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(RESEARCH ARTICLE)

Effectiveness of lemon juice and honey in shelf life enhancement of kunun zaki

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Abstract

Kunun zaki, a refreshing non-alcoholic local beverage commonly consumed in Nigeria, has a short shelf life. This study was therefore carried out to determine the abilities of lemon juice and honey to improve the shelf life of the product. Traditionally produced kunun zaki was treated with lemon juice and honey in singles and in combinations at concentrations of 1.5, 2.0, 2.5 and 3.0 ml per 100 ml of kunun zaki. The treated kunun zaki samples together with the control (kunun zaki without preservative) were kept at room temperature (25±2 ^{o}C) for a period of five days during which physico-chemical characteristics and sensory qualities of the samples were monitored every 24 hours. Titratable acidity (TA) and pH were observed to increase and decrease respectively as keeping period increased. The observed changes became statistically significant ($p < .05$) after three days of keeping for most of the samples. At the end of the 5-day preservation period, the sample treated with 3 ml of honey recorded the lowest TA of 2.05±0.02 and the highest pH of 5.36±0.04. This sample also was the most accepted in terms of overall acceptability and other sensory parameters. It is concluded that the shelf life of kunun zaki can be improved using appropriate concentrations of lemon juice and honey but especially with honey (3 ml per 100 ml kunun zaki) which was able to preserve the product throughout the five-day period.

Keywords: Honey; Kunun zaki; Lemon juice; Shelf life; Sensory quality

1. Introduction

Kunun zaki is a non-alcoholic beverage mostly consumed by people of the Northern parts of Nigeria. It is a product of fermentation of grains. Kunun zaki is a Hausa phrase which means "*sweet beverage*". Among the group of non-alcoholic beverage called kunu, kunun zaki is the most consumed in Nigeria with about 73% of Nigerians consuming it daily and 26% consuming it occasionally [1]. Osuntogun and Aboabo [2] reported that on dry matter basis, kunun zaki contains 76.3% starch, 11.6% protein, 3.3% fats, 1.9% fiber and 1.3% ash, showing it to be a nutritious product of fermentation.

Kunun zaki, however, has been reported to have a short shelf life ranging from 18 – 36 hours without pasteurization and refrigeration [3]. The short shelf life of the product is attributable to high moisture content among other factors. Akoma et al. [4] reported a moisture content of 78.8% for kunun zaki. The high moisture content of kunun zaki predisposes the product to rapid microbial spoilage. Due to the short shelf life of the product, large scale production is often avoided to avoid economic losses, due to spoilage. This reduces the economic value of the product [4].

In an attempt to solve the problem of short shelf life associated with kunun zaki, preservatives of both natural and chemical sources have been used, resulting in some level of improvement in shelf life [5]. There is however, need to search further for more preservatives especially from natural sources, these being more acceptable than chemical preservatives. Enhancement of the shelf life of kunun zaki through the use of natural preservatives would reduce cost of preservation by pasteurization and refrigeration methods. It will also allow production of kunun zaki in a larger scale without fear of easy spoilage thus meeting market demands for the product. This will enhance the economic value of the product, retain its nutritional quality and also reduce the risk of health related issues due to development of

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pathogens in the product. The aim of the study was to determine the effectiveness of the use of honey and lemon juice in improving the shelf life of kunun zaki.

2. Material and methods

2.1. Sample collection and preparation [1]

Raw materials used in the work (i.e. guinea corn, ginger, cloves, black pepper, dried sweet potato chips, sugar, lemon fruits and honey) were purchased from Terminus market in Jos metropolis of Plateau State, Nigeria. The raw materials were transported to the laboratory in clean polythene bags. The materials were sorted to remove unwanted particles including sand.

2.2. Production of kunun zaki [2]

One kilogramme of guinea corn (*Sorghum bicolor*) was washed thoroughly with clean tap water and steeped in 2 L of tap water (1:2 w/v) for a period of 18 h at room temperature (25±2 ^{o}C). After the steeping period, the grains were washed again and then wet-milled together with pre-washed spices – black pepper (*Piper* sp., 2 g), cloves (*Eugenia caryophyllata*, 2 g), ginger (*Zingiber officinale*, 50 g) and dried sweet potato (*Ipomoea batatas*, 20 g) using a properly washed grinding machine. The obtained paste was divided into two unequal portions (1:3 v/v). The larger portion was gelatinised by adding boiling water (1:1 v/v) in a plastic container. It was stirred vigorously for about 3 minutes after which 100 g of ground malted sorghum grains was added. The pastes mixture was stirred vigorously for 4 minutes to aid liquefaction and saccharification of the gelatinized starch and left for a period of 18 h to ferment. One litre of clean water was added to the fermented product which was then stirred and sieved using a clean muslin cloth. Two hundred and fifty grammes of sugar (sucrose) was added to the filtrate (kunun zaki) as a sweetening agent.

2.3. Preparation of preservatives and preservation experiment procedure [3]

The test preservatives used in this experiment were lemon juice, honey, and a 1:1 mixture of lemon juice and honey. Lemon fruits were washed with clean tap water, sliced into halves with the aid of a sterile knife, and fruit juice was squeezed out into a clean sterile beaker. The juice was sieved to remove seeds and chaff. Using a sterile syringe, 1.5, 2.0, 2.5 and 3.0 ml volumes of lemon juice were separately introduced into 100 ml volumes of kunun zaki in clean plastic screw-capped bottles. The kunu-lemon juice mixtures were hand-shaken to ensure proper mixing. The procedure was repeated with honey and also with the 1:1 mixture of lemon juice and honey. A total of 12 kunun zaki samples were thus treated in three groups of four samples each. Each group was treated with a different preservative at concentrations of 1.5, 2.0, 2.5 and 3.0 ml each in 100 ml of kunun zaki. The whole experiment was replicated thrice.

2.4. Effects of lemon juice and honey on pH and titratable acidity of kunun zaki [4]

With the aid of sterile syringes, 1.5, 2.0, 2.5 and 3.0 ml volumes of lemon juice, honey, and a 1:1 mixture of lemon juice and honey were separately introduced into 100 ml volumes of kunun zaki in clean plastic screw-capped bottles. The bottles were hand-shaken to properly mix their contents. Plastic bottles containing 100 ml of kunun zaki without lemon juice, honey or their combinations were also provided and these served as the control. The bottles that contained the experimental kunun zaki samples were allowed to stand on the laboratory bench at room temperature (25±2 ^{o}C) for five days. pH of the samples were determined in triplicates at the beginning of the experiment and at 24 h intervals for 5 days using a pH meter (Horiba, M-8) that had been standardized with pH 4 and pH 7 buffers. Titratable acidity was also determined in triplicates for the variously treated kunun zaki samples at 24-hour intervals. For the determination of titratable acidity, 10 ml of sample was measured into a conical flask and four drops of phenolphthalein indicator was added. This was titrated with standard 0.1N sodium hydroxide to a distinct faint pink point. The titratable acidity, expressed as % lactic acid, was calculated for each sample as described by [6].

2.5. Effects of lemon juice and honey on sensory quality of kunun zaki [5]

Daily sensory analysis was conducted on the treated kununn zaki samples using a panel of four University of Jos students who were familiar with the product. Parameters analysed included aroma, taste, colour, texture and overall acceptability. The kunun zaki samples were served the panelists in coded transparent plastic cups. Each panelist was provided with water for mouth rinsing before and after assessment of each kunun zaki sample. The samples were assessed on a five point hedonic scale where 1 = dislike very much, 2 = dislike slightly, 3 = indifferent, 4 = like slightly, and 5 = like very much, a slight modification of the scale described by [7].

2.6. Statistical analysis [6]

The effect of lemon juice, honey and their combinations on pH, titratable acidity, and sensory quality were analyzed statistically with the aid of SPSS software version 16 using One-Way Analysis of Variance (ANOVA). P value less than .05 were considered statistically significant. Means with significant differences were separated using LSD.

3. Results

3.1. Physico-chemical characteristics of kunun zaki samples [7]

pH values of the kunun zaki samples decreased with increase in keeping time for both control and for samples treated with lemon juice and honey. The daily pH values for the kunun zaki samples under preservation ranged from 5.35±0.01 to 6.57±0.03 for Day 1, 5.27±0.02 to 6.90±0.07 for Day 2, 5.21±0.05 to 6.27±0.03 for Day 3, 5.14±0.02 to 5.90±0.02 for Day 4 and 5.08±0.02 to 5.36±0.04 for Day 5. The lowest pH value was thus observed on day 5 for most of the samples with few exceptions. The observed decreases in pH values of the kunun zaki preserved with 3 ml of honey remained statistically non-significant (p> .05) until Day 4 while that of the kunun zaki sample preserved with 3 ml of lemon juice became significant by Day 3. The effects of the preservatives on the pH of the kunun zaki samples under preservation are presented in Table 1.

Table 1 Effects of preservation with lemon juice and honey on pH of kunun zaki

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	6.23 ± 0.01^{a}	6.41 ± 0.02^{a}	6.27 ± 0.03^{a}	5.90 ± 0.02^{b}	5.32 ± 0.01^{b}
LJ(2.0)	6.28 ± 0.04^{a}	6.16 ± 0.03^{ab}	6.00 ± 0.05^{b}	5.23 ± 0.04^{c}	5.29 ± 0.02^{c}
LJ(2.5)	6.33 ± 0.03^{a}	6.14 ± 0.02^{ab}	6.10 ± 0.05^{b}	5.20 ± 0.01^{c}	5.26 ± 0.01^{c}
LJ(3.0)	6.38 ± 0.04^{a}	6.11 ± 0.06^{b}	6.01 ± 0.07^{b}	5.23 ± 0.02^{c}	5.30 ± 0.01^{c}
H(1.5)	6.51 ± 0.04^{a}	6.90 ± 0.07^{ab}	6.09 ± 0.04^{b}	5.23 ± 0.02^{c}	5.24 ± 0.01^{c}
H(2.0)	6.57 ± 0.03^{a}	6.40 ± 0.03^{a}	6.19 ± 0.02^{a}	5.32 ± 0.02^{b}	5.25 ± 0.01^{b}
H(2.5)	6.36 ± 0.05^{ab}	6.25 ± 0.05^{a}	5.79 ± 0.08^{b}	5.30 ± 0.01^{c}	5.27 ± 0.01^{c}
H(3.0)	6.29 ± 0.06^{a}	6.17 ± 0.06^{ab}	5.89 ± 0.01^{ab}	5.58 ± 0.01^{ab}	5.36 ± 0.04^{b}
H+LJ(1.5)	6.31 ± 0.04^{a}	6.22 ± 0.03^{ab}	5.97 ± 0.08^{b}	5.29 ± 0.03^{b}	5.35 ± 0.01^{b}
H+LJ(2.0)	6.30 ± 0.07^{a}	6.14 ± 0.02^{a}	5.83 ± 0.03^{b}	5.26 ± 0.01^{b}	5.35 ± 0.01^{b}
H+LJ(2.5)	6.24 ± 0.03^{a}	6.11 ± 0.03^{a}	5.91 ± 0.03^{b}	5.26 ± 0.03^{c}	5.24 ± 0.07^{c}
H+LJ(3.0)	6.28 ± 0.03^{ab}	6.11 ± 0.03^{a}	6.10 ± 0.06^{a}	5.25 ± 0.03^{b}	5.23 ± 0.03^{b}
Control	5.35 ± 0.01^{a}	5.27 ± 0.02^{a}	5.21 ± 0.05^{b}	5.14 ± 0.02^{c}	5.08 ± 0.02^{c}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different (p < .05). Control: 100 ml kunun zaki kept at room temperature without any preservative

Table 2 Effects of preservation with lemon juice and honey on titratable acidity of kunun zaki

Sample (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	1.23 ± 0.15^{a}	1.61 ± 0.01^{ab}	1.98 ± 0.16^{b}	2.03 ± 0.05^{b}	3.74 ± 0.04^{c}
LJ(2.0)	1.12 ± 0.07^{a}	1.60 ± 0.05^{b}	1.90 ± 0.05^{c}	2.17 ± 0.05^{d}	3.04 ± 0.03^{e}
LJ(2.5)	1.04 ± 0.03^{a}	1.54 ± 0.08^{b}	2.08 ± 0.06^{c}	2.06 ± 0.06^{c}	2.46 ± 0.06^{d}
LJ(3.0)	1.46 ± 0.22^{a}	1.86 ± 0.04^{ab}	1.99 ± 0.05^{ab}	2.93 ± 0.42^{b}	2.51 ± 0.06^{b}
H(1.5)	0.99 ± 0.09^{a}	1.32 ± 0.06^{b}	1.59 ± 0.06^{bc}	2.04 ± 0.01^{cd}	2.25 ± 0.05^{d}
H(2.0)	0.84 ± 0.29^{a}	1.31 ± 0.00^{ab}	1.85 ± 0.01^{bc}	2.04 ± 0.02^{c}	2.41 ± 0.03^{c}
H(2.5)	1.30 ± 0.12^{a}	1.46 ± 0.03^{ab}	1.63 ± 0.1^{b}	2.08 ± 0.04^{c}	2.36 ± 0.04^{c}
H(3.0)	0.97 ± 0.03^{a}	1.02 ± 0.02^{a}	1.42 ± 0.05^{a}	1.64 ± 0.05^{a}	2.05 ± 0.02^{b}
H+LJ(1.5)	1.30 ± 0.21^{a}	1.48 ± 0.18^{ab}	1.85 ± 0.08^{bc}	2.07 ± 0.08^{bc}	2.15 ± 0.04^{c}
H+LJ(2.0)	1.31 ± 0.18^{a}	1.54 ± 0.07^{ab}	1.76 ± 0.07^{bc}	2.17 ± 0.02^{cd}	2.32 ± 0.03^{d}
H+LJ(2.5)	1.21 ± 0.05^{a}	1.79 ± 0.03^{b}	1.99 ± 0.05^{c}	2.21 ± 0.03^{d}	2.35 ± 0.03^{c}
H+LJ(3.0)	1.10 ± 0.34^{ac}	1.59 ± 0.05^{ab}	1.69 ± 0.04^{b}	2.33 ± 0.03^{bc}	$2.36.0.08^{c}$
Control	0.76 ± 0.13^{a}	1.48 ± 0.13^{a}	1.51 ± 0.06^{a}	1.57 ± 0.01^{b}	2.57 ± 0.06^{c}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different (p < .05). Control: 100 ml kunun zaki kept at room temperature without any preservative

Table 2 shows the effects of preservation with lemon juice and honey on titratable acidity (TA) of the kunun zaki samples under preservation. The TA of all the kunun zaki samples increased with increase in keeping time. Highest TA was observed on day 5 for all the samples. TA values for the different samples under preservation ranged from 0.76±0.13 to 1.23±0.15 for Day 1, 1.48±0.13 to 1.61±0.01 for Day 2, 1.51±0.06 to 1.98±0.16 for Day 3, 1.57±0.01 to 2.03±0.05 for Day 4 and 2.57±0.06 to 3.74±0.04 for Day 5. The observed increases in TA values were statistically significant (P< .05).

3.2. Sensory quality of experimental kunun zaki samples under preservation [8]

Table 3 Effects of lemon juice and honey preservatives on the aroma acceptability of kunun zaki

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	4.75±0.50 ^{a}	3.25±0.50^{ac}	2.75±1.50^{bc}	2.00±0.82^{c}	1.75±0.50^{c}
LJ(2.0)	4.75±0.50 ^{a}	3.50±1.29^{ab}	2.50±0.58^{b}	2.00±0.82 ^{b}	1.75±0.50 ^{b}
LJ(2.5)	4.00±0.82^{a}	3.50±1.00^{ab}	2.50±0.58^{ab}	2.00±0.82^{b}	1.75±0.50^{b}
LJ(3.0)	3.75±0.96^{a}	3.50±1.00 ^{a}	2.75±0.50^{a}	2.00±0.00 ^{b}	1.25±0.25^{b}
H(1.5)	4.75±0.50 ^{a}	3.75±0.50^{ab}	2.75±0.50^{bc}	2.50±1.00^{bc}	1.75±0.50^{c}
H(2.0)	4.50±0.58 ^{a}	3.00±0.00^{b}	3.00±0.00^{b}	2.50±1.00^{b}	1.75±0.50^{b}
H(2.5)	4.75±0.50^{a}	3.50±0.58^{b}	3.00±0.00^{b}	2.75±0.50^{bc}	1.75±0.50^{c}
H(3.0)	4.25±0.96^{a}	3.50±0.58^{a}	3.25±0.50^{ab}	3.00±0.82^{ab}	1.75±0.50^{b}
H+LJ(1.5)	3.25±0.50^{a}	2.75±0.50^{ab}	2.50±0.58^{a}	1.50±0.58^{b}	1.25±0.96^{b}
H+LJ(2.0)	3.25±0.96^{a}	3.25±0.50^{a}	2.50±0.58^{a}	1.50±0.96^{b}	1.25±0.50^{b}
H+LJ(2.5)	3.50±0.58^{a}	3.00±0.82^{ab}	2.50±0.58^{ab}	1.50±0.96^{b}	1.00±0.58^{b}
H+LJ(3.0)	3.00±0.82^{a}	3.00±0.00^{a}	2.50±0.58^{a}	1.50±0.82^{b}	1.25±0.50^{b}
Control	3.50±0.58^{a}	3.00±0.00^{ab}	2.75±0.50^{a}	1.75±0.96^{b}	1.25±0.50^{b}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different (p < .05). Control: 100 ml kunun zaki kept at room temperature without any preservative.

Sensory quality evaluation revealed that all the kunun zaki products were acceptable on the day of production, but acceptability values gradually declined for all the sensory parameters (i.e. aroma, texture, color, taste and overall acceptability) as keeping time increased. The aroma of most of the samples including the control was acceptable up to Day 3. By Day 4, the aroma quality of the control and most of the other samples had significantly decreased (p < .05). Though there were gradual decreases in the aroma scores for the kunun zaki sample preserved with 3 ml of honey, the decreases were not statistically significant even up to the Day 5. Details of the effects of lemon juice and honey on the aroma of kunun zaki are given in Table 3.

Table 4 Effects of preservation with lemon juice and honey on taste acceptability of kunun zaki samples

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	5.00±0.00 ^{a}	3.25±0.50^{bc}	2.25±0.96^{cd}	1.75±0.50^{d}	1.25±0.50^{d}
LJ(2.0)	4.50±0.58^{a}	3.00±0.82^{b}	2.50±0.58^{bc}	2.00±0.00^{bc}	1.50±0.58^{c}
LJ(2.5)	3.50±1.00^{a}	2.75±0.96^{ab}	2.00±0.00^{ab}	2.00±0.00^{ab}	1.50±0.58^{b}
LJ(3.0)	3.25±0.50^{a}	2.75±0.96^{a}	2.50±0.58^{a}	2.00±0.00^{a}	1.50±0.58^{b}
H(1.5)	4.50±0.58^{a}	3.75±0.96^{ab}	3.00±0.00^{abc}	2.50±1.00^{bc}	1.50±0.58^{c}
H(2.0)	4.50±0.58^{a}	3.50±0.58^{ab}	3.00±0.00^{abc}	2.75±1.26^{bc}	1.50±0.58^{c}
H(2.5)	4.50±1.00^{a}	3.25±0.50^{ab}	3.25±0.50^{ab}	2.50±1.00^{bc}	1.25±0.50^{c}
H(3.0)	4.00±0.82^{a}	3.25±0.50^{a}	3.25±0.50^{a}	2.75±1.26^{a}	2.00±0.60^{a}
H+LJ(1.5)	4.00±0.82^{a}	3.25±0.82^{a}	2.00±0.00^{b}	1.75±0.82^{bc}	1.00±0.58^{c}
H+LJ(2.0)	2.75±0.50^{a}	3.00±0.00^{ab}	2.25±0.50^{abc}	2.00±0.82^{bc}	1.25±0.50^{c}
H+LJ(2.5)	3.00±0.00^{a}	2.75±0.50^{a}	2.50±0.00^{a}	1.50±0.82^{b}	1.25±0.58^{b}
H+LJ(3.0)	2.75±0.50^{a}	2.75±0.96^{a}	1.50±0.50^{b}	1.25±0.96^{b}	1.00±0.58^{b}
Control	3.75±0.50^{a}	3.50±0.58^{ab}	3.00±0.82^{bc}	1.75±1.50^{c}	1.50±0.58^{cb}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different (p < .05). Control: 100 ml *Kunun zaki* kept at room temperature without any preservative

The taste acceptability ratings of the kunun zaki samples under preservation are presented in Table 4. The most accepted sample was again the sample preserved with 3 ml of honey. The sample did not show any significant difference in the taste scores up to Day 5. The samples preserved with 2.5 ml and 3 ml of lemon juice were the next best in terms of taste acceptability. They had no significant changes in their taste scores up to Day 4. The control sample exhibited a significant decrease in taste acceptability after two days.

Table 5 Colour acceptability ratings of kunun zaki samples preserved with lemon juice and honey

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	4.50±0.58^{a}	4.25±0.50^{a}	3.50±0.58^{ab}	3.00±0.00^{bc}	2.25±0.50^{c}
LJ(2.0)	5.00±0.00^{a}	4.00±0.00^{b}	3.25±0.50^{bc}	2.75±0.50^{cd}	2.25±0.50^{d}
L J(2.5)	4.50±0.58^{a}	4.00±0.00^{ab}	3.25±0.50^{abc}	2.75±0.50^{bc}	2.00±0.82^{c}
LJ(3.0)	4.75±0.50^{a}	4.00±0.00^{ab}	3.50±1.00^{abc}	2.75±0.50^{bc}	2.25±0.50^{c}
H(1.5)	4.75±0.50 ^{a}	4.00±0.00^{ab}	3.25±1.26^{abc}	2.75±0.50^{bc}	2.25±0.50^{c}
H(2.0)	4.50±0.58 ^{a}	4.00±0.00^{ab}	3.50±1.00^{abc}	2.50±1.00^{bc}	2.25±0.50^{c}
H(2.5)	4.50±0.58 ^{a}	3.75±0.50^{ab}	3.50±1.00^{abc}	2.75±0.50^{bc}	2.00±0.82^{c}
H(3.0)	4.75±0.50^{a}	4.00±.0.00^{ab}	3.75±0.50^{a}	3.25±0.50^{ab}	2.25±0.50^{b}
H+LJ(1.5)	4.25±0.50^{a}	4.00±0.00^{ab}	3.00±0.00^{bc}	2.25±0.96^{c}	2.25±0.50^{c}
H+LJ(2.0)	4.50±0.58^{a}	3.75±0.50^{ab}	3.25±0.50^{abc}	2.25±0.96^{bc}	2.00±0.82 ^{c}
H+LJ(2.5)	4.25±0.50^{a}	3.75±0.50^{ab}	3.25±0.50^{abc}	2.25±0.96^{bc}	1.75±0.96^{c}
H+LJ(3.0)	3.75±0.96^{a}	3.75±0.50^{a}	3.25±0.50^{ab}	2.25±0.96^{ab}	1.50±1.00^{b}
Control	4.75±1.00^{a}	3.75±0.50^{a}	3.00±0.82^{b}	2.00±1.16^{b}	1.50±1.00^{b}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different ($p < .05$). Control: 100 ml Kunun zaki kept at room temperature without any preservative.

In terms of colour acceptability, the scores for the control kunun zaki decreased significantly after two days while there were no significant changes for most of the other samples up to Day 3. The samples preserved with 3 ml of honey and 3 ml of the mixture of honey and lemon exhibited non-significant changes in colour up to Day 4. By Day 5 the decrease in colour acceptability values had become significant for all the samples. Table 5 shows the mean daily ratings for colour acceptability of the kunun zaki samples.

Table 6 Texture acceptability ratings of kunun zaki samples preserved with lemon juice and honey

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	4.75±0.50^{a}	3.75±0.50^{ab}	2.75±0.50^{bc}	2.25±0.96^{c}	1.75±0.50^{c}
LJ(2.0)	4.5±0.58 ^{a}	3.75±0.50^{ab}	2.75±0.50^{bc}	2.50±0.58^{c}	1.75±0.50^{c}
LJ(2.5)	4.25±0.50^{a}	3.75±0.50^{ab}	2.75±0.50^{bc}	2.25±0.96^{c}	1.75±0.50^{c}
LJ(3.0)	4.00±0.82^{a}	4.00±0.00^{a}	2.50±0.58^{b}	2.50±0.58^{b}	2.00±0.00^{b}
H(1.5)	4.75±0.50^{a}	4.25±0.50^{ab}	3.25±0.50^{bc}	2.75±0.50^{cd}	1.75±0.50^{d}
H(2.0)	4.50±0.58^{a}	3.75±0.50^{ab}	3.00±0.00^{abc}	2.75±1.26^{bc}	1.75±0.50^{c}
H(2.5)	4.50±0.58^{a}	3.75±0.50^{ab}	3.00±0.00^{bc}	2.75±0.50^{cd}	2.00±0.00^{d}
H(3.0)	4.00±0.82^{a}	3.75±0.50^{ab}	3.25±0.50^{ab}	3.00±0.82^{ab}	2.25±0.50^{b}
H+LJ(1.5)	4.00±0.00^{a}	3.50±1.00^{ab}	2.50±0.58^{ab}	1.25±1.00^{b}	1.00±0.00^{b}
H+LJ(2.0)	4.00±0.00^{a}	3.25±0.50^{ab}	2.75±0.50^{abc}	2.50±1.00^{bc}	1.75±0.50^{c}
H+LJ(2.5)	4.00±0.82^{a}	3.75±0.50^{a}	2.00±0.58^{b}	1.50±1.00^{b}	1.25±0.00^{b}
H+LJ(3.0)	3.75±0.96^{ab}	3.50±0.58^{a}	2.50±0.50^{ab}	1.25±0.96^{b}	1.00±0.00^{b}
Control	3.50±0.58^{a}	2.75±0.50^{a}	1.50±0.50^{b}	1.25±0.96^{b}	1.00±0.00^{b}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different ($p < .05$). Control: 100 ml Kunun zaki kept at room temperature without any preservative.

The texture quality of the control sample was not acceptable after two days while that of five other samples were acceptable up to Day 3. Only the sample preserved with 3 ml of honey remained acceptable up to Day 4. Details of the texture acceptability of kunun zaki samples preserved with lemon juice and honey are presented in Table 6.

Table 7 Overall acceptability scores of kunun zaki samples preserved with lemon juice and honey

Samples (ml)	Day 1	Day 2	Day 3	Day 4	Day 5
LJ(1.5)	5.00±0.50^{a}	4.00±0.50^{ab}	3.00±0.83^{bc}	3.00±0.58^{bc}	2.00±0.50^{c}
LJ(2.0)	5.00±0.50^{a}	4.00±0.58^{b}	3.00±0.00^{bc}	3.00±0.58^{bc}	2.00±0.50^{c}
LJ(2.5)	4.00±0.00^{a}	4.00±0.58^{ab}	3.00±0.00^{ab}	3.00±0.58^{bc}	2.00±0.58^{c}
LJ(3.0)	3.80±0.50^{a}	3.50±0.58^{ab}	2.50±0.58^{bc}	2.30±0.50^{c}	2.00±0.00^{c}
H(1.5)	5.00±0.50^{a}	4.00±0.50^{ab}	3.00±0.50^{b}	3.00±0.50^{bc}	2.00±0.50^{c}
H(2.0)	5.00±0.58^{a}	4.00±0.82^{ab}	3.00±0.50^{abc}	2.00±0.96^{bc}	2.00±0.58^{c}
H(2.5)	4.00±0.82^{a}	4.00±0.58^{ab}	3.00±0.50^{ab}	2.00±0.96^{bc}	1.00±0.50^{c}
H(3.0)	5.00±0.58^{a}	4.00±0.50^{a}	4.00±0.50^{a}	3.00±0.50^{a}	3.00±0.58^{a}
H+LJ(1.5)	4.00±0.58^{a}	3.00±0.50^{a}	2.75±0.50^{ab}	1.25±0.96^{b}	1.00±0.50^{b}
H+LJ(2.0)	5.00±0.58^{a}	4.00±0.50^{ab}	3.00±0.50^{bc}	3.00±1.00^{c}	2.00±0.50^{c}
H+LJ(2.5)	4.00±0.82^{a}	4.00±0.58^{ab}	3.00±0.50^{abc}	2.00±0.96^{bc}	2.00±0.58^{c}
H+LJ(3.0)	4.00±0.50^{a}	4.00±0.50^{ab}	3.00±0.50^{abc}	3.00±0.50^{bc}	2.00±0.50^{c}
Control	4.75±0.58^{a}	4.00±0.58^{ab}	3.00±0.58^{bc}	2.00±0.96^{c}	2.00±0.58^{c}

LJ = Lemon Juice; H = Honey. Each value is the mean ± standard deviation of duplicate readings. Values with different letters in the same row are significantly different ($p < .05$). Control: 100 ml Kunun zaki kept at room temperature without any preservative.

In terms of overall acceptability, the most acceptable kunun zaki sample was the sample treated with 3 ml of honey. It was found acceptable all through the 5-day preservation period. After Day 2, the control sample was no longer acceptable while seven out of the twelve samples preserved were found to be acceptable up to Day 3. Details of the overall acceptability of the samples are presented in Table 7.

4. Discussion

4.1. Physico-chemical characteristics of kunun zaki [9]

The pH and titratable acidity of the samples (treated and control samples) was observed to decrease and increase respectively as the period of keeping increased which is consistent with the findings of [8, 9, 10]. This increases in TA and decrease in pH is an indication of fermentation activity by microorganisms taking place in the samples resulting in acid production and accumulation which manifests as increase in titratable acidity and decrease in pH. This is typical of carbohydrate rich foods such as *Kunun zaki*. Therefore, effectiveness of a preservative is dependent on the ability of the preservative to inhibit the activity of microorganisms in the food sample thereby slowing down changes in TA and pH. The fact that changes in the TA and pH of the kunun zaki sample treated with honey (3ml) were not statistically significant up to Day 4 and only became significant on Day 5, added to the fact that the same sample recorded the lowest TA and highest pH values among all the other samples indicate that the 3 ml honey treatment must have had an inhibitory effect on the microorganisms present in the sample [11, 12].

4.2. Sensory quality of kunun zaki [10]

The sensory quality (aroma, taste, colour, texture and overall acceptability) of the variously treated kunun zaki samples declined with increase in keeping time. This agrees with the findings of Fapohunda and Adeware [13] and Ojimelukwe [10] who reported that the sensory quality of kunun zaki under preservation with natural products declined with time. This decline in sensory quality is suggestive of continuous microbial activities in the product which would result in the production of metabolic wastes such as hydrogen sulphide and other nitrogenous wastes that affect the sensory quality of the product. In spite of the aforesaid, the fact that the observed decline in taste, color, texture and overall acceptability for the treated samples remained statistically non-significant for a period of three days as against two days observed for the control sample suggests that the preservatives used must have had some inhibitory effects on spoilage organisms in the product. Though there were gradual decreases in the taste, aroma, color, texture and overall acceptability qualities of the sample treated with honey (3 ml), the changes were not statistically significant all through the five days of preservation. This retention of sensory quality of kunun zaki sample treated with 3ml of honey points to the preservative quality of honey on the product. The observed decline in aroma quality of the samples could be as result of production of off flavors associated with the production of hydrogen sulphide (H_2S) and acetic acid [14]. The decline in taste of the samples could be as a result of continuous accumulation of acids and toxic metabolites as a product of microbial fermentation. Colour deterioration of the samples could have resulted from possible accumulation of microbial metabolic products which may have affected the colour. The decline in texture of the kunun zaki samples

could have, among other reasons, resulted from possible increase in microbial load of the product over time. Kunun zaki preserved with 3 ml of honey was found to be the best in terms of overall acceptability. The overall acceptability of the kunun zaki samples under preservation would naturally depend on how acceptable the resultant changes in the other sensory characteristics are to the consumers.

The acceptability of the samples treated with lemon juice (1.5, 2 and 2.5 ml), honey (1.5 and 3 ml) and their combination (2 and 3 ml) up to a period of four days of keeping suggests that these treatments possess preservative properties. The sample treated with 3 ml of honey, however, exhibited the best preservative property, being found to be acceptable throughout the 5-day preservation period. Honey can therefore be used at this concentration to extend the shelf life of kunun zaki for five days. The samples that contained the combination of lemon juice and honey showed the least preservative effect on the products. This could be as a result of the effect of lemon juice and honey on each other with possible formation of a more complex product. This is in agreement with the findings of [15] who reported that preservative effect of natural products decreased with increase in complexity of the food.

4.3. Conclusion

Appropriate concentrations of lemon juice, honey, and their combinations can be used as preservatives for extension of the shelf life of kunun zaki at room temperature (25±2 ^{o}C). Honey, when used at a concentration of 3 ml per 100 ml of kunun zaki, slows down undesirable changes in the physicochemical characteristics of kunun zaki. This concentration of honey brought about the least changes in pH and titratable acidity compared to the other preservative treatments and also exhibited the best potential for use in the preservation of kunun zaki. Honey can be used to extend shelf life of kunun zaki up to a period of five days when preserved at room temperature (25±2 ^{o}C). In addition to having the ability to extend the shelf life of kunun zaki, honey has been considered to be a highly nutritious substance due to the various nutrients found in it. Its addition to Kunun zaki will mean more nutrients for the product, thus improving its nutritional benefits for consumers. Though honey is relatively expensive, the extension of shelf life of kunun zaki by 3 days (from 2 to 5 days) probably justifies its use.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors, Onyimba, Isaac Amechi and Dishon, Charibu Hurdison declare that there is no conflict of interest that exists.

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