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Original Research Article

Evaluation of the Effects of Pectin Extracted from Jackfruit (*Artocarpus Heterohyllus*) and Passion Fruit (*Passiflora Edulis* Var *Flavicarpa Deg.*) Peels on the Quality Attributes of Yoghurt from Skimmed Milk

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Abstract

Fermented milk products such as yoghurts can be produced without the addition of any stabilizers. However, some sedimentation of the milk solids would occur in the products (especially drink-type products) and has to be accepted, especially if the shelf-life of the product is more than one week. Sedimentation can, however, be avoided by the addition of stabilizer(s). Pectin has been established as a stabilizing agent in cultured milk products. However, the pectin used is majorly extracted from apple pomace and citrus peels. With the increase in production of processed fruit products, the amount of fruit wastes generated is increasing enormously. Large amount of these wastes poses the problem of disposal without causing environmental pollution. These wastes can be effectively disposed by manufacturing useful by-products from them and one such product is pectin. The peel of passion fruit, for example, constitutes about half of the fruit mass. Given the background of numerous studies which have been carried out on the extraction and characterization of pectin from tropical fruit sources, it is, therefore, necessary to formulate yoghurt stabilized with pectin from these sources and to evaluate its performance in yoghurt. The study was carried out to evaluate pectin extracts from jackfruit and passion fruit peels and their performance in yoghurt production. The samples were subjected to physicochemical, microbial and sensory analyses were determined. Pectin from jackfruit (JFP) and passion fruit (PFP) peels were extracted by boiling in citric acid (pH 3.3, 75 min). Stirred yoghurt was formulated using skimmed milk and the extracted pectins were used as stabilizers, each at three concentrations (0.1, 0.2 and 0.3 %). Plain yoghurt was used as a control. Proximate, physicochemical, microbial and sensory analyses were carried out on the formulated stirred yoghurt samples and analysed for its quality. The yoghurt sample without the stabilizers (0.0%) served as then control. Physicochemical, microbial and sensory analyses were carried out using standard methods. Statistical analyses were done using SPSS. Results showed that the degree of esterification (DE) and yield of pectins were 32.13, 11.3 and 38.26, 12.0%. JFP and PFP, respectively. The addition of pectin reduced moisture content from 86.28 ± 0.34 % (in the control) to 85.09 ± 0.02 % (in yoghurt stabilized with 0.3 % jackfruit pectin) and 85.27 ± 0.18 % (in yoghurt stabilized with 0.2 % passion fruit pectin). The protein decreased from 3.75 to 3.45% (JFP_1 to JFP_3) and 3.67 to 3.03% (PFP_1 to PFP_3) but ash and titratable acidity increased with increased pectins. There were no significant ($p > 0.05$) differences in the fat and carbohydrate contents of the samples. However, the ash content increased significantly ($p < 0.05$) with increase in concentration of extracted pectins and there were significant differences in the calcium contents of the formulated yoghurts. The pH was 3.99 (control) to 4.08 (PFP_3). Total solids increased with pectin between 0.1 and 0.2% but decreased at 0.3%. The viscosity increased with pectin from 104.60 (control) to 153.46 (JFP) and 161.99 Cp (PFP) but decreased at 0.3%. Total titratable acidity decreased significantly ($p < 0.05$) with increase in concentration of pectin. The total solids increased on addition of pectin between 0.1 and 0.2 % concentrations but decreased at 0.3 % concentration. The microbial counts were within acceptable limit. Sensory scores for mouthfeel, firmness and consistency showed that pectin-stabilized (0.1% PFP) samples were most preferred. Good quality stirred yoghurt with better consistency and mouthfeel was made through incorporation of low-methoxyl pectins from passion fruit and jackfruit fruit peels.

Keywords: Jackfruit, Passion fruit, Pectin, Stabilizer, Yoghurt.

INTRODUCTION

Yoghurt is a semisolid fermented product made from a heat-treated standardized milk mix by the activity of a symbiotic blend of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* [1, 2]. Yoghurt is made by introducing

specific bacteria strains into milk, which is subsequently fermented under controlled temperatures (42–43 °C) and environmental conditions (in fermentation tank), especially in industrial production [3, 4]. The bacteria break down natural milk sugars and release lactic acid as a waste product. The increased acidity causes milk proteins to coagulate into a solid mass (curd) in a process called denaturation [4]. The increased acidity (pH 4–5) also prevents the proliferation of potentially pathogenic bacteria [3].

Different types, styles or categories (and subgroups) of yoghurt have entered the marketplace in response to consumer preference, changing lifestyles and dietary adjustments. Set yoghurt is a type of yoghurt which when produced, is incubated and cooled in the final retail package and it is characterized by a firm jelly-like texture [5]. On the other hand, stirred yoghurt is a type of yoghurt that is produced and incubated in a tank and the final coagulum is "broken" by stirring prior to cooling, addition of flavours and packaging [5, 6].

Stabilizers are hydrocolloids of plant and animal origin and the primary purpose of adding stabilizers to the milk base during yoghurt making is to enhance and maintain certain characteristics in yoghurt, for example, body and texture, viscosity/consistency, appearance and mouthfeel [7, 8]. Pectin extracted from plants has been used as a gelling agent in food for many years. However, in recent years, new application opportunities have emerged and pectin no longer used just as a gelling agent but also as a stabilizer and thickener [9].

Pectin is a natural constituent of all and plants, and together with cellulose, plays a key role in the cell wall structure. The term pectin usually refers to the group of plant polysaccharides in which D-galacturonic acid is the principal component [10]. The degree of esterification (DE) is one of the properties influencing pectin application as it determines the gelling nature of pectin[11]. The DE above 50 % is classified as high methoxyl (HM) pectin while those less than 50 % is known as low methoxyl (LM) pectin [9, 12, 13].

High methoxyl pectin gel only under acidic conditions and when the sugar (sucrose) content is at least 55 % [13]. High methoxyl pectin is thus normally used in jams, jellies, sweetened milk drinks and other products with high sugar content and high acidity. Low-methoxyl pectins do not require high sugar or low pH to initiate gelations, but gel in the presence of divalent cations such as calcium[9]. The ability of low methoxyl pectin to form gels with less sugar content allows the production of dietetic jams or jellies, whereas their ability to gel with calcium at higher pH enables them to produce gels in acid sensitive foods such as milk [13].

Yellow passion fruit (*Passiflora edulis* var *flavicarpa* Deg.), consumed mainly as juice in many parts of the world, is a new crop in Nigeria[14]. It is exploited for its economic importance due to the presence of volatile compounds and a comparatively high acid content, which are responsible for its characteristic exotic flavour and aroma [14]. Consequently, passion fruit stands a good chance of large-scale cultivation in Nigeria because of the ban on imported fruit drinks into Nigeria, which has stimulated a demand for locally produced juice concentrates by the fruit drink industry for local and export markets [15]. A wide-scale use of this fruit, inevitably leads to the generation of vast quantities of the fruit peels, which constitutes about half of the fruit mass. These fruit peels are discarded as a major waste, causing a substantial burden on the environment.

Jackfruit (*Artocarpus heterohyllus)* is among the foreign fruits introduced into Nigeria from India which has adapted so well in Nigeria. Ripe jackfruit comprises three parts namely: the skin (fibrous portion), the pulp (bulbs) and the seeds. The skin constitutes 50% of the fruit weight, the pulp 25 – 40% of the fruit weight while the seed, which is embedded in the pulps, constitute 12 – 15% of the fruit weight[16]. The pulp has a sweet- aromatic soft tissue and is a good source of vitamins A, B and C. It is mainly eaten fresh or as a preserve in syrups. The seeds of the jackfruit are rich in protein and carbohydrate and are consumed when roasted, boiled or milled into flour for snacks. The skin, rind, sheath, core, unfertilized floral parts are discarded as wastes because they are fibrous in nature [17, 18].

Large amount of fruit wastes poses the problem of disposal without causing environmental pollution. These wastes can be effectively disposed by manufacturing useful by-products from them and one such product is pectin. A wealth of research has been dedicated to the extraction of pectin from well-known fruits such as orange [19-21]; lemon pomace [22, 23] and grape [24]. Majority of the pectin used in cultured milk products worldwide is obtained from these well-studied sources. However, with the increase in production of processed fruit products, especially tropical fruits, interest has grown in the use of other fruit sources for the production of pectin.

Jackfruit and passion fruit have both been identified as sources of low-methoxyl and high-methoxyl pectins, respectively. Pectin has been successfully extracted and characterised from jackfruit rind [25-28] and from passion fruit peels [11, 29-31].

The objectives of this work were to extract pectin from jackfruit and passion fruit peels and estimate their degree of esterification (DE), produce stirred yoghurt containing graded levels of the extracted pectin from jackfruit and passion fruit, respectively as well as to evaluate the effect of the extracted pectins on

the physicochemical, sensory and microbiological characteristics of the formulated stirred yoghurt.

MATERIALS AND METHODS

Procurement of raw materials

The materials that were used include: skimmed milk, starter culture (yógourmet®), yellow passion fruit (*Passiflora edulis* var *flavicarpa* Deg.), jackfruit (*Artocarpus heterophyllus*) and sugar. The skimmed milk, starter culture (yógourmet®) and sugar were purchased from Ogige main market in Nsukka Local Government Area of Enugu state. Mature yellow passion fruit was obtained from Department of Crop Science, University of Nigeria, Nsukka. Jackfruit was obtained from the jackfruit trees at St. Teresa's Cathedral Church, Nsukka. Both fruits were mature and ripe. All chemical reagents employed in this study were of analytical grade and were obtained from the Department of Food Science and Technology, University of Nigeria, Nsukka, Enugu State, Nigeria.

Production of fruit peel flours

Ripe matured jackfruit and passion fruits were washed thoroughly with water and the fruit peels were separated from the flesh. Jackfruit and passion fruit peels were processed into flours using the method described by Seixas *et al.*, [29]**.** The peels were washed thoroughly and then immersed in water at a temperature of 97 ^{o}C for 3 minutes and thereafter, transferred to another water bath at room temperature and maintained for 15 minutes. Subsequently, the peels were dried in a hot air oven at 50 ^{o}C until a constant weight was obtained. The dried peels were then milled to 60 mesh size. Powdered jackfruit and passion fruit peels and the resulting products were referred to as "jackfruit peel flour (JPF)" and "passion fruit peel flour (PFF)", respectively. Each fruit peel flour was used as raw material for pectin extraction. The fruit peel flours were packaged in a polyethylene bag and stored in a freezer until required (Figure-1).

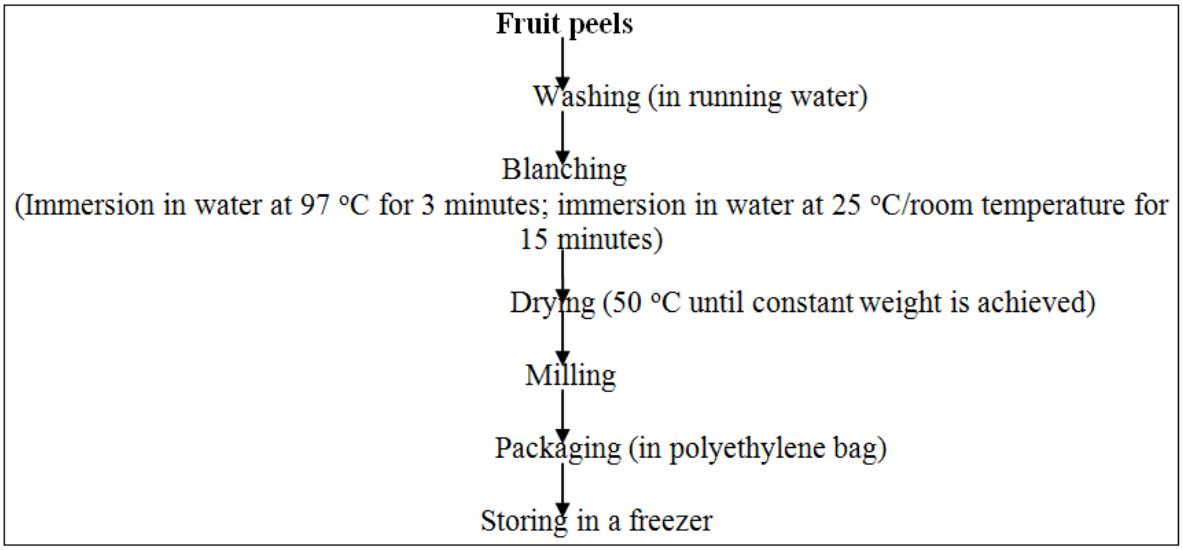

Fig-1: Preparation of fruit peel flour
Source: Seixas *et al.*, (2014) [29]

Pectin Extraction

Pectin was extracted following steps from Liew *et al.*, [11]. Ten grams (10 g) of fruit peel powder was measured on an analytical balance (Mettler Toledo™ ML-T Analytical Balance ML204T, made in Columbus, Ohio, USA), blended with 250 ml distilled water and acidified with an appropriate volume of 0.1 N citric acid to meet the designed pH of 3.3. The mixture was stirred using a stirrer until all the fruit peel powder was evenly wetted by acidified water in homogenous form. The pectin extraction procedure was continued by heating the acidified samples at 70 °C for 75 minutes in a heater. The mixture was cooled to room temperature. The suspension, still warm, was vacuum filtered in synthetic fabrics (muslin cloth); the retentate was discarded and the filtrate (containing the soluble pectin) was obtained (Figure 2). Precipitation of the pectin was carried out by adding 95 % ethanol to the filtrate in ratio of 1:2 (filtrate:ethanol, v/v). The mixture was stirred for 30 min at room temperature followed by keeping it under refrigeration at 5 °C for 1.5 h. The coagulated pectin was separated by centrifugation at 3000 rpm and washed with 70 % ethanol. Acetone was then added in a drop wise manner to remove unwanted pectin colour [32]. The resultant pectin substance was dried in a conventional oven at 65 °C until a constant weight was reached. The resulting material was then milled to dry powdered pectin.

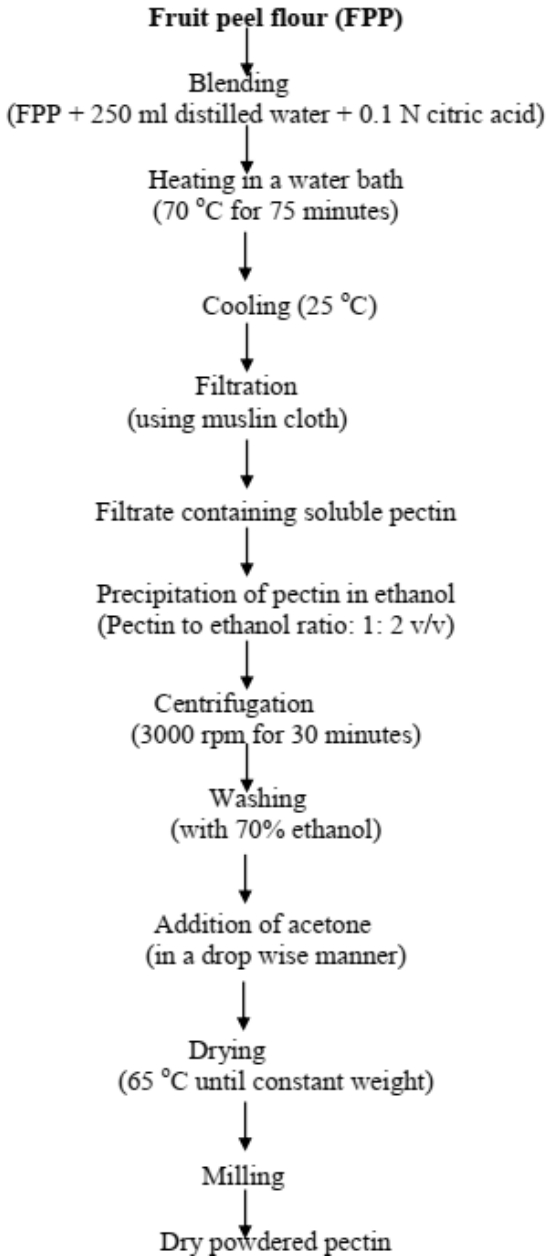

Fig-2: Extraction of pectin

Sources: Koh *et al*., (2014) [26]; Liew *et al*., (2014) [11]; Seixas *et al*., (2014) [29]

A total of 50 g of each of the fruit peel flours was used for extraction. The percentage yield of the fruit peel pectin was determined as gram of product obtained per 50 g of fruit peel powder used:

$$\text{Pectin yield (\%)} = \frac{\text{mass of extracted pectin (g)}}{\text{total mass of ground peels (g)}} \times 100$$

Yoghurt Production

Yoghurt was produced in accordance with the procedure by Ihekoronye [33]. One hundred and twelve grams (112 g) of skimmed milk powder was dissolved in 1000 ml of water to produce an equivalence of fresh skimmed milk. The milk and extracted pectin were appropriately weighed and reconstituted in water. The mixed product was homogenized to obtain a creamy and uniform product. The milk mix was pasteurized at 85 ^{o}C for 30 minutes in a water bath to inactivate the pathogens. Subsequently, the milk (1 litre) was cooled to inoculation temperature of 43 ± 1 ^{o}C and then inoculated with 3% yoghurt starter culture (yógourmet®) consisting of *Lactobacillus bulgaricus*, *Streptococcus thermophilus* and *Lactobacillus acidophilus*. The yoghurt was fermented for 16 hours at 42±2 ^{o}C in a water bath (Gallenkamp model 2XM10/250, made in European Economic Community)

after which the milk was stirred and smoothened (Figure-3).

Analysis on extracted pectin

Equivalent Weight

Equivalent weight was calculated using the method described by Ranganna [34]. A quantity (0.5 g) sample was taken in a 250 ml conical flask and 5 ml ethanol was added. One gram (1 g) of sodium chloride and 100 ml of distilled water were added followed by 6 drops of phenol red. The mixture was titrated against 0.1 N NaOH. Titration point was indicated by purple colour. This neutralized solution was stored for determination of methoxyl content. Equivalent weight was calculated by the following formula.

$$\text{Equivalent weight} = \frac{\text{Weight of sample} \times 1000}{\text{ml of alkali} \times \text{Normality of alkali}}$$

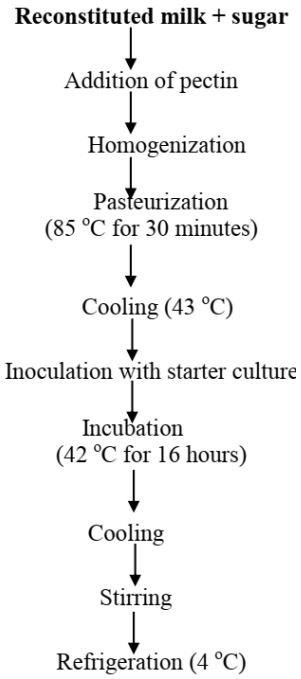

Fig-3: Yoghurt production

Source: Ihekoronye (1999) [33]

Determination of methoxyl (MeO) content

Determination of methoxyl content was done according to Ranganna [34]. The neutral solution was collected from determination of equivalent weight, and 25 ml of sodium hydroxide (0.25 N) was added. The mixed solution was stirred thoroughly and kept at room temperature for 30 minutes. After 30 minutes, 25 ml of 0.25 N hydrochloric acid was added and titrated against 0.1 N NaOH. Methoxyl content was calculated from the following formula:

$$\text{Methoxyl content (\%)} = \frac{\text{ml of alkali} \times \text{normality of alkali} \times 3.1}{\text{Weight of sample}} \times 100$$

Determination of Total Anhydduronic Acid (AUA) content

AUA content of pectin was obtained using the following formula given by Mohamed and Hasan [35].

$$\%\ \text{AUA} = \frac{176 \times 0.1z \times 100}{w \times 1000} + \frac{176 \times 0.1y \times 100}{w \times 1000}$$

Where: molecular unit of AUA (1 unit) = 176 g; z = ml (titre) of NaOH from equivalent weight determination; y = ml (titre) of NaOH from methoxyl content determination; w = weight of sample.

Determination of Degree of Esterification (DE)

Degree of Esterification was measured on the basis of the methoxyl (MeO) and AUA content [36] and calculated by following formula:

$$DE\ (\%) = \frac{176 \times \%\ MeO}{31 \times \%\ AUA}$$

Physicochemical Analyses

Determination of pH

The pH was determined according to the methods of AOAC [37] using a digital pH meter (A standard pH meter (model 20 pH conductivity meter, Denver Instrument, United Nations Inventory Database). Buffer solutions of pH 4.0 and 7.0 were used to standardize the pH meter and pH measurements were carried out in duplicate.

Determination of total titratable acidity

The total titratable acidity was determined using the AOAC [37] method. Five (5) ml of the yoghurt sample was measured into a flask and diluted to twice its volume with distilled water. Phenolphthalein indicator (2 ml) was added to each yoghurt sample and titrated with 0.I M NaOH to the first permanent pink colour. The acidity was reported as the percentage lactic acid by weight.

$$\text{Total titratable acidity} = \frac{M\ (NaOH) \times N\ (NaOH) \times 0.09 \times 100}{\text{Volume of sample}}$$

Determination of Apparent Viscosity

The viscosity was determined by using a Ferranti portable viscometer [37]. A tube was connected to the arm of the viscometer having the smaller bulb. Through the arm of the large bulb, water was sucked into the viscometer and time taken to fall back on its own after sucking to the mark was noted. The process was repeated for the yoghurt sample. The apparent viscosity was calculated in centipoise using the formula below:

$$\text{Apparent viscosity (cp)} = \frac{n_2 \times e_1 \times t_1}{e_2 \times t_2}$$

Where: n_2 = viscosity of water; e_1 = density of yoghurt from calculation; e_2 = density of water from calculation; t_1 = time taken for water to flow back and t_2 = time taken for yoghurt sample to flow back.

Determination of total solids

The total solids content of the freshly prepared yoghurt with different concentrations of stabilizers was determined using AOAC [37] procedure. The sample (5 g) was dried to a constant weight in hot air oven at 130 ^{o}C. Then, the total solid content was obtained as percentage (%) total solids.

$$\text{Percentage total solids} = \frac{\text{Weight of dried sample}}{\text{Weight of sample}} \times 100$$

Determination of ash content

The ash content of the freshly prepared yoghurt samples was determined according to the standards of AOAC [37]. A preheated and cooled crucible was weighed (W_1) and 3 ml of the yoghurt sample was weighed into the preheated cooled crucible (W_2). The sample was charred on a Bunsen flame inside a fume cupboard. The charred sample in the crucible was transferred into a preheated muffle furnace at 550 ^{o}C for 2 hours until a white or light grey ash was obtained. It was cooled in a desiccator and weighed to obtain W_3.

$$\text{Percentage ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where; W_1 = initial weight of empty crucible; W_2 = weight of crucible + weight of sample before ashing; W_3 = weight of crucible + weight of sample after ashing.

Determination of Moisture Content

The moisture content of the samples was determined according to the hot air oven method described by Association of official Analytical Chemist [37]**.** The crucibles were washed thoroughly and afterwards dried in the oven at 110 ^{o}C for 1 hour. The hot dried crucibles were cooled in a desiccator and then the weight was noted as W_1. Three millilitres (3 ml) of the yoghurt sample was weighed into the crucible and the weight of the crucible with the yoghurt sample was noted as W_2. The sample was then at 103 ^{o}C until a constant weight (W_3) was obtained.

$$\text{Percentage moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where; W_1 = initial weight of empty crucible; W_2 = weight of crucible + weight of sample before drying and W_3 = weight of crucible + weight of sample after drying

Determination of Crude Fat Content

The fat content of the yoghurt samples was determined using the standard method [37]. A Soxhlet extractor with a reflux condenser and a 250 ml round bottom flask was fixed. Three millilitres of yoghurt sample was pre-dried in an oven at 70 ^{o}C for 1 hour to reduce the moisture content. The yoghurt sample was then placed in a thimble and petroleum ether (200 ml) was filled into the round bottom flask. The extraction thimble was sealed with cotton wool. The Soxhlet apparatus after assembling was allowed to reflux for 3 hours. The thimble was removed with care and the petroleum ether collected on the top and drained into a container for reuse. When the flask was free of ether, it

was removed and dried at 70 ^{o}C for 1 hour in an oven. It was cooled in a desiccator and then weighed.

$$\text{Percentage (\%) fat content} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of crude protein

The protein content of the samples was determined according to the Kjeldahl method [37].

a. Digestion of the sample: Five millilitres (5 ml) of the yoghurt sample was weighed into a Kjeldahl digestion flask and 1 tablet of Kjeldahl catalyst was added. Twenty five millilitres (25 ml) of concentrated H_2SO_4 was added with few boiling chips. The flask with its content was heated in the fume chamber until a clear solution was obtained. The solution was cooled to room temperature after which it was transferred into a 250 ml volumetric flask and made up to the level with distilled water.

b. Distillation: The distillation unit was cleaned and the apparatus set up. A 100 ml conical flask (receiving flask) containing 5 ml of 2 % boric acid was placed under the condenser with the addition to 2 drops of methyl red indicator. A digest of 5 ml was pipetted into the apparatus through the small funnel, washed down with distilled water followed by the addition of 5 ml of 60 % NaOH (sodium hydroxide) solution. The digestion flask was heated until 100 ml of distillate (ammonium sulphate) was collected in the receiving flask. The solution in the receiving flask was titrated with 0.04 M HCl to get a pink colour. The same procedure was carried out on the blank.

$$\text{Percentage (\%) nitrogen content} = \frac{V_S - V_B \times N_{acid} \times 0.01410}{\text{Weight of sample}} \times 100$$

Percentage (%) crude protein = % N × 6.25 (conversion factor)

Where V_S = volume (ml) of acid required to titrate the sample; V_B = volume (ml) of acid required to titrate the blank; N_{acid} = Normality of acid (0.1N) and 0. 01410 = millilitre equivalent weight of nitrogen.

Microbial Analysis

Preparation of Ringer Solution

Quarter strength ringer solution was prepared by dissolving one ringer tablet in 500 ml of distilled water. The clear solution formed was sterilized by autoclaving for 15 minutes at 121 ^{o}C and 15 lb pressure. The Ringer solution was allowed to cool completely to a temperature of about 28±2^{o}C.

Determination of Total Viable Count

The total viable count test was carried out using the method described by Prescott *et al.*, [38]. One millilitre (1 ml) of the sample and 9 ml of ringer solution were used to make serial dilutions up to 10^{-5}. The diluted sample was pipetted into a marked Petri dish, 15 ml of prepared nutrient agar solution was added. The solution was swirled to mix and incubated at the temperature of about 37 ^{o}C for 24 hours. After incubation, the number of colonies was counted and represented as colony forming unit per millilitre (cfu/ml).

Determination of lactic acid bacteria (LAB)

The lactic acid bacteria (LAB) count of the formulated yoghurt was determined using deMan Rogosa Sharpe (MRS) agar (Oxoid CM 361) according to Sharma [39]. Samples were serially diluted in duplicates using the surface pour plate method. The plates were incubated in an anaerobic jar under anaerobic conditions at 37 ^{o}C for 48 hours and then counted.

Coliform determination

The method described by Prescott *et al.*, [38] was used in this determination. Ten millilitres (10 ml) of prepared MacConkey agar was added into the petri dish containing 1 ml of the sample. After inoculation, it was incubated at temperature of about 37 °C for 24 h, after incubation, the number of colony was counted and represented as colony forming unit per ml.

Mould Count Determination

Mould count determination was done according to the method described by Prescott *et al* [38]. The media used was Sabouraud dextrose agar. Fifteen (15) ml of Sabouraud dextrose agar was added to the 1 mL of sample in the Petri dish. It was thoroughly mixed and allowed to set before incubating at the temperature of 37 °C for 48 hours. After incubation, the number of colonies was counted and represented as colony forming unit per ml.

Sensory Evaluation

Sensory evaluation of the formulated yoghurt samples was conducted in the sensory booth. Twenty semi-trained panelists randomly selected among staff and students from the Department of Food Science and Technology, Nsukka, evaluated the samples. The panelists were given portable water and instructed to rinse their mouth immediately after tasting each samples to avoid bias. The samples were evaluated for colour, homogeneity, taste, mouth feel, after taste and overall acceptability. The extent of differences among samples for each sensory quality was measured using a 9-point Hedonic scale where 9 represents extremely like and 1 represents extremely dislike [40].

Experimental design and Data analyses

The Statistical Package for the Social Sciences (SPSS) version 21 was used for all statistical analyses.

The data obtained were analysed using 2 × 4 split plot in completely randomized design. Least significant difference was used to compare the treatment means and significance was accepted at $p < 0.05$. Statistically significant differences were indicated by labelling the mean values with different letters.

RESULTS AND DISCUSSION

Characterization of Extracted Pectins

Table-1 shows the extraction yield, equivalent weight, methoxyl content, anhydrouronic acid content and degree of esterification of the extracted pectins.

Table-1: Physicochemical constituents of jackfruit and passion fruit pectins*

Characteristic	Jackfruit	Passion fruit
Yield (%)	11.3	12.0
Equivalent Weight	419.66 ± 32.28	488.10 ± 16.84
Methoxyl Content (%)	3.50 ± 0.13	3.94 ± 0.13
Anhydrouronic Acid Content (%)	61.95 ± 3.98	58.43 ± 0.50
Degree of Esterification (%)	32.13 ± 0.86	38.26 ± 1.60
Colour	Brown	Brown

*Values are means ± standard deviations of duplicate determinations

Pectin yield

The yield of the pectins were 11.3 and 12.0 % for jackfruit and passion fruits, respectively. Passion fruit gave a higher pectin yield and the yields obtained for both fruits were similar to that for overripe lemon pomace (10.33 %) extracted using strong mineral acids and a pH of 2 [22]. The pectin yield for any pectin extraction depends on the stage of maturity of the fruit, pectin source and extraction conditions [42]. Hence, the yield of jackfruit pectin was significantly lower than 17.21 % reported by Koh *et al.,* [26**]** using microwave assisted extraction. It was, however, similar to the 14.7 % pectin yield for jackfruit peels reported by Ahmmed [27] using conventional extraction. The same trend is observed in passion fruit pectin where the yield was similar to 12.5 % yield for passion fruit pectin extracted with conventional boiling at a pH of 3.3 using citric acid [11]. It was, however, lower than the 30.3 % yield reported by Seixas *et al.,* [29] for pectin extracted from passion fruit using microwave heating. Azad *et al.,* [22] stated that pectin yield is generally lower at ripening because the pectin in fruits is usually converted to protopectin, sugar and other constituents.

Equivalent Weight

The equivalent weights of the pectins extracted from jackfruit and passion fruit peels were 419.66 ± 32.28 and 488.10 ± 16.84, respectively. The results obtained are consistent with the wide range of equivalent weights reported by several authors: 368 ± 3 to 1632 ± 137 for lemon pomace [22]; 833.2 to 1666.30 for apple pectin [42] and 460.63 to 475.74 reported for jackfruit [27]. Azad *et al.,* [22] observed that equivalent weight depends on the maturity stage of the fruit. Pectins from overripe fruits show lower equivalent weight while pectins from mature fruits show higher equivalent weights. The lower equivalent weight could be due to higher partial degradation of pectin. The results were therefore appropriate because peels of ripe fruits (representing important waste materials) were used for the extraction.

Methoxyl Content

Methoxyl content is an important factor in controlling the setting time of pectins and the ability of the pectin to form gels [43]. The methoxyl contents were 3.50 ± 0.13 % and 3.94 ± 0.13 % for jackfruit and passion fruit peels respectively. Similar to pectin yield and equivalent weight, methoxyl contents are lower for ripe fruits than for premature or mature fruits. Madhav and Pushpalatha [30] reported the methoxyl content of pectin extracted from passion fruit rind to be 4.96 % using citric acid and boiling time of 45 minutes. The methoxyl content for jackfruit was similar to the result for jackfruit peel (3.43 %) reported by Ahmmed [27**].** Both results were, however, significantly lower than the methoxyl content of premature lemon pomace (10.25 %) as reported by Azad *et al.,* [22]. Due to ripening, the sugar content of fruits are increased and the methoxyl content is decreased [44]. Spreading quality and sugar binding capacity of pectin are increased with increase in methoxyl content [30]. Based on the methoxyl contents of the extracted pectins in this study, the pectins were categorized as low methoxyl pectins. Hence, the gelling quality of the pectins would not be affected by sugar content of the food product but by the presence of calcium ions contributed by the milk [9].

Total Anhydrouronic Acid (AUA) content

The AUA indicates the purity of the extracted pectin and its value should not be less than < 65 % [47]. In this study, the AUA content of the extracted pectins were 61.95 ± 3.98 % and 58.43 ± 0.50 % for jackfruit and passion fruits respectively. Both values are lower than the stipulated minimum by Food Chemical Codex [45].

However, the AUA content is also related to the degree of maturity and similar values have been reported for apple pomace pectin (59.52 to 70.50 %) and 61.72 % for commercial apple pectin [42]. The AUA content of jackfruit pectin was close to 66.0 % [31] but that for passion fruit was higher than 46.17 % for passion fruit reported by the same authors. Koh *et al.,* [26] reported AUA contents up to 75.34 % for

pectin extracted from jackfruit by microwave heating whereas Seixas *et al.*, [29] reported AUA content up to 82.3 % for passion fruit extracted by the same method. The results indicate that an optimization of the extraction process may be required so as to obtain pure pectins from both fruits. Commercial pectins are usually standardized to ensure consistency between batches and to improve pectin performance in designated foods [9, 46, 47].

Degree of Esterification

Table-1 showed that the DE of the extracted pectins were 32.13 ± 0.86 % and 38.26 ± 1.60 % for jackfruit and passion fruit pectins respectively. Based on DE, pectin can be classified as low methoxyl pectin with ≤ 50 % DE and high methoxyl pectin with > 50 % DE [9,12,13]. Thus, both pectins are classified as low methoxyl pectin. Similar to methoxyl content, the degree of esterification decreases with the increase in maturity. Therefore, the results are consistent since fruit peels of mature fruits were used for the extraction. Liew *et al* [11] extracted pectins with degree of esterifications ranging from 45 to 65 % from mature passion fruit. Ahmmed [27] reported DE value of 34.29 % for pectin extracted from jackfruit peel. According to Sundar Raj *et al* [48], the degree of esterification depends on species, tissue and stages of maturity.

Effect of pectin on organoleptic properties of stirred yoghurt

Table-2 shows the sensory scores for stirred yoghurts stabilized with extracted pectins. There were no ($p < 0.05$) significant differences in acceptability for colour, taste, aftertaste and flavour in all the samples. Within the stirred yoghurt group stabilized with jackfruit pectin, sample containing 0.3 % pectin (sample JFP_3) scored highest for colour (7.80 ± 0.29), aftertaste (6.55 ± 0.38) and flavour (6.50 ± 0.36). Within the stirred yoghurt group stabilized with passion fruit pectin, sample containing 0.1 % pectin (sample PFP_1) scored highest for colour (7.80 ± 0.24) and taste (6.45 ± 0.34). The control sample scored highest for taste (6.70 ± 0.39) and had the second highest score for colour (7.60 ± 0.22). The differences in colour likeability between the jackfruit and passion fruit stabilized groups may be attributed to the fact that passion fruit pectin had a darker colour than jackfruit pectin. Thus, at higher concentrations, the acceptability of the colour of yoghurt stabilized with passion fruit pectin decreased whereas this trend was not observed for jackfruit stabilized yoghurt samples.

Table-2: Sensory scores for colour, taste, aftertaste and flavour of stirred yoghurt stabilized with extracted pectins*+

Sample	Pectin Concentration	Colour	Taste	Aftertaste	Flavour	Mouthfeel	Consistency	Firmness	Overall acceptability
JFP_1	0.1 %	7.50^{a} ±0.27	6.35^{a} ±0.34	6.40^{a} ±0.34	5.90^{a} ±0.32	6.40^{ab} ±0.31	6.85^{abc} ±0.28	6.20^{ab} ±0.31	6.45^{b} ±0.29
JFP_2	0.2 %	7.60^{a} ±0.27	6.55^{a} ±0.34	6.20^{a} ±0.35	6.15^{a} ±0.31	6.80^{ab} ±0.35	7.20^{ab} ±0.28	6.45^{ab} ±0.37	7.10^{ab} ±0.24
JFP_3	0.3 %	7.80^{a} ±0.29	6.10^{a} ±0.42	6.55^{a} ±0.38	6.50^{a} ±0.36	6.75^{ab} ±0.30	7.10^{abc} ±0.24	7.10^{a} ±0.23	6.55^{b} ±0.29
PFP_1	0.1 %	7.80^{a} ±0.24	6.45^{a} ±0.28	6.45^{a} ±0.34	6.45^{a} ±0.27	7.05^{a} ±0.25	7.45^{a} ±0.25	7.05^{a} ±0.28	7.45^{a} ±0.24
PFP_2	0.2 %	7.30^{a} ±0.28	6.15 ±0.32	6.20^{a} ±0.37	5.90^{a} ±0.35	5.95^{b} ±0.33	6.90^{abc} ±0.26	5.95^{b} ±0.29	6.65^{ab} ± 0.26
PFP_3	0.3 %	7.40^{a} ±0.34	6.40^{a} ± 0.37	6.70^{a} ±0.36	6.80^{a} ±0.34	6.75^{ab} ±0.27	6.35^{c} ±0.25	7.00^{a} ±0.26	7.10^{ab} ±0.27
Control	0.0 %	7.60^{a} ±0.22	6.70^{a} ±0.39	6.55^{a} ±0.35	6.35^{a} ±0.30	7.10^{a} ±0.27	6.45^{bc} ±0.28	6.55^{ab} ±0.31	7.00^{ab} ±0.25

*Values are means ± standard deviations of sensory scores of 20 panelists.
+Values in the same column carrying similar superscript are not significantly ($p > 0.05$) different.
Key: JFP = Jackfruit pectin-stabilized yoghurt; PFP = Passion fruit pectin-stabilized yoghurt.

There were significant ($p < 0.05$) differences in acceptability for all mouthfeel, consistency, firmness and overall acceptability (Table-2). The control sample scored highest for mouthfeel (7.10 ± 0.27). Within the stirred yoghurt group stabilized with passion fruit pectin, sample containing 0.1 % pectin (sample PFP_1) scored highest for mouthfeel (7.05 ± 0.25) while within the jackfruit group, sample containing 0.2 % pectin (sample JFP_2) scored highest for mouthfeel (6.80 ± 0.35). Within the yoghurt group stabilized with jackfruit pectin, acceptability for mouthfeel increased with increase in concentration while within the passion fruit group, acceptability decreased with increase in concentration. This may be attributed to the grainy mouthfeel which develops when low methoxyl pectins are used at levels above their optimum.

Yoghurt sample containing 0.1 % passion fruit pectin (sample PFP_1) scored highest for consistency (7.45 ± 0.25). The acceptability for the consistency of yoghurt stabilized with jackfruit pectin increased with increase in concentration of pectin but decreased in the passion fruit group. Thus, at 0.3 % concentration, the consistency of yoghurt stabilized with jackfruit pectin was 7.10 ± 0.24 while that for passion fruit was 6.35 ± 0.25 which was also the lowest score recorded for consistency.

Similar trends were observed in the scores for firmness. Acceptability of firmness for yoghurt stabilized with jackfruit pectin increased with increase in concentration of the pectin (6.20 ± 0.31 to 7.10 ± 0.23). However, preference for firmness in the passion fruit pectin-stabilized samples decreased with increase in concentration (from 7.05 ± 0.28 to 5.95 ± 0.29). The decrease in acceptability for both firmness and consistency in passion fruit pectin-stabilized yoghurt may be attributed to the graininess which develops at higher concentrations for low methoxyl pectin.

Stirred yoghurt containing 0.1 % passion fruit pectin (sample PFP_1) was the most preferred sample (7.45 ± 0.24). Within the yoghurt group stabilized with jackfruit pectin, sample with 0.2 % pectin (sample JFP_2) was the most preferred sample (7.10 ± 0.24). The overall acceptability scores (ranging from 6.45 ± 0.2 to 7.45 ±0.24) indicates that all the samples were acceptable. Generally, stirred yoghurt stabilized with passion fruit pectin received higher scores at 0.1 % concentration while yoghurt stabilized with jackfruit pectin received higher scores at 0.2 % for most parameters tested.

Effect of extracted pectins on the physicochemical properties of stirred yoghurt

The proximate composition of the formulated yoghurt samples are shown in Table 3. There were significant ($p < 0.05$) differences in the moisture content of yoghurt stabilized with the extracted pectins (Table-3). They ranged from 85.09 ± 0.02 to 87.16 ± 1.23 %. Yoghurt stabilized with 0.3 % jackfruit pectin (sample JFP_3) had the lowest moisture content while yoghurt stabilized with 0.3 % passion fruit pectin (sample PFP_3) had the highest moisture content. The concentration effect of the different pectins also show significant ($p < 0.05$) differences at various levels. This is evident in the fact that the moisture content decreased with increase in concentration of pectins. Herbstreith and Fox [47] found that the addition of pectin in acidified food products such as yoghurts prevents the agglomeration the milk proteins, caseins, thus preventing water loss.

Table-3: Proximate composition of formulated stirred yoghurt*+

Sample	Pectin Concentration	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Protein (%)	Carbohydrate (%)	Calcium (mg/100g)
JFP_1	0.1 %	86.08^{ab} ±0.04	1.40^{ab} ±0.05	0.23^{a} ±0.03 0.22^{a} ±0.02	3.75^{a} ±0.07	8.54^{a} ± 0.05	58.0^{ef} ± 2.8
JFP_2	0.2 %	85.55^{ab} ±0.21	1.39^{ab} ±0.11	0.27^{a} ±0.03	3.75^{a} ±0.07	8.60^{a} ± 0.77	68.0^{e} ± 5.6
JFP_3	0.3 %	85.09^{b} ±0.02	1.54^{ab} ±0.07		3.45^{ab} ±0.07	9.65^{a} ± 0.16	217.5^{a} ± 7.8
PFP_1	0.1 %	85.57^{ab} ±0.56	1.52^{ab} #±0.18	0.22^{a} ±0.05 0.28^{a} ±0.02	3.67^{a} ±0.29	9.02^{a} ± 0.56	114.5^{c} ±3.5
PFP_2	0.2 %	85.27^{b} ±0.18	1.66^{a} ±0.10	0.26^{a} ±0.03	3.67^{a} ±0.00	9.12^{a} ± 0.80	83.0^{d} ± 4.2
PFP_3	0.3 %	87.16^{a} ±1.23	1.74^{a} ±0.78		3.03^{b} ±0.21	7.81^{a} ± 2.07	53.0^{f} ± 1.4
Control	0.0 %	86.28^{ab} ±0.34	1.29^{b} ±0.+02	0.28^{a} ±0.02	3.45^{ab} ±0.07	8.70^{a} ± 0.27	125.0^{b} ± 1.4

*Values are means ± standard deviations of duplicate determinations.
+Values in the same column carrying similar superscript are not significantly ($p > 0.05$) different
Key: JFP = Jackfruit pectin-stabilized yoghurt; PFP = Passion fruit pectin-stabilized yoghurt.

However, the interaction effect between the pectins and their concentrations on moisture content show significant ($p < 0.05$) differences. This indicates that the behaviour of the pectins were not the same at different concentrations. Within the yoghurt group stabilized with jackfruit pectin, moisture content decreased with increase in concentration. However, within the yoghurt group stabilized with passion fruit pectin, moisture content only decreased up to the 0.2 % concentration. A significant increase in the moisture content was observed at the 0.3 % concentration (87.16 ± 1.23 %). Brejnholt [9] reported that small amounts of low methoxyl pectin increase firmness, mouthfeel and creaminess through excellent water-binding ability, calcium reactivity and interaction with milk proteins. However, that at larger pectin dosages, reactions may be so strong that destabilization of the product occurs.

Hence, using levels above 0.2 – 0.3 % is not recommended [9].

The ash contents of yoghurt stabilized with jackfruit and passion fruit pectins show significant ($p < 0.05$) differences. The values ranged from 1.29 ± 0.02 to 1.74 ± 0.78 %. Yoghurt stabilized with 0.3 % passion fruit pectin (sample PFP_3) had the highest ash content while the control sample had the lowest ash content (1.29 ± 0.02 %). There were no significant ($p > 0.05$) differences in the fat and carbohydrate contents of yoghurt stabilized with extracted pectins. The values for fat ranged from 0. 22 ± 0.02 (sample JFP_2) to 0.28 ± 0.02 % (sample PFP_2). The low fat content may be attributed to the skimmed milk used in the production. Carbohydrate contents ranged 7.81 ± 2.07 (sample PFP_3) to 9.65 ± 0.16 % (sample JFP_3). Slightly higher carbohydrate contents were recorded in samples containing pectin and this may be attributed to the neutral sugars present in pectin.

Protein content of yoghurts produced with extracted pectins show significant differences ($p < 0.05$). The values ranged from 3.03 ± 0.21 % (sample PFP_3) to 3.75 ± 0.07 % (samples JFP_1 and JFP_2). Yoghurt containing pectins recorded slightly higher protein contents (3.75 ± 0.07 and 3.67 ± 0.29) than the control sample (3.45 ± 0.07). This may be attributed to difference in moisture content. Among the samples containing pectin, protein contents decreased at 0.3 % concentration for both groups of stabilized yoghurts as a result of dilution effect. As already stated by Brejnholt [9], when pectins are used at levels above 0.3 %, their water-binding capacity decreases, thus increasing the moisture content relative to the protein content.

There were significant differences ($p < 0.05$) in the calcium content of the stirred yoghurt samples. Yoghurt stabilized with 0.3 % passion fruit pectin (sample PFP_3) had the lowest calcium content (53.0 ± 1.4 mg/100g) while yoghurt stabilized with 0.3 % jackfruit pectin (JFP_3) had the highest calcium content (217.5 ± 7.8 mg/100g). The control sample had a calcium content of 125.0 ± 1.4 mg/100g. Generally, it appears that inclusion of the pectin decreased calcium content. According to Harte *et al* [49], low methoxyl (LM) pectin was combined with 3-kDa molecular weight cut-off permeates from milk subjected to pH 6.7 to 5 and 7 degrees C or 40 degrees C reduced the effect of solubilized micellar calcium on viscoelastic properties of LM-pectin-milk mixes.

Table-4 shows the mean values for titratable acidity, pH, total solids and viscosity of formulated stirred yoghurts. There were significant ($p < 0.05$) differences in the viscosities of yoghurt stabilized with extracted pectins (Table-4). The values for viscosity ranged from 104.60 ± 5.53 cp in the control sample to 161.99 ± 0.78 cp in yoghurt stabilized with 0.2 % passion fruit pectin (sample PFP_2). Within the yoghurt group stabilized with jackfruit pectin, viscosity increased with increase in concentration from 120.94 ± 0.98 (sample JFP_1) to 153.46 ± 1.56 cp (sample JFP_3). This indicates that the addition of pectin significantly increased the viscosities of the stirred yoghurt samples. Ramaswamy and Basak[50] found that the addition of pectin concentrate to stirred commercial yoghurt increased the apparent viscosity. Within the yoghurt group stabilized with passion fruit pectin, the viscosities increased from 145.97 ± 5.08 (sample PFP_1) to 161.99 ± 0.78 cp (sample PFP_2). That is, viscosity increased from 0.1 % concentration to 0.2 % concentration before a drop in the viscosity was observed at the 0.3 % concentration of passion fruit pectin (116.60 ± 1.31 cp for sample PFP_3). This implies that the extracted passion fruit pectin has optimum performance at 0.2 % concentration beyond which a negative effect is observed.

Table-4: Physicochemical properties of formulated stirred yoghurt*+

Sample	Pectin concentration	Titratable acidity (%)	pH	Total solids	Viscosity (cp)
JFP_1	0.1 %	1.03^{a} ±0.02	4.01^{b} ±0.01	13.92^{ab} ±0.04	120.93^{e} ±0.98
JFP_2	0.2 %	1.02^{a} ±0.03	4.02^{b} ±0.02	14.45^{ab} ±0.21	131.95^{d} ±1.84
JFP_3	0.3 %	1.00^{a} ±0.03	4.00^{b} ±0.01	14.97^{a} ±0.05	153.46^{b} ±1.56
PFP_1	0.1 %	0.94^{bc} ±0.01	4.00^{b} ±0.00	14.43^{ab} ±0.56	145.97^{c} ±5.08
PFP_2	0.2 %	0.92^{c} ±0.02	4.01^{b} ±0.01	14.73^{ab} ±0.18	161.99^{a} ±0.78
PFP_3	0.3 %	0.95^{bc} ±0.01	4.08^{a} ±0.03	12.84^{b} ±1.23	116.60^{e} ±1.31
Control	0.0 %	0.88^{c} ±0.02	3.99^{b} ±0.01	13.73^{ab} ±0.34	104.60^{f} ±5.53

*Values are means ± standard deviations of duplicate determinations.
+Values in the same column carrying similar superscript are not significantly ($p > 0.05$) different.
Key: JFP = Jackfruit pectin-stabilized yoghurt; PFP = Passion fruit pectin-stabilized yoghurt

There were significant ($p < 0.05$) differences in the total titratable acidity of yoghurt stabilized with extracted pectins (Table 4). The control sample had the lowest titratable acidity (0.88 ± 0.02) while yoghurt stabilized with 0.1 % jackfruit pectin (JFP_1) had the highest titratable acidity (1.03 ± 0.02). The low acid production could be attributed to reduced mobility of reactants and the consequence was reduction of the rate at which reacting species came together for fermentation to take place [51]. The interaction effect between the extracted pectins and concentrations was found to be significant ($p < 0.05$) suggesting that

jackfruit and passion fruit pectins produced different effects at varying concentrations. Yoghurt group stabilized with passion fruit pectin had significantly ($p < 0.05$) lower titratable acidity values than yoghurt stabilized with jackfruit pectin. This indicates that the extracted passion fruit pectin impeded the production of titratable acidity more than jackfruit pectin. However, mixing did not modify the duration or the shape of the pH profiles during the exponential phase. In fermentors with poor heat-transfer characteristics, important differences in microbial dynamics were observed between the agitated and nonagitated fermentation experiments (that is, agitation significantly increased the observable specific growth rate and the final microbial count of *L. bulgaricus*) [52]. Pectin could be recovered from fruit wastes and the conversion of passion fruit peel into pectin offered a great scope for utilization. Citric acid and enzymatic extraction methods effectively used for pectin extraction which may be of interest by pectin industry and consumer with these eco-friendly processing technology with no using harmful chemicals. The peels of yellow passion fruit using the acidic and enzymatic extraction methods gave pectin yield of 7.16 and 7.12%, and DE of 71.02 and 85.45% in the optimized condition of extraction time of 102 min with citric acid concentration of 0.19% (w/w) at 75C and Celluclast concentration of 1.67% (w/w) at 61.11C, respectively [53]. These are unlike that of pectin from jackfruit that has lesser acid.

The results for total solids (Table-4) show that there were significant ($p < 0.05$) differences in the total solids content of yoghurt stabilized with extracted pectins. The values ranged from 12.84 ± 1.23 % in sample PFP_3 to 14.97 ± 0.05 in sample JFP_3. Generally, the total solids content increased with increase in concentration. The interaction effect between pectins and concentrations was found to be significant ($p < 0.05$), which implies that the effects were different for both pectins. This is evident in the fact that whereas the total solids content of the yoghurt group stabilized with jackfruit pectin increases steadily with increase in concentration (from 13.92 ± 0.04 in sample JFP_1 to 14.97 ± 0.05 % in sample JFP_3), the total solids content of the yoghurt group stabilized with passion fruit decreased at the 0.3 % concentration (12.84 ± 1.23 % for sample PFP_3). The results are in agreement with the findings of Mekana and Mehanna [54] who reported that the addition of stabilizers increases the solids content of yoghurt. There were no significant ($p < 0.05$) differences in the pH of yoghurt stabilized with extracted pectins. The pH of the formulated stirred yoghurts ranged from 3.99 ± 0.01 in the control sample to 4.08 ± 0.03 in yoghurt containing 0.3 % passion fruit pectin (PFP_3).

Effect of extracted pectin on the microbial characteristics of the formulated stirred yoghurts

Table-5 shows the total viable count, lactic acid bacteria, mould and coliform counts of the formulated stirred yoghurts. The total viable count (TVC) ranged from 1.5×10^4 cfu/ml in sample JFP_3 to 2.8×10^5 cfu/ml in sample PFP_1. The control sample had a total viable count of 9.6×10^4 cfu/ml. Lactic acid bacteria count ranged from 1.1×10^5 cfu/ml in samples JFP_2 and JFP_3 to 9.4×10^5 cfu/ml in sample PFP_3. It has been suggested that "yoghurt should contain abundant and viable organisms of starter origin" [55] or above 1.0×10^7 cfu/ml of the starter culture organisms [56] and, whichever format is adopted, there is a general agreement that yoghurt should contain live bacteria unless specifically designated as pasteurised or heat-treated [7**]**. Thus, the values were consistent with the standard. Generally, total viable count and lactic acid bacteria count decreased with increase in concentration and this could be attributed to the conditions of fermentation which did not favour the rapid growth of microorganisms [57].

Table-5: Microbial count (cfu/ml) of formulated stirred yoghurt samples

Sample	Concentration	Total Viable Count (TVC) cfu/ml	Lactic Acid Bacteria (LAB) count cfu/ml	Mould count cfu/ml	Coliform count cfu/ml
JFP_1	0.1 %	8.4×10^4	2.3×10^5	1.0×10^0	4.0×10^0
JFP_2	0.2 %	3.8×10^4	1.1×10^5	2.0×10^0	4.0×10^0
JFP_3	0.3 %	1.5×10^4	1.1×10^5	1.0×10^0	5.0×10^0
PFP_1	0.1 %	2.8×10^5	5.0×10^5	2.0×10^0	2.0×10^0
PFP_2	0.2 %	3.1×10^4	2.7×10^5	3.0×10^0	2.0×10^0
PFP_3	0.3 %	6.8×10^4	9.4×10^5	5.0×10^0	2.0×10^0
Control	0.0 %	9.6×10^4	1.4×10^5	3.0×10^0	3.0×10^0

*Values are means of duplicate determinations.

Key: JFP = Jackfruit pectin-stabilized yoghurt; PFP = Passion fruit pectin-stabilized yoghurt.

Mould and coliform were detected in all the samples. Sample PFP_3 had the highest mould count of 5 cfu/ml while sample JFP_3 had the highest coliform count of 5 cfu/ml. The values were, however, within the acceptable range as a maximum range of 10 cfu/ml for mould and coliform have been stipulated in stirred yoghurt [7]. The insignificant mould and coliform counts could be attributed to environmental factors and signifies that better sanitary production conditions are required and more stringent hygiene measures may be required.

CONCLUSION

This research shows that low methoxyl pectin can be extracted from ripe passion fruit and jackfruit peels. The extracted pectins significantly influenced the quality attributes of stirred yoghurt when used as a stabilizer. Yoghurt samples with pectin at concentrations of 0.1 – 0.2 % had higher viscosities and lower moisture contents than the control samples containing no pectin. Pectin-stabilized samples were also preferred by panelists for consistency and firmness. Use of the extracted low methoxyl pectin from passion fruit peel above 0.2 % concentration showed negative effects for most of the parameters tested. Stirred yoghurts stabilized with jackfruit pectin gave best performance at 0.2 % pectin concentration while stirred yoghurt stabilized with passion fruit pectin gave best performance at 0.1 % pectin concentration. Overall, stirred yoghurt produced with 0.1 % passion fruit pectin was the most preferred sample. Therefore, low methoxyl pectins should only be used at minimal levels (< 0.3 %) to prevent precipitation of proteins from stirred yoghurts.

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