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Development and sensory evaluation of yoghurt flavoured with solar dried fruits

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ABSTRACT

A study of developing solar dried fruit (5%) flavoured yoghurts using three types of fruits was conducted to determine acceptability and shelf life of developed products. A total of six samples namely banana, mango, pineapple, banana/mango, banana/pineapple and mango/pineapple were used as flavours in yoghurts. They were added either as fruit pieces or as powders. Shelf life projection study suggested that developed yoghurt products could be stored for up to 21 days at 4 °C without undergoing spoilage. Plain yoghourt (control) was the most liked sample and scored highest mean values for all attributes, which was significantly different from all other samples ($p<0.05$). Among the fruit flavoured yoghourts, mango was the most preferred sample in terms of flavor, aroma and general acceptability whereas the pineapple was the least acceptable. Although yoghurts flavoured with fruits pieces scored higher mean values in all sensory attributes than yoghurts flavoured with powdered fruits, no significant differences ($p>0.05$) between the two forms of fruit flavours was found. This needs to be further investigated. Thus, although the control was the most liked sample, solar dried fruit can be successfully used as yoghurt flavour, which may improve the texture and nutritional quality of the formulated yoghurts, making them available throughout the year, hence increasing farmer's income.

Keywords: Acceptability, coliforms, fruit flavours, sensory evaluation, shelf life.

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INTRODUCTION

Tanzania's climatic condition is favourable for the production of a wide range of tropical fruits which have increasingly gained global importance due to their characteristic exotic aroma and colour. The most important horticultural fruits in the region include pineapples, passion fruits, citrus fruits, mangoes, peaches, pears, and bananas. They are excellent sources of essential vitamins, minerals, antioxidants, fibres and carbohydrates which improve the quality of the human diet and protect the bodies from chronic diseases (Barret, 2007; FAO/WHO 2003). Fruits and vegetables are also important components of a healthy diet and their sufficient daily consumption has been strongly associated with reduced risk of some major diseases such as cardiovascular, diabetes, hypertension, and certain types of cancer (Bazzano et al., 2002). The growing awareness in recent years of the health promoting and enhancing properties of non-nutrient bioactive compounds found in fruits and vegetables has directed increased attention to fruits and vegetables as vital components of daily diets. According to FAO/WHO (2003), up to 2.7 million lives could potentially be saved each year with sufficient intake of fruits and vegetables. Their full exploitation, however, is limited by lack of affordable and appropriate processing technologies to develop acceptable value-added products. Fresh fruits are highly perishable and incur both quantitative and qualitative losses (Kader, 2002). Post-harvest losses of fruits can reach as high as 40 to 50% in the tropics and sub-tropics (Okaka, 2005).

Due to high postharvest losses and the resulting nutritional and economic losses, appropriate postharvest preservation techniques are required to mitigate the problem. Processing reduces post-harvest losses, increases quality, shelf life, wholesome, sensory

acceptability, affordability and availability throughout the year (Wakjira, 2010). Drying is an efficient way to preserve fruits (foods) and the use of solar dryer is an appropriate food preservation technology for a sustainable world (David and Whitfield, 2000). Perceived as a "value-added" ingredient, dried fruit adds flavour, colour, texture, and diversity with little alteration to an existing formula. They are more widely available in different forms, including whole dried, cut, diced and powders (Dauthy, 1995). Product development is another way of reducing post-harvest losses as well as improving farmers position in the food chain (Mali et al., 2006).

Yoghurt is one of the popular fermented dairy products widely consumed all over the world. Lactic acid in the composition of fermented milk products stimulates the functions of various digestive glands, so it fosters the digestion process (Tamime and Robinson, 1985). The regular consumption of fermented milk and yoghurts, also improves the function of the intestines, helping to avoid constipation. The use of probiotic bacteria in the starter of the fermented milk is especially beneficial as they also contribute to improving the health of consumers (Parvez et al., 2016). The bacteria in a certainly selected starter can produce compounds in fermented milk and yoghurts that have an antibiotic effect (Mazahreh and Ershidat, 2009). Furthermore, they improve appetite, stimulate the functions of the pancreas and the liver and the secretion of bile. Consumption of yogurt and other fermented dairy products provided with probiotics, enhance the function of the gastrointestinal tract (Holzapfel, 2001; Mazahreh and Ershidat, 2009). Yogurt is abundant in calcium, zinc, B vitamins, and probiotics; it is a good source of protein; and it may be supplemented with vitamin D and additional probiotics associated with positive health outcomes (El-Abbadi et al., 2014).

Yogurt and lactic acid bacteria contribute to several factors that enhance the gut function and health: the make of gastrointestinal flora, the immune response against pathogens (Mazahreh and Ershidat, 2009). One of the preventive effects is the protection against colon cancer (Tavan et al., 2002) and also the therapeutic action of diarrhea (Heyman, 2000) caused by infectious pathogens, in addition to the beneficial effect of yogurt containing live and active culture on the digestion of lactose in patients who suffer from lactose intolerance (Mazahreh and Ershidat, 2009).

In addition, yoghurts blend well with tropical fruits, the popularity of drinking yoghurt is rising. It is obtained by lactic acid fermentation of milk by the action of a starter culture containing *Streptococcus thermophilus* and *Lactobacilus bulgaricus* (Fadela et al., 2006). Fruits are added to the fermentation media to enhance nutritional value and organoleptic properties (Barnes et al., 1991). Different forms of yoghurt are now available in the market like stirred, set, frozen and liquid yoghurt (Fadela et al., 2006). In stirred yoghurt, fruits are added after fermentation while in set yoghurt they are added prior to the fermentation (Salvador and Fiszman, 2004). However, despite adequate literature, studies on solar dried fruit flavoured products such as yoghurts are lacking.

Therefore this study was conducted to assess sensory attributes and shelf life of yoghurts flavoured with solar dried mango, pineapple and banana (and various combinations of these fruits). Addition of dried fruits into yoghurts will reduce postharvest losses of these fruits, develop new value-added fruit-based products and enhance agricultural production and creation of employment.

MATERIALS AND METHODS

Materials

Banana, mangoes, and pineapples were obtained from selected sellers at Morogoro open market in Tanzania. A total of 10 kg mangoes, 9 kg pineapples and 7 kg ripe bananas were purchased. Chemicals and reagents were purchased from registered pharmacies in Tanzania. Laboratory analysis was carried out at the Department of Food Technology, Nutrition and Consumer Sciences at Sokoine University of Agriculture (SUA), Morogoro, Tanzania.

Research design

A completely randomized study design (CRD) was used to study the effect of treatment (different single or combination of dried fruits; mango, banana, pineapple, mango/pineapple, mango/banana and banana/pineapple) on sensory attributes and shelf life of yoghurt products. Plain yoghurt was the control.

A purposive sampling procedure was used to collect fruits from selected farmers and fruit vendors in Morogoro, Tanzania

Solar drying of fruits and powder preparation

This was done according to the method by King'ori et al., (1999). A locally fabricated direct solar cabinet dryer was used for drying the fruits. It consisted of two parts namely collector and a drying unit/tunnel. The dryer had collector dimension of (1.17 × 2.35 m) and drying section of 0.67 × 1.44 × 2.29 m, respectively. Both the collector and the drying units were covered with UV stabilized visqueen sheets and food grade black paint was used as an absorber in the collectors. The products to be dried were placed in trays in cabinet dryers and a single layer on a wire mesh in the tunnel dryer. The fruits were then loaded into a solar dryer at a temperature ranging between 28-50 °C for 3 days. The dried products were packed in polyethylene bags and stored at -4 °C prior to laboratory analysis (King'ori et al., 1999). A total of 12 fruit flavours were developed- six dried whole pieces and the rest powdered. The mixed flavours were prepared by mixing different fruits at a ratio of 1:1. Powders were made by cutting and blending the dried fruits.

Yoghurt preparation

Yoghurts were prepared according to Kurwijila (2003).

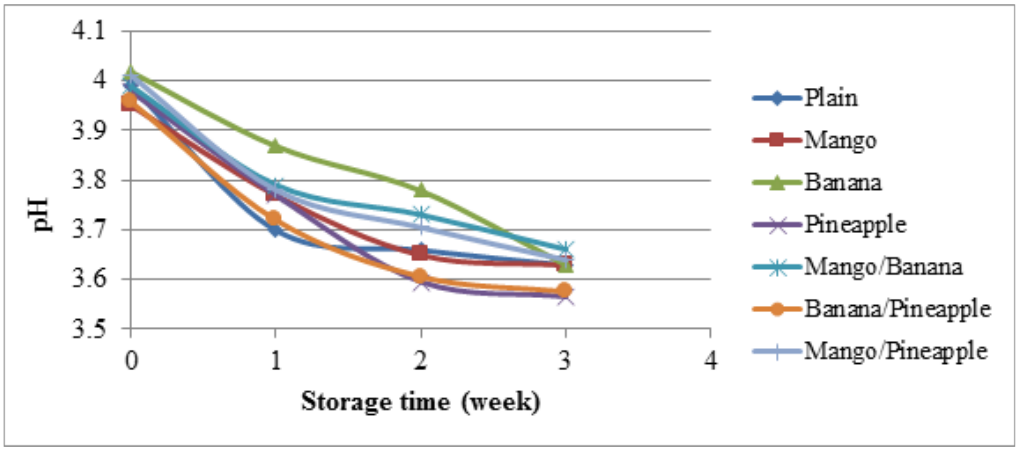

Figure 1. pH changes of fruit flavoured yoghurts during storage.

Whole cow's milk was locally obtained from Magadu farm at SUA in Morogoro. The milk was first filtered and pasteurized in a water bath (ZD Grant W28, Grant Instruments- Cambridge, England) at 80 ºC for 15 min, rapidly cooled in ice-chilled water to 44 ºC and then inoculated with 2% (v/v) yoghurt starter culture of *Streptococcus salivarius, thermophilus* and *Lactobacillus delbruickii* ssp *bulgaricus.* Fermentation was done in an incubator at 44 ºC and stopped when the pH reached 4.6 which was after 4 hours. Yoghurts were stored at 4 ºC for 24 hours before sensory evaluation and shelf life studies. Microbial (total and coliform counts) and chemical (pH and total titratable acidity) analysis were carried out on a weekly basis for 4 weeks. The powders were mixed with the yoghurt at a rate of 5% (Kurwijila, 2003). Controls were sampled without added solar dried fruits. Samples for sensory evaluation were then randomly coded with three digits for analysis.

Determination of shelf life

Shelf life was determined weekly for three weeks. Plain and dried fruit flavoured yoghurt samples were examined for viable microbial count by McConkey agar media and pour plate methods as described by Harrigan and McCance (1976).

Total titratable acidity and pH

Total titratable acidity was determined by potentiometric titration (AOAC, 2005). The pH of the extract was measured using a glass electrode laboratory pH-meter (JENWAY 3305,Wagtech, UK).

Sensory evaluation

Sensory evaluation was conducted to determine consumer's response and for discerning the best type of yoghurt. This was done on yoghurt that had been stored for 24 hr at 4 ˚C for proper flavor development. The sensory attributes of the yoghurts were evaluated by 30 untrained panelists consisting of 15 males and 15 females. Yoghurt samples were served in plastic disposable cups labeled with a three-digit random number at room temperature (25 ˚C). Water was given to the panelists for palate cleansing between samples. Panelists were presented with 30 ml of each of the 7 yoghurt samples, a control and six treatments each (for powders and fruit pieces) as described above. The sensory attributes evaluated were: flavour, appearance, texture, aroma/smell and general acceptability (Salvador and Fiszman, 2004; Karagul-Yuceer et al., 1999). Seven points hedonic scale was used to determine the responses of panelists on each attribute indicating their degree of liking or disliking (Larmond, 1977). To avoid fatigue, the panelists were allowed to test only seven products per day and the remaining samples were tested on a different day.

Statistical data analysis

Data was analyzed using SAS (1990) and results were reported as mean of duplicate analyses. One-way analysis of variance (ANOVA) was used to determine differences between the mean scores. Differences between means obtained from the ANOVA were ascertained using Duncan's multiple range tests. Significance was accepted at $p<0.05$.

RESULTS AND DISCUSSION

pH of the developed yoghourts

There was a decrease in pH in all samples as storage time increased (Figure 1). This is due to the formation of lactic acid, which eventually decreased the pH. Previous studies have also shown similar trends in yoghurt production (Dlamini et al., 2006). A significant difference ($p < 0.05$) in pH were observed among all yoghurt samples from the second to the fourth week of storage. The pH of banana yoghurt was slightly higher than mango/pineapple yoghurt. According to Jongen (2007) banana is less acidic(pH=5.00-5.29) than mangoes (pH =3.40-4.80) and pineapples (pH=3.20-4.00) and hence the high acidity in

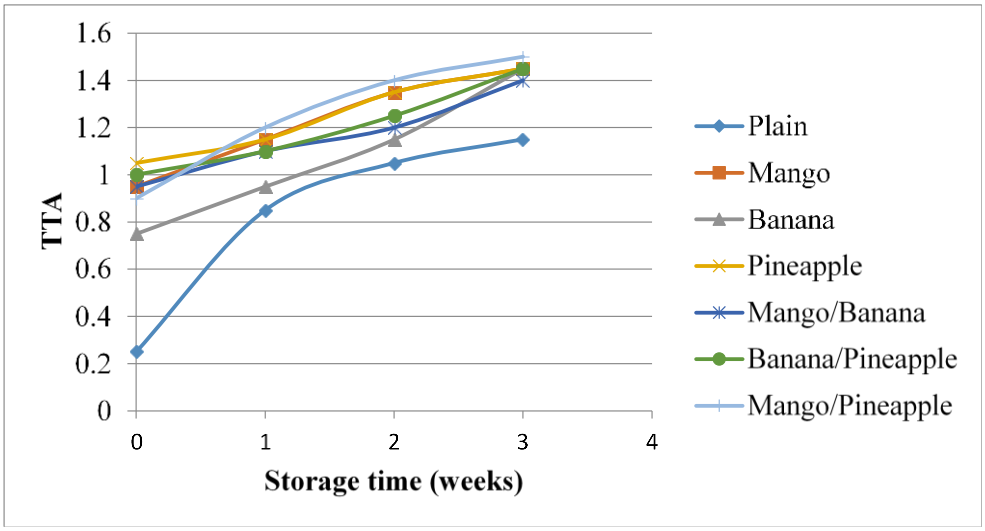

Figure 2. TTA changes of fruit flavoured yoghurts during storage.

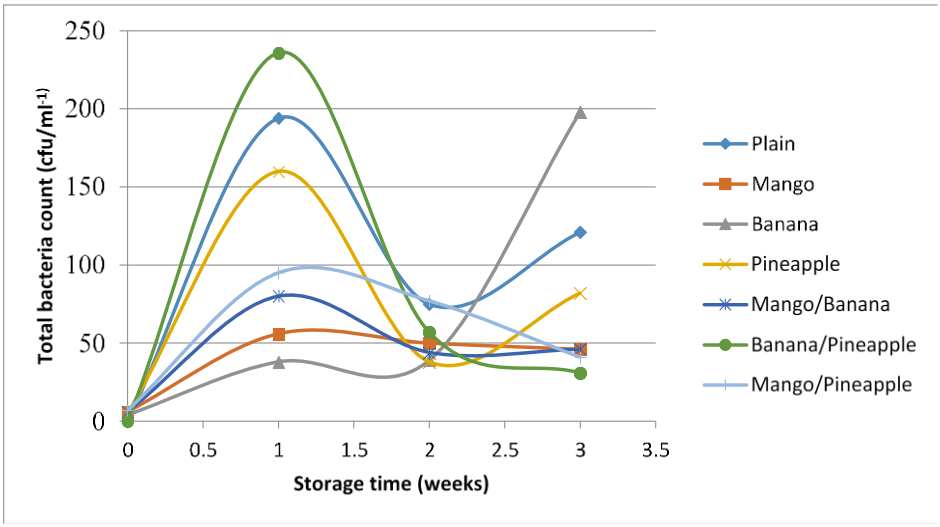

Figure 3. Total bacterial count (cfu/ml) of fruit flavoured yoghourts.

mango, lowered the pH. Similar results were also reported by Mongi (2013) whereby banana had highest pH values (pH=4.68) with corresponding lowest acidity values than pineapple (3.73), mango (pH=3.83) samples. The general decrease in pH during fermentation and storage is due to the breakdown of lactose into lactic acid. The pH lag phase decreases during storage and this reflected in the acidification rate of the culture involved (Hassan and Amjad, 2010). During storage, the added LAB starter culture produced acids which resulted in pH decrease (Rodrigues et al., 2004).

Total titratable acidity (TTA) of the developed yoghurts

TTA results of yoghurts are shown in Figure 2. Solar dried fruits flavoured yoghurts had the highest TTA values compared to plain yoghurt due to acidity from fruits. Pineapple flavoured yoghurt sample had the highest TTA (lowest pH) on production day followed by banana/pineapple and the least TTA containing sample was plain yoghurt). TTA values were directly proportional to storage time i.e. TTA increased as storage time increased. Previous studies have also shown that organic acids trend in yoghurt increases during the fermentation process and storage and this may be attributed to increases in organic acids produced during storage (Dlamini et al., 2006). Increases in acidity are perceived as a negative attribute in yoghurt processing if the acidity results in very low pH values, below 3.5 (Salvador and Fiszman, 2004).

Microbiological quality of the developed products during storage

Total bacteria count

Figure 3 presents results on the total bacterial count of the developed yoghurt products stored at 4°C.

Table 1. Acceptability of yoghurt flavoured with solar dried fruits powder and pieces.

Form	Colour	Flavour	Smell	Texture	General Acceptability
Powder	4.7^{a}	4.3^{a}	4.9^{a}	4.5^{a}	4.3^{a}
Pieces	5.4^{a}	4.4^{a}	5.1^{a}	4.7^{a}	4.7^{a}

Means with different superscript in the same column are significantly different at $p< 0.05$. Rating scores for sensory attributes; 7- Like extremely, 6- Like moderate, 5- like, 4- Neither like nor dislike, 3- dislike, 2- Dislike moderately, and 1- Dislike extremely.

Table 2.Sensory attributes of plain and solar dried fruit flavoured yoghurts samples.

Samples	Colour	Flavour	Aroma/Smell	Texture	General Acceptability
Mango	4.9^{bc}	4.9^{a}	5.3^{abc}	4.5^{c}	4.9^{b}
Banana	4.9^{bc}	4.6^{a}	5.1^{bc}	4.6^{bc}	4.8^{b}
Pineapple	4.5^{c}	2.2^{c}	4.1^{d}	3.4^{d}	2.5^{d}
Mango/banana	5.1^{b}	4.6^{a}	5.3^{ab}	4.9^{bc}	4.8^{b}
banana/pineapple	4.7^{bc}	4.7^{a}	5.1^{bc}	4.5^{c}	4.7^{bc}
Mango/pineapple	5.1^{b}	3.7^{b}	4.6^{c}	5.2^{ab}	4.2^{c}
Plain	6.2^{a}	4.9^{a}	5.6^{a}	5.6^{a}	5.5^{a}

Means with different superscript in the same column are significantly different ($p< 0.05$). Rating scores for sensory attributes; 7- Like extremely, 6- Like moderate, 5- like, 4- Neither like nor dislike, 3- dislike, 2- Dislike moderately, and 1- Dislike extremely.

Results ranged between 0 and 2.25 $x10^2$ CFU/ ml for the 4 week storage time. These could be due to microorganisms from the environment. There was a sharp increase in bacterial counts in the first week for all developed yoghurt products. The fluctuation in the microbial load may be as a result of fermentation and competition among microbes present and post-storage (Mbaeyi and Anyanwu, 2010). There were no particular trend for plain yoghurt and four developed products, mango, mango/banana, pineapple and mango/pineapple flavoured yoghurts during the storage period. However, solar dried banana and mango/pineapple yoghurt showed that the total viable count (cfu/ml) decreased as storage time increased (from 0-3rd week). The total viable count decreased slightly from the first to the third week of storage these results are similar to the one obtained by Mbaeyi and Anyanwu (2010). pH decreased slightly during the storage period for all the developed yoghurt products which resulted in a reduction of the total viable count of the samples. This could probably be due to the depletion of the nutrients and death of some survivors of the products. The pH drop created a highly acidic environment which led to the loss of viability or death of the microorganism present.

Coliform count

No coliforms were found in any of the developed products throughout storage time. This indicated that the developed products were not contaminated during the storage. Previous studies had also shown the absence of coliform bacteria in the product samples was due to pasteurization prior to incubation (Mbaeyi and Anyanwu, 2010; Younus et al., 2002). Coliforms are not supposed to be present in yoghurt because of high-temperature short time pasteurization and effective cleaning and good hygienic procedures (Kawo et al.,2006) the presence of coliforms from this poses a great danger to the health of the consumers and suggest neglect on the part of the processors or the yoghurt vendors. The tolerable limit for coliform presence in yoghurt is less than 10 CFU/ml. The absence of *E. coli* signifies that all the samples were free from fecal contamination (Osundahunsi, 2007**).** The microbial status of the developed yoghurt products conforms to the required standard (Nwagu and Amadi, 2010).

Sensory analysis

Table 1 presents the results on sensory attributes of the yoghurts based on their forms i.e. fruit pieces and fruit powders as evaluated by the panelists in fruit flavoured yoghurts. Although yoghurts flavoured with fruits spices scored higher mean values in all sensory attributes than yoghurts flavoured with fruit powder no significant differences ($p>0.05$) between these two forms of fruit flavours were observed. It is possible that the powdered fruit yoghurts were not well crushed due to high sugar content. This was mostly observed for solar dried mango and pineapple. The addition of powders also increased the total solids and hence the viscosity of the yoghourt which could have affected acceptability. This needs to be investigated further. From this study, it may be concluded that fruit flavoured yoghurts are acceptable in either form. Table 2 shows that plain yoghurt scored highest values for all attributes, indicating that it was the most liked sample. This is probably due to the fact that plain yoghurt is one of the most common types of yoghurt consumed in Tanzania. Traditionally fermented milk is also in various outlets in Morogoro and sold without any flavours added,

and that is the reason for the preference of plain yoghurt over the flavoured yoghurts.

Based on general acceptability, there were no significant differences between mango and banana flavoured yoghourts and also the mixed mango/banana yoghourt ($p>0.05$). Table 2 also shows that pineapple flavoured yoghurt was significantly different from all other samples and was the least liked. According to panelists' comments, pineapple yoghurt was ranked least because of its bitter taste. High mean values were obtained in plain yoghurt for all sensory attributes and these results are similar to previous study (Mbaeyi and Anyawu, 2010). Another possible reason could be that the plain yoghurt is already in the market and panelists are familiar with it (Sowonola et al., 2005). Overall the mean values for sensory attributes of dried fruit flavoured yoghurts were approximately 5.0, indicating that the fruit flavours were liked and they can be used to improve the texture, aroma, and flavour of the yoghurt (Karagul-Yuceer et al.,1991; Dlamini et al., 2006**)**.

CONCLUSION

From this study, it may be concluded that developed products can have a shelf life of up to 21 days when stored at 4^0C . This study further confirmed that plain yoghurt was the most liked followed by mango. Although initial results suggested that yoghurt with fruit pieces were more preferred than the powdered form, no statistical differences ($p<0.05$) were found between the acceptability of the two forms of yoghourt.

It may thus be concluded that the use of solar dried fruit to flavour yoghurt not only produced more varieties of yoghurt but also reduced post-harvest losses of these fruits. Solar drying also extends the shelf life of these fruits, making them available for use throughout the year, and can be used to flavour yoghurts . In addition, they add value to fruit-based products and hence improve the nutritional and economic status of the stakeholders.

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