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Prebiotic Effects of *Colocasia esculenta* Starch on the Nutritional, Physicochemical and Microbial Properties of Yogurt

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Abstract

Native cocoyam (*Colocasia esculenta*) was modified using heat moisture conditioning process to obtain Resistant Starch (RS). The native and modified starch samples were used to partially replace the milk content of yogurt at three different levels (0.5, 1.0 and 1.5%). The stirred yogurt samples produced were analyzed for proximate and mineral compositions, physicochemical, and microbial properties using standard methods. The results showed that the yogurt samples with native and modified starches had 76.89 - 82.09, 2.64 - 2.87, 5.39 - 5.55, 0.75-0.78, and 8.72 - 14.34% moisture, fat, protein, ash and carbohydrate, respectively while the control sample had 85.92, 3.02, 5.64, 0.79, 4.63% carbohydrate, respectively. The mineral content, pH, total soluble solids, syneresis of the yogurt samples decreased with increases in the addition of native and resistant starches while the titratable acidity and lactic acid bacteria count increased. During storage at refrigerated temperature, the pH and lactic acid bacteria count decreased while titratable acidity, total soluble solids and syneresis increased. The yogurt sample with 1.5% resistant starch had the least fat content, highest viscosity, lowest rate of syneresis and highest lactic acid bacteria count.

Keywords: Cocoyam, Resistant starch, Yogurt, Syneresis, Storage

Introduction

Yogurt is obtained from the lactic acid bacteria fermentation of milk by *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. The presence of live lactic bacteria characterizes yogurt (Sandoval-Castilla *et al*., 2004; FDA, 2013). Yogurt is traditionally manufactured from the milk of cows, water buffaloes, goats, and sheep. In some parts of the world, however, milk from mares and camels is used to make yogurt (Weerathilake *et al*., 2014). Lactose, the sugar in milk, is fermented to acid (lactic acid), which causes the curd to form. The acid also inhibits the growth of germs that cause food poisoning and some bacteria that cause spoilage. Yogurt has been linked to nutraceutical, therapeutic (Sloan, 2001), and probiotic effects (Shah, 2001), including improved digestion, immune system support, anticarcinogenic activity, and serum cholesterol lowering (Milo-Ohr, 2002). Yogurt is a nutritious food because of its excellent digestion and nutrient absorption. People with lactose intolerance, as well as gastrointestinal illnesses such as inflammatory bowel disease and irritable bowel disease, can benefit from it. It also boosts immune system and helps to control weight (Lourens-Hattingh and Viljoen, 2001; Mckinley, 2005).

Reduced fat solids in yogurt have been linked to poor texture, and the fat is usually replaced with skim milk powder, sodium caseinate, or whey protein concentrates (WPCs). The proportions of these ingredients required to create a total solids content equivalent to full-fat yogurt can result in a powdered taste, excessive acid formation from lactose fermentation, excessive hardness, greater whey outflow, and a gritty texture (Guzman-Gonzalez *et al*., 2000). A proper texture and body profile with a low syneresis rate is one of the most essential quality criteria of yogurt (Toniazzo *et al*., 2014). Yogurt can be made by partially replacing the fat content of the milk base with fat replacers, which are low-calorie products. Native and modified starch-based fat replacers (from maize, rice, potato, tapioca, amaranth, oat, pea, quinoa and waxy maize) have been tested in a variety of low-fat foods, including yogurt, cheese, sausage, mayonnaise, and frozen desserts. Addition of starch results in increased product production, water-holding capacity, and gel hardness, as well as changes in flow behaviors (e.g., viscosity) and sensory quality adjustments (e.g., creaminess and tenderness) (Ognean *et al*., 2006).

Before heat treatment and acidification, yogurt's rheological and stability properties can be altered by supplementing the milk with dairy-based components, non-dairy additives, or a combination of both (Oh *et al.,* 2006). Non-dairy additions such as polysaccharides and starches can be used in yogurt to change the rheological qualities, either in combination with dairy components or on their own. Yogurts manufactured from various starches have variable viscosity rates; for example, wheat starch had the highest shear consistency compared to other kinds (Keogh and O'Kennedy, 1998).

Starch has been used in several low-fat products to improve some properties such as texture, colour and stability of foods (Esteller et al., 2004). The amount of starch and starch breakdown products not absorbed in the small intestine of healthy people is known as resistant starch (RS) (Asp, 1992). In most definitions, RS is now classified as dietary fiber (Champ *et al*., 2003). Resistant starch is classified into five different types according to Birt *et al*. (2013). Type I is physically inaccessible starch synthesized in the endosperm of cereal grains or seeds, where starch granules are surrounded by protein matrix and cell wall material. Granular starch with the B- or C-type polymorphism and highly resistant to enzymatic hydrolysis is classified as Type II resistant starch. Type III is retrograded starch formed during processing when heating and subsequent cooling of starch renders the molecules of amylose and amylopectin inaccessible to enzymatic hydrolysis. Type IV is chemically modified starch resistant to enzymatic hydrolysis. Type V is amylose-lipid complexed starch. The nature of RS in foods varies and is classified on the basis of its botanical source and the method of modification it has been subjected to.

Tuber crop starches are getting a lot of attention these days. Alternate options that could meet commercial demands of starch are now being explored because grain starch is under increasing strain (Falade and Okafor, 2013). Cocoyam (*Colocasia esculenta*), a member of the Araceae family, is an ancient crop used for its tasty corms and leaves and it is grown throughout the humid tropics (Ikpeme *et al.*, 2010). It is well-known and has a lengthy history of cultivation. Its corms provide a significant amount of starch. Cocoyam produces corms with starch of small size granules (Perez *et al.*, 2007; Ammar *et al.*, 2009). *Colocasia esculenta* contains 66.62% moisture, 4.09% ash, 6.40% crude protein, 1.83% fibre, 0.78% fat and 20.28% carbohydrate (Lewu *et al*., 2010). Despite its great nutritional content, most Nigerians consume cocoyam at a low quantity when compared to other root and tuber crops (Shittu *et al*., 2007). Cocoyam has a high starch content, which can be harvested and used in a variety of sectors depending on its appropriateness (Moorthy, 2002). Although it has been shown that *Colocasia esculenta* taro corms contain 24.5% starch (Owusu-Darko *et al*., 2014), this source of starch is underexploited.

Starch is rarely eaten in its natural state. Because they are unstable when exposed to changes in temperature, pH, and shear stresses, most native starches are limited in their direct application. Decomposition and retrogradation of native starches are common (Berski *et al*., 2011). Native starches are modified to achieve specific qualities such as solubility, smoothness, adhesion, and temperature endurance in industrial operations (Singh *et al*., 2007; Sweedman *et al*., 2013). Starches are physically or chemically modified, or both, to enhance their favorable traits, reduce their negative qualities, or introduce new characteristics.

Processing cocoyam to obtain native starch and modifying the starch to get resistant starch II could be one of the greatest strategies to preserve cocoyam and improve earnings from it. Short chain fatty acids produced by the RS fermentation process have a variety of physiological and prebiotic effects that are beneficial to human health (Fuentes-Zaragoza *et al*., 2011). There is a scarcity of information on the use of modified starches in the manufacturing of yogurt. Consumers have demanded lower milk-fat dairy products, including yogurt, in order to lower the risk of coronary heart disease due to the supposed hypercholesterolemic effect of milk fat and the need to assure overall good health (Sloan, 2000; INEGI, 2002). The goal of this study was to produce and apply native and resistant starch from cocoyam as a prebiotic in the formulation of ‘probiotic’ yogurt.

Materials and Methods

Materials

Cocoyam (Colocasia esculenta taro) corms was identified at Herbarium unit, Botany Department, Obafemi Awolowo university, Ile-Ife, Nigeria. Whole milk powder (Peak® milk) and sucrose were purchased from Ile-Ife market, Nigeria. Freeze died starter culture (Lactobacillus bulgaricus, Streptococcus thermophilus and Lactobacillus acidophilus), produced in 500 Aeroparc, CP 598, QC, Canada, J8H 4G4 was used. All reagents used were of analytical grade and were obtained from Fisher Scientific (Oakville, ON, Canada) and Sigma-Aldrich Chemical Company (MO Loius, USA).

Methods

Starch extraction from cocoyam

The modified method of Sit et al. (2013) method was used to extract starch from cocoyam corms. The corms were rinsed under running water, peeled manually with a stainless-steel knife, and cubed. A laboratory blender (Philips HL1632, India) was used to grind the cubes for 2 minutes at the highest speed. The slurry was mixed with distilled water 10 times its volume. The suspension was filtered through double fold cheese cloth and the filtrate was allowed to sediment for 12 h. The supernatant was discarded and the sediment obtained was washed with distilled water (1:3 w/v) twice. The final sediment was oven-dried using a hot air-oven (Uniscope, SM9053, England) at 50 ± 2 °C until the moisture content of about 10% was reached (after about 8 h). The dried starch was ground using an electric blender (SAISHO Magic Blender S-742 at maximum speed for 1 minute), passed through 200 µm mesh sieve and kept in air-tight Ziploc bags for further processing.

Starch modification using heat moisture conditioning (RS II)

This procedure was carried out according to Shin et al. (2005). The moisture level of the starch samples was raised to 20% (the moisture level of the raw unmodified starch was pre-determined). The sample was kept in stainless steel containers at room temperature for 24 h for equilibration. The starch sample was wrapped in aluminum foil, placed in the stainless-steel containers and covered prior to heat treatment. The heat treatment was performed in a hot air oven (Uniscope, SM9053, England) at 100 °C for 12 h. The stainless-steel container was subsequently opened, and the sample was oven-dried at 50 ± 2 °C until the moisture content of 10% was reached (after 5 h) after which the starch sample was finely ground using an electric blender (SAISHO Magic Blender S-742 at 900 rpm for 1 minute) and stored in air-tight Ziploc bags at ambient temperature (28 ± 2 °C). The moisture level of the starch sample was raised according to Equation 1;

$$M_w = \frac{M_s\,(M_f - M_i)}{100 - M_f},$$
(Equation 1)

M_w = Mass of water to be added to the sample ,
M_s = Initial mass of the sample ,
M_f = Final (desired) moisture content of the sample ,
M_i = Initial moisture content of the sample .

Production of yogurt

The yogurt was produced using a modified method (Okoth et al. 2011). The control sample contained 14% w/v whole milk powder and 0% cocoyam starch in water. The native and resistant starches substituted the milk powder in the proportions of 0.5, 1.0 and 1.5% w/v. The native or resistant starch and whole milk powder were mixed with water. Thereafter, the samples were pasteurized at 85 °C for 30 min. The milk was cooled to 45 °C and inoculated with 0.5% yogurt starter culture (Streptococcus thermophiles, Lactobacillus bulgaricus and Lactobacillus lactis) (CHOOZIT MY 800, Danisco France, SAS, Dange Saint Romain, France). For a thorough dissolution and even distribution of the culture particles in the milk, it was mixed for about 30 seconds. A firm curd was developed after about 8 hours of incubation at 45 °C. To get a smooth uniform product, the curd was broken and homogenized with a hand stirrer. For further examination and storage stability testing, it was packaged and kept refrigerated. The yogurt samples were stored for four weeks at refrigerated temperature (5 ^{o}C).

Proximate composition of yogurt samples

The moisture, crude protein, crude fat, ash, and carbohydrate contents of the samples were determined using the Association of Official Analytical Chemist (AOAC, 2010) method of analysis

Mineral composition of yogurt samples

The atomic absorption spectrophotometric method specified by the AOAC (2010) was used to conduct the analysis for calcium, magnesium, iron, phosphorous and potassium. 2 ml of the sample was weighed into a 75 ml digestion flask, followed by 10 ml nitric acid and 10 ml HCl. In a fume cupboard, the mixture was digested at 150°C in a heating mantle until it became clear. The digested mixture was filtered using Whatman No 1 filter paper after it had cooled. The quantitative measurement of calcium, magnesium, phosphorous and iron were determined using a Flame Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 400, PerkinElmer Inc. Waltham, USA) and potassium using flame photometric technique.

Physicochemical properties of yogurt samples

pH

The pH was measured using a calibrated pH meter (Hanna instrument, HI 98129, Romania).

Titratable acidity (% lactic acid)

A clean burrette was clamped to the retort stand and filled to the zero mark with 0.1M sodium hydroxide (NaOH), 20 ml of the yogurt sample was measured and poured into a clean conical flask, 2-3 drops of phenolphthalein were added to the solution, and then NaOH was titrated against it until a pink colour was detected. The value of the titre was monitored and recorded (Olugbuyiro and Oseh, 2011). The TTA was then calculated using the titre value according to the equation below;

$$\text{TTA (\% lactic acid)} = \frac{\text{ml} \times \text{N} \times 0.09 \times 100}{\text{V}}, \qquad \text{(Equation 2)}$$

ml = volume of 0.1 N NaOH used
N = Normality of NaOH
V = ml of yogurt used

Total soluble solids

This was done with the use of a hand refractometer. After cleaning the refractometer prism with distilled water and tissue paper, a drop of the sample was placed on the prism of the refractometer. The reading was taken using the refractometer's eyepiece, and the soluble sugar was expressed in °Brix (AOAC, 2010).

Viscosity

Viscosity measurements were performed according Abbas et al. (2010) by using the Ostwald or Capillary viscometer. A standard volume of fluid was passed (flowed) through a length of capillary tubing, and the time it took was measured. The viscometer had been precisely filled with a known volume of sample. The sample was then sucked up through the capillary tube from the other limb until it was above the specified level (A). The suction was then withdrawn, and fluid was allowed to flow through the capillary tube, with the time it took for the fluid to flow from mark A to mark B being recorded. This time served as a direct indicator of kinematic viscosity.

Syneresis evaluation

This was evaluated according to the method described by Lobato-Calleros et al. (2014) at 0, 24, 48, 72, 96 and 120 h. About 14 g of yogurt sample was placed in tube and centrifuged. The samples were centrifuged using a centrifuge (0502-1 Hospibrand, USA) at 1500 x g for 20 min. Syneresis was determined as the percentage ratio of the weight of separated liquid (W_1) to that of the initial weight of the yogurt sample (W_2). Syneresis was calculated using the equation below;

$$\text{Syneresis (\%)} = \frac{W_1}{W_2} \times 100 \qquad \text{(Equation 3)}$$

W_1 = weight of separated liquid

W_2 = weight of yogurt sample

Microbial Analyses

Total viable count was done on nutrient agar, lactic acid bacteria count was done on de Man Rogosa and Sharpe agar (MRS), and yeast and mold count were carried out on Potato Dextrose Agar (PDA) (Harrigan and McCance, 1976; Harrigan, 1998). Colonies on each plate were counted with a Gallenkamp colony counter, and the counts were recorded as colony forming units per millilitre (cfu/ml).

Storage Stability Tests

The samples were kept under refrigeration. Viscosity, pH, Titratable acidity (as lactic acid), Syneresis, Total soluble solids and Microbial analyses (total viable count, lactic acid bacteria count, yeast and mould count) were monitored weekly for a period of four weeks.

Statistical Analyses

The Statistical Package for the Social Sciences software version 16.0 (SPSS, Chicago, USA) was used for statistical analysis. Analyses were carried out in triplicates and results were expressed as mean ± standard deviation. The one-way Analysis of Variance (ANOVA) approach was used to evaluate statistically significant differences in all obtained data, when appropriate. At a 95% confidence level, Duncan multiple range tests were used to separate the differences in the mean values.

Results and Discussion

Proximate Composition of Yogurt samples

Table 1 shows the proximate compositions of the yogurt samples. The moisture contents of the Yogurt samples ranged between 76.89 and 85.92% and the values decreased significantly ($p < 0.05$) as the amount of native and resistant starch samples added increased and all the values were significantly ($p< 0.05$) different. Sample RS,1.5 had the least value while Sample CON (control sample without starch) had the highest value. This was not unexpected because the substitution of milk with starch would have reduced the moisture content of the samples. Yogurt samples with lower starch content have higher moisture contents and vice versa. The lower moisture content of yogurt samples can be attributed to increased viscosity of the samples.

Table 1: Proximate Compositions (%) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Moisture	Fat	Ash	Protein	Carbohydrate
CON	85.92 ± 0.02^{a}	3.02 ± 0.01^{a}	0.79 ± 0.01^{a}	5.64 ± 0.01^{a}	4.63 ± 0.02^{g}
NS,0.5	82.09 ± 0.01^{b}	2.87 ± 0.01^{b}	0.78 ± 0.00^{b}	5.55 ± 0.01^{b}	8.72 ± 0.01^{f}
NS,1.0	81.60 ± 0.03^{c}	2.78 ± 0.01^{d}	0.77 ± 0.01^{bc}	5.47 ± 0.01^{d}	9.40 ± 0.04^{e}
NS,1.5	80.38 ± 0.01^{d}	2.68 ± 0.01^{f}	0.76 ± 0.01^{c}	5.30 ± 0.01^{f}	10.90 ± 0.01^{d}
RS,0.5	79.61 ± 0.01^{e}	2.83 ± 0.01^{c}	0.78 ± 0.01^{b}	5.56 ± 0.00^{b}	11.23 ± 0.01^{c}
RS,1.0	78.34 ± 0.03^{f}	2.74 ± 0.01^{e}	0.76 ± 0.01^{c}	5.51 ± 0.01^{c}	12.66 ± 0.03^{b}
RS,1.5	76.89 ± 0.03^{g}	2.64 ± 0.01^{g}	0.75 ± 0.01^{c}	5.39 ± 0.00^{e}	14.34 ± 0.04^{a}

The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

The fat contents of the samples ranged from 2.64 to 3.02%. As the amount of native and modified starches added to the yogurt samples increased, the fat content decreased. All the values were significantly ($p<0.05$) different and the extent to which the modified starch decreased the fat content was higher than the native starch at the same proportion. The value (3.02%) for the control sample was lower than the 6.04% and 3.71% reported by Okoye and Obi (2016) and Mukisa and Birungi (2018), respectively but similar to the value (3.2%) reported by Curti et al. (2017) for control yogurt. The difference might be due to the type and the amount of powdered milk used in the preparation of yogurt.

The ash contents of the yogurt samples ranged from 0.75 to 0.79%. As the amount of native and resistant starch samples added increased, the values decreased and this might be attributed to the fact that milk contains more ash compared to native and resistant starches. The control sample (CON) had a significantly higher value ($p<0.05$) (0.79%) than all the native and resistant starches containing samples. The ash content of the control sample was comparable to the values (0.76%, 0.7% and 0.73%) reported by Okoye and Obi (2016), Curti et al. (2017) and Mukisa and Birungi (2018), respectively for yogurt.

The protein contents of the samples ranged from 5.39 to 5.64%. The lowest value was NS,1.5, while the maximum value was CON. The values decreased when the amount of native and resistant starches added to the yogurt samples increased. This was due to the fact

that milk has more protein than native and resistant starches. The protein content of samples with RS were higher than the samples with NS at the level of substitution. The protein content of the control sample was lower than 6.96%, 5.8% and 5.95% reported by Okoye and Obi (2016), Curti et al. (2017) and Mukisa and Birungi (2018), respectively for control yogurt. The values for all the samples were within the range of 4.87 to 7.41% reported by Ezonu et al. (2016) for yogurt samples. All the yogurt samples met the Codex requirement of a minimum value of 2.7% (Codex Alimentarius, 2003). The difference might be due to the type and the amount of milk used in the preparation of the yogurt.
The carbohydrate contents of the samples ranged from 4.63 to 14.34%. The lowest value was CON, while the highest was RS,1.5. All the values were significantly ($p<0.05$) different and the carbohydrate contents of the samples increased with increase in addition of the starches. Samples with RS had higher values than samples with native starch at the same level.

Mineral Composition of Yogurt Samples

The results of the mineral composition of the yogurt samples are presented in Table 2. As the amount of native and resistant starch samples to the yogurt samples increased, the calcium, magnesium, iron, phosphorous and potassium contents of the yogurt samples decreased. However, samples with RS showed lower decrease than samples with NS at the same substitution levels for all the minerals analyzed.

Table 2: Mineral Compositions (%) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Calcium	Magnesium	Iron	Phosphorous	Potassium
CON	185.30 ± 0.18^{a}	169.21 ± 0.01^{a}	0.172 ± 0.001^{a}	146.57 ± 0.62^{a}	229.27 ± 0.33^{a}
NS,0.5	180.24 ± 0.21^{c}	165.53 ± 0.10^{c}	0.163 ± 0.002^{d}	142.22 ± 0.15^{d}	227.71 ± 0.23^{b}
NS,1.0	176.20 ± 0.31^{e}	159.81 ± 0.05^{e}	0.158 ± 0.001^{e}	137.48 ± 0.23^{f}	219.83 ± 0.33^{f}
NS,1.5	170.95 ± 0.37^{f}	153.03 ± 0.12^{g}	0.152 ± 0.001^{f}	130.54 ± 0.74^{g}	214.54 ± 0.11^{g}
RS,0.5	182.18 ± 0.24^{b}	167.13 ± 0.08^{b}	0.166 ± 0.000^{c}	143.64 ± 0.53^{c}	226.76 ± 0.07^{c}
RS,1.0	177.19 ± 0.06^{d}	161.91 ± 0.03^{d}	0.162 ± 0.001^{d}	141.13 ± 0.15^{e}	224.49 ± 0.63^{d}
RS,1.5	176.68 ± 0.15^{e}	158.73 ± 0.04^{f}	0.168 ± 0.001^{b}	144.81 ± 0.00^{b}	221.86 ± 0.08^{e}

The mean values along the same column with different superscripts are significantly different ($p < 0.05$).
CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

The differences in the values obtained from this study and those of previous studies might be due to the amount and source of milk used in the production of the yogurt samples. The calcium contents of the yogurt samples ranged from 170.95 to 185.30mg/100 g. Sample NS,1.5 had the least value while CON had the highest value. The values obtained from this study for the calcium content of the yogurt samples were higher 180 mg/100 g reported by Ihemeje et al. (2015) but lower than 195.04 mg/100 g, 281.43 mg/100 g and 686.92 mg/100g reported by Amellal-Chibane and Benamara (2011), Ezeonu et al. (2016) and Kibui et al. (2018), respectively for yogurt samples. The yogurt sample with the highest amount of resistant starch and lowest reduction of calcium was RS,1.5 (176.68 mg/100g). Calcium is essential for bone development and its deficiency has been linked with rickets in infants and osteoporosis in menopausal women (Odunlade et al., 2019).

The magnesium content of the yogurt samples ranged between 153.03 and 169.2 mg/100 g. Sample NS,1.5 had the least value while CON had the highest value. The yogurt sample with the highest amount of resistant starch and lowest reduction of magnesium was RS,1.5 (158.73 mg/100 g). The values obtained for yogurt samples in this study were similar to 170 mg/100 g reported by Ihemeje et al. (2015) but higher than the 132.16 mg/100 g and 41.65 mg/100g reported by Amellal-Chibane and Benamara (2011) and Kibui et al. (2018), respectively for yogurt samples. According to Schulz et al. (1993), RS is able to boost calcium and magnesium absorption by increasing mineral solubility in the caecum and/or large intestine as a result of RS fermentation-induced acidity of the content. Magnesium is one of the regulators of hundreds of biochemical reactions involving cell growth as well as synthesis of nucleic acids and proper functioning of the heart (Mooren, 2015).

The values of the iron content of the yogurt samples ranged from 0.152 to 0.172 mg/100 g. Sw `1QAAZZZZZZAAAAAAAAAAAAAample NS,1.5 had the lowest value while CON had the highest value. The iron contents of the yogurt samples were higher than 0.108 mg/100 g reported by Ihemeje et al. (2015) but lesser than 0.526 and 0.412 mg/100 g reported by Amellal-Chibane and Benamara (2011) and Kibui et al. (2018), respectively for yogurt samples. Iron is largely essential for preventing abnormal cognitive and neuro-psychomotor development. It is essential for synthesis of erythrocytes (Hallberg et al., 1995; Odunlade et al., 2019).

The phosphorous content of the yogurt samples ranged between 129.81 and 146.57 mg/100 g. Sample NS,1.5 had the least value while CON had the highest value. The phosphorous contents from this research were higher than 37.07 mg/100 g reported by Kibui et al. (2018) but lower than 158 mg/100 g and 202.25 mg/100 g reported by Ihemeje et al. (2015) and Ezeonu et al. (2016), respectively for yogurt samples. Phosphorous is desirable as it increases the health of bones in humans (Kibui et al., 2018).

The potassium content of the yogurt samples ranged from 210.06 to 229.27 mg/100 g. Sample NS,1.5 had the least value while CON had the highest value. The values from this research were higher than the 121 mg/100 g and 69.05 mg/100 g reported by Ihemeje et al. (2015) and Kibui et al. (2018) but lower than 540.58 mg/100 g and 561.42 mg/100 g reported by Amellal-Chibane and Benamara (2011) and Ezeonu et al. (2016), respectively for yogurt samples. The yogurt sample with the highest amount of resistant starch and lowest reduction of potassium was RS2,1.5 (221.86 mg/100 g). Potassium helps the nerves to function and muscles to contract as well as helping with normal heartbeat, increasing iron utilization (Elinge et al., 2012), and is beneficial to people taking diuretics to control hypertension who suffer from excessive excretion of potassium through the body fluid (Gbadegesin et al., 2017).

pH and Titratable acidity of yogurt samples

The results of the pH and Titratable acidity (% lactic acid) of the yogurt samples are presented in Figures 1 and 2, respectively. The pH of the samples ranged between 4.53 and 5.20. RS,1.5 had the lowest value while CON (yogurt sample without starch) had the highest value. The pH of the samples decreased with addition of native and resistant starches to the yogurt samples. Yogurt samples with resistant starch had lower pH than samples with native starch. The pH ranged from 4.43 to 5.06, 4.39 to 4.79, 4.37 to 4.69 and 4.19 to 4.60 at weeks 1, 2, 3 and 4, respectively. The pH of all the samples decreased during storage. The pH value of 4.6 and 4.62 for yogurt samples reported by Ihemeje et al. (2015) and Gustaw et al. (2011), respectively were within the range obtained from this study. Vianna et al. (2017) also reported pH of 4.56 to 4.67 for yogurt samples. The results obtained from this study agreed with the report of Gustaw et al. (2011) that yogurt samples with prebiotics (Inulin and Resistant starch) had lower pH than the control yogurt.

The titratable acidity (% lactic acid) as shown in Figure 2 ranged between 0.702 to 1.216%, 0.767 to 1.295%, 1.008 to 1.368%, 1.104 to 1.398% and 1.162 to 1.501% at weeks 0,1, 2, 3 and 4, respectively. CON had the least values while RS,1.5 had the highest values. Adebisi et al. (2017) reported 0.720 to 1.350% for Titratable acidity of yogurt samples. Casarotti et al. (2014) and Curti et al. (2017) found a decrease in pH and an increase in Titratable acidity of yogurt samples during storage. The pH reduction and elevation in total acidity of the fortified yogurts during storage could be explained by lactic acid bacteria consuming more residual lactose, resulting in post-acidification (Curti et al., 2017). The pH of yogurts also decreased with prolonged cold storage, according to Aryana and McGrew (2007) and Anand et al. (2020).

CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

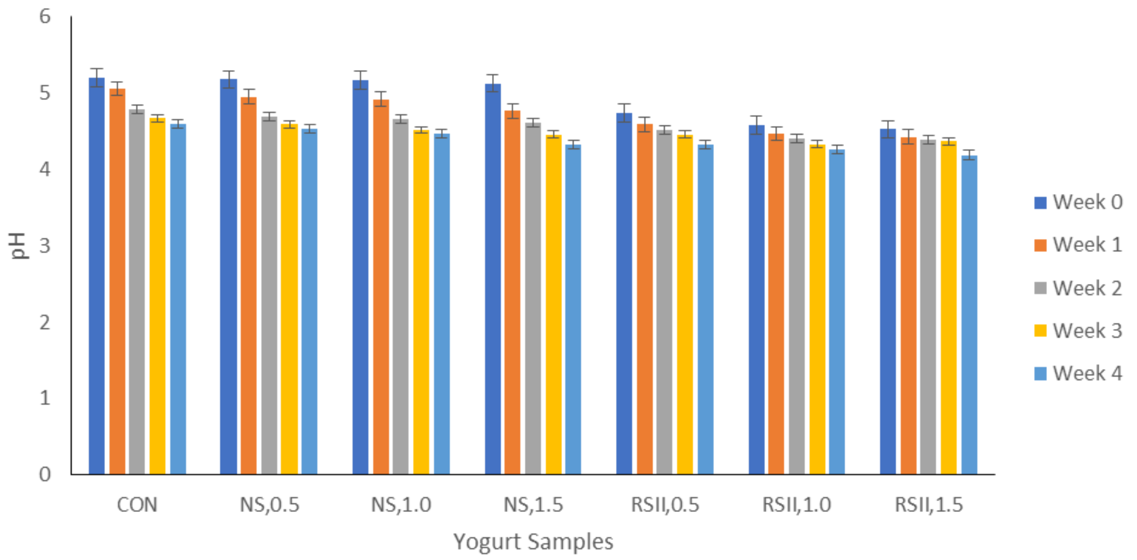

Figure 1: pH of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples at Refrigerated Temperature

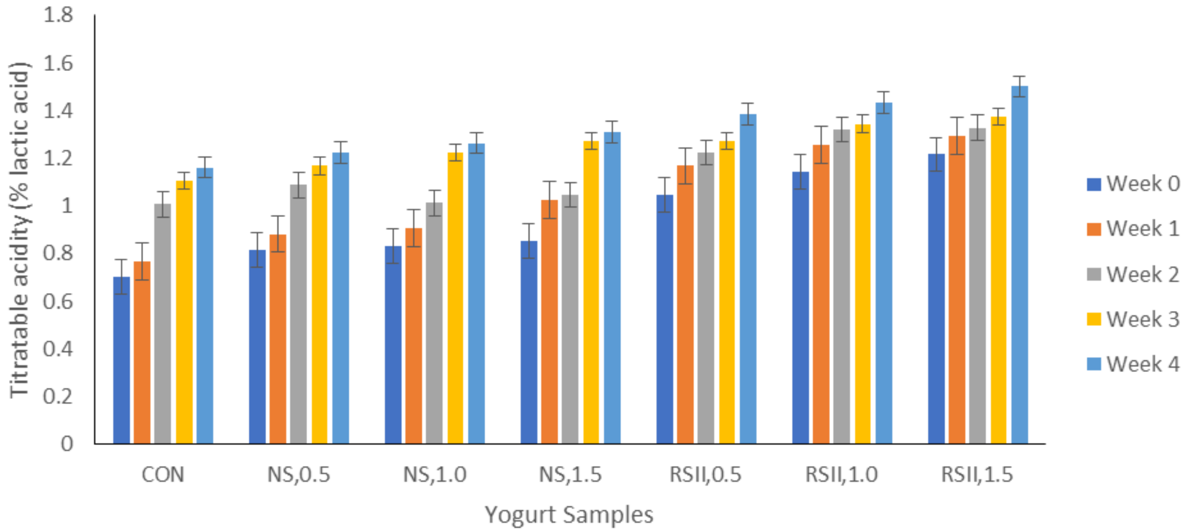

Figure 2: Titratable acidity (% lactic acid) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Total Soluble Solids of Yogurt Samples

Table 3 shows the results of the TSS of the yogurt samples. The values ranged from 7.00 to 10.00, 7.00 to 10.00, 7.20 to 10.50, 7.50 to 10.70 and 7.80 to 11.40 ^{o}Brix at weeks 0, 1, 2, 3 and 4, respectively. With the addition of native and resistant starches, the TSS of yogurt samples reduced. Throughout the four weeks of storage, CON had the highest values. Also, the TSS of the samples increased significantly ($p < 0.05$) during the storage period but there was no significant ($p > 0.05$) difference at weeks 0 and 1 for sample CON and RS,1.5. The samples with the highest rate of increase during storage were CON (10.00-11.40 ^{o}Brix), NS,0.5 (9.20-10.60 ^{o}Brix) and NS,1.0 (8.30-9.70 ^{o}Brix) and they increased by 1.40 ^{o}Brix. The sample with the lowest rate of increase storage was RS,1.5 (7.00-7.80 ^{o}Brix) and it increased by 0.80 ^{o}Brix. The increase in TSS during storage could have been due to the lactic acid bacteria consuming more residual lactose, leading to the breaking down of the lactose into glucose and galactose.

Table 3: Total Soluble Solids (°Brix) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	**Week 0**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
CON	10.00 ± 0.02^{aD}	10.00 ± 0.04^{aD}	10.50 ± 0.06^{aC}	10.70 ± 0.00^{aB}	11.40 ± 0.13^{aA}
NS,0.5	9.20 ± 0.04^{bD}	9.30 ± 0.06^{bD}	9.60 ± 0.02^{bC}	10.00 ± 0.03^{bB}	10.60 ± 0.07^{bA}
NS,1.0	8.30 ± 0.03^{dE}	8.50 ± 0.04^{dD}	8.70 ± 0.04^{dC}	9.00 ± 0.02^{dB}	9.70 ± 0.00^{dA}
NS,1.5	8.00 ± 0.02^{eD}	8.10 ± 0.05^{eD}	8.40 ± 0.03^{eC}	8.60 ± 0.07^{eB}	9.00 ± 0.03^{eA}
RS,0.5	9.00 ± 0.06^{cD}	9.10 ± 0.02^{cD}	9.30 ± 0.08^{cC}	9.60 ± 0.12^{cB}	9.80 ± 0.02^{cA}
RS,1.0	7.50 ± 0.06^{fD}	7.70 ± 0.12^{fD}	8.00 ± 0.05^{fC}	8.40 ± 0.05^{fB}	8.60 ± 0.08^{fA}
RS,1.5	7.00 ± 0.02^{gD}	7.00 ± 0.10^{gD}	7.20 ± 0.05^{gC}	7.50 ± 0.12^{gB}	7.80 ± 0.03^{gA}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).
CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

Viscosity of Yogurt samples

Table 4 shows the results of the viscosity of yogurt samples. At week 0, the results varied from 5.22 to 7.14 mm^2/s. The lowest value was for CON, while the highest was for RS,1.5, indicating that this was the most viscous sample. The results revealed that increasing the amount of native and resistant cocoyam starches added to the yogurt increased the viscosity. The sensory features of stirred yogurt are influenced by the increase in viscosity values, which is a critical quality parameter for yogurt. Cui et al. (2014) found that adding native and modified cassava starches improved viscosity in the same way.

Table 4: Viscosity (mm^2/s) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	**Week 0**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
CON	5.22 ± 0.01^{gA}	5.17 ± 0.01^{hA}	5.10 ± 0.01^{fB}	4.99 ± 0.02^{gC}	4.43 ± 0.03^{gD}
NS,0.5	5.91 ± 0.02^{fA}	5.88 ± 0.01^{gA}	5.84 ± 0.01^{eB}	5.75 ± 0.00^{fC}	5.47 ± 0.01^{fD}
NS,1.0	6.23 ± 0.01^{eA}	6.22 ± 0.01^{eA}	6.11 ± 0.00^{dB}	6.02 ± 0.02^{eC}	5.75 ± 0.01^{eD}
NS,1.5	6.49 ± 0.02^{dA}	6.47 ± 0.01^{dA}	6.36 ± 0.02^{cB}	6.18 ± 0.00^{dC}	5.85 ± 0.01^{dD}
RS,0.5	6.98 ± 0.01^{cA}	6.97 ± 0.02^{cA}	6.91 ± 0.01^{bB}	6.82 ± 0.02^{cC}	6.67 ± 0.02^{cD}
RS,1.0	7.05 ± 0.01^{bA}	7.03 ± 0.01^{bA}	6.96 ± 0.01^{aB}	6.87 ± 0.02^{bC}	6.78 ± 0.00^{bD}
RS,1.5	7.14 ± 0.01^{aA}	7.12 ± 0.02^{aA}	6.98 ± 0.01^{aB}	6.91 ± 0.00^{aC}	6.82 ± 0.01^{aD}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).
CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

During storage, the values ranged from 5.17 to 7.12 mm^2/s, 5.10 to 6.98 mm^2/s, 4.99 to 6.91 mm^2/s and 4.43 to 6.82 mm^2/s at weeks 1, 2, 3 and 4, respectively. The viscosity of the yogurt samples reduced with increase in the storage period. Throughout the storage period, CON had the least values and RS,1.5 had the highest values. Similar decrease in viscosity during storage of yogurt samples at refrigerated temperature were documented by Gustaw et al. (2011), Lobato-Calleros et al. (2014) and Anand et al. (2020). Donkor et al. (2007) found a decrease in viscosity of yogurts enhanced with resistant starch during refrigerated storage. Aryana and McGrew (2007) noticed a decrease in apparent viscosity during storage in probiotic Lactobacillus casei yogurts with different oligofructose and inulin chain lengths. The activity of bacterial enzymes on the casein micelle structure was blamed by the researchers.

Syneresis of Yogurt Samples

The syneresis of the yogurt samples after production and during storage at refrigerated temperature are presented in Table 5. After production, the syneresis of the yogurt samples ranged from 4.92 to 13.74 percent, and the values were significantly different ($p<0.05$). The lowest value was RS,1.5, while the maximum value was CON. The syneresis of the control sample (sample without starch) had higher value than the yogurt samples with native and modified starches (4.92-10.09%). The higher the amount of native and resistant starches in the yogurt samples, the lower the syneresis. Similar results of decreased syneresis were found in the studies of yogurt with fiber supplementation by Santillan-Urquiza et al. (2017).

The value (13.74%) for syneresis of the control sample was slightly higher than 12.8% reported by Lobato-Calleros et al. (2014) for control yogurt sample. The values (5.3-7.4%) reported by Lobato-Calleros et al. (2014) for yogurt samples with modified maize starches falls within the range obtained from this study of yogurt samples with native and resistant starches. As storage period increased, the syneresis of the yogurt samples increased and the values were significantly ($p<0.05$) different for all the samples. The values ranged between 5.77 and 14.44%, 7.05 and 16.37%, 7.91 and 21.77%, 9.07 and 28.78% at week 1, week 2, week 3 and week 4, respectively for all the yogurt samples. The samples with the lowest and highest values of syneresis after production and all through the storage periods were RS,1.5 and CON, respectively.

Table 5: Syneresis (%) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Week 0	Week 1	Week 2	Week 3	Week 4
CON	13.74 ± 0.02^{aE}	14.44 ± 0.05^{aD}	16.37 ± 0.06^{aC}	21.77 ± 0.05^{aB}	28.78 ± 0.05^{aA}
NS,0.5	10.71 ± 0.04^{bE}	10.95 ± 0.05^{bD}	11.95 ± 0.06^{bC}	13.16 ± 0.08^{bB}	15.57 ± 0.06^{bA}
NS,1.0	10.09 ± 0.05^{cE}	10.49 ± 0.06^{cD}	11.72 ± 0.04^{cC}	12.93 ± 0.05^{cB}	14.96 ± 0.04^{cA}
NS,1.5	9.58 ± 0.06^{dE}	9.96 ± 0.04^{dD}	10.56 ± 0.07^{dC}	11.49 ± 0.04^{dB}	13.96 ± 0.05^{dA}
RS,0.5	6.40 ± 0.04^{eE}	7.94 ± 0.05^{eD}	8.15 ± 0.06^{eC}	8.80 ± 0.01^{eB}	11.33 ± 0.05^{eA}
RS,1.0	5.71 ± 0.06^{fE}	6.73 ± 0.06^{fD}	7.65 ± 0.06^{fBC}	8.14 ± 0.06^{fB}	10.38 ± 0.04^{fA}
RS,1.5	4.92 ± 0.04^{gE}	5.77 ± 0.02^{gD}	7.05 ± 0.04^{gC}	7.91 ± 0.04^{gB}	9.07 ± 0.06^{gA}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).
CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

Vianna et al. (2017) reported similar observation of increased syneresis of yogurt with increase in storage period. Syneresis is a key factor in determining yogurt quality. It is a natural occurrence that occurs in dairy products such as yogurt and is described as the separation of phases in a suspension or mixture (Celik et al., 2006). Syneresis is an undesirable property in fermented milk products. Also, the acidity of the yogurts can be a further contributing factor, since higher acidity is known to stimulate syneresis in yogurt (Yilmaz-Ersan and Kurdal, 2014). In the yogurt samples, native starch had much more syneresis than starch including resistant starch and this was in agreement with the report of Lobato-Calleros et al. (2014) that also discovered that modified maize starches have less syneresis than native maize starches in yogurt samples.

Microbial Characteristics of Yogurt Samples

The results of the microbial counts (Lactic acid bacteria (LAB), Total Viable Count (TVC) and Yeast and Mould counts) of the yogurt samples after production and during the four-week storage period are presented in Tables 6, 7 and 8, respectively.

Table 6: Lactic Acid Bacteria Count (log cfu/ml) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Week 0	Week 1	Week 2	Week 3	Week 4
CON	9.06 ± 0.02^{eA}	9.01 ± 0.02^{gA}	6.54 ± 0.04^{gB}	5.51 ± 0.03^{gC}	4.97 ± 0.01^{gD}
NS,0.5	9.94 ± 0.02^{dA}	9.21 ± 0.01^{fB}	7.02 ± 0.02^{fC}	6.52 ± 0.05^{fD}	5.04 ± 0.02^{fE}
NS,1.0	10.05 ± 0.02^{cA}	9.28 ± 0.01^{eB}	7.35 ± 0.07^{eC}	6.67 ± 0.05^{eD}	5.14 ± 0.03^{eE}
NS,1.5	10.07 ± 0.02^{cA}	9.36 ± 0.01^{dB}	7.49 ± 0.02^{dC}	6.75 ± 0.03^{dD}	5.24 ± 0.01^{dE}
RS,0.5	10.12 ± 0.01^{bA}	9.56 ± 0.02^{cB}	8.78 ± 0.03^{cC}	7.76 ± 0.03^{cD}	6.76 ± 0.04^{cE}
RS,1.0	10.21 ± 0.01^{aA}	9.68 ± 0.04^{bB}	9.26 ± 0.01^{bC}	8.20 ± 0.01^{bD}	6.97 ± 0.02^{bE}
RS,1.5	10.24 ± 0.02^{aA}	9.84 ± 0.02^{aB}	9.36 ± 0.02^{aC}	8.30 ± 0.01^{aD}	7.18 ± 0.02^{aE}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).

CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

Table 7: Total Viable Count (log cfu/ml) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Week 0	Week 1	Week 2	Week 3	Week 4
CON	10.66 ± 0.05^{fA}	10.06 ± 0.02^{gB}	7.65 ± 0.03^{gC}	6.78 ± 0.02^{dD}	5.71 ± 0.03^{gE}
NS,0.5	10.91 ± 0.02^{eA}	10.19 ± 0.01^{fB}	8.61 ± 0.02^{fC}	7.98 ± 0.02^{cD}	6.57 ± 0.02^{fE}
NS,1.0	10.94 ± 0.07^{eA}	10.31 ± 0.01^{eB}	8.70 ± 0.03^{eC}	8.17 ± 0.11^{bD}	6.81 ± 0.01^{eE}
NS,1.5	11.04 ± 0.01^{dA}	10.39 ± 0.01^{dB}	9.01 ± 0.02^{dC}	8.20 ± 0.01^{bD}	6.99 ± 0.03^{dE}
RS,0.5	11.09 ± 0.02^{cA}	11.01 ± 0.01^{cB}	9.51 ± 0.03^{cC}	9.26 ± 0.01^{aD}	8.09 ± 0.02^{aE}
RS,1.0	11.15 ± 0.01^{bA}	11.09 ± 0.01^{bB}	9.64 ± 0.03^{bC}	9.29 ± 0.01^{aD}	7.99 ± 0.02^{bE}
RS,1.5	11.19 ± 0.01^{aA}	11.15 ± 0.02^{aA}	9.92 ± 0.03^{aB}	9.30 ± 0.01^{aC}	7.91 ± 0.02^{cD}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).

CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with

1.5% Resistant Starch

Table 8: Yeast and Mould Count (log cfu/ml) of Yogurt with Native and Heat Moisture Conditioned Colocasia esculenta Starch samples

Samples	Week 0	Week 1	Week 2	Week 3	Week 4
CON	0	0	0	1.39 ± 0.12^{eB}	2.04 ± 0.06^{dA}
NS,0.5	0	0	1.00 ± 0.00^{cC}	1.48 ± 0.00^{dB}	2.19 ± 0.02^{cA}
NS,1.0	0	0	1.15 ± 0.21^{bcC}	1.54 ± 0.09^{cB}	2.28 ± 0.03^{bA}
NS,1.5	0	0	1.30 ± 0.00^{abC}	1.70 ± 0.00^{bB}	2.29 ± 0.02^{bA}
RS,0.5	0	0	0	1.30 ± 0.02^{fB}	2.16 ± 0.02^{cA}
RS,1.0	0	0	0	1.54 ± 0.09^{cB}	2.31 ± 0.01^{bA}
RS,1.5	0	0	1.15 ± 0.21^{bcB}	1.81 ± 0.05^{aB}	2.37 ± 0.03^{aA}

The mean values along the same column with different superscripts (small letters) are significantly different ($p < 0.05$) and the mean values along the same row with different superscripts (capital letters) are significantly different ($p < 0.05$).

CON- Yogurt without starch; NS,0.5- Yogurt with 0.5% Native starch; NS,1.0- Yogurt with 1.0% Native starch; NS,1.5- Yogurt with 1.5% Native starch; RS,0.5- Yogurt with 0.5% Resistant Starch; RS,1.0- Yogurt with 1.0% Resistant Starch; RS,1.5- Yogurt with 1.5% Resistant Starch

The LAB counts of the samples ranged from 9.06 to 10.24 log cfu/ml, 9.01 to 9.84 log cfu/ml, 6.54 to 9.36 log cfu/ml, 5.51 to 8.30 log cfu/ml and 4.97 to 7.18 log cfu/ml at weeks 0, 1, 2, 3 and 4, respectively. After production and throughout the storage period, CON had the least values while RS,1.5 had the highest values. With the addition of native and resistant starches, the LAB counts of the samples increased. Also, it was observed that samples with resistant starches had higher counts than samples with native starch.

This might be because the modification of the cocoyam native starch to obtain resistant starches caused the decrease in the digestibility of the resistant starch fractions thereby increasing the amount of the non-digestible fractions. The increase in the non-digestible fractions (prebiotics) of the resistant starches could have led to the increase in the probiotic counts of the yogurt samples. It has been stated that the counts that qualify a fermented product as probiotic is a minimum of 6 log cfu/ml (Codex Alimentarius, 2010; Bedani et al., 2013) at the time of ingestion to have the expected health benefits. Sample CON (yogurt sample without starch) met this criterion for two weeks while the values for samples with native and resistant starches were within this range up till three to four weeks.

The TVC of the samples ranged between 10.66 and 11.19 log cfu/ml, 10.06 and 11.15 log cfu/ml, 7.65 and 9.92 log cfu/ml, 6.78 and 9.30 log cfu/ml and 5.71 and 7.91 log cfu/ml at weeks 0, 1, 2, 3 and 4, respectively. After production and all through the storage period, CON had the least values. With the addition of native and resistant starches, the TVC of the samples increased. Also, it was observed that samples with resistant starches had higher counts that samples with native starch. This observation was similar to the results obtained for LAB counts. Total viable bacterial count is the commonest microbiological test usually employed to give a quantitative idea about the presence of microorganisms such as bacteria in a sample (Matin et al., 2018). It measures LAB and other bacteria that could have been present due to contamination. The result obtained from this research was within range of 9.15 - 11.78 log cfu/ml reported by Lamye et al. (2017) for yogurt samples.

As presented in Table 8, there were no counts for yeast and mould growth in the samples after at weeks 0 and 1. At week 2, samples CON, RS,0.5 and RS,1.0 had no count while all other samples had growth counts. At weeks 2, 3 and 4, the values ranged from 1.00 to 1.30 log cfu/ml, 1.30 to 1.81 log cfu/ml and 2.04 to 2.37 log cfu/ml, respectively. CON had the least counts while RS,1.5 had the highest counts. The results of the counts found in this study were lower than the range of 0.00 to 4.11 log cfu/ml reported by Lamye et al. (2017). However, for all the yogurt samples during storage, the counts were lower than the maximum level of 3 log cfu/ml (Lamye et al., 2017) recommended for yogurt samples. The presence of mould is an indication of contamination. The sources of contamination could be from starches, water, surfaces and processing equipment. Also, pasteurization of the milk before fermentation would have just inactivated some microorganisms and not eliminate them. Increase in storage time could have made the inactivated microorganisms to become active again.

Conclusions

Native starch was extracted from cocoyam (Colocasia esculenta) corms and then modified using heat-moisture conditioning process to obtain Resistant Starch II. Yogurt samples were made by partially substituting the milk content with native and resistant starches for the purpose of reduced fat level, increased viscosity, decreased rate of syneresis and increased probiotic count of yogurt. The yogurt sample with 1.5% RSII had least fat content, lowest rate of syneresis, highest viscosity and highest LAB count of yogurt sample suggest that the application of this resistant starch as a perbiotic could be used to produce ‘probiotic’ yogurt.

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