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Research Article

Effect of hydrocolloid obtained from African Star Apple (*Chrysophyllum albidum*) fruit pulp on the physicochemical and sensory properties of Yoghurt.

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Abstract

Hydrocolloid present in African star apple fruit pulp (*Chrysophyllum albidum*) was extracted and used as a stabilizer in the preparation of yoghurt. The effect of the gum extract on the physicochemical properties, sensory properties and proximate compositions of yoghurt samples were evaluated. Results of the physicochemical properties show values of syneresis ranged from 19.50 - 30.99%. Sample D (control) had the highest syneresis of 30.99% while Sample C had the lowest syneresis of 19.50%. values for viscosity ranged from 58.38 - 159.6pa/s. Sample G had the highest viscosity of 159.6pa/s while Sample A had the lowest viscosity of 58.38pa/s, followed by Sample D with viscosity of 85.57pa/s. Values for pH ranged from 4.65 in sample D to 4.75 in sample A, while titratable acidity ranged from 1.02 in sample A -1.40 in sample G The result of sensory evaluation of the yoghurt samples showed that sample G had the highest mean sensory score across most parameters (4.35 - flavour, 4.20 - colour, 4.15 - texture, 4.25 - mouthfeel, 4.18 - overall acceptability). Sample D had the lowest mean sensory score for flavour (3.30), texture (3.00), mouthfeel (2.95) and overall acceptability (3.37). The result of the proximate composition determination showed that there was a significant difference ($p<0.05$) between the seven samples (A-G). Moisture content ranged from 79.12- 83.66%, Ash content ranged from 0.40 -0.77%, Protein content ranged from 2.24 -3.86%, Fat value ranged from 5.41 - 6.01%, Carbohydrate values ranged from 8.05 -11.92%, The results from this study showed that the gum extracted from African star apple fruit pulp can be used to stabilise yoghurt since its addition increased its viscosity reduced syneresis in the yoghurt without a negative impact on sensory attributes

1. Introduction

Yoghurt is defined as a coagulated milk product resulting from the fermentation of milk sugar lactose into lactic acid by *Lactobacillus bulgaricus* and *Streptococcus thermophilus* [1]. It is believed that the word "yoghurt" comes from the Turkish word "yoğurmak," which means to thicken, coagulate, or curdle. While the origins of yoghurt are unknown, it is thought to have been invented in Mesopotamia around 5000 BC. Yoghurt is an ancient food that has gone by many names over the millennia: katyk (Armenia), dahi (India), zabadi (Egypt), mast (Iran), leben raib (Saudi Arabia), laban (Iraq and Lebanon), roba (Sudan), iogurte (Brazil), cuajada (Spain), coalhada (Portugal), dovga (Azerbaijan), and matsoni (Georgia, Russia, and Japan), [2]. The consumption of yoghurt has become popular over time due its nutritional properties and potentially beneficial effects on human health.

Good quality yoghurt should have a firm and smooth consistency with a sweet aroma and pleasant taste. Syneresis (whey separation) happens to be a textural defect in yoghurt. It refers to the shrinkage of gel that occurs along with expulsion of liquid or whey separation due to instability of the gel network [3]. Some possible reasons that lead to whey-off in acid gels include high incubation temperature, excessive whey protein to casein ratio, low solids content and physical mishandling of the product during processing, storage and transportation [4]. To overcome this defect, the most common approach is the use of different hydrocolloids.

Hydrocolloids are widely used in many food formulations to improve quality attributes and shelf-life. They could function as an emulsifying or a stabilising agent to either enable the mixing of two or more immiscible liquids or thicken/gel foods into the required consistency.

Hydrocolloids are a heterogeneous group of long chain polymers (polysaccharides and proteins) characterised by their property of forming viscous dispersions and/or gels when dispersed in water [5].

Chrysophyllum albidum commonly referred to as "African star apple" or "Udara" or "Agbalumo" is a forest fruit tree commonly found throughout tropical Africa. It belongs to the family Sapotaceae. It naturally occurs in Nigeria, Uganda, Niger Republic, Cameroon, and Ivory Coast. Its roots, barks, and leaves have been employed in folk medicine for the treatment of diseases. A major benefit of the African star Apple trees lies in the production of sweet fleshy fruits, which have been reported to be a rich source of vitamin C and Iron. The fruit also adds flavours to diets. It contains invaluable raw materials for the production of many cherished consumable items such as desserts, confectionery, syrups, and beverages, while the leaves and seeds are used in the pharmaceutical industry as an anticoagulant. Within the pulp are three to five seeds which are not edible. The fruits are also suitable for the production of fruit jams and jellies because they are rich in pectin [6].

This study on the effect of hydrocolloids obtained from African star apple fruit pulp on the sensory and physicochemical properties of yoghurt is essential as it could provide another form in which the pulp can be utilized, and offer an alternative source of hydrocolloids as a stabilizer in food preparations.

2. Materials and methods

2.1 Materials

African Star Apple, (*Chrysophyllum albidum*) in adequate quantity was obtained from Sangana Market, Port Harcourt Local Government Area. The chemicals and reagents used for the generation of samples and their analysis were obtained from the Department of Food Science and Technology, Rivers State University, Port Harcourt, Rivers State.

2.2 Extraction of Hydrocolloid

The method described by Ikonji *et al.* [7] as shown in Fig.1 was used for the extraction process. A 200g of oven-dried African Star Apple was accurately weighed using the electronic weighing balance (model TP-512A, Germany) and placed in 100g portion into two different beakers containing 1000ml of 1% NaCl each and heated at 78°C in a shaker bath (Gallenkamp, England). The mixture was allowed to stand for 24h at room temperature, and was then thoroughly homogenised using the homogenizer (FJ-3005, China). The homogeneous mixture (liquid mucilage) was filtered using a muslin cloth, and then centrifuged (80 – 5, USA) at 3500 rpm for 30 minutes. The resulting clear supernatant was dried in a hot air oven (Gallenkamp, England) at 50^0C for 12h, producing the hydrocolloid in gel-like form/state. This was then stored in the fridge using an airtight container.

2.3 Production of Yoghurt

The method as shown in Fig. 2. was used for the preparation/production of the yoghurt. Yoghurt was produced by weighing 140g of powdered whole milk and dissolving it in 1L of distilled water. The milk solution was then divided into seven portions and the gums added in specific concentrations as shown in Table 1. The milk solution was pasteurized at 75^0C for 30 mins using a water bath (technotest, Italy), cooled to 45^0C and inoculated with a commercial yoghurt starter culture. This was incubated for 12h using an incubator (DHP-9053A, England), packed and stored in the refrigerator for analysis.

2.4 Physicochemical Properties of Yoghurt Samples

2.4.1 Determination of Viscosity and Syneresis

The viscosity was determined using a rotary digital viscometer (NDJ-8S China) using spindle number 4 at 3rpm. The beaker was brought onto the rotating spindle and the viscosity values were displayed on the LCD screen in pa.s. Syneresis determination was

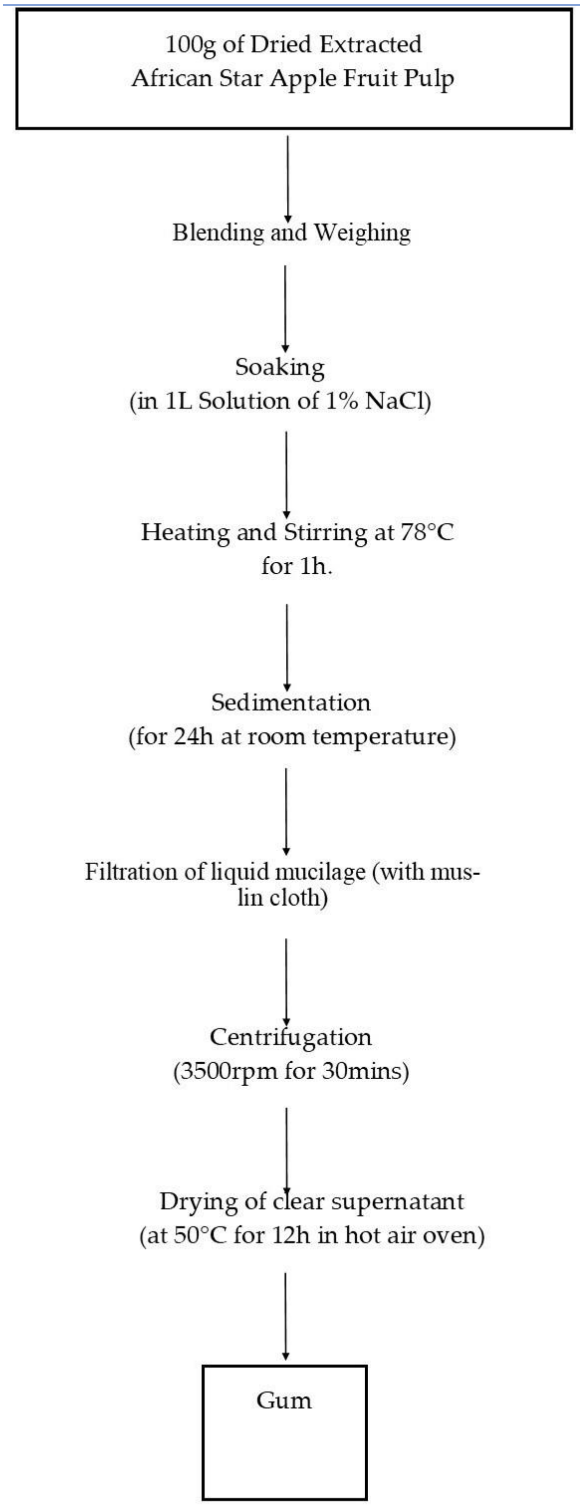

Figure 1. Extraction of hydrocolloid (Gum) Source: (Ikonji et al, [7])

done by weighing 10 ml of each yoghurt sample and centrifuging at 3500 rpm for 30 minutes, and the resulting clear supernatant was then poured into a measuring cylinder, its volume noted and recorded. Syneresis was then calculated by dividing the volume difference by the initial sample weight and multiplying by 100 [8].

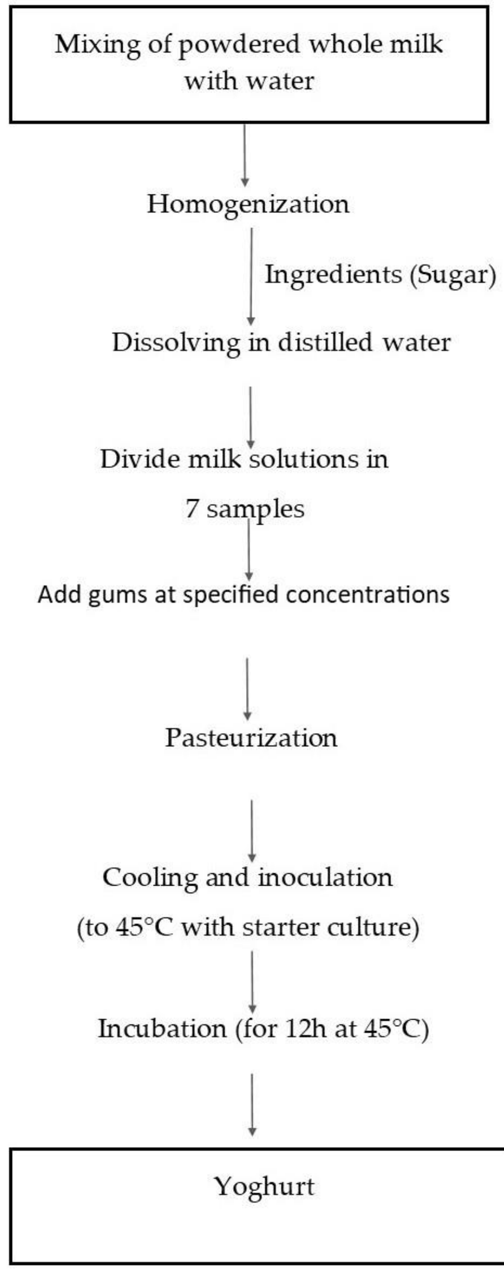

Figure 2. Production of Yoghurt

2.4.2 Determination of Total Titratable Acidity

The total titratable acidity was determined by weighing 10 ml of each yoghurt sample into a conical flask and adding 2 drops of phenolphthalein. The mixture was then titrated against 0.1N Sodium Hydroxide (NaOH).

2.4.3 Determination of pH

The pH of the yoghurt samples was determined using a standard pH meter. 10 ml of each yoghurt sample was measured into beakers and the pH meter (PHS-3SC, China) was then dipped into the beaker containing the sample and was held still until steady readings were steady.

Table 1. Formulation Table of Gum Concentration

Samples	Xanthan Gum (%)	African Star Apple Gum (%)
A	0.1	0
B	0.2	0
C	0.3	0
D	0	0
E	0	0.1
F	0	0.2
G	0	0.3

2.4.4 Determination of Total Soluble Solids

The total soluble solids (TSS) of the yoghurt samples were determined using a hand held refractometer. The instrument was cleaned and adjusted to zero using distilled water. The cover board of the refractometer was lifted and a few drops of each sample was placed on the prism-plate of the refractometer and the cover board was then placed to cover the prism-plate. For each sample, the instrument was calibrated using distilled water. The reading which appeared on the screen was directly recorded as the Total Soluble Solids (in °Bx).

2.5 Sensory Evaluation

Owuno *et al.* [9] method was used for sensory analysis and evaluation of the yoghurt samples containing the hydrocolloids, including the control sample. A twenty-member panel consisting of students of the Department of Food Science and Technology was selected based on their conversance with sensory qualities to evaluate the sensory properties of the yoghurt samples. A 5-point hedonic scale was used to carry out the evaluation, where 5 = like extremely and 1 = dislike extremely.

2.6 Proximate Composition of Yoghurt

Moisture Content, Ether Extract, Total Ash and Protein Content were determined by the following standard methods [10]. Carbohydrate content was calculated by difference. The protein factor N × 6.38 was used in the conversion of Nitrogen to Crude Protein.

2.7 Statistical Analysis

All analysis was carried out in duplicate. The data obtained were subjected to analysis of variance (ANOVA), the means separated and level of significance tested using Tukey's Honest Significance Test.

3. Results and discussion

3.1 Effect of the Varying Concentrations of Hydrocolloids on Viscosity and Syneresis.

Table 2 shows the effects of the hydrocolloids and their varying concentrations on the viscosity and syneresis of the yoghurt samples. From the results, it was observed that an increase in the concentration of the hydrocolloids led to a corresponding increase in the viscosity of the yoghurt samples. The results showed that significant difference ($p<0.05$) exists in the viscosity values of the samples in both the xanthan gum hydrocolloid category (where A= 0.1%, B= 0.2%, C=0.3%), and the African star apple gum category (where E= 0.1%, F= 0.2%, G=0.3%) and the sample D which is the control (0% hydrocolloid).

Table 2: Effect of hydrocolloids on syneresis and viscosity

Samples	Syneresis	Viscosity (pa/s)
A	$30.37^{ab}\pm1.103$	$58.38^{c}\pm2.690$
B	$26.43^{ab}\pm7.380$	$87.81^{b}\pm1.700$
C	$19.50^{b}\pm0.050$	$151.0^{a}\pm3.960$
D	$30.99^{a}\pm0.269$	$85.57^{bc}\pm7.170$
E	$21.14^{ab}\pm0.127$	$100.85^{b}\pm5.730$
F	$19.95^{ab}\pm0.445$	$112.3^{b}\pm6.100$
G	$19.75^{b}\pm0.184$	$159.6^{a}\pm1.560$

Values are mean standard deviation of duplicate samples. Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).

KEY:
A = 0.1% Xanthan Gum
B = 0.2% Xanthan Gum
C = 0.3% Xanthan Gum
D = 0% Gum (CONTROL)
E = 0.1% African Star Apple (Fruit Pulp) Gum
F = 0.2% African Star Apple (Fruit Pulp) Gum
G = 0.3% African Star Apple (Fruit Pulp) Gum

The viscosity values ranged from 58.38 - 159.6 Pa. S. This result is in agreement with the effect of increasing hydrocolloids concentration on the viscosity of yoghurt was reported where it was observed that the viscosity of the yoghurt samples significantly increased with the addition of stabilisers/hydrocolloids [10].

The viscosity of yoghurt is usually enhanced by the addition of stabilisers and thickeners such as modified or natural starches, alginates, agar, carrageenan, edible gums, pectin and celluloses [11]. This result implies that the higher the concentration of the hydrocolloids, the more viscous the yoghurt samples become.

From the results of this study, it was observed that an increase in the concentration of the hydrocolloids led to a corresponding decrease in the syneresis of the yoghurt samples. The values of the syneresis of the yoghurt samples ranged from 19.50 to 30.99% whereas Sample D (having 0% hydrocolloid concentration) had the highest value for syneresis. The results showed a significant difference ($p<0.05$) in the values for syneresis. Syneresis can reflect a lower structural stabilisation, becoming one of the worst defects in the final product, negatively affecting the consumer's acceptance [12]. It was also reported that values for syneresis of yoghurt samples decreased with an increased concentration of hydrocolloid (the hydrocolloid in this case being beta-glucan gum) as a result of its role in the formation of a denser gel network [13]. The result implies that the higher the concentration of the hydrocolloids, the lower the syneresis and hence less separation in the yoghurt samples.

3.2 Effect of Hydrocolloids on Physicochemical Properties.

Table 3 shows the effects of the hydrocolloids and their varying concentrations on the pH, Total Titratable Acidity and Total Soluble Solids of the yoghurt samples. The pH values ranged from 4.65 to 4.75, and the result showed that significant differences ($p<0.05$) exist. However, increasing concentrations of the hydrocolloids in the yoghurt did not have any significant effect on the pH values of the yoghurt samples. This is in line with the results were reported where it was reported that the addition of xanthan gum or its mixtures had no marked effect on pH values of the yoghurt manufactured [14].

The total titratable acidity values ranged from 1.02 - 1.40% and the results showed a significant difference ($p<0.05$) between the total titratable acidity values of the yoghurt. There is a noticeable increase in the total titratable acidity values with corresponding increase in the concentrations of hydrocolloids in both the xanthan gum and the African star apple gum addition. This scenario corresponds with findings by [15] where it was observed that the addition of stabiliser/hydrocolloid (in this case, jujube mucilage was used) to yoghurts led to a significant increase in the titratable acidity.

The total soluble solids values ranged from 14.25 to 18.25 brix. And the values of the total soluble solids of the samples showed that significant difference ($p<0.05$) exist. Sample D (Control) had the lowest total soluble solids value. These values agree with the results of [16] where they reported that the total soluble solids contents of samples significantly ($p < 0.05$) increased with increase in concentration of the stabilisers because the stabilisers are solids themselves. These results also agree with the findings of reported data [17] who reported that addition of stabilisers increases the solid contents of yoghurt.

Table 3. Effect of hydrocolloids concentrations on selected physicochemical properties of Yoghurt

Sample	pH	TTA (%)	TSS (brix)
A	$4.75^{a}\pm0.049$	$1.02^{b}\pm0.042$	$14.25^{d}\pm0.354$
B	$4.73^{ab}\pm0.000$	$1.18^{ab}\pm0.099$	$15.50^{c}\pm0.000$
C	$4.65^{bc}\pm0.014$	$1.38^{a}\pm0.035$	$16.75^{b}\pm0.354$
D	$4.68^{abc}\pm0.007$	$1.07^{b}\pm0.085$	$13.75^{d}\pm0.354$
E	$4.65^{c}\pm0.007$	$1.13^{ab}\pm0.092$	$14.00^{d}\pm0.000$
F	$4.74^{a}\pm0.014$	$1.15^{ab}\pm0.078$	$17.25^{ab}\pm0.354$
G	$4.67^{abc}\pm0.000$	$1.40^{a}\pm0.021$	$18.25^{a}\pm0.354$

Values are mean standard deviation of duplicate samples. Mean values bearing different superscripts in the same column differ significantly ($p<0.05$)

KEY:

A = 0.1% Xanthan Gum
B = 0.2% Xanthan Gum
C = 0.3% Xanthan Gum
D = 0% Gum (CONTROL)
E = 0.1% African Star Apple (Fruit Pulp) Gum
F = 0.2% African Star Apple (Fruit Pulp) Gum
G = 0.3% African Star Apple (Fruit Pulp) Gum

3.3 Effect of Hydrocolloids on Sensory Properties of Yoghurt Samples

Table 4 shows the results of the sensory properties of the yoghurt samples made with varying concentrations of hydrocolloids. Sample G had the highest mean sensory score for most parameters including overall acceptability, and there was no significant difference ($p<0.05$) in all parameters except taste. Sample F followed closely after Sample G and there was no significant difference ($p<0.05$) in all parameters except colour and flavour.

Sample D was rated the lowest mean sensory score in most parameters and there was significant difference ($p<0.05$) in all parameters. Sample G was the most generally accepted by the panellists, this was followed by Sample F and Sample C, respectively. Sample D was the least accepted. These results implied that the increase in concentration of hydrocolloids in both the xanthan gum/hydrocolloid and African star apple

Table 4. Mean sensory score of Yoghurt made with varying concentrations of hydrocolloids

Sample	Flavour	Colour	Texture	Taste	Mouth feel	Overall accept
A	3.95^{ab}±0.759	3.95^{a}±0.877	3.45^{bc}±0.510	3.50^{b}±0.607	3.20^{cd}±0.616	3.61^{cd}±0.432
B	4.10^{ab}±0.718	4.05^{a}±0.826	3.60^{ab}±0.598	3.65^{ab}±0.671	3.55^{bc}±0.510	3.79^{bc}±0.447
C	4.20^{a}±0.616	4.30^{a}±0.801	4.00^{ab}±0.795	4.15^{a}±0.489	3.65^{bc}±0.671	4.06^{ab}±0.338
D	3.30^{c}±0.571	4.00^{a}±0.725	3.00^{c}±0.562	3.60^{b}±0.503	2.95^{d}±0.605	3.37^{d}±0.396
E	3.55^{bc}±0.605	4.05^{a}±0.826	3.90^{ab}±0.553	4.00ab±0.562	3.45^{bcd}±0.510	3.79^{bc}±0.308
F	4.10^{ab}±0.718	4.25^{a}±0.786	4.00^{ab}±0.562	3.95^{ab}±0.605	4.00^{ab}±0.649	4.06^{ab}±0.298
G	4.35^{a}±0.587	4.20^{a}±0.834	4.15^{a}±0.489	3.95^{ab}±0.605	4.25^{a}±0.550	4.18^{a}±0.317

Values are mean standard deviation of duplicate samples. Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).

KEY:

A = 0.1% Xanthan Gum
B = 0.2% Xanthan Gum
C = 0.3% Xanthan Gum
D = 0% Gum (CONTROL)
E = 0.1% African Star Apple (Fruit Pulp) Gum
F = 0.2% African Star Apple (Fruit Pulp) Gum
G = 0.3% African Star Apple (Fruit Pulp) Gum

Table 5. Proximate Composition of Yoghurt Made with Hydrocolloids

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
A	83.25^{a}±0.354	0.72^{ab}±0.037	2.55^{bcd}±0.000	5.43^{e}±0.028	8.05^{d}±0.419
B	82.22^{b}±0.184	0.40^{c}±0.069	3.86^{a}±0.226	5.71^{c}±0.007	7.82^{d}±0.105
C	81.14^{c}±0.198	0.60^{abc}±0.069	2.87^{bc}±0.184	5.94^{ab}±0.007	9.46^{bc}±0.320
D	83.66^{a}±0.007	0.55^{abc}±0.069	2.24^{d}±0.177	5.41^{e}±0.035	8.16^{d}±0.066
E	81.30b^c±0.417	0.67^{ab}±0.030	3.13^{b}±0.177	5.56^{d}±0.000	9.35^{c}±0.271
F	80.65^{c}±0.205	0.77^{a}±0.101	2.42^{cd}±0.000	5.86^{b}±0.035	10.31^{b}±0.139
G	79.12^{d}±0.134	0.48^{bc}±0.036	2.49^{cd}±0.000	6.01^{a}±0.035	11.92^{a}±0.135

Values are mean standard deviation of duplicate determination. Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).

A = 0.1% Xanthan Gum
B = 0.2% Xanthan Gum
C = 0.3% Xanthan Gum
D = 0% Gum (CONTROL)
E = 0.1% African Star Apple (Fruit Pulp) Gum
F = 0.2% African Star Apple (Fruit Pulp) Gum
G = 0.3% African Star Apple (Fruit Pulp) Gum

categories, increased the overall acceptability of the samples.

3.4 Proximate Composition of Yoghurt Samples

Table 5 shows the proximate composition of yoghurt, the moisture content of the yoghurt ranged from 79.12 - 83.66%. These values are in line with the reported moisture content of yoghurt samples ranging from 78.62 - 82.41% [17]. These values also correspond with the report of Matela [17] who posited stated that the moisture content of yoghurt should be less than 84% as the presence of higher moisture content affects the texture and mouth feel.

The ash content ranged from 0.40 - 0.069 to 0.77% showing significant difference ($p<0.05$) in the ash content values of the samples. These values also corresponded with the reported results where the ash content ranged from 0.41% to 1.02% [18]. The protein content of the yoghurt samples ranged from 2.24 to 3.86%; This closely corresponds with values reported where the protein content ranged from 1.95%-2.70% [18].

According to the standards [19], the yoghurt sample should contain not less than 2.70% protein content.

The results showed that the protein content of some samples were found to be slightly lower than 2.70%. However, literature reviews have shown that the percentage of protein content of yoghurts samples have previously been reported in the range of 1.29-3.52% from other studies [20].

The fat content ranged from 5.41-6.01%. The result showed significant difference ($p<0.05$) in the fat content values of the samples. Although the fat content result was contrary to the reported results where the fat content ranged from 1.32 -3.25% [17], this contradiction indicated by an increase in the fat content, can be attributed to the source of the milk powder as it was not a skimmed milk. Value did increase with the presence of the gum. It also reported an increase in fat content with hydrocolloid concentration [21].

Fat plays an important role in improving the consistency of yoghurt and also provides twice as much energy as the same quantity of carbohydrates and protein [22]. It was also reported that the percentage of fat content plays a vital role in yoghurts since it improves texture, appearance, flavour and taste of yoghurts [23]. The carbohydrate content of the yoghurt samples ranged from 8.05 to 11.92% showing significant difference ($p<0.05$) in the carbohydrates content values of the samples. This result closely corresponds with results reported in the literature where the carbohydrate content ranged from 9.38 - 12.85% [17]. The low carbohydrate value is attributed to the process of fermentation which converts carbohydrates, basically lactose to lactic acid. This makes yoghurt an ideal food for lactose intolerance individuals [24].

4. Conclusions

The results from this study showed that the gum extracted from African star apple fruit pulp could be used to stabilise yoghurt by increasing its viscosity and reducing syneresis in the yoghurt, without negatively affecting the sensory attributes of the yoghurt. The results showed that the stabilising effect of the gum from the African star apple fruit pulp compares favourably with the already known xanthan gum (control). The characteristics and behavioural pattern of the gum extracted from African star apple fruit pulp shows that it can be used as a stabiliser, additive, thickener and emulsifying agent in food industries. Hence providing another means of utilizing African star Apple fruit pulp.

Authors' contributions

All the authors contributed equally

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Conflicts of interest

Authors have declared that no competing interests exist.

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