International Journal of Biotechnology and Food Science
Vol. 5(2), pp. 23-31, June 2017
ISSN: 2384-7344
Research Paper

Production and evaluation of yoghurt contained local stabilizers - *Brachystegia eurycoma* ('Achi') and *Detarium microcarpuim* ('Ofo')

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Accepted 11th May, 2017

Abstract. The aim of this investigation was to study the effect of using local stabilizers; *Brachystegia eurycoma* ('Achi') and *Detarium microcarpuim* ('Ofo') as natural stabilizers on physicochemical, sensory and microbiological properties of yoghurt. Achi (0.1 to 0.4%) and Ofo (0.1 to 0.4%) were added to milk used in yoghurt production. Results showed that the sensory scores of the formulated yoghurt was generally accepted by the panelists. Yoghurt contained natural stabilizers possessed higher protein, fat, ash and carbohydrate levels and lower moisture value than those of control. The calcium, vitamin A and C contents decreased in yoghurt made using stabilizers. The calcium content had an inverse relationship with pH as calcium increased with decreasing in pH values. The viscosity of the samples increased with higher concentration of the stabilizers while the total titratable acid increased with decrease in pH of the samples. The microbial count showed that the total viable count of the samples ranged from 1.2×10^3 cfu/ml for sample Y+O (0.4 % stabilizer) to 9.1×10^3 cfu/ml for sample Y+A (0.1% stabilizer) while the lactic acid bacteria ranged from 2.1×10^4 cfu/ml for sample Y+A (0.1% stabilizer) to 8.7×10^4 cfu/ml for sample Y+A (0.4% stabilizer). No mould growth was found in the samples. This shows that the use of local stabilizers such as' achi' and 'ofo' improved the proximate and physicochemical properties of stirred yoghurt.

Keywords: Yoghurt, achi, ofo, stabilizers.

INTRODUCTION

Stabilizers are commonly used in cultured products to control texture and reduce whey separation since they impart good resistance to syneresis and a smooth sensation in the mouth by binding water to reduce water flow in the food matrix space (Amatayakul *et al.*, 2006). Some may interact with protein in the food matrix and hence further increase hydration behaviour. Two of the most frequently used stabilizers are gelatin and starch. The use of modified food starch helps to create a creamier texture but the type should be selected based on the processing conditions (shear, heat, pressure and pH) that would be encountered (Melesa, 2015). In this study local stabilizers such as *Brachystegia eurycoma* 'achi' and *Detarium* 'ofo' were used as stabilizing agents due to their nutritional and gum content. The seed flour has good gelation properties and imparts a gummy texture (Agukwe and Muazu, 2014). These gums are called the seed gum and food gum (hydrocolloids). These are not true gums but are of simpler structures. These seed gums are extracted from the seeds when crushed to flour and when in powder form have the ability to swell in water and thus, are able to influence the viscosity of the liquid. It is possible for these gums to impact desirable textural and functional properties to the yoghurt (Nwosu *et al.*, 2012).

Yoghurt is fermented and coagulated milk product with a smooth texture having mildly sour taste and pleasant flavour. It is obtained from pasteurized or boiled milk by souring naturally or otherwise using lactic acid fermented bacteria. It is one of the oldest popular foods of the world

Figure 1. Tree of *Brachystegia eurycoma* Source: Nduka (2005).

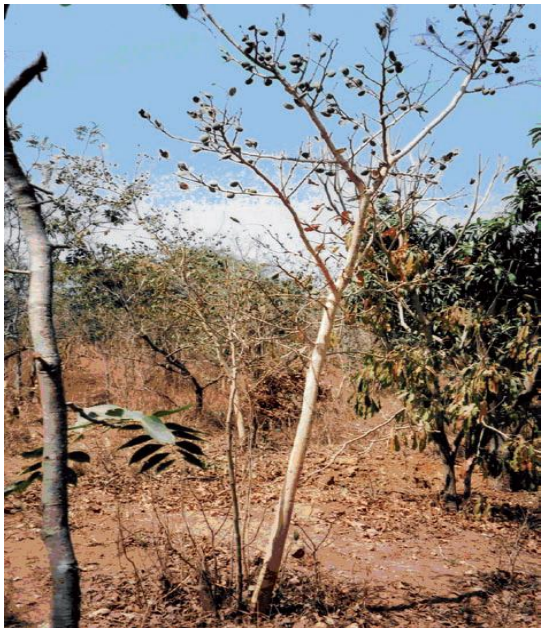

Figure 2. Young fruiting *Detarium microcarpum* tree Source: Vautier *et al*. (2007).

because of its nutritional and therapeutic value in the human diet. Yoghurt has been attributed nutraceutical, therapeutic activity and reduction in serum cholesterol, for example, non-dairy based yoghurt from oat bran are known to reduce serum cholesterol due to their beta-glucan and soluble fiber content. Yoghurts are increasingly popular due to their nutritional and potentially therapeutic characters. Yoghurt may have two primary defects: variation in viscosity and/ or expulsion of serum (syneresis). Processing, incubation and storage condition have an effect on these changes.

Diary ingredients and hydrocolloids have sometimes been added to combat such defects. In the realm of food development, combination of more than one type of hydrocolloids is commonly used in food product to modify rheological characters and satisfy processing requirement in the industry (Nima *et al.*, 2012). Some yoghurts exhibit a heavy consistency that closely resemble custard of milk pudding. In contrast, others are purposely soft boiled and are essentially drinkable. The most important textural characteristics of yoghurt are firmness and ability to retain water. The type of culture is an important factor affecting microstructure and the textural properties of yoghurt (Syed *et al*., 2008). Proteins in yoghurt are of excellent biological quality, as are that in milk, because the nutritional value of milk proteins is well preserved during the fermentation process (Guroy *et al*., 2010). It has been argued that protein from yoghurt is more easily digested than is protein from milk, as bacterial pre-digestion of milk proteins in yoghurt may occur. Both the caseins and the whey proteins in yoghurt are rich source of amino acids (93%) and high in nitrogen availability. Dairy products are vulnerable to spoilage or contamination with pathogens or microbial toxins; therefore, the microbiology of milk products is of key interest to milk handlers and those in the dairy industry as reported by Igwegbe *et al*. (2015).

Meanwhile, the quality of yoghurt can be enhanced by the use of stabilizers with protective colloid properties. Stabilizers enhance the viscosity, influence texture, creaminess and mouthfeel as well as help to prevent separation of whey from yoghurt. Sources of stabilizers are many and varied (Alakali *et al*., 2008). The use of local seeds, like *D. microcarpum* (ofo) and *B. eurycoma* (achi), has the ability to produce high viscosity in water at low concentration. Stabilizers or hydrophilic colloids bind water, prevent separation of various ingredients, increase the viscosity and inhibit the formation of large crystals, which are attributes for consumer acceptability. It is therefore necessary to rebuild yoghurt with thickeners and stabilizers such as *D. microcarpum* (ofo) and *B. eurycoma* (achi) at such concentrations that would give the desired body to the final product and in addition add medicinal values to the yoghurt, they may also help to treat diseases like obesity, cardiovascular disease, diabetes and cancer.

D. microcarpum (ofo) and *B. eurycoma* (achi) are cheap and readily available; offer important nutritional and economic advantages as shown in Figures 1 and 2. They are good sources of protein, carbohydrate, calories as well as certain vitamins and minerals. It is cheap and available.

Therefore, the main thrust of this research was to produce, optimize and evaluate the effect of some selected properties of yoghurt treated using two local stabilizers – *B. eurycoma* ('Achi') and *D. microcarpuim* ('Ofo').

Figure 3. Seeds of *Detarium microcarpum* (ofo).

Figure 4. Seeds of *Brachystegia eurycoma* (achi).

Figure 5. Formulated stirred yoghurt samples produced with Achi (Y+A).

MATERIALS AND METHODS

Procurement of raw materials

The skimmed milk (Dano), yoghurt culture (yoghurment) and local stabilizers, 'ofo' (*D. microcarpum*) and 'achi' (*B. eurycoma*), were purchased from Ogige market, Nsukka, Enugu State. Ofo and achi were authenticated by a botanist, Department of Botany, University of Nigeria, Nsukka, Enugu State.

Manufacture processing of *Brachystegia eurycoma* (achi) *and Detarium microcarpum* (ofo) stabilizers

The seeds of *Brachystegia eurycoma* (achi) and *Detarium microcarpum* (ofo) as seen in Figures 3 and 4 are cleaned to remove dirt. The seeds are soaked in water at room temperature (25°C) for six hours before dehulling, dried at 60°C for 3 h in a moisture extraction oven, milled into flour using a laboratory Thomas Wiley mill model ED-5, packaged in airtight containers and stored.

The flour of 'achi' and 'ofo' prior to addition to the milk were gradually poured into water (2 g/ 200 ml) heated to 100°C, brisked thoroughly and continuously using a whisker until it formed homogenous solution.

Manufacture of yoghurt

Dried milk sample (250 g) was reconstituted in 1750 ml of water and in accordance with the procedure by Schmidt (1991), yoghurt was processed. Milk was pasteurized at 85°C for ~30 min and homogenized at this temperature. Then milk was cooled to 43 ± 2°C and mixed with 0.1, 0.2, 0.3 and 0.4% Ofo and 0.1, 0.2, 0.3 and 0.4% Achi flours as natural stabilizers. Mixtures of milk and stabilizers were inoculated with 10 % yoghurt starter culture (Yoghurmet) consisting of *Lactobacillus bulgaricus, Streptococcus thermophilus* and *Lactobacillus acidophilus.* After fully coagulation, yoghurt treatments were cold, stirred, stored in refrigerator and presented for sensory evaluation. The stabilized yoghurt with ofo and achi are seen in Figures 5 to 7.

Physicochemical analysis

The pH, total titratable acidity, apparent viscosity, as well as fat, carbohydrate, ash, moisture and protein were determined in duplicate according to the standard methods of AOAC (2010).

Determination of vitamin C content

Vitamin C content was determined according to the

Figure 6. Formulated stirred yoghurt samples produced with “ofo” (Y+O).

Figure 7. Formulated stirred yoghurt samples produced with no stabilizer (C+Y).

method described by Onwuka (2005). Five grams of the sample and 2.5 ml of 20% metaphosphoric acid (as a stabilizing agent) was diluted with distilled water and weighed into a 100 ml volumetric flask. Ten millilitres of the solution was mixed with 2.5 ml acetone and homogenized. The absorbance reading at 264 nm wavelength using ultra-violet spectrophotometer gave the Vitamin C content.

$$\text{Vitamin C} = \frac{\text{Absorbance of test} \times \text{dilution factor}}{\text{Slope (from standard curve)}}$$

Determination of vitamin A content

Vitamin A content was determined according to Prentice and Langridge (1992) procedure. The sample was first saponified using an alcoholic solution of potassium hydroxide in the presence of pyrogallol. This freed the vitamins from the food matrix and converted any retinyl ester to retinol. The unsaponified matter containing vitamin A was extracted using a mixture of diethyl ether and petroleum spirit. The extract was evaporated under nitrogen and the residue dissolved in methanol. The extract was chromatographed using a reverse phase octa deccyl silane (ODS) column with the mobile phase consisting of 95% acetonitrile with 5% water. The separated retinol was then quantified using an ultraviolet absorbance detector at 328 nm.

$$\text{Vitamin A} = \frac{\text{Absorbance of test} \times \text{dilution factor}}{\text{Slope (from standard curve)}}$$

Determination of phosphorus content

Phosphorus in the sample was determined according to Onwuka (2005) by molybdate method using hydroquinone as a reducing agent. A mixture of 1.0 ml ammonium molybdate, 1.0 ml sodium sulphate, 1.0 ml hydroquinone and 0.5 ml of the mineral digest was agitated and allowed to stand for 30 min. The blue colour developed was quantified using a colorimeter at 660 nm against a standard.

$$\text{Phosphorous} = \frac{\text{Absorbance of test} \times \text{dilution factor}}{W \times 5}$$

Determination of calcium content

The calcium content was determined by titration method according to Kirk and Sawyer (1998) procedure. Ten millilitres of the sample was pipetted into 250 ml conical flask and 25 ml of KOH with a pinch of calcine indicator was added. The mixture was titrated against EDTA (ethylenediaminetetraacetate) solution to get an end point. The volume of Ethylenediaminetetraacetic acid is the equivalent volume of calcium in the sample.

$$\text{Calcium} = \frac{\text{Absorbance of test} \times \text{dilution factor}}{W \times 5}$$

Microbial analysis

Microbial count was determined using the method described by Prescott *et al.* (2005) for total viable count

Table 1. Effect of two local stabilizers on the proximate composition of the formulated stirred yoghurt.

Stabilizer	Samples (%)	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Achi	Y+A (0.1)	87.36 ± 0.04^{b}	0.55 ± 0.02^{b}	1.40 ± 0.02^{b}	3.09 ± 0.08^{b}	7.11 ± 0.18^{b}
	Y+A (0.2)	87.09 ± 0.02^{c}	0.84 ± 0.04^{c}	1.83 ± 0.01^{c}	3.13 ± 0.02^{b}	7.60 ± 0.11^{b}
	Y+A (0.3)	83.14 ± 0.01^{d}	0.98 ± 0.07^{d}	1.90 ± 0.05^{c}	3.15 ± 0.04^{b}	10.83 ± 0.18^{c}
	Y+A (0.4)	79.22 ± 0.09^{e}	1.04 ±0.02^{d}	3.00 ± 0.02^{d}	3.46 ± 0.07^{c}	13.28 ± 0.22^{d}
Ofo	Y+O (0.1)	84.68 ± 0.05^{b}	0.11 ± 0.14^{a}	1.25 ± 0.08^{b}	3.33 ± 0.05^{b}	9.67 ± 1.13^{b}
	Y+O (0.2)	84.65 ± 0.02^{b}	0.15 ± 0.14^{a}	1.30 ± 0.02^{b}	3.70 ± 0.02^{c}	10.20 ± 0.25^{b}
	Y+O (0.3)	75.76 ± 0.02^{c}	0.46 ± 0.00^{b}	1.45 ± 0.01^{c}	3.74 ± 0.02^{c}	18.59 ± 0.07^{c}
	Y+O (0.4)	71.15 ± 0.05^{d}	0.49 ± 0.05^{b}	2.43 ± 0.02^{d}	3.77 ± 0.01^{c}	22.11 ± 0.21^{d}
Control	C+Y (0.0)	90.78 ± 0.11^{a}	0.11 ± 0.02^{a}	1.00 ± 0.08^{a}	2.75 ± 0.08^{a}	5.35 ± 0.05^{a}

Values are means ± standard deviation of duplicate readings. Values are means on the same column bearing different superscripts are significantly ($p > 0.05$) different. Key: Y = Yoghurt, A = Achi, O = Ofo, C = Control.

and mould count while the method described by Oxoid manual (1982) was used to determine lactic acid bacteria count.

Sensory evaluation of yoghurt

The sensory evaluation was carried out according to Ihekoronye and Ngoddy (1985) using a 20-man semitrained panelists. The panelists were instructed to indicate their preference of the samples. A nine-point Hedonic scale (where 9 was the highest score and 1 the lowest score) for each characteristic such as colour, flavour, mouth feel, and overall acceptability was determined.

Data analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) using split-plot (3 by 4 factorial) in completely randomized design according to the methods of Gomez and Gomez (1985). Significant means were separated using Duncan's new multiple range test and significance accepted at $p < 0.05$.

RESULTS AND DISCUSSION

The control (sample C+Y) had the highest moisture content (90.78%) compared to sample Y+A (Table 1). Moisture content decreased from 87.36% for concentration 0.1 to 79.22% for concentration 0.4%. Also sample Y+O had moisture content decreased from 84.68% for concentration 0.1 to 71.15% for concentration 0.4%. This result showed that the moisture content of yoghurt decreased with increasing of stabilizer concentration. This could probably be due to the ability of stabilizers to increase the viscosity of yoghurt (Syed *et al.*, 2008). From the result, sample Y+A at concentrations 0.1, 0.2, 0.3 and 0.4% had more viscous effect than sample Y+O at concentrations of 0.1, 0.2, 0.3 and 0.4%, respectively. There was no significant ($p < 0.5$) difference between samples Y+A and samples Y+O. However the control (sample C+Y) was significantly ($P < 0.5$) different from sample Y+A (and sample Y+O).

From Table 1, sample C+Y had the least amount of fat (1.00%) probably because skim milk was used and the standard composition of low fat yoghurt is 0.8% (Holland *et al.*, 1991; Buttriss, 1997). The fat content of samples Y+A and Y+O increased from 1.40 % at concentration of 0.1 to 3.00% at concentration of 0.4 and 1.25% at concentration 0.1 to 2.45 % at concentration of 0.4% respectively and progressively due to increase in the concentration of the 'achi' and 'ofo' stabilizers which is in contrast with Alakali *et al.* (2008). According to Nwosu (2012) the fat content of 'achi' and 'ofo' were 8.48 and 5.60%, respectively but during pasteurization the fat is reduced. This was also in agreement with other reported works of Bhat and Karim (2009) who also gave fat content of 'achi' to be 5.87% and 'ofo' ranged between 1.5 to 12.0%.

The result also showed that the control (sample C+Y) had the lowest ash content compared to yoghurt formulated from 'ofo'and 'achi' but yoghurt formulated from 'achi' had a higher ash content, presumably due to the high content of calcium in 'achi' (Uhegbu *et al*., 2009) and phosphorous. Normal extracellular calcium concentration is necessary for blood coagulation and for integrity of intracellular cement substances (Okaka and Okaka, 2001).

The protein content of sample Y+A increased from 3.09% at concentration of 0.1% stabilizer to 3.46% at concentration of 0.4% stabilizer while that of Y+O increased from 3.33% at concentration 0.1% stabilizer to 3.33% at concentration of 0.4% stabilizer. It is shown that there is no significant ($p < 0.5$) difference among the protein samples and its concentrations. Milk and its derivative yoghurt, are known sources of high quality dietary proteins with high biological value (Alakali *et al.*, 2008).

Table 2. Effect of two local stabilizers ('achi' and 'ofo') on the micronutrient composition of stirred yoghurt.

Stabilizer	Samples (%)	Phosphorous (mg/100 g)	Calcium (mg/100 g)	Vitamin A (mg/100 g)	Vitamin C (mg/100 g)
Achi	Y+A (0.1)	180.51 ± 0.01^{b}	25.52 ± 0.01^{a}	30.83 ± 0.03^{d}	34.15 ± 0.01^{d}
	Y+A (0.2)	188.69 ± 0.02^{c}	25.64 ± 0.02^{b}	24.36 ± 0.01^{c}	32.82 ± 0.01^{c}
	Y+A (0.3)	198.81 ± 0.04^{d}	27.92 ± 0.04^{c}	20.21 ± 0.01^{b}	32.74 ± 0.03^{b}
	Y+A (0.4)	201.53 ± 0.03^{e}	30.02 ± 0.01^{d}	18.02 ± 0.01^{a}	30.59 ± 0.04^{a}
Ofo	Y+O (0.1)	178.01 ± 0.01^{b}	29.55 ± 0.01^{d}	32.26 ± 0.02^{d}	32.46 ± 0.01^{d}
	Y+O (0.2)	180.45 ± 0.00^{c}	29.46 ± 0.01^{c}	29.16 ± 0.02^{c}	29.16 ± 0.02^{c}
	Y+O (0.3)	188.67 ± 0.01^{e}	28.12 ± 0.03^{b}	26.16 ± 0.03^{b}	26.10 ± 0.01^{b}
	Y+O (0.4)	183.81 ± 0.04^{d}	26.03 ± 0.01^{a}	22.80 ± 0.04^{a}	26.00 ± 0.01^{a}
Control	C+Y (0.0)	153.03 ± 0.03^{a}	34.03 ± 0.01^{e}	35.63 ± 0.04^{e}	40.15 ± 0.01^{e}

Values are means ± standard deviation of duplicate readings. Values are means on the same column bearing different superscripts are significantly ($p > 0.05$) different. Key: Y = Yoghurt, A = Achi, O = Ofo, C = Control.

The low protein content of sample C+Y could be as a result of the high mineral (nitrogen) level of 'achi' and 'ofo' (Uhegbu *et al*., 2009).

It was also observed that sample C+Y had the lowest amount of carbohydrate and is significantly ($p > 0.5$) different from samples Y+A and Y+O. Also samples Y+A which had mean values of 7.11, 7.60, 10.83 and 13.28% at concentrations of 0.1, 0.2, 0.3 and 0.4% and samples Y+O which had mean values of 9.67, 10.20, 18.59 and 22.11% at concentration of 0.1, 0.2, 0.3 and 0.4% respectively were significantly ($p < 0.5$) the same. The high carbohydrate content of these seeds as well as their ability to form viscous gums at such low concentrations of 0.1 to 1% showed that they belong to the class of food ingredients known as hydrocolloids (Ihekoronye and Ngoddy, 1985). Apart from the supply of energy, from studies it had been shown that viscous polysaccharides could slow the rate of gastric emptying (Schwarts *et al*., 1982).

The control, sample C+Y (0% stabilizer) had the highest calcium content compared to samples Y+A and sample Y+O (Table 2). The calcium content of samples Y+A increased with increase in concentration of 'achi' while the calcium content of sample Y+O decreased with increase in concentration of 'ofo'. This could be attributed to the variations in pH. Lowering pH causes important alterations in the composition structure and reactivity of casein micelles and modifying the mineral absorption of calcium from milk.

The phosphorous content of the formulated stirred yoghurt increased with increase in concentration of the local stabilizers. The control, sample C+Y had the lowest phosphorous content. The phosphorous content of sample Y+A and sample Y+O increased with increase in concentration of local stabilizers. However it was observed that sample Y+A had more phosphorous than sample Y+O.

From the results, the vitamin A and C contents of sample Y+ and sample Y+O were not significantly ($p < 0.5$) different but the concentrations caused a significant ($p < 0.5$) difference in the vitamin A and C contents. The control, sample (C+Y) had the highest vitamin A and C contents. The vitamin A and C contents of sample Y+A and sample Y+O decreased significantly with increase in concentration of 'achi' and 'ofo', respectively.

Table 3 showed that sample Y+O were significantly ($p > 0.5$) differed from sample Y+A. The pH of sample Y+A decreased with increase in concentration of 'achi' while the pH of sample Y+O increased with increase in concentration of 'ofo'. The increase in acidity of sample Y+A with increase in concentration of 'achi' could be attributed to the stability of 'achi' in acidic conditions and its low buffering effect. It could also be as a result of 'achi' fermenting alongside with lactose to produce lactic acid, phenolic acid and phytic acid (Giami and Wachuku, 1997). The decrease in the acidity of sample Y+O with increase in concentration could be attributed to the inability of the ions to travel through the viscous liquid.

It was also observed that there was an increase in viscosity of sample Y+A and sample Y+O with increase in concentration of 'achi' and 'ofo' respectively, while sample C+Y (0 % stabilizer) had the lowest viscosity. The increase in viscosity resulted from the interaction between the proteins, which is positively charged and the polysaccharides, which are negatively charged (Gaonkar, 1995). Sample Y+A was significantly ($p < 0.5$) the same for all the physicochemical parameters analysed. Sample Y+O did not show much significant ($p < 0.5$) difference. However sample Y+A differed significantly ($p > 0.5$) from sample Y+O. With decrease in pH, the total titratable acidity increased. This could be attributed majorly to the lactic acid produced during fermentation of yoghurt.

Table 4 shows the effect of two local stabilizers ('achi' and 'ofo') on the sensory characteristics of stirred yoghurt. The sensory scores showed that the flavour of samples Y+A decreased with increase in concentration of the stabilizer. Also the flavour of the sample Y+O decreased with increase in concentration. This could be

Table 3. Effect of two local stabilizers ('achi and 'ofo') on the physicochemical properties of stirred yoghurt.

Stabilizer	Sample (%)	Viscosity (Cp)	pH	Total titrable acid
Achi	Y+A (0.1	44.44 ± 0.04^{b}	5. 40 ± 0.00^{d}	0.27 ± 0.00^{c}
	Y+A (0.2)	44.62 ± 0.05^{c}	5.50 ± 0.00^{d}	0.26 ± 0.01^{c}
	Y+A (0.3)	50.09 ± 0.01^{d}	4.65 ± 0.07^{c}	0.33 ± 0.00^{bc}
	Y+A (0.4)	55.66 ±0.02^{e}	4.65 ± 0.07^{b}	0.40 ± 0.01^{b}
Ofo	Y+O (0.1)	44.24 ± 0.02^{b}	4.20 ± 0.00^{b}	0.50 ± 0.03^{a}
	Y+O (0.2)	48.91 ± 0.04^{c}	4.20 ± 0.00^{b}	0.44 ± 0.04^{a}
	Y+O (0.3)	57.66 ± 0.05^{d}	4.25 ± 0.00^{b}	0.41 ± 0.05^{a}
	Y+O (0.4)	59.67 ± 0.05^{d}	4.30 ± 0.07^{b}	0.54 ± 0.00^{a}
Control	C+Y (0.0)	33.87 ± 0.02^{a}	3.85 ± 0.07^{a}	0.49 ± 0.06^{a}

Values are means ± standard deviation of duplicate readings. Values are means on the same column bearing different superscripts are significantly ($p > 0.05$) different. Key: Y = Yoghurt, A = Achi, O = Ofo, C = Control.

attributed to masking of the sour yoghurt taste with the flavour of the stabilizers, thereby making them less acceptable with increase in concentration. Sample Y+A (0.1 and 0.2%) was more preferred than the control, sample C+Y (0% stabilizer) which was more preferred than sample Y+O (0.1, 0.2, 0.3 and 0.4% stabilizer). This could probably be attributed to the fact that at low concentrations, the flavour of achi had no significant effect on product.

The mouth feel of sample Y+A (0.1, 0.2 and 0.3% stabilizer) decreased with increase in concentration of the stabilizer although sample Y+A at concentration 0.4% had a better mouth feel than sample Y+A at concentration of 0.3 %. Sample Y+O (0.3% stabilizer) had a better mouth feel than sample C+Y (0% stabilizer). However, sample Y+A (0.1% stabilizer) had the most preference, possibly due to the thickening and viscosity effect it gave to the yoghurt (Ajayi *et al.*, 2006).

It was observed that sample Y+A (0.1% stabilizer) had the best aroma which could probably be attributed to the fragrance of 'achi' flours (Vautier *et al.*, 2007). The aroma of sample Y+A (0.1, 0.2 and 0.4 % stabilizer) decreased with increase in concentration of the stabilizer while the aroma of sample Y+A (0.3% stabilizer) varied. However, the aroma of sample Y+O (0.1, 0.2 and 0.3% stabilizer) increased with increase in concentration of the stabilizer with the exception of sample Y+O (0.4% stabilizer).

The taste of sample Y+A (0.1, 0.2 and 0.3% stabilizer) decreased with increase in concentration of the stabilizer while sample Y+A (0.4% stabilizer) varied. Also the mean score of sample Y+O (0.1, 0.2 and 0.3% stabilizer) decreased with increase in concentration of the stabilizer while sample Y+O (0.4 % stabilizer) varied. Sample Y+O (0.3% stabilizer) and sample Y+A (0.2% stabilizer) had better taste than the control, sample C+Y (0% stabilizer) while sample Y+A (0.1% stabilizer) had the highest mean score (7.10).

The aftertaste of the yoghurt sample shows that sample Y+O (0.1, 0.2 and 0.4% stabilizer) decreased with increase in concentration of stabilizer while Y+O (0.3% stabilizer) varied. The highest mean score was observed in sample Y+A (0.1 % stabilizer) while sample C+Y (0% stabilizer) had better aftertaste than sample Y+O (0.1, 0.2, 0.3 and 0.4% stabilizer).

From Table 4, it was also observed, that the colour of sample Y+A (0.1, 0.2 and 0.4% stabilizer) had decreasing mean scores with increase in concentration of the stabilizer while sample Y+A (0.3% stabilizer) had the lowest mean score. Sample Y+A (0.1 and 0.2 % stabilizer) and sample Y+O (0.2 and 0.3% stabilizer) had higher mean scores than the control, sample C+Y (0% stabilizer). The highest mean score was observed in sample Y+A (0.1% stabilizer).

The consistency of sample Y+A (0.1, 0.2 and 0.4% stabilizer) decreased with increase in concentration of the stabilizer while sample Y+A (0.3% stabilizer) was the least preferred concentration. Sample Y+O (0.3% stabilizer) had the highest consistency. This could probably be attributed to the ability of 'ofo' to impact desirable textural and functional properties to finished food products particularly "convenience foods" (Adebowale and Lawal, 1986).

Sample Y+A (0.2 % stabilizer) had the highest overall acceptability and were significantly ($p > 0.5$) the same with same sample at (0.1% stabilizer).This could be the concentration that gave the maximal effect of the yoghurt sample. Also, the acceptability of sample Y+O (0.1, 0.2 and 0.4%) decreased with increase in concentration of the stabilizers while (0.3% stabilizer) varied.

The total viable count of sample Y+A decreased from 9.1×10^3 to 2.1×10^3 cfu/ml (Table 5). However, the total viable count of sample Y+O decreased from 4.9×10^3 to 1.2×10^3 cfu/ml with increase in concentration of the local stabilizers ('achi' and 'ofo'). The result indicates that the

Table 4. Effect of two local stabilizers ('achi' and 'ofo') on the sensory characteristics of stirred yoghurt.

Stabilizer	Samples (%)	Flavor	Mouth feel	Aroma	Taste	After taste	Colour	Consistency	Overall acceptability
Achi	Y+A (0.1)	7.35 ± 0.31^{a}	7.45 ± 0.31^{a}	7.50 ± 0.24^{a}	7.10 ± 0.30^{a}	6.75 ± 0.38^{a}	7.40 ± 0.29^{a}	6.80 ± 0.43^{ab}	7.40 ± 0.31^{a}
	Y+A (0.2)	6.80 ± 0.32^{ab}	6.85 ± 0.30^{ab}	7.05 ± 0.29^{abc}	6.40 ± 0.39^{ab}	6.95 ± 0.26^{a}	7.11 ± 0.32^{a}	6.37 ± 0.42^{abc}	7.42 ± 0.25^{a}
	Y+A (0.3)	5.25 ± 0.47^{c}	3.95 ± 0.45^{d}	5.30 ± 0.39^{d}	4.40 ± 0.39^{d}	4.45 ± 0.43^{d}	4.57 ± 0.50^{c}	3.24 ± 0.50^{e}	4.62 ± 0.51^{c}
	Y+A (0.4)	4.85 ± 0.46^{c}	4.55 ± 0.41^{d}	5.35 ± 0.46^{d}	4.65 ± 0.43^{d}	4.90 ± 0.57^{cd}	5.45 ± 0.39^{bc}	5.00 ± 0.42^{cd}	5.30 ± 0.42^{c}
Ofo	Y+O (0.1)	5.80 ± 0.42^{bc}	4.60 ± 0.37^{d}	6.05 ± 0.37^{cd}	5.50 ± 0.35^{bcd}	5.45 ± 0.37^{bcd}	6.55 ± 0.26^{a}	4.80 ± 0.51^{d}	5.50 ± 0.47^{bc}
	Y+O (0.2)	5.65 ± 0.32^{bc}	4.35 ± 0.47^{d}	6.25 ± 0.34^{bcd}	5.20 ± 0.40^{cd}	5.15 ± 0.43^{cd}	7.15 ± 0.39^{a}	3.40 ± 0.50^{e}	5.00 ± 0.40^{c}
	Y+O (0.3)	6.50 ± 0.36^{ab}	6.60 ± 0.32^{ab}	7.20 ± 0.26^{ab}	6.60 ± 0.36^{ab}	6.50 ± 0.41^{ab}	7.10 ± 0.38^{a}	7.25 ± 0.38^{a}	6.90±0.38^{a}
	Y+O (0.4)	4.95 ± 0.44^{c}	5.10 ± 0.38^{cd}	5.45 ± 0.41^{d}	4.35 ± 0.39^{d}	5.10 ± 0.39^{cd}	6.25 ± 0.35^{ab}	5.65 ± 0.47^{bcd}	5.45 ± 0.37^{bc}
Control	C+Y (0.0)	6.60±0.29^{ab}	6.05 ± 0.37^{bc}	6.36 ± 0.42^{bcd}	5.85 ± 0.53^{bc}	5.80 ± 0.34^{abc}	7.00 ± 0.30^{a}	5.80 ± 0.43^{bcd}	6.60 ± 0.43^{ab}

Values are mean ± standard deviation of duplicate readings. Means on the same column with different superscripts are significantly ($p > 0.05$) different. Key: Y = Yoghurt, A = Achi, O = Ofo, C = Control.

Table 5. Effect of two local stabilizers on the microbial count (cfu/ml) of stirred yoghurt.

Stabilizer	Sample (%)	Total viable count	Lactic acid bacteria	Mould count
Achi	Y+A (0.1)	9.1×10^3	2.1×10^4	NG
	Y+A (0.2)	5.3×10^3	5.4×10^4	NG
	Y+A (0.3)	3.0×10^3	7.2×10^4	NG
	Y+A (0.4)	2.1×10^3	8.7×10^4	NG
Ofo	Y+O (0.1)	4.9×10^3	7.8×10^4	NG
	Y+O (0.2)	3.9×10^3	7.1×10^4	NG
	Y+O (0.3)	3.8×10^3	4.9×10^4	NG
	Y+O (0.4)	1.2×10^3	3.5×10^4	NG
Control	C+Y (0.0)	6.1×10^4	3.5×10^4	NG

Key: Y= Yoghurt, A= Achi, O= Ofo, C= Control, NG: No growth.

control (sample C+Y) contained 6.1×10^4 cfu/ml. The depressing rate of total viable count in samples Y+A and Y+O with increase in concentration of 'achi' and 'ofo' might suggest that the local stabilizers has anti-microbial effect (Miguel *et al*., 2003).

It was also observed that lactic acid bacteria content of sample Y+A increased from 2.1×10^4 to 8.7×10^4 cfu/ml while that of sample Y+O decreased from 7.8×10^4 to 3.5×10^4 cfu/ml. The control (sample C+Y) had lactic acid bacteria content of 4.2×10^4 cfu/ml. These variations could be as a result of possible generation of acids or alkali in 'achi' and 'ofo' during processing (Nwosu, 2012).

The increase in lactic acid bacteria content of sample Y+A and the decrease in lactic acid bacteria content of sample Y+O was probably be due to the increase and decrease in the acidity of the medium.

Conclusion

In this study on the laboratory production of yoghurt samples with local stabilizers, sample Y+A (0.4% achi) had the highest fat, ash, phosphorous and calcium while sample Y+O (0.4% ofo) had the highest protein, carbohydrate and pH content. From the sensory scores, it was observed that 'achi' at 0.1 to 0.2% concentration was optimal and most preferred for stirred yoghurt while 0.3 % concentration of 'ofo' was the less preferred. From the microbial count, it was also deduced that the product is safe for consumption since the highest total viable count was found in sample Y+A (0.1% achi) which is within the acceptable range. No mould growth was observed in any of the product while the highest lactic acid bacteria count was found in sample Y+A (0.4% achi). The results obtained from this study indicate that the addition of 'achi' and 'ofo' improved the nutritional content and organoleptic characteristics of stirred yoghurt with opportunities for future industrial application. It is recommended that the food industries adopt the commercialization of the yoghurt stabilized using 'achi' and 'ofo'.

ACKNOWLEDGEMENT

We wish to appreciate the grant obtained from Friesland Campina WAMCO, Nigeria Plc.

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