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Evaluation of Set Yoghurt Quality Enhanced With Selected Indigenous Fruits

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ABSTRACT

A study was conducted to evaluate the quality of yoghurt produced from cow's milk and some tropical fruits such as lemon, grape, pawpaw, orange and synthetic pineapple as flavourants. The milk (18L) was clarified, homogenised, pasteurized at 80^0C for 3minutes and then cooled to 42^0C and inoculated. The inoculated milk was divided into six treatments; reconstituted synthetic pineapple flavour, fruit juices; grape, lemon, orange, pawpaw and plain. The flavourants were added at 200 ml/ litre of the inoculated milk. Each yoghurt was replicated thrice and incubated for 14hrs at 43^0C. Product was then refrigerated for 14days and the physico-chemical and rheological qualities of the samples were analyzed and determined at different storage days (1, 7 and 14). The completely randomized design in a 4x3 factorial arrangement was adopted.

The results obtained showed that water holding capacity (WHC) was highest (42.69%) at the 7th day, highest viscosity (68144.28mPa/s) and syneresis (38.58%) were recorded at day 1. Treatment effect revealed that grape yoghurt had the highest WHC (46.21%), viscosity (97053.89 mPa/s) and least syneresis (11.87%). Treatment and storage effects showed that grape yoghurt at day 7 had the highest (52.17%) WHC, viscosity (98540.33mPas/) at day 1and least syneresis (0.23 %) at day 14. The highest moisture (85.11%), ash (1.52%), fat (2.43%), protein (7.90%) and carbohydrate (11.86%) contents were observed in orange, lemon, plain, orange and grape yoghurts respectively. The pH, lactic acid, vitamin C, cholesterol values decreased as storage days increased. Orange yoghurt had higher concentration of Lactic acid and vitamin C concentrations. At days 7 and 14 of storage, the synthetic pineapple flavoured yoghurt was most acceptable. Conclusively, the nutritional qualities of yoghurt could be enhanced using tropical fruits, however, yoghurt should not be stored beyond 7days in order to sustain the nutrient value.

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INTRODUCTION

Milk is a nutritious food that is highly relished by young and old. It is secreted by female mammals for the purpose of feeding their offspring as it contains essential nutrients for promoting good health and survival of their young ones [1]. Due to its high nutrient concentration, it easily undergoes spoilage, hence can be processed into other products like yoghurt in order to retain its basic nutrients. Yogurt is considered one of the major dairy products [2]. It is a non-Newtonian, rheological unstable, viscoelastic and pseudoplastic fluid [3]. The uniqueness of yoghurt is attributed to lactic acid fermentation during its production which makes yoghurt easily digestible [4] and increase the bioavailability of calcium in intestine [5]. Its nutritional and physical qualities is largely dependent on the milk source, substances such as fruits and sugar, hydrocolloids added during production. Commercially sold yoghurt is most often flavoured with synthetic flavour such as strawberry, pineapple, vanilla, banana flavours. Due to the negative perception of consumers towards synthetic flavourants in recent times, there is therefore the need for alternative natural flavourants. However, [6] have reported that the nutritional and sensory qualities of

yoghurt can be improved using natural fruits. In Nigeria, there are varieties of fruits that have not been explored in improving the nutritional quality of yoghurt, among such are grape, lemon, orange and pawpaw. These fruits are rich in vitamins, minerals as well as antioxidants which have health benefits. The thrust of this study was to investigate the physico-chemical and sensory potentials of these fruits in yoghurt production.

Methods

Milk collection site

Fresh milk (18L) from White Fulani cows was obtained at the Fulani herdsmen settlement at ItaOgbolu, Ondo State and transported in a cold chain immediately to the nutrition laboratory of the Department of Animal Production and Health for refrigeration.

Yoghurt production site

Yoghurt production was carried out in the Nutrition Laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure (FUTA) Ondo State, Nigeria, located on longitude 4.944055^{o}Eand 5.82864^{o}E, and latitude 7.491780^{o}N with annual rainfall ranging between 1300mm and 1650mm average maximum and minimum daily temperature of 38^{o}C and 27^{o}C respectively [7] .

Procurement of experimental materials

Starter culture, pineapple flavourant and sucrose were purchased from a reputable store in Lagos while the fruits (ripe orange, grape, pawpaw and lemon) were sourced from fruit shops in Akure.

Preparation of naturally flavoured fruit juices

The commercial (synthetic) pineapple flavour was reconstituted with distilled water at a ratio of 1:2 v/v, the pH value was determined using a pH meter and kept in a labelled container. The fruits (orange, pawpaw, lemon and grape) were washed properly with water. The oranges, lemon and grape were cut and squeezed to obtain the juice while the pawpaw fruit was peeled and the seeds removed and the edible parts was blended using the electric blender (Philip model) and the juice was extracted using the cheese cloth. All fruits extracts were placed in labelled containers. The pH value of the juices and reconstituted synthetic pineapple flavourant were determined using pHep pocked-sized pH meter. The juice obtained from each fruit was pasteurized at 80^{0}C for 3 minutes and cooled to room temperature.

Preparation of flavoured yoghurt

The yoghurt was prepared according to the method described by [8]. The fresh cow's milk obtained from the White Fulani cows was clarified, homogenized and pasteurized at 80^{0}C for 3 minutes. Sucrose (5%) was then added as sweetener. Thereafter, the milk was cooled to a temperature of 42^{0}C for inoculation. Commercial freeze-dried starter culture was added to 18 litres of the milk at 5g/litre. The inoculated milk was divided into six portions representing the treatments as; Reconstituted synthetic pineapple flavour, plain, orange, lemon, grapeand pawpaw juices. Each treatment was replicated thrice. The flavourants were added at 200mL into 1 litre each of the inoculated milk excluding the plain milk. The samples were incubated at 43^{0}C for 14 hours in an incubator. The flavoured yoghurts produced were stored in a refrigerator at 4^{o}C for analyses and sensory evaluations at storage periods of 1, 7 and 14 days.

Analyses of Nutrient Composition

Moisture, total titratable acidity, fat, protein, ash were determined according to the procedure of [9]. The ascorbic acid content was determined using the method described by [10].

pH determination

The pH of flavourants and yoghurt samples were determined using the pHep pocket- sized pH metre by dipping the electrode into the samples and then the pH was read.

Determination of Viscosity of the Flavoured Yoghurt

The viscosity of the flavoured yogurt sample was determined using a rotational viscometer (Fungilab, ALPHA H,Spain) at the speed of 100 rpm at 30 second with spindle 7 as P. The samples were analysed by a texture profile analyser using TA4/1000 probe.

Determination of Peroxide Value of the Flavoured Yoghurt

Peroxide values was determined according to Pearson D analysis [11].

Whey Drainage

Whey Drainage was removed from the Yogurt, using a syringe within 24h after the Yoghurt fermentation is completed. The relative amount of whey drained off (in mL per 100mL of initial sample) was calculated as the whey Drainage [12].

Syneresis

An amount of 20g of the yoghurt was spread in a thin layer to cover the surface of the filter paper. The yoghurt was filtered under vacuum for 10mins. The liquid that passed through the filter paper was collected and recorded. The Percentage Syneresis (PS) was calculated as the weight of the liquid divided by the weight of the initial sample multiplied by 100 [13].

Sensory evaluation of yoghurt samples

The sensory characteristics of the flavoured yoghurt samples was judged using 20 panellists chosen from students and staff of the Department of Animal Production and Health, Federal University of Technology, Akure, for colour, flavour, mouth feel, consistency and overall acceptability. Evaluation was done at five-point hedonic scale ranging from 5=like extremely, 4=like, 3=like moderate, 2=dislike moderately, 1= dislike extremely.

Experimental Design and Statistical Analysis

The experimental design was completely randomized design in a 6 x 3 factorial arrangement (6 yoghurt types x 3 storage periods of 1, 7, and 14 days). Data obtained were subjected to two-way analysis of variance and significant means were separated using Duncan's multiple range test using [14].

Results

Table 1: pH values of natural fruits juices and synthetic pineapple flavourants used

Flavourants	pH
Lemon	2.8
Grape	3.6
Orange	4.6
Pawpaw	5.7
Synthetic pineapple	4.1

Physical properties of flavoured yoghurts at different storage periods

The physical properties of the flavoured yogurt samples at 1, 7 and 14 days storage periods is presented in Table 2. At 7 days storage period, WHC was significantly ($p<0.05$) highest (42.69%) while the highest viscosity and syneresis values were 68144.28mPa/s and 38.58% respectively at 1 day storage. Treatment effect showed WHC (46.21%) was highest in grape flavoured yoghurt and least (36.93%) in plain yoghurt. Viscosity was highest (97401.89mPa/s) in the synthetic pineapple flavoured yoghurt and least (1821.44mPa/s) in lemon flavoured yoghurt. The syneresis of the synthetic pineapple flavoured yoghurt was at peak (33.99%), while pawpaw, lemon, orange, plain and grape flavoured yogurts recorded 32.96, 29.57, 24.37 17.52 and 11.87% respectively. The interaction between storage periods and treatments had significant effect ($p<0.05$) on WHC, viscosity and syneresis. Grape flavoured yogurt stored for 7 days recorded the highest WHC of 52.17%, viscosity was highest (98540.33mPa/s) in grape sample at day 1 and least (678.33mPa/s) in orange yoghurt. However, syneresis was least (0.23%) in grape yoghurt at 14 days of storage and highest (56.43%) in orange flavoured yoghurt at day 1 of storage.

Table 2: Physical Properties of flavoured yoghurts at different storage periods

Treatment	Water holding capacity (%)	Viscosity (mPa/s)	Syneresis (%)
Grape	46.21 ± 2.56^{a}	97053.89 ± 437.58^{b}	11.87 ± 4.74^{f}
Lemon	37.71 ± 0.63^{d}	1821.44 ± 392.10^{f}	29.57 ± 7.24^{c}
Orange	37.26 ± 4.17^{e}	69420.78 ± 13389.03^{c}	24.37 ± 8.22^{d}
Pawpaw	43.04 ± 1.04^{b}	65542.78 ± 15281.97^{d}	32.96 ± 3.43^{b}
S. Pineapple	40.00 ± 1.16^{c}	97401.89 ± 234.73^{a}	33.99 ± 3.33^{a}
Plain	36.93 ± 1.20^{f}	32766.63 ± 15921.02^{e}	17.52 ± 3.78^{e}
P value	**0.0001**	**0.0001**	**0.0001**
Storage periods			
1	35.57 ± 1.85^{c}	68144.28 ± 10080.91^{a}	38.58 ± 3.00^{a}
7	42.69 ± 1.50^{a}	64266.04 ± 10834.03^{b}	23.57 ± 3.41^{b}
14	42.31 ± 1.07^{b}	49593.39 ± 11529.45^{c}	12.99 ± 3.72^{c}
P value	**0.001**	**0.001**	**0.001**
Storage periods*Treatments			
Grape 1	36.03 ± 0.03^{l}	98540.33 ± 0.33^{a}	30.65 ± 0.33^{g}
Grape 7	52.17 ± 0.09^{a}	95510.33 ± 0.33^{i}	4.73 ± 0.12^{l}
Grape 14	50.43 ± 0.22^{b}	97111.00 ± 0.58^{d}	0.23 ± 0.03^{o}
Lemon 1	35.23 ± 0.12^{m}	3323.00 ± 1.00^{l}	50.97 ± 0.03^{b}
Lemon 7	38.53 ± 0.03^{j}	1463.00 ± 0.58^{n}	35.80 ± 0.06^{e}
Lemon 14	39.37 ± 0.20^{h}	678.33 ± 0.33^{q}	1.95 ± 0.03^{m}
Orange 1	20.60 ± 0.06^{o}	15870.67 ± 0.33^{m}	56.43 ± 0.22^{a}
Oange 7	45.03 ± 0.03^{e}	95501.00 ± 0.58^{j}	14.72 ± 0.15^{i}
Orange 14	46.13 ± 0.09^{c}	96890.67 ± 0.67^{e}	1.97 ± 0.01^{m}
Pawpaw 1	46.03 ± 0.03^{d}	96510.67 ± 0.33^{g}	20.10 ± 0.10^{h}

Pawpaw 7	44.03±0.03^{f}	95701.00±0.58^{e}	35.27±0.15^{e}
Pawpaw 14	39.07±0.07^{i}	4416.67±0.33^{k}	43.50±0.29^{c}
S. Pineapple 1	36.30±0.15^{k}	98170.67±0.67^{b}	40.70±0.35^{d}
S. Pineapple 7	44.27±0.13^{f}	96690.67±0.33^{f}	40.60±0.31^{d}
S. Pineapple 14	39.43±0.22^{g}	97344.33±333.33^{c}	20.68±0.09^{h}
Plain 1	39.23±0.12^{h}	96450.33±0.33^{h}	32.63±0.32^{f}
Plain 7	32.13±0.13^{n}	730.23±0.09^{p}	10.33±0.17^{j}
Plain 14	39.43±0.03^{g}	1119.33±0.33^{o}	9.58±0.04^{k}
P value	**0.001**	**0.001**	**0.001**

^{abcdef}Means along the same column with different superscripts are significantly ($p<0.05$) different. S. Pinaepple = synthetic pineapple

Proximate composition (%) of flavoured yoghurts at different storage periods

Table 3 shows the proximate composition (%) of flavoured yoghurts at 1, 7 and 14 days storage periods. Storage periods showed significant ($p<0.05$) effect. The peak value of moisture (82.63%) was recorded at 14 days storage. The moisture content of the yoghurt ranged from 79.64 to 82.63% from day 1 to day 14. Ash content of the yoghurt was high in yoghurt stored for a day with 1.85% but decreased as storage period increased. The highest value of fat (2.45%) was recorded at 1 day storage period while 7 and 14 days storage periods recorded 1.56% and 0.99% respectively. Protein was significantly ($p<0.05$) high at 7 days storage period with recorded value of 8.79% while 7.665 and 5.80% were recorded at 1 and 14 days storage periods respectively. Carbohydrate was the highest in yoghurt at 14 days storage period with recorded value of 9.76% while 7.95% and 7.34% were recorded at 1 and 7 days storage periods respectively. Treatment effect revealed significant ($p<0.05$) difference as orange flavoured yoghurt recorded the highest moisture content of 85.11%, while the grape flavoured yoghurts had the least value of 78.01%. The highest ash content (1.52%), was obtained in lemon flavoured yoghurt and the least concentration in plain yoghurt. Protein concentration was of the same value (7.90%) in orange and pawpaw flavoured yoghurt. Grape flavoured yoghurt had the maximum carbohydrate content (11.86%) while orange flavoured yoghurt had the least value of 4.61%. The interaction between the storage periods and treatments also showed significant effect ($p<0.05$) on the nutrient composition. Plain yoghurt stored for 14 days recorded the highest moisture content of 86.50% and least (72.46%) in synthetic pineapple flavoured yoghurt 7 days. Orange and plain yoghurts recorded the highest percentage of ash as 1.96% at 1 day storage period. Lemon flavoured yoghurt at day 1 had the highest percentage of fat as 3.27% while grape and synthetic pineapple flavoured yoghurt recorded the lowest percentage of fat as 0.72% each at days 14 and 7 respectively. The highest percentage of protein as 9.57% was observed in Pawpaw flavoured yoghurt at day 7. The synthetic pineapple flavoured yoghurt stored for 7 days recorded the highest carbohydrate (17.36%) value.

Table 3: Proximate composition (%) of flavoured yoghurts at different storage periods

Treatment	Moisture	Ash	Fat	Protein	Carbohydrate
Grape	78.01±0.46^{d}	1.29±0.16^{d}	1.32±0.28^{e}	7.20±0.52^{c}	11.86±0.95^{a}
Lemon	81.99±0.29^{b}	1.52±0.17^{a}	1.95±0.36^{b}	6.74±0.38^{d}	7.43±1.06^{d}
Orange	85.11±0.35^{a}	1.42±0.15^{b}	1.00±0.07^{f}	7.90±0.51^{a}	4.61±0.81^{f}
Pawpaw	81.86±0.67^{b}	1.31±0.16^{cd}	1.82±0.20^{c}	7.90±0.46^{a}	7.07±1.30^{e}
S. Pineapple	78.38±1.92^{d}	1.34±0.12^{c}	1.49±0.36^{d}	7.21±0.45^{c}	11.31±1.55^{b}
Plain	80.86±1.58^{c}	1.22±0.19^{e}	2.43±0.28^{a}	7.55±0.40^{b}	7.81±1.01^{c}
P value	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Storage periods					
1	79.64±0.82^{c}	1.85±0.03^{a}	2.45±0.20^{a}	7.66±0.14^{b}	7.95±0.72^{b}
7	80.84±1.07^{b}	1.40±0.07^{b}	1.56±0.20^{b}	8.79±0.15^{a}	7.34±1.24^{c}
14	82.63±0.76^{a}	0.79±0.02^{c}	0.99±0.05^{c}	5.80±0.10^{c}	9.76±0.85^{a}
P value	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**
Storage periods*Treatment					
Grape 1	76.87±0.47^{h}	1.90±0.01^{b}	2.44±0.01^{e}	7.39±0.01^{i}	10.79±0.11^{c}
Grape 7	79.65±0.32^{f}	1.16±0.01^{g}	0.80±0.01^{l}	8.88±0.01^{d}	9.23±0.03^{d}
Grape 14	77.50±0.29^{g}	0.80±0.01^{j}	0.72±0.01^{m}	5.33±0.01^{n}	15.55±0.29^{a}
Lemon 1	82.86±0.46^{c}	1.80±0.01^{d}	3.27±0.02^{a}	6.76±0.01^{k}	4.56±0.03^{i}
Lemon 7	81.69±0.35^{d}	1.91±0.01^{b}	1.73±0.02^{h}	8.05±0.03^{f}	6.20±0.01^{g}

Lemon 14	81.43±0.30^{d}	0.83±0.01^{j}	0.84±0.03^{k}	5.41±0.02^{m}	11.53±0.29^{b}
Orange 1	84.64±0.32^{b}	1.96±0.03^{a}	0.76±0.01^{l}	8.44±0.03^{e}	3.94±0.03^{j}
Oange 7	86.35±0.32^{a}	1.41±0.05^{f}	1.04±0.03^{k}	9.33±0.01^{b}	2.23±0.03^{l}
Orange 14	84.33±0.33^{b}	0.89±0.01^{i}	1.21±0.01^{j}	5.92±0.01^{j}	7.65±0.33^{e}
Pawpaw 1	80.61±0.31^{e}	1.84±0.03^{c}	2.31±0.01^{f}	7.79±0.01^{h}	7.25±0.03^{f}
Pawpaw 7	84.47±0.29^{b}	1.37±0.02^{f}	2.13±0.06^{g}	9.57±0.01^{a}	2.47±0.01^{k}
Pawpaw 14	80.49±0.29^{e}	0.71±0.01^{k}	1.02±0.01^{k}	6.36±0.03^{l}	11.48±0.29^{b}
S. Pineapple 1	77.19±0.61^{g}	1.61±0.01^{d}	2.93±0.01^{d}	8.34±0.01^{f}	9.36±0.18^{d}
S. Pineapple 7	72.46±0.29^{i}	1.52±0.01^{e}	0.72±0.01^{m}	7.83±0.01^{g}	17.36±0.18^{a}
S. Pineapple 14	85.50±0.29^{a}	0.87±0.01^{i}	0.82±0.01^{l}	5.45±0.01^{m}	7.21±0.11^{f}
Plain 1	75.64±0.32^{h}	1.96±0.03^{a}	3.01±0.01^{b}	7.26±0.03^{j}	11.79±0.01^{i}
Plain 7	80.44±0.29^{e}	1.05±0.03^{h}	2.97±0.01^{c}	9.07±0.03^{c}	6.56±0.03^{g}
Plain 14	86.50±0.29^{a}	0.65±0.01^{l}	1.30±0.01^{i}	6.32±0.01^{l}	5.10±0.06^{h}
P value	0.0001	0.0001	0.0001	0.0001	0.0001

$^{A-m}$ means along the same column with different superscripts are significantly ($p<0.05$) different.

Table 4: Chemical properties of flavoured yoghurts at different storage periods

Treatment	pH	Lactic acid (%)	Vitamin C (mg/ml)	FFA (mg/ml)	Lactose (mg/ml)	Cholesterol (mg/dl)	Peroxide value (mq/KOH)
Grape	4.69±0.22^{b}	1.14±0.02	5.73±1.34^{b}	3.24±0.21^{b}	12.32±1.83^{a}	22.56±2.75^{a}	11.89±1.07^{ab}
Lemon	4.84±0.18^{a}	0.92±0.02	5.71±1.59^{b}	3.05±0.49^{c}	8.68±2.22^{f}	18.66±0.99^{d}	12.00±1.37^{ab}
Orange	4.61±0.20^{c}	2.34±1.21	6.36±1.57^{a}	2.77±0.40^{f}	9.91±0.99^{e}	20.25±3.58^{c}	12.11±2.03^{ab}
Pawpaw	4.62±0.18^{c}	0.99±0.05	5.54±1.63^{b}	2.81±0.57^{e}	10.81±1.71^{d}	20.19±3.37^{c}	11.78±1.65^{b}
S.pineapple	4.55±0.19^{d}	1.12±0.02	6.25±1.44^{a}	2.93±0.10^{d}	12.16±1.92^{b}	18.84±2.64^{d}	12.56±2.04^{a}
Plain	4.54±0.19^{d}	0.96±0.03	5.05±1.43^{c}	3.33±0.62^{a}	11.30±1.80^{c}	21.05±2.02^{b}	12.11±1.34^{ab}
P value	0.0001	0.31	0.0001	0.0001	0.0001	0.0001	0.19
Storage period							
1	5.29±0.03^{a}	0.96±0.03	11.01±0.08^{a}	2.63±0.11^{b}	5.41±0.41^{c}	28.86±1.03^{a}	7.33±0.31^{c}
7	4.66±0.02^{b}	1.71±0.61	4.05±0.23^{b}	4.53±0.18^{a}	17.23±0.41^{a}	19.4±1.02^{b}	11.17±0.45^{b}
14	3.97±0.03^{c}	1.06±0.04	1.83±0.12^{c}	1.90±0.14^{c}	9.95±0.50^{b}	12.52±0.78^{c}	17.72±0.43^{a}
P value	0.0001	0.26	0.0001	0.0001	0.0001	0.0001	0.0001
Storage period* Treatment							
Grape 1	5.46±0.00^{a}	1.19±0.01	11.05±0.05^{a}	3.29±0.05^{d}	6.15±0.08^{o}	30.59±0.30^{c}	8.33±0.33^{k}
Lemon 1	5.46±0.05^{a}	0.91±0.01	3.70±0.06^{e}	3.94±0.03^{d}	18.79±0.00^{a}	25.05±0.05^{e}	11.67±0.33^{g}
Orange 1	5.28±0.00^{b}	0.87±0.01	2.45±0.03^{h}	2.50±0.00^{h}	12.03±0.03^{h}	12.04±0.04^{n}	15.67±0.33^{e}
Pawpaw 1	5.25±0.01^{c}	0.89±0.01	10.55±0.29^{b}	2.15±0.05^{j}	1.85±0.03^{r}	22.29±0.15^{g}	6.67±0.33^{l}
S.Pineapple 1	5.19±0.01^{d}	1.05±0.01	3.57±0.04^{f}	5.02±0.02^{b}	17.01±0.01^{e}	15.56±0.29^{j}	13.67±0.33^{f}
Plain 1	5.14±0.02^{e}	0.86±0.01	1.03±0.03^{m}	1.99±0.00^{k}	7.17±0.02^{l}	18.14±0.14^{i}	15.67±0.33^{e}
Grape 7	4.66±0.00^{g}	1.06±0.03	11.39±0.31^{a}	2.25±0.03^{i}	6.95±0.03^{m}	34.57±0.03^{a}	6.67±0.33^{l}
Lemon 7	4.81±0.01^{f}	0.97±0.01	5.50±0.50^{c}	4.33±0.16^{c}	13.66±0.03^{f}	13.00±0.00^{m}	9.67±0.33^{i}
Orange 7	4.62±0.01^{g}	1.30±0.01	1.89±0.01^{j}	1.72±0.01^{k}	9.12±0.06^{j}	13.16±0.08^{l}	20.00±0.58^{a}
Pawpaw 7	4.58±0.01^{h}	1.19±0.01	11.06±0.06^{a}	2.21±0.01^{j}	6.64±0.03^{n}	32.61±0.31^{b}	8.33±0.33^{k}
S. Pineapple 7	4.62±0.02^{g}	1.13±0.01	3.00±0.00^{g}	5.02±0.02^{b}	17.59±0.01^{d}	18.54±0.29^{i}	8.67±0.33^{j}
Plain 7	4.66±0.03^{g}	1.04±0.02	1.71±0.01^{k}	1.19±0.00^{m}	8.21±0.10^{k}	9.43±0.01^{o}	18.33±0.33^{c}
Grape 14	3.94±0.02^{k}	1.16±0.03	11.01±0.01^{a}	2.77±0.03^{f}	5.13±0.07^{q}	25.05±0.05^{e}	5.33±0.33^{m}
Lemon 14	4.24±0.03^{i}	0.86±0.01	4.95±0.05^{c}	3.33±0.02^{d}	18.32±0.16^{b}	23.12±0.12^{f}	13.00±0.58^{f}
Orange 14	3.92±0.01^{k}	1.30±0.01	2.36±0.03^{i}	2.69±0.01^{g}	13.03±0.03^{g}	8.36±0.03^{p}	19.33±0.33^{b}
Pawpaw 14	4.03±0.03^{j}	0.88±0.01	11.02±0.02^{a}	3.12±0.12^{e}	5.75±0.03^{p}	28.03±0.03^{d}	8.67±0.33^{j}
S.Pineapple 14	3.85±0.03^{l}	1.19±0.01	4.00±0.00^{d}	5.57±0.04^{a}	18.02±0.02^{c}	21.10±0.10^{h}	10.33±0.33^{h}
Plain 14	3.82±0.02^{l}	1.00±0.01	1.55±0.03^{l}	1.31±0.01^{l}	10.13±0.06^{i}	14.03±0.03^{k}	17.33±0.33^{d}
P value	0.0001	0.4	0.0001	0.0001	0.0001	0.0001	0.0001

^{abcdef}Means along the same column with different superscripts are significantly ($p<0.05$) different.

Chemical properties

Presented in Table 4is the chemical properties of flavoured yoghurts at 1, 7 and 14 days of storage. Storage periods had significant ($p<0.05$) effect on parameters examined. The highest (5.29) pH value, cholesterol (28.86mg/dl) and vitamin C (11.01mg/ml) were recorded on the first day of storage but decreased with storage time. The FFA was highest (4.53mg/ml) on day 7 while the peroxide value was highest on day 14 (17.72mq/KOH). Treatment effect also showed significant differences ($p<0.05$). Lemon flavoured yoghurt had the highest pH value of 4.84 while the plain yoghurt had the least pH value of 4.54. Orange flavoured yoghurt had the utmost (6.36mg/ml) vitamin C content. The FFA concentration (3.33mg/ml) was highest in plain yoghurt. Lactose concentration (12.32mg/ml) was at peak in grape flavoured yoghurt. Peroxide value concentration (12.56mq/KOH) was significantly higher in synthetic pineapple flavoured yoghurt.

Sensory Attributes of yoghurt samples

Shown in figures 1-3 is the sensory evaluation of the fruits flavoured yoghurt. At day 1 of storage, the overall acceptability revealed that plain yoghurt had the highest acceptability score of 40 and least (22) in pawpaw. At day 7 of storage, synthetic flavoured yoghurt was most accepted with a score of 45 while the pawpaw flavoured sample was least accepted with a score of 21.

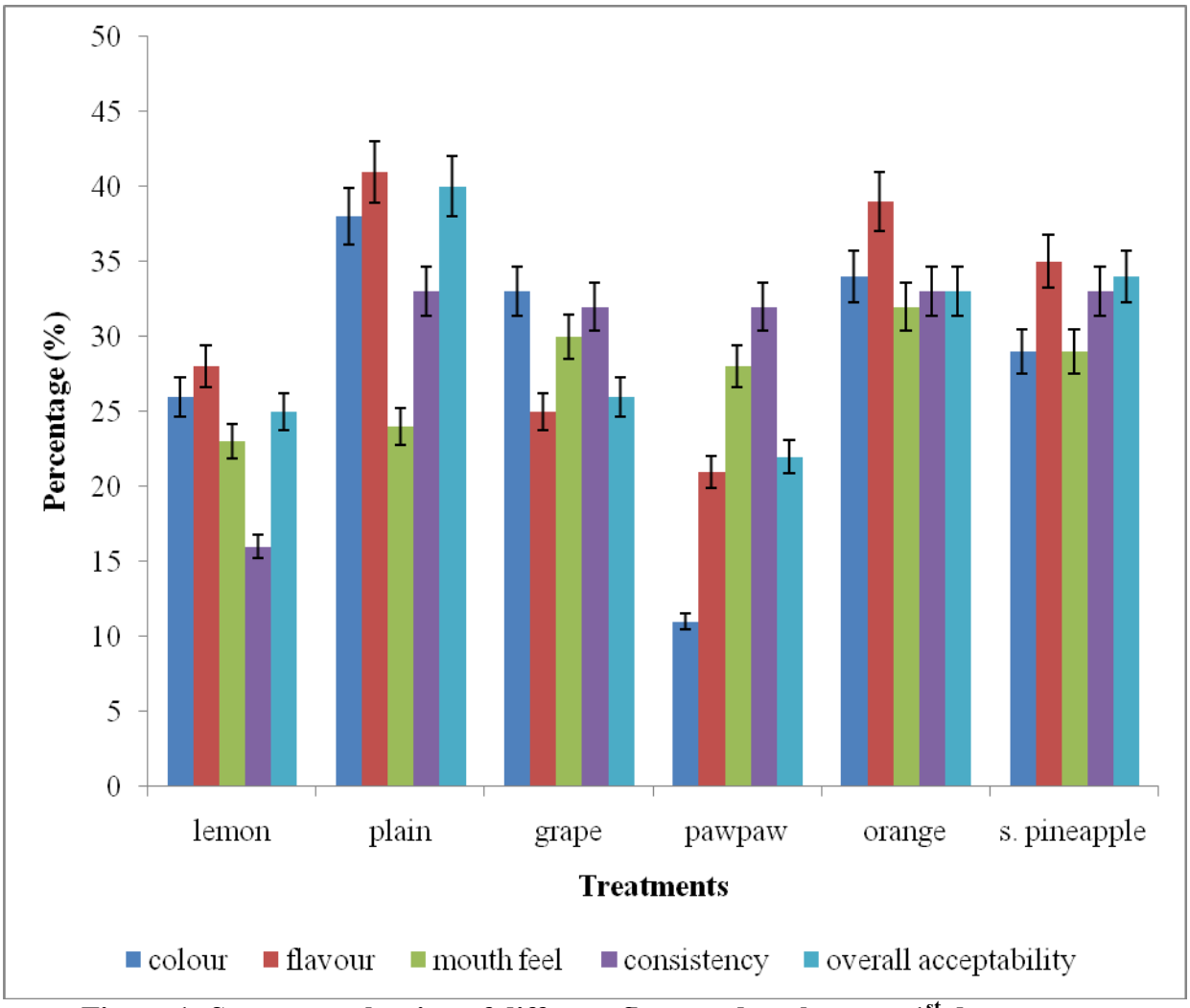

Figure 1: Sensory evaluation of different flavoured yoghurts at 1st day storage.

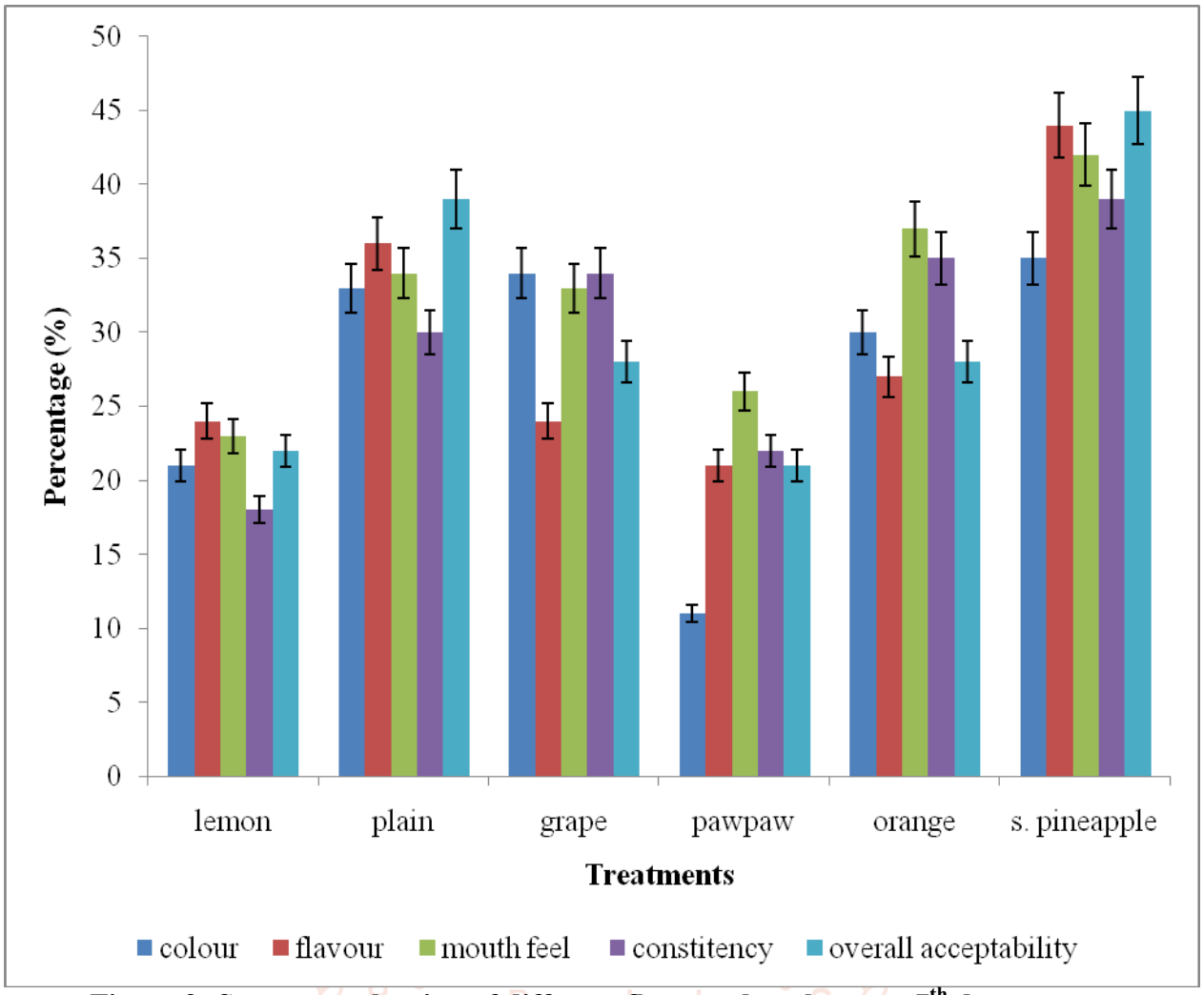

Figure 2: Sensory evaluation of different flavoured yoghurts at 7th day storage.

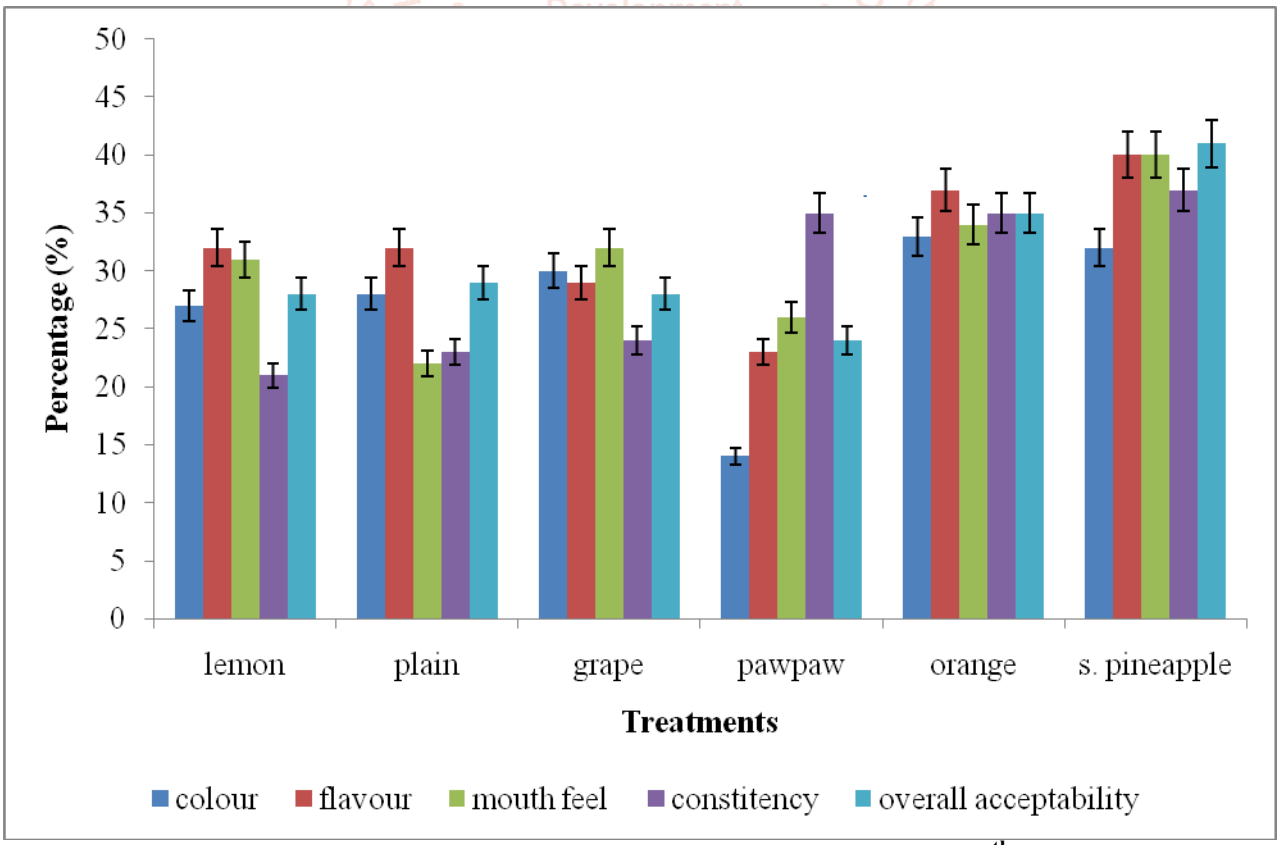

Figure 3: Sensory evaluation of different flavoured yoghurts at 14th day storage.

Discussion

The result of the WHC obtained is lower than the range 65.35- 92.74 reported by [15] in yoghurt made from mixture of cow and sheep milk. The least syneresis value obtained in grape yoghurt may be that it contained more total solids thereby improving the WHC of the product than other yoghurt samples. [16]reported that increasing total solids can result in higher water holding capacity and can be further associated with reduced syneresis.

Syneresis is the collection of whey on the surface of yoghurt [17]. It is a phenomenon that is objectionable in yoghurt production and it is a vital criterium in evaluating the quality of yogurt and fermented milks. It occurs in the whey separation during storage due to the shrinkage of the casein gel, thus becoming visible as surface whey and negatively affecting consumer perception [18]. A higher degree of syneresis is generally associated with a weak gel, characterized by the presence of larger pore size and a propensity toward casein particle rearrangement in the network of gelled coagulum [19; 20]. The reduced syneresis observed in this study as the storage period increased could be due to the restriction of water within the matrix which is made up of casein.

Apparent viscosity is affected by the strength and number of bonds between casein micelles in yoghurt, as well as their structure and spatial distribution [21]. The least viscosity (1821.44mPa/s) observed in lemon yoghurt could be that lemon has the ability of dissociating the milk components thereby preventing maximum absorption of water from the medium resulting in the decreased viscosity. According to [22], specific germs of yogurt, particularly, *Streptococcus thermophilus* produce an exopolysaccharide during the lactic acid fermentation, capable of binding to the casein of milk which confer a viscosity and a particular rheological quality to the finished product. The results of this study shows that the viscosity of flavoured yoghurts decreased with increasing storage period. This is in line with the reports of [23; 24] who reported that apparent viscosity of yoghurt during storage time decreases. However, this report disagrees with the findings of [25] who opined that apparent viscosity can increase over time due to the rearrangement of protein and protein-protein contacts.

The increase in moisture content as storage period increased could be due to the gain of moisture or water from the internal atmosphere of the refrigerator during storage. However, this was slightly lower than the range 87.76% reported by [26]. Highest ash and fat contents (1.85% and 2.45% respectively) were observed at day 1 but decreased as storage period increased. The protein value (8.79%) which was at peak at 7 days storage was higher than the values (5.03%) at day 7 storage period reported by [27]. This result disagrees with that of [28] who reported an increase in protein content as storage period progressed which may be due to the increase in the *Lactobacillus bulgaricus* and *Streptococcus thermophiles* microbe biomass. Carbohydrate content increased at day 14 storage period with recorded value of 9.76%. This disagrees with the reports of [29] who reported a decrease in carbohydrate as storage period increased in carrot and pineapple flavoured yoghurt. Fat content ranged from 2.45 - 0.99% as storage period increased which is in agreement with the results of [30]. The differences in proximate composition observed in this study may be due to the different flavourants used. Treatment effect revealed that protein was significantly ($p<0.05$) higher in both orange and pawpaw flavoured yoghurts having 7.90% each. Grape flavoured yoghurt had the highest carbohydrate value of 11.86%.

The decrease in lactose, pH, vitamin C and free fatty acid as storage period increased disagrees with the report of [31] and[32] who reported increase in lactose, pH, vitamin C and free fatty acid as storage period increased. The reduction in vitamin C content in this study as storage period increased corroborates the report of [33] that vitamin C is always sensitive to losses during processing and storage and is frequently used as a marker for product quality deterioration [34]. The observed fall in pH as the storage period increased could be due to the fermentation during the storage period as more production of lactic acid can lead to a drop in pH. This findings is in disagreement with the findings of [35 who reported an increase in pH as storage period increased. The pH values of the samples is suitable for yoghurt marketed in tropical areas due to poor handling, poor storage condition (epileptic electricity supply), high temperature which could predispose the product to deterioration. The lower the pH of a food material, the fewer the types of microorganisms that can thrive in that food [36]. The FFA values fluctuated during the storage periods. The presence of large amounts of free fatty acids (FFA) can facilitate the rate of lipid oxidation [37].The higher FFA of plain yoghurt suggests that it would be more predisposed to lipolysis. The cholesterol reduced as storage period increased which is in line with the report of [23]. Colour appears to be a very important criterion for the initial acceptability of food product [38]. The plain yoghurt had the highest colour score (38%) and was most accepted on the first day of storage while pawpaw flavoured yoghurt had the least score (11%) implying least acceptance. The highest acceptability observed in

plain yoghurt may be due to the high fat content as reflected in Table 3. [39] opined that fats promote good mouth feel of beverages. However, at day 14 of storage, synthetic pineapple yoghurt was most acceptable, this could be due to the fact that consumers are used to synthetic flavoured yoghurt than natural fruit flavoured ones and perhaps the synthetic pineapple flavour may have contained some sweetener.

Conclusion

From the study, it could be concluded that storage period had significant effect on the physico-chemical qualities and sensory attributes of flavoured yoghurts. Although, synthetic pineapple flavoured yoghurt was most preferred by the consumers at day 14, the nutrient concentration was superior in natural fruits flavoured yoghurt. Natural fruits could be used as flavourantsin yoghurt production, however, lemon juice should not be used to flavour yoghurt as its high acidity results in curdling of milk and preventing gel formation in the yoghurt. Also, from the sensory evaluation score, pawpaw showed the least acceptance throughout the days of evaluation, hence may not be considered in yoghurt production. Yoghurt flavoured with natural fruits should not be stored for more than 7 days as this reduces the nutrient concentration.

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