min) and adding sodium metabisulphite. Increasing the shelf life of pito via chemical means such as sodium metabisulphite can have adverse effects such as respiratory tract irritation and anaphylactic symptoms which is life threatening (Pavord et al., 1991; Vally et al., 2009).

Although synthetic antimicrobial and antioxidant agents are approved in many countries, its usage has created environmental and health concerns, which has called for natural, safe and effective preservatives by consumers and producers (Ortega-Ramirez et al., 2014; Regnier et al., 2012). Ortega-Ramirez et al. (2014) proposed that medicinal plants traditionally used to treat health disorders and prevent diseases can serve as a source of bioactive compounds for food additives. This is because these medicinal plants are rich in antimicrobial phyto-chemicals. *M. oleifera* leaf, in that regard is also found to possess antimicrobial properties (Eilert et al., 1981). Information on the use of *M. oleifera* in the brewing of sorghum beer has not received any attention. Therefore, using pasteurization and a natural preservative (*M. oleifera*), which is easily accessible in Ghana and in the tropics (Fahey, 2005; Quarcoo, 2008) in pito comparatively can be less expensive.

In light of the highlighted aforementioned problem associated with the pito industry, ways are needed to supply it to the citizens in a more quality and presentable manner. Hence the relevance of this study is to improve the shelf-life of pito by the addition of *M. oleifera* leaves under producers' condition, combined with pasteurization at 75 to 80°C for 15 min.

MATERIALS AND METHODS

Sample collection

Moringa oleifera processing

Fresh young green moringa (*M. oleifera*) leaves were collected from the Nyankpala community into a clean polyethylene bag. The leaves were washed thoroughly under tap running water, and dried at a room temperature (29 ± 2°C) and relative humidity of 46.5 to 61.7% (Ghana Meteorological Agency, 2014) for 72 h. The dried leaves were milled into fine powder using Philips blender HR2000/16. The moringa powder was collected into a clean airtight bowl, and then stored in a refrigerator at 5°C.

Obtaining Moringa oleifera extracts

Dried moringa powder of 50 g was added to 500 ml distilled water in 1 litre conical flask, stoppered and kept for 1 week in a refrigerator (5°C) with periodical manual shaking. The extract was filtered using a clean, sterilized muslin cloth, and then boiled for 30 min with continuous stirring.

Sourcing of pito

Dagarti pito samples were obtained from a commercial brewer in Nyankpala Township, in the Tolon District of Northern Region. Dagarti pito was prepared as shown in the flow chart.

Treatments

In this study, four treatments were applied thus: untreated pito (control), pasteurised pito, moringa pito (moringa leaf extract + pito) and pasteurized moringa pito. Nine (9) litres of each treatment was dispensed from kegs into sterilised 300 ml glass bottles and crowned immediately using a manual hand crowner, then packaged into its respective box and labelled. Moringa pito treatments had *M. oleifera* extracts and pito in the ratio 1:3 (v/v). The ratio of moringa to pito was achieved through preliminary study of moringa pito, which showed that 25% moringa extract composition of the beverage was preferred by consumers. All pasteurised treatment samples were carried at 75 to 80°C for 15 min using a water bath. Pasteurised samples were allowed to cool before storage. The samples were stored for two months at an ambient temperature. Analysis were carried during 0, 7, 14, 28 and 56 days of storage.

Microbial analysis of samples

Microbial analysis was carried out for each treatment thus untreated

pito, pasteurised pito, moringa pito, and pasteurized moringa pito during 0, 7, 14, 28 and 56 days of storage. MacConkey agar and potato dextrose agar were used to determine coliforms and fungi (moulds and yeast), respectively. MacConkey agar and potato dextrose agar media were prepared using the manufacturer's protocol from Sigma-Aldrich. The pour plate method as described by Hoben and Somasegaran (1982) was used in the microbial count.

Analysis of physico-chemical properties

Four replicates of each treatment (untreated pito, pasteurized pito, moringa pito and pasteurized moringa pito) were sampled and examined for pH, sugar and alcohol levels at 0, 7, 14, 28 and 56 days of storage. The pH was determined using basic 20 pH meter and the hand held refractometer was used to measure extract % in mass saccharose. The alcohol content was carried out using the specific gravity method described by Mathapati et al. (2010).

Sensory evaluation of bottled pito

Sensory evaluation of each treatment (untreated pito, pasteurised pito, moringa pito, and pasteurized moringa pito) was assessed by 150 subjects (taste panel). The panel consists of students and lecturers of UDS Nyankpala Campus, as well as community members from Nyankpala, selected based on their familiarity with pito. Consumer preferences of the samples listed were compared at 0, 7, 14, 28 and 56 days of storage. Sensory ballot sheet was provided for each subject and the sensory scale adapted was the 5-point hedonic scale, just-about right scale and the forced-choice (yes/no) scale (Stone and Sidel, 2004). Samples were coded and presented to the assessors to indicate their preferences. Samples were served in clean, transparent plastic containers with tight lids.

Statistical analysis

Data obtained from the paired preference test were analysed using the Microsoft Excel Programme. All other data were subjected to analysis of variance (ANOVA) for variation of means of treatments with their respective period of storage, using the Genstat Discovery edition 4. Multiple mean comparisons were also carried out with the Minitab. Statistical significance was set at $P < 0.05$.

RESULTS

Microbial quality of samples during storage

Microbial quality of pito beverage in this study reveals the presence of enterobacteriaceae (coliforms) when samples were analysed on MacConkey. Coliform count of samples of untreated pito, pasteurized pito, moringa pito and pasteurized moringa pito were between 1.5×10^5 to 40×10^5, 2.6×10^5 to 3.1×10^5, 1.3×10^5 to 7.1×10^5 and 0.8×10^5 to 1.5×10^5, respectively during 56 days of storage (Figure 5). Coliform growth/population was significanlty different ($P < 0.05$) among treatment during storage. Coliform growth and population reduced in each pito treatment during the period of storage (Figure 2). Varied levels of coliforms were, however, observed with respect to treatments as well as the duration of storage.

There was a general decline of coliform growth during storage. Pasteurized pito, moringa pito and pasteurized moringa pito had similar ($P > 0.05$) coliform count. The treated pito (pasteurized, moringa and pasteurized moringa pito) showed a relative reduction of coliform growth as compared to the untreated pito 0 day of storage. The reduction of pasteurized moringa pito was two times that of the pasteurized pito and four times that of the moringa pito. The untreated pito recorded the highest coliform growth than the treated pito samples.

As in the coliform growth, there was also a general decline of fungi growth during storage (Figure 3). The study reveals the presence of fungi in each treatment. Mycological count of samples of untreated pito, pasteurized pito, moringa pito and pasteurized moringa pito ranged between 4.6×10^5 to 37×10^5, 2.1×10^5 to 0.9×10^5, 21×10^5 to 1.4×10^5 and 0.7×10^5 to 0.2×10^5, respectively within 56 days of storage as shown in Figure 5. Pasteurized pito and pasteurized moringa pito had the low fungi load compared to untreated pito and moringa pito prior to storage and after storage. There was significance difference ($P< 0.05$) in fungi population among treatments. Generally, pasteurized moringa pito had relatively low fungi load.

Physico-chemical properties

pH levels

The pH value of pito treatments during storage is presented in Figure 1. Untreated pito, pasteurized pito, morringa pito and pasteurized pito had pH between 3.2 to 3.4, 3.2 to 3.5, 3.5 to 3.2 and 3.2 to 3.6, respectively during the entire period of storage (Figure 4). pH values were decreased during storage. The pasteurized pito and pasteurized moringa pito showed significantly ($P < 0.05$) higher pH values than the untreated pito from the 0 day to the 56 days of storage and with moringa pito from 0 day to the 28 days of storage. The level of pH reduction in the untreated pito, moringa pito and pasteurized pito was 0.2, 0.1 and 0.04 times that of pasteurized moringa pito, respectively.

Levels of extract in % mass saccharose

Levels of extract (%) in the various treatment of pito during storage are shown in Figure 5. There was a general decline in the levels of extract (%) in each treatment. Levels of extract (%) in untreated pito, pasteurized pito, moringa pito, and pasteurized moringa pito during 56 days of storage ranged from 5.00 to 7.00, 6.00 to 7.00, 4.20 to 6.52 and 5.00 to 6.28%, respectively. Pasteurized moringa pito were significantly ($P < 0.05$) higher in the extract (%) than in the untreated pito from the 7 days to the 56 days of storage, and for the

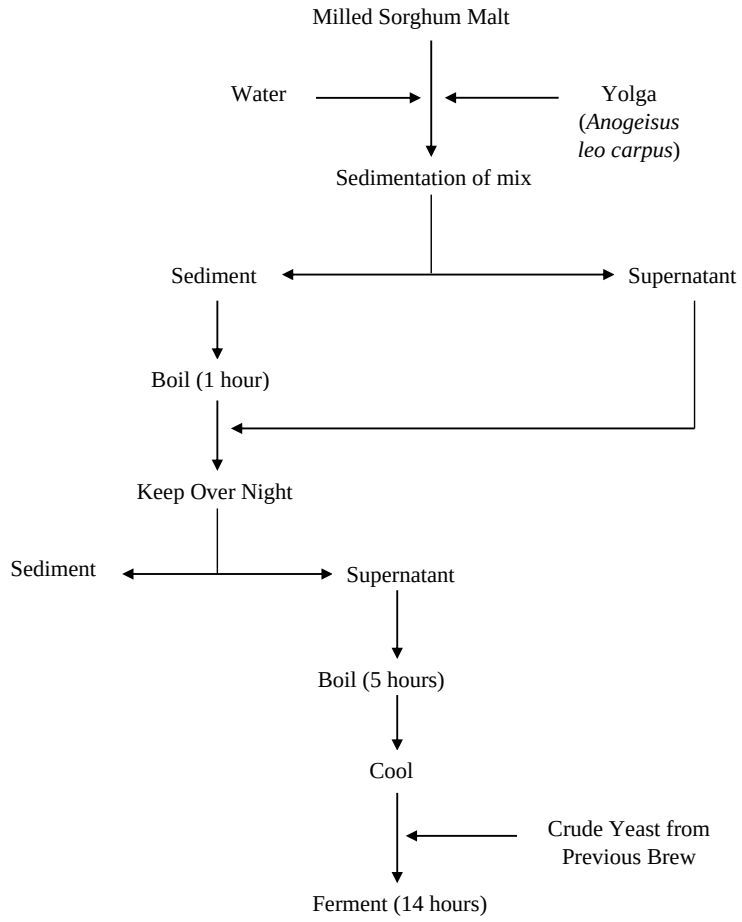

Figure 1. A flow chart of the brewing process of Dagarti pito (Demuyakor, 1994).

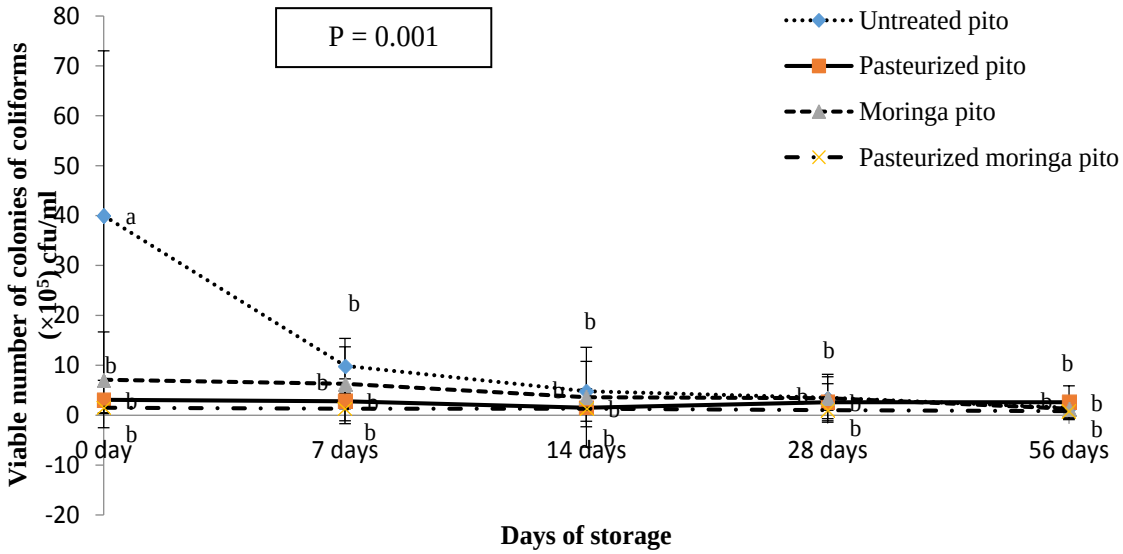

Figure 2. Viable number of coliforms when conventional and treated pito were stored for two months. Values are means and standard deviations of colony forming unit per millilitres; values that do not share the same letter are significantly different (P < 0.05). All treatments were stored at an ambient room temperature.

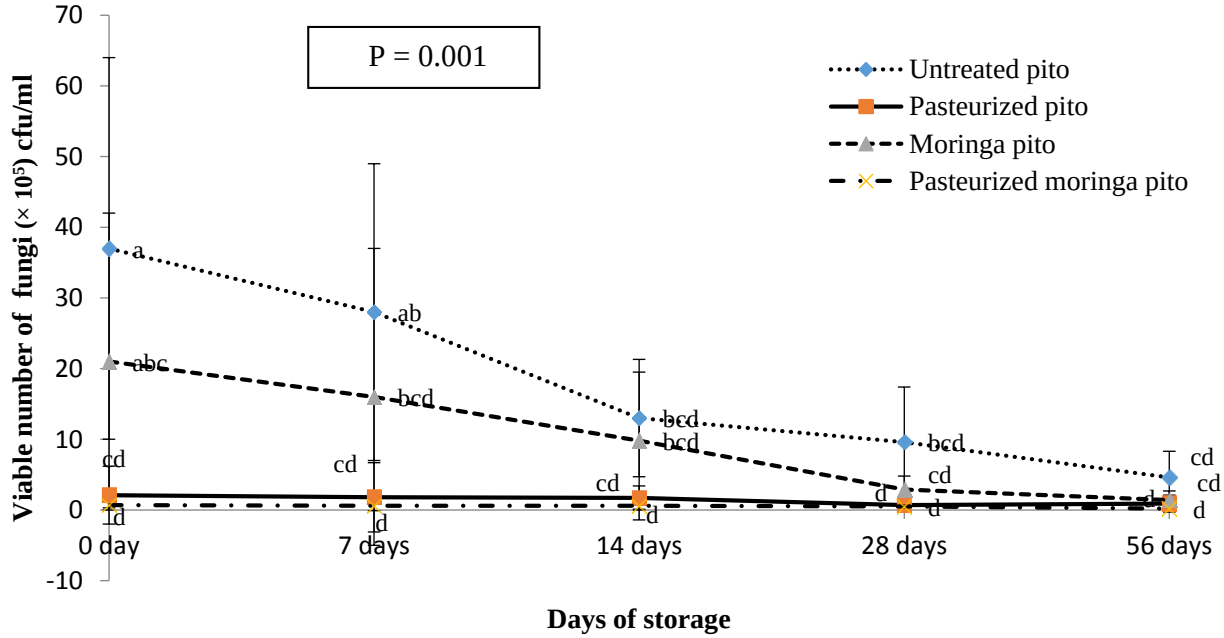

Figure 3. Viable number of fungi for conventional and modified pito stored for two months. Values are means and standard deviations of fungi forming units per millilitres; values that do not share the same letter are significantly different (P< 0.05). All treatments were stored at an ambient room temperature.

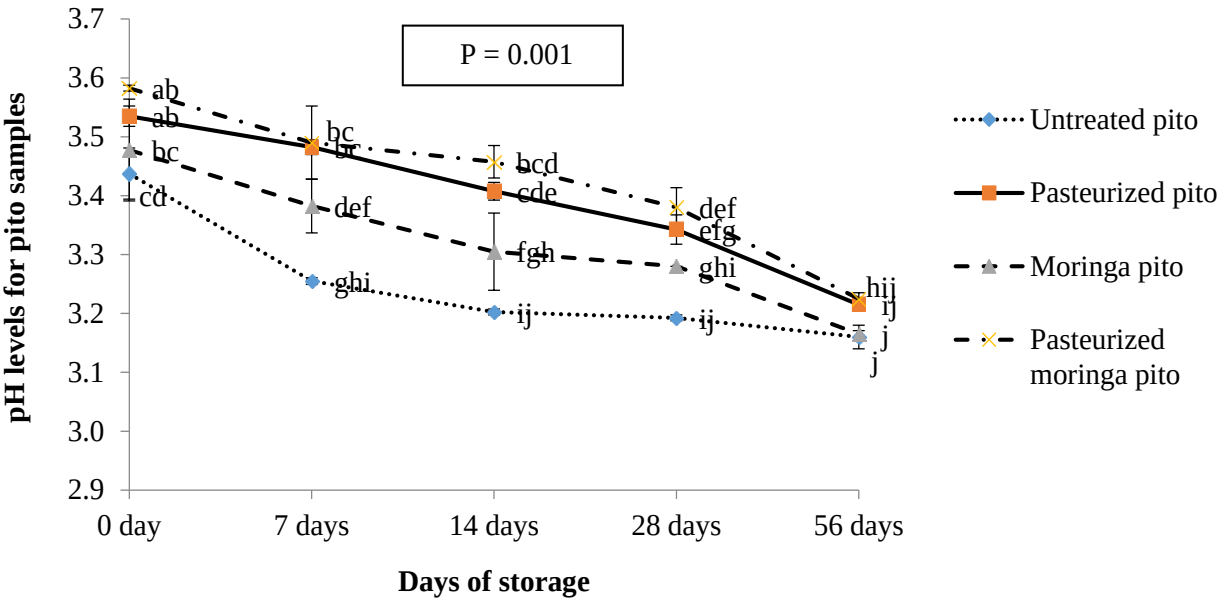

Figure 4. Levels of pH during 56 days. Values are the means ± standard deviation of quadruple determinations. Values that do not share the same letter are significantly different (P< 0.05). All treatments were stored at an ambient room temperature.

moringa pito from the 14 days to the 56 days of storage. The extract (%) in all the treatments was reducing with increasing duration of storage. Untreated pito, moringa pito and pasteurized pito, recorded a percentage difference of 19, 11 and 8%, in that order with respect to pasteurized moringa pito during storage. From 0 day to 14 days of storage, there was no significant (P > 0.05) reduction of extract (%) of the pasteurized pito and

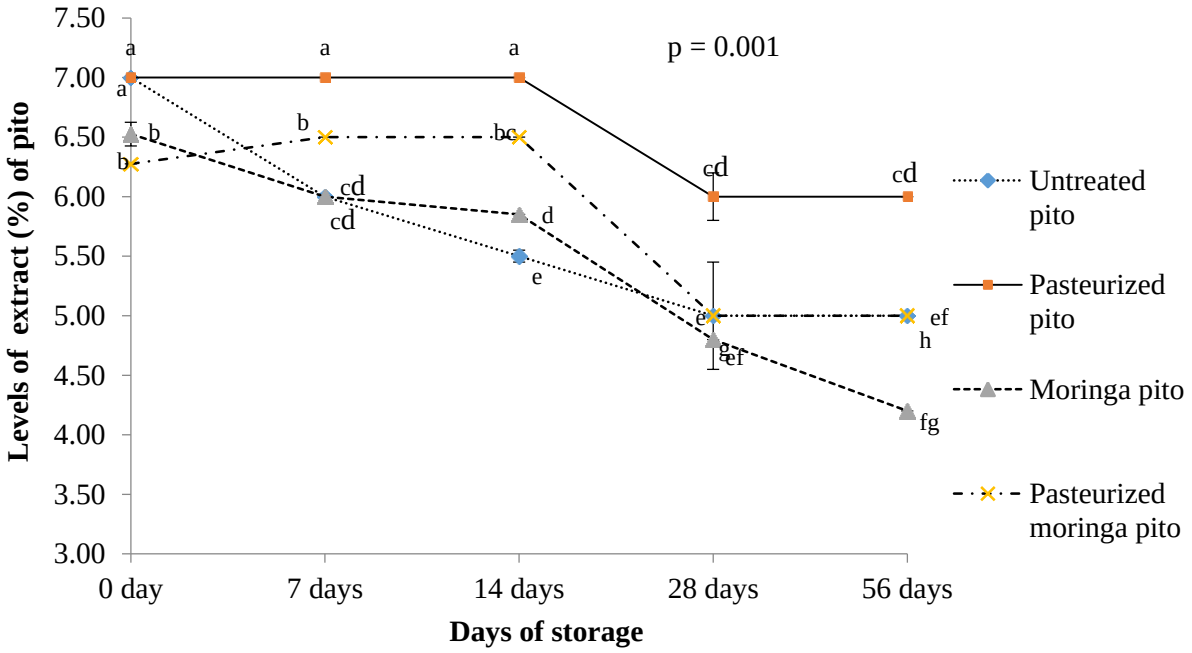

Figure 5. Extract (%) during 56 days of storage. Values are the means ± standard deviation of quadruple determinations. Values that do not share the same letter are significantly different (P< 0.05). All treatments were stored at an ambient room temperature.

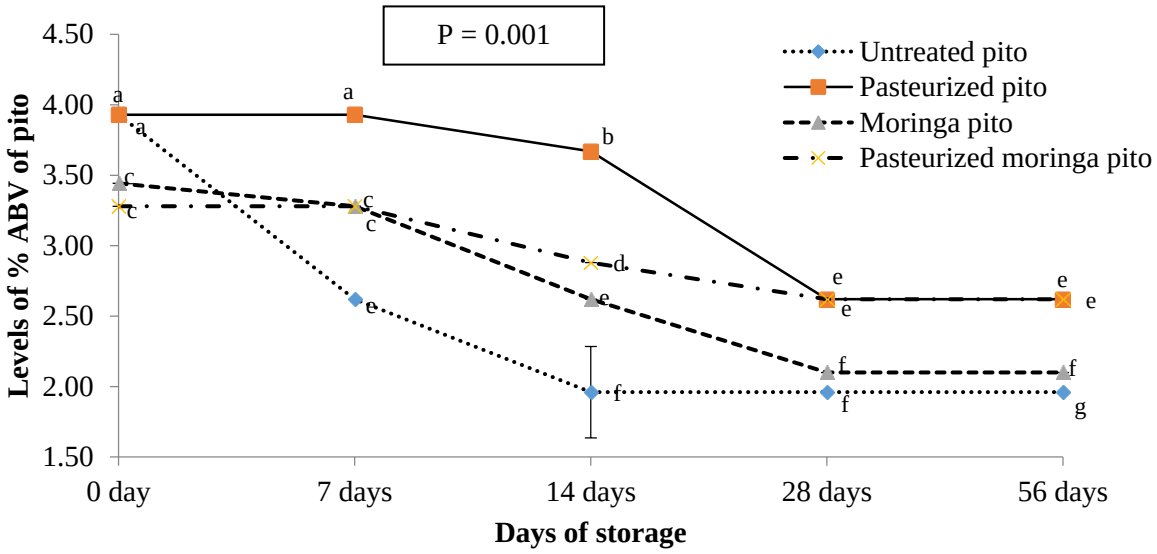

Figure 6. Percentage of alcohol by volume (% ABV) during 56 days of storage of untreated pito and treated pito. Values are the means ± standard deviation of quadruple determinations. Values that do not share the same letter are significantly different (P < 0.05). All treatments were stored at an ambient room temperature.

pasteurized moringa pito.

Alcohol levels

The alcohol content decreased during storage (Figure 6). Alcohol levels were between 1.96 and 3.93, 2.62 and 3.93, 2.10 and 3.44 and 2.62 and 3.28% in untreated pito, pasteurized pito, moringa pito and pasteurized moringa pito, respectively. Pasteurized pito, moringa pito and pasteurized moringa pito had higher alcohol content than the untreated pito from 7 days to 56 days of storage.

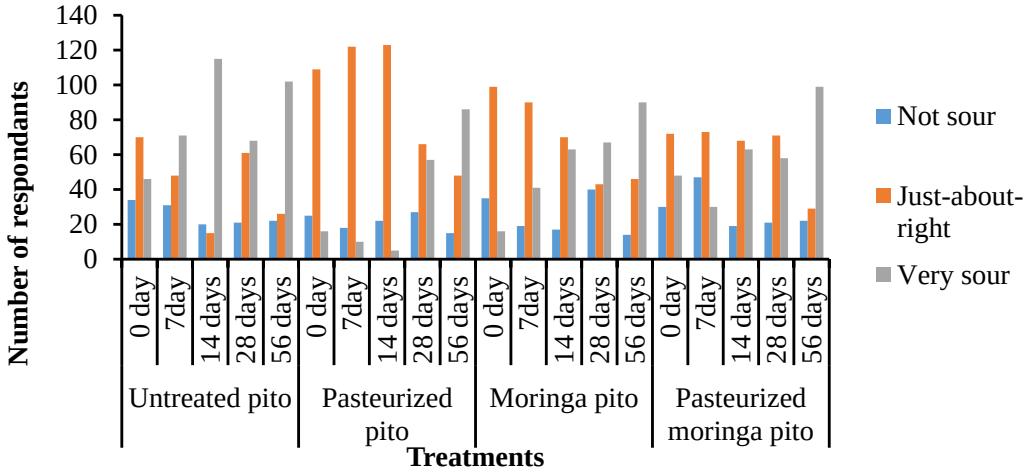

Figure 7. The degree of sourness of pito samples. Market acceptability of pito samples.

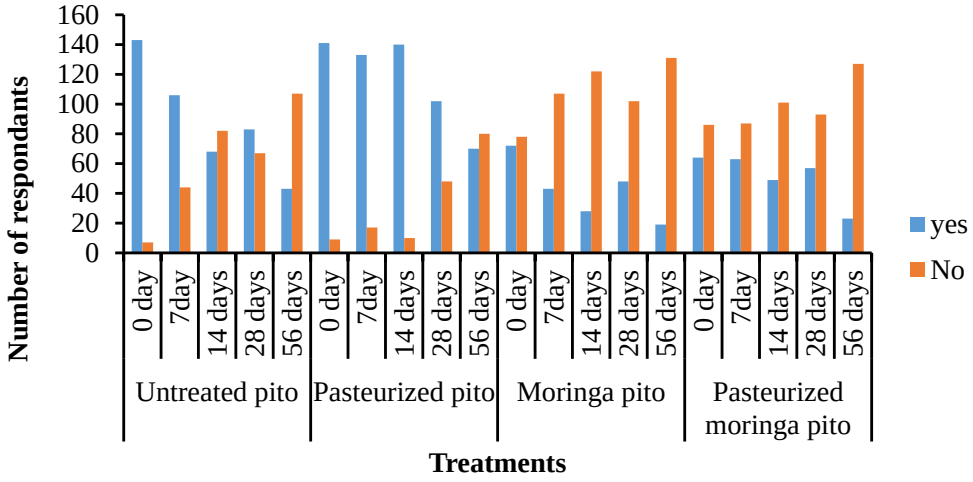

Figure 8. Preference of pito samples in the Ghanaian market.

There was significant difference ($P < 0.05$) in alcohol value in the samples investigated. The percentage difference of the untreated pito during the 56 days of storage with respect to pasteurized moringa pito was 33%; and moringa pito, pasteurized pito, recorded 24 and 20%, respectively. Statistically, no significant ($P > 0.05$) reduction in the alcohol levels was observed when the treated pito samples: pasteurized pito, moringa pito and pasteurized moringa pito, were stored for seven days.

Sensory evaluation of bottled pito

Consumer preference for the degree of sourness of pito samples

The degree of sourness of pito samples (Figure 7) showed that untreated pito samples were very sour after 0 day of storage; followed by moringa pito, then the pasteurized pito samples (pasteurized pito and pasteurized moringa pito) which became very sour after 14 and 28 days of storage, respectively. The preference of pito samples in the Ghanaian market (Figure 8) showed that respondents favoured pito samples without moringa extract in the Ghanaian market than those with the moringa extract.

The findings of this study (Table 1) clearly showed significant difference ($P < 0.05$) in the overall degree of liking. Pito samples without moringa extract were highly acceptable by the assessors than those with moringa extract. The untreated pito was disliked extremely by assessors after a week of storage. Pasteurized pito was extremely liked throughout a storage period of 4 weeks.

Table 1. Presentation of the acceptability of treatments during storage.

Parameter	Storage (days)	Pito sample				Fpr < 0.05
		Untreated pito	Pasteurized pito	Moringa Pito	Pasteurized moringa pito	
Overall degree of liking	0	4.41±0.70^{a}	4.27±0.75^{ab}	2.86±1.19^{efg}	2.83±1.27^{efg}	0.001
	7	3.87±0.99^{bc}	4.29±0.69^{ab}	2.60±1.22^{g}	2.78±1.24^{fg}	
	14	3.26±1.23^{de}	4.23±0.73^{ab}	2.69±1.08^{fg}	2.65±1.11^{fg}	
	28	3.30±1.38^{de}	3.61±1.36^{cd}	2.55±1.37^{g}	2.65±1.31^{fg}	
	56	2.51±1.51^{g}	3.08±1.36^{ef}	1.87±0.92^{h}	1.91±1.09^{h}	

Values are means and standard deviations of triplicate determinations; values within interactions of individual sensory attributes that do not share the same letter are significantly different (P< 0.05). A 5-hedonic scale was used (1= dislike extremely/least acceptable; 3= neutral; 5= like extremely/ highly acceptable).

DISCUSSION

Moringa pito exhibited antimicrobial activity which is a characteristic of moringa extract hence contributed to the reduction of coliforms in pito at zero day compared to the high coliform load in untreated pito. The heat shock from pasteurized pito and pasteurized moringa pito reduced coliform load in samples prior to storage. The lowest reduction of microbial load in pasteurized moringa pito can be attributed to the cocktail of treatment hence can enhanced microbial stability in pito during 56 days of storage. However the reduction of coliform load in untreated pito during storage would be as a result of spontaneous microbial activity; this include accumulation of lactic acid and acetic acids during storage produced by bacteria, which are detrimental to some sensitive bacteria (Ekundayo, 1969; Fadahunsi et al., 2013) as well as the lowering of pH values in pito during the storage which some coliforms cannot survive (Ray and Bhunia, 2013) hence explaining the drastic reduction of coliform population in untreated pito samples. Similar inference could be made for the reduction of coliform in various treatments applied to the sorghum beer (pito).

Unlike coliform, the mould population did not reduce very significantly in moringa pito. This implied that, antimicrobial activity of moringa varied with the type of microbe which confirms the findings made by some researchers, on the inhibitory effect of *M. oleifera* leaf extract on some selected fungal strains (Bukar et al., 2010; Devendra et al., 2011) but a combination of pasteurization and moringa extract treatment can reduce mould population to abitarily acceptable levels. This corroborates with previous reports that pasteurization is capable of inactivating microbial activity in traditionally brewed sorghum beers (Ellis et al., 2005; Osseyi et al., 2011). The significant reduction of the number of fungi growth in the untreated pito during storage might have resulted from the exhaustion of nutrients in the products, thus reducing the overall food availability for the microorganisms as reported by other researchers (Fadahunsi et al., 2013). Also, the growth of fungi might have been impeded by unfavourable conditions as stated in the case of coliforms. Generally, the addition of moringa extract and/or the heat treatment might have been the major contributing factor, influencing the overall reduction of microbial growth in moringa pito, pasteurized pito and pasteurized moringa pito.

In order to improve the shelf life of sorghum beer (pito), the addition of *M. oleifera* to and pasteurization of sorghum beer were employed in comparison with traditionally brewed sorghum beer (pito). The pH values for all pito samples (untreated pito, pasteurized pito, moringa pito, and pasteurized moringa pito) were within the stipulated pH range for sorghum beer of 3 to 4 as indicated in previous study of increasing shelf of pito and microbial assessment of pito during storage (Fadahunsi et al., 2013; Ellis et al., 2005; Kalawole et al., 2007). However, each treatment lacked stability with respect to pH (3.2 to 3.5) value, which can be attributed to activities of microbes with the pito samples during the period of storage. Microbial activities were much more in untreated pito which led to a lower pH value compared to moringa pito, pasteurized pito and pasteurized moringa pito which had higher pH values. The lower pH can also be attributed to organic acid produced by some microorganisms (bacteria, moulds and yeast) that were isolated in the pito treated samples and also suggested by Fadahunsi et al (2013). The pH values recorded did not corroborate with Ellis et al. (2005) and Osseyi et al. (2011) reports in which sorghum beer pasteurized at 60 to 70°C had a stabilized pH value of 3.4 and 3.45 for 8 weeks and 6 months, respectively during storage. The high pH in moringa pito, pasteurized pito and pasteurized moringa pito signifies low microbial activity in the treated pito samples. Comparatively, pH variation in moringa pito, pasteurized pito, and pasteurized moringa was due to the difference in each treatment carried out. Moringa pito suggested that *Moringa oleifera* inclusion only could minize microbial activity to some extent when compared to untreated pito. Both pasteurized pito, and pasteurized moringa pito were better off in reducing microbial activity hence having a higher pH value than moringa pito and untreated pito. This implies that pasteurized pito, and pasteurized moringa pito would be less acidic compared

to moringa pito and untreated pito, since it has been reported that the souring in sorghum beer is owned to the presence of lactic acid bacteria or acetic acid bacteria (Ekundayo, 1969; Demuyakor, 1994; Steinkraus, 2004; Lyumugabe et al., 2012).

Levels of extract (% mass saccharose) in sorghum beer (pito) brewing were determined by fermentation period and yeast cells activities in pito brewing. The decline of the extract (%) was expected because sugar was converted into alcohol. The extract (%) showed a decline in all the treatments. This implied that fermentation was still on-going, hence the presence of some microbes and yeast cell as revealed in the microbiology of the pito sampled. The decline of the extract (%) which showed a reduction in sugar content in pito during 56 days storage corroborates with earlier report of Demuyakor and Ohta, (1993), thus the sugar content in pito reduced during storage since it served as carbon source for energy by the microorganisms present. The low extract (%) levels in moringa pito and pasteurized moringa prior to storage might be due to the 25% reduction in the volume of pito to allow for the addition of the moringa extract. Despite *Moringa oleifera* leaves known to contain carbohydrate (Mustapha and Babura, 2009), conversion rate into fermentable sugars may be low because of *Saccharomyces cerevisiae* inability to convert starch/complex carbohydrate to simple sugars and later to alcohol as well as the large proportion of carbohydrate in malted sorghum prior to fermentation (Lyumugabe et al., 2010). In additon, *M. oleifera* extract might have influenced *S. cerevisiae* activity hence translating into the low percentages of sugar in the pito at the initial stage of storage when treated with moringa extract (moringa and pasteurized moringa pito). Untreated pito encountered high microbial activity hence resulting in the rapid decline of the amount of sugar for 14 days of storage. Pasteurized pito had minimum about of microbial load hence resulting in sugar stability for 14 days of storage. This period could be described as lag periods/phase as sugar usage was almost negligible. The decline in extract (%) in pasteurised pito from day 14 to 28 might be due to microbial build up hence sugar utilization increased.

It was expected that, the amount of the sugar utilized should be equivalent to alcohol produced but this was not observed. Stability of alcohol level observed for a week (seven days) in pasteurized pito, pasteurized moringa pito and moringa pito could be attributed to treatment shock on microbes and change in the physico-chemical properties of the medium (pito), and hence sugar utilization as a carbon source by microbes and yeast cell was not efficient for the first seven days. Unlike untreated pito, it was characterized by alcohol reduction from day 1 to 14. Pasteurized pito, pasteurized moringa pito and moringa pito had a decrease in alcohol level after seven days. This implied that alcohol reducing microbes were associated with each sample. The reduction of alcohol produced more acids contributing to the sourness of pito during storage hence the low pH recorded for each sample during storage. The reduction of alcohol in all samples during storage would be linked to alcohol degrading microbes. Similar inference could be made for untreated pito. The significant reduction of alcohol in the untreated pito led to early spoilage. This observation indicated that for the efficient conversion of sugar to alcohol involves other factors (Demuyakor and Ohta, 1993; Lin et al., 2012). The stability of alcohol level in untreated pito might have resulted from inadequate carbon source for the microorganisms present and also the low pH of the medium might not have been appropriate for some microbial activity. This study suggests that moringa and/or pasteurization treatments were capable of maintaining the alcohol content in the pito during storage for seven days of storage.

The undesirable sensory characteristics of sorghum pito are as a result of microbial presence and activity (metabolic processes) that leads to the sorghum beer spoilage. The presence of coliforms and moulds in the pito samples may have resulted from unhygienic practices during and after the brewing process of the pito, causing the relatively high increase of coliform and mould growth at the initial stage of storage in the untreated pito. The high coliform and fungi count in the fresh pito might have led to the present coliform in the pito samples after pasteurization and/or the addition of moringa extract.

The intensity of the sourness is a reflection of the product acidity. The right degree of sourness is considered as part of the general characteristics of a good pito (Demuyakor, 1994); if it becomes very sour it is an indication of deterioration. Also, the untreated pito was very sour after seven days of storage indicating the impact of the decrease of pH level during storage. The panelists reported that the sourness was just about right for pasteurized pito, moringa pito and pasteurized moringa pito, until after 28 days of storage.

The overall degree of liking and potential of products being accepted on the Ghanaian market mirrored the choices made by panels in each of the sensory attributes earlier discussed. On the whole, pasteurized pito was mostly liked up to 28 days of storage. The untreated pito was further not preferred after seven days of storage. The reason may be attributed to off-flavours which alter the quality of the beer causing it to deteriorate (Harayama et al., 1991; Rodrigues et al., 2011). Also the pito treated with moringa extract which was less liked throughout the storage period shows that consumers are not familiar with the product, and this confirms report by Barcellos et al. (2009) that, some consumers find it very difficult to change.

Conclusion

The addition of moringa extract and/or pasteurization had

reduced the fungi and coliform growth in the treated pito samples than the untreated pito. The physical composition, that is, pH, sugar and alcohol levels were significantly influenced by pasteurization and the addition of *Moringa oleifera* leaf extract: The untreated pito had lower pH than the treated pito samples during storage. Comparatively causing the untreated pito to be very sour than the treated pito samples. Also the pasteurized pito, moringa pito and pasteurized moringa pito had higher sugar and alcohol content than the untreated pito during storage. Although pito with the moringa did improve the shelf life, organoleptically, it was less liked by the assessors. The sensory results showed that pasteurized pito was more preferred by the consumers. Pasteurized pito was liked for the four weeks of storage. Based on the findings of this study, the research concludes that the shelf life of pito can be improved through pasteurization and/or the addition of *Moringa oleifera* leaf extract for 28 days, however pito samples that contained the moringa extract was less favoured by consumers.

Conflict of Interests

The authors have not declared any conflict of interests.

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