Production and Quality Assessment of Plant-based Yoghurt from Coconut milk fortified with Date Syrup

Abstract

Yoghurt is a product of bacterial fermentation of animal based milk. In recent time, prices of milk have skyrocketed, making such products expensive, especially for the common man. This calls for possible substitutes for animal milk in production of products like yoghurt. In this study, quality of yoghurt produced from plant-based milk obtained from coconut and date syrup blends were evaluated. Five samples; T0 (control), T1, T2, T3, T4, and T5 coconut milk substituted with date syrup at 0%, 15%, 20%, 25%, and 30% were used for the production of yoghurt. The physicochemical, microbial, sensory attributes and storage stability were evaluated using standard methods. Results obtained show slight decrease in pH (4.50 to 4.41), while other parameters like titratable acidity (0.82 – 0.94 %), viscosity (12.0 -72.40 cP) and total solid (11.64 – 18.81 %) increased significantly ($p<0.05$) with increase in the proportion of date syrup. The proximate parameters showed significantly value increment with increase in the proportion of date syrup ($p<0.05$). The total bacterial count ranged from 6.95 to 8.20, with Yeast and moulds were not detected. There were no coliforms detected in the samples. The produced yoghurt samples all have quality attributes of animal milk yoghurt and better storage stability. Therefore, production commercial yoghurt using plant-based milk like coconut milk blended with nutritiously rich sweeteners like date fruit is be encouraged.

Key Words: Plant-based milk, Animal Milk, Yoghurt, Physicochemical properties, Sensory Properties, Storage Stability

1. Introduction

Yoghurt, a fermented dairy product, is obtained through an anaerobic fermentation of lactose in milk by lactic acid bacteria (*Streptococcus thermophilus and Lactobacillus delbrueckii)* most of these being probiotic (Priya & Ramaswamy, 2016). It is nutritionally rich in protein, carbohydrates, milk fat, potassium, magnesium, vitamin B2, B6 and vitamin B12. (Ndife~~Ndife~~ et al., 2014). This beverage is made by introducing specific bacteria strains in to milk and subsequently ferment it under controlled temperature (42 – 43 ºC) and environment. The bacterial feed on the milk sugars and release lactic acid as by-product. Increase in the acidity of milk causes milk protein to coagulate forming gel like structure (Middle et al., 2016). Yoghurt is widely recognised as a "functional food" due to its high concentration of probiotic bacteria (Priya & Ramaswamy, 2016)(Kola, 2020).

In recent years there have been increased demands for plant-based functional foods that can improve the general health and well-being of humans. Plants contain natural bioactive components that when consumed can boost the immune system and provide health benefits to the host. Milk-like products derivable from plants have grown in popularity and they can provide a cost-effective option for low-income countries where animal milk is scarce, or expensive. Plant-based milks are free from cholesterol and lactose, thus providing additional beneficial to people who suffer from lactose intolerance, high cholesterol intake, cardiovascular dysfunctions, among others(Kosterina et al., 2020)(Konuşkan, 2021); (Montemurro et al., 2021)

The overall consumers' awareness about the effects of their food choices on environment and health, and the growing trend of vegetarians, in addition to the limited use of dairy products in some areas, are leading to higher demand for plant-based products (Konuşkan,

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2021)Subsequently, it has been discovered that yoghurt produced using coconut milk-like extract provides a delightful and a nutritional rich product that can satisfy the needs of consumers today. It is classified as a "functional food" because it provides many health benefits beyond its nutritional content, due to its fibre content and antioxidant properties (Sanful, 2009). Yoghurt produced from coconut has both probiotics (lactic acid bacteria) and prebiotics (fibre) function and give additional nutritional benefits to help in the overall health and wellbeing of the consumer (Belewu et al, 2010)

Coconut milk is a white milky liquid extracted from the meat or kernels of the coconut fruit. It can also be considered as oil-in-water emulsion obtained by squeezing the freshly shredded meat mix with water. Coconut (*Cocosnucifera*) milk is being used by confectionaries, bakeries, biscuits and ice cream industries worldwide, to enhance flavour and taste of various products (Sanful, 2009). Coconut milk contains a complex blend of nutritional constituents like carbohydrates, vitamins, fat, protein, minerals and antioxidants.(Belewu et al., 2015), (Krupa et al., 2011)

Coconut milk contains a complex blend of nutritional constituents like carbohydrates, vitamins, fat, protein, minerals and antioxidants. (Belewu et al., 2015);(Krupa et al., 2011). It is particularly rich in medium chain fatty acids like lauric acid, which are efficiently converted into energy rather than being stored as fat in the body. Lauric acid has various beneficial properties, being anti-fungal, antiviral, and antimicrobial. This is important for heart health. (Victor, 2013),(Bibek Adhikaria, 2018).

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Date is the fruit of date palm considered an ideal food capable of providing a wide range of essential nutrients with many potential health benefits. It is consumed as fresh or in a dried form. Dates fruit are often used as sweetener in coffee, milk or yoghurt. In the processed form, they are consumed as paste, syrup, pickles, jams, jellies, and are used in many bakery or confectionary products together with chocolate, coconut, honey, vinegar, and others (Ali et al., 2018). Dates are rich in sugar (glucose, fructose, and sucrose), protein, dietary fiber, minerals, and some vitamins. The sugars in dates are easily digested and metabolized to release energy for various cells activities. Dates have an advantage over many sweet confections due to its' natural sugars which are principally glucose, sucrose and fructose. Date fruits serve as a good source of natural antioxidants and could potentially be considered as a functional food or functional food ingredient.(Ahmed & Al-jasass, 2014a), (Al-Farsi & Lee, 2008). Despite the continued demand for dairy products due to the natural benefits milk offers, non-dairy foods containing probiotic bacteria strains can be an alternative stream of functional foods that can satisfy consumers need.(S. A. Ibrahim, 2020).

In this study, quality of yoghurt produced from plant-based milk obtained from coconut and blended with date syrup was evaluated. Thus producing yoghurt from coconut and date blends will increase product functionality and valorisation
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Materials and Methods

Sourcing of material and preparation

Mature coconut fruits and dry dates were gotten from Railway Market in Makurdi-Nigeria. After de-shelling to obtain the meat, the brown seed coat on the meat was carefully removed using stainless knife. The pure white meat was washed and blended with water using an

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electric blender. It was then pressed through muslin cloth and strained to obtain the milk. (Bibek Adhikaria, 2018)

Date syrup was prepared using a method as reported by (Najjar et al., 2020). Date fruits where selected, washed followed by the removal of the seed and steeped in warm water (60° C) for 30 minutes. The juice was extracted and filtered using cheese cloth. The juice was then concentrated into syrup through a vacuum evaporator.(…..)

Comment [DV9]: Mention the pH and acidity of date syrup

Cow milk yoghurt which is the control sample was produced following method described by (Corrieu & Béal, 2016)Corrieu & Béal (2016)

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Coconut yoghurt fortified with date syrup was produced following the flow chart below.

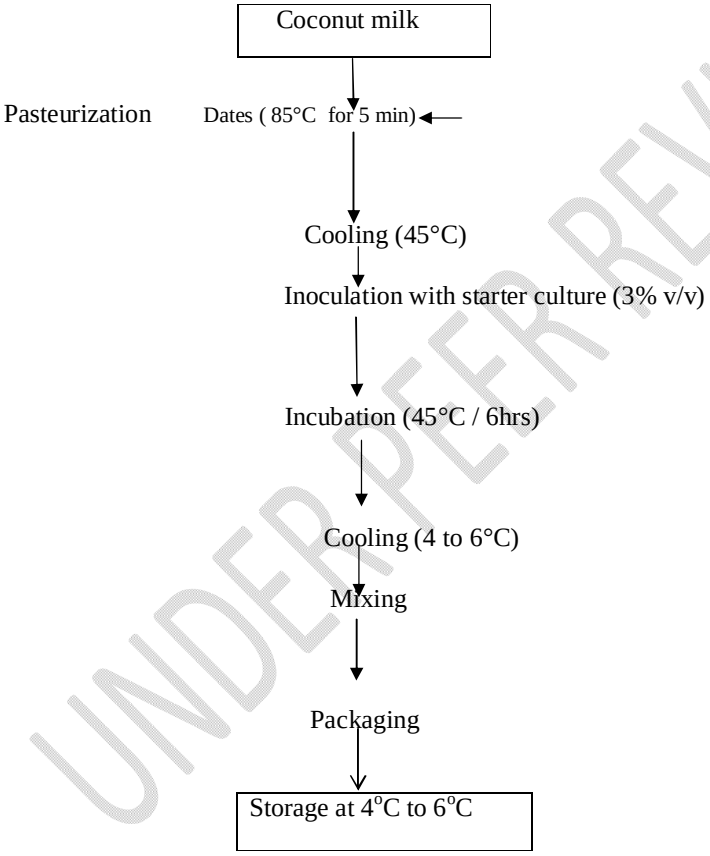

Figure 1: Flow chart for the production of coconut yoghurt

Sample Formulation

Different yoghurt samples were prepared by varying the concentration of dates added to the coconut milk. The experimental designed was made up of 6 samples performed in triplicates.

Table 1:Yoghurtsample formulation (%)

Sample	Cowmilk	Coconutmilk	Date syrup
T0	100	0	0
T1	0	100	0
T2	0	85	15
T3	0	80	20
T4	0	75	25
T5	0	70	30

Physico-chemical analysis of yoghurt

The pH of the yoghurt sample was determined using digital pH meter (Mettler Toledo 320 USA) at room temperature (27 ^{o}C), while the apparent viscosity was obtained at 27 ± 1˚C using a Brookfield digital viscometer (Model DV-II, Spindle-0, Canada). Yoghurt samples were gently stirred 5 times in clockwise direction with a plastic spoon prior to viscosity measurements. The sample was then subjected to a speed of 100 rpm with spindle No.1. (Hymavathi*et al.*, 2020). Viscosity was expressed as Pascal (cp). Titratable acidity was determined using the method described by AOAC (2012).

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Moisture content was determined by deducting the total water evaporated from known yoghurt wet weight (AOAC, 2012), while protein was determined using Macro-Kjeldahl method. The percentage of crude protein was estimated by multiplying the total nitrogen by factor of 6.25. The fat content was determined using Gerber method, fiber and ash were determined according to Association of Official Analytical Chemist method (AOAC, 2012)Carbohydrates was determined by difference by subtracting the sum of moisture, protein, fat, crude fiber and ash from 100.

Microbiological analysis

This was carried out according to the method as described by (Matin et al., (2018),**O. M.** Makanjuola, 2012)

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Sensory evaluation

Sensory evaluation was carried out using 9-point hedonic scale as described by Ranganna (2000). Sensory panellists were semi trained among students from Centre for Food Technology and Research, Benue State University, Makurdi-Nigeria. Sensory evaluation was carried out on the following attributes; colour and appearance, taste, texture, flavour and overall acceptability. An evaluation form was distributed to panel members to be complete after testing the product.

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Storage stability (shelf-life)

This was done by storing yoghurt samples in the refrigerator at < 6 °C for a period of 4 weeks. During this period, TTA and pH analyses were done after every 7 days.

RESULTS AND DISCUSSION

Physico-chemical properties of the yoghurt

Table 2: Physicochemical Properties of Yoghurt Sample at production

Sample	pH	Titratable Acidity (%)	Viscosity/cp	Total solid/ (%)
T0	4.50^{a}±0.05	0.82^{b}±0.01	27.97^{d}±0.05	11.64±0.01
T1	4.48^{a}±0.05	0.83^{b}±0.01	12.00^{e}±0.00	13.89±0.01
T2	4.44^{b}±0.05	0.92^{a}±0.02	28.03^{d}±0.40	16.93±0.00
T3	4.42^{c}±0.10	0.94^{a}±0.01	35.60^{c}±0.69	17.11±0.01
T4	4.41^{c}±0.05	0.94^{a}±0.01	46.40^{b}±1.83	18.25±0.01
T5	4.41^{c}±0.05	0.94^{a}±0.00	72.40^{a}±0.69	18.81±0.00

Key: values are means of triplicate determinations ± S.D Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

T0 = 100 % cow milk control 1
T1 = 100 % coconut milk control 2
T2 = 85 % coconut milk and 15% date syrup
T3 = 80 % coconut milk and 20 % date syrup
T4 = 75 % coconut milk and 25 % date syrup
T5 = 70 % coconut milk and 30 % date syrup

The pH of yoghurt is one of the aspects that affect its quality, physiological activity, and bacteria viability. Additionally, it plays a significant role in determining the shelf-life of the product and ensuring its acceptance at post-fermentation. It is important to keep these factors in mind when producing and storing yoghurt to maintain its quality and safety.

The pH of the produced yoghurt samples as shown in Table 2 ranged from 4.41 (T5) to 4.50 (T0), indicating a slight decrease as the amount of date syrup was been introduced. Sample T0 (plain yoghurt) has the highest pH 4.50 which is within the standard value. The pH of the plant-based yoghurt shows no significant difference. The pH of the plant-based yoghurt shows a slight decrease as compare to the sample T0 (plain yoghurt from cow milk). The pH values of all the samples were within the standard value of 3.7 to 4.5 for yoghurt. These results werein line with the one obtained by(Priya & Ramaswamy, 2016). The reason for the drop in pH during production is because of the breakdown of milk sugars into lactic acid which intends increase the acidity.

The titratable acidity of the yoghurt samples ranged from 0.82 to 0.94% respectively. Coconut yoghurt fortified with date syrup has the highest percentage of acidity while sample T0(cow milk yoghurt) has the lowest value. Total titratable acidity increased significantly from sample T2 as date syrup was added to the plant-based yoghurt. This aligns with the results reported byIbrahim & Salman (2019) and Salman (2014). An increase in acidity could be due to the rise in total solid sugar content in dates having a high proportion of reduced sugar such as glucose and fructose, which in turn increased the activity of the starter converting it into acid[23]. However, the titratable acidity was within the Nigerian standard

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limit for yoghurt 1.5 max. Total titratable acidity (TTA) is the concentration of acid within a food system

Total solid is the indication of the dry matter content of a food sample (Belewu, et al., 2010). Table .2 presents the total solid content of various yoghurt samplesare as follows; 11.64, 13.89, 16.93, 17.11, 18.25 and 18.81 for T0, T1, T3, T4, T4 and T5, respectively. The total solids increased significantly ($P<0.05$) as ratio of date syrup was added to the plant-based yoghurt. This is because date syrup has72.4 to 74.3 total solid content which may indirectly influence a rise in the total solid content of the yoghurt. Sample T0 (plain cow milk) has the lowest total solid which shows that coconut milk is higher in total solids than dairy milk. This result are in harmony with the result of (Priya & Ramaswamy, 2016)

Viscosity is an important parameter in yoghurt production because of it influences appearance and consumer preference. The viscosity of the yoghurt sample ranged from 12.00 to72.40 cp. It can be observed that viscosity increased significantly from sample T2 to T5 as the proportion of date syrup increased in the plant-based yoghurt. This result agrees with the results of (Shahein et al., 2022)who reported that the viscosity of fermented Camel milk increased with increased proportion of date syrup. It was also observed that the viscosity of sample T0 (100% cow milk) was significantly higher ($p<0.05$) than sample T1 (100% coconut milk). This may be due to the high protein content in sample T0 resulting in increased gel firmness and viscosity.

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3.3 Proximate Composition of the Coconut Yoghurt Samples

Table 3: Proximate Composition of Coconut Yoghurt Samples (g/100g)

Samples	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate
T0	$88.36^{a}\pm0.54$	$0.61^{d}\pm0.01$	$3.20^{f}\pm0.10$	$3.72^{a}\pm0.02$	$0.00^{f}\pm0.00$	$4.11^{f}\pm0.34$
T1	$86.11^{ab}\pm2.66$	$0.66^{d}\pm0.02$	$4.84^{a}\pm0.04$	$2.83^{d}\pm0.03$	$0.34^{e}\pm0.02$	$5.22^{e}\pm0.02$
T2	$83.09^{bc}\pm2.03$	$0.76^{c}\pm0.02$	$4.79^{ab}\pm0.01$	$2.83^{d}\pm0.02$	$0.44^{d}\pm0.01$	$8.09^{d}\pm0.04$
T3	$82.89^{bc}\pm2.03$	$0.93^{b}\pm0.06$	$4.73^{bc}\pm0.02$	$2.87^{c}\pm0.02$	$0.47^{c}\pm0.01$	$8.11^{c}\pm0.01$
T4	$81.75^{c}\pm0.37$	$0.97^{b}\pm0.03$	$4.37^{d}\pm0.02$	$2.93^{b}\pm0.03$	$0.55^{b}\pm0.02$	$9.43^{b}\pm0.00$
T5	$81.19^{c}\pm1.14$	$1.14^{a}\pm0.02$	$4.10^{e}\pm0.05$	$2.96^{b}\pm0.02$	$0.66^{a}\pm0.01$	$10.00^{a}\pm0.02$

Key: values are means of triplicate determinations ± S.D Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

The proximate compositions of the samples are presented in Table 3. The results reveal that the control sample T0 had the highest moisture content (88.36%) which corresponds to the result (87.85%) as obtained by Ibrahim & Salman (2019).. High moisture content in milk implies high susceptibility to microbial growth and consequently leads a reduction in the shelf-life of the product if not properly stored. It was also observed that there was a decrease in the level of moisture as the proportion of date syrup to coconut milk increased. A significant decrease in the moisture content was observed from T2 to T5 compared to the control sample (T0). This decrease in moisture content may be due to the addition of date syrup increasing the total soluble solids of the product. This result is in line with the one obtained by Ibrahim & Salman (2019) and Salman (2014) where different concentrations of date syrup were added to cow milk yoghurt.(Ndife, 2014) also obtained similar results on

functional yoghurt enriched with coconut. The percentages of the moisture content fall within the range of commercial yoghurt (80 – 86%). This implies that coconut yoghurt fortified with date syrup can be used to replace dairy yoghurt in yoghurt production.

The ash content of the yoghurt samples as illustrated in table 3 showed no significant difference between the control sample (T0) and coconut milk yoghurt (T1). Coconut milk is rich in mineral as well as cow milk. The result agrees with that of (Syazwani et al., 2020)for similar yoghurt product . The ash content increased significantly ($p<0.05$) as the proportion of dates increased in coconut yoghurt. This might be because of high content of mineral in dates as described by (Ahmed & Al-jasass, 2014b)(Ahmed & Al-jasass, 2014a). Therefore, coconut yoghurt fortified with date syrup can replace cow milk yoghurt in plant-based yoghurt formulation. Ash content is an important parameter in yoghurt as gives an indication of the mineral content of the product.Mineral are necessary for the maintenance of electrolyte balance and the formation of bones and teeth in children.

The fat content of the coconut yoghurt T1 ($4.84^{a}\pm0.04$) as seen in table 3 was significantly higher than that of the cow milk yoghurt (**$3.20^{f}\pm0.10$**). Coconut milk contains high fat than cow milk as reported by (Dawane, 2010) and (Priya & Ramaswamy, 2016). Coconut milk contains predominantly medium chain fatty acid which are highly absorbed in the intestine and easily utilized by the body. One of the saturated fat, Lauric acid, is also supportive in enhancing the immune system and keeping the elasticity of the blood vessels (Victor, 2013, Belewu, et al., 2010). It could also be noted that the substitution of date syrup into coconut yoghurt resulted in a decreased significantly ($P<0.05$) in fat content, and the decrease was proportional to the dates syrup ratio. This is because date syrup contains low fat content and as is been substituted to coconut milk a significant decrease is recorded. This result were in harmony with the one obtained by (D. Ibrahim & Salman, 2019).

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The protein content in the control yoghurt samples was found to be significantly ($P< 0.05$) higher than that of sample T1(coconut milk). This is because dairy milk content more protein than coconut milk (Montemurro et al., 2021). However there was an increased in protein content of samples substituted with date syrup concentrations. This result are in agreement with the result obtained by(Belewu et al., 2015)who also noticed an increased in the protein content of date-coconut drink. The results were different from that of(Matela et al., 2019) and (D. Ibrahim & Salman, 2019) who reported that there was a significant decreased in protein content as date syrup was added to dairy yoghurt. This might be due to the differences in concentration of date syrup used and variation in product formulation

The fiber content in yoghurt samples ranged from (0.00-0.66). Coconut milk contains high fiber which is an important factor in the digestibility of yoghurt. The fiber content in T0 was negligible. This means people who depend on dairy yoghurt may be deficient in fiber. Fibre content improves textural properties and structure of food, reduces lipid retention and reduces caloric content by acting as a bulking agent. Also, it could be observed that the fiber content increased as the proportion of date syrup increased in coconut yoghurt. This is might be because date is rich in dietary fiber (5-11%) as reported by (Ghnimi et al., 2017). This result also agrees with the result obtained by(Belewu et al., 2015)

There was a significant increase ($p<0.05$) in the percentage of carbohydrates ranging from $4.11^{f}\pm0.3$ to $10.03^{a}\pm0.01$ %. This was notable with the corresponding addition of date syrup as compared to the control sample T0. This is due to the high content of carbohydrate in date syrup(Ahmed & Al-jasass, 2014a). Dates fruits are rich source of carbohydrate such glucose,

sucrose and fructose Other similar work carried by (D. Ibrahim & Salman, 2019),(Belewu et al., 2015) also show increment in carbohydrate level. Carbohydrate is necessary for the production of energy in the body.

3.3 Microbial properties of the coconut yoghurt samples

Table 4: Microbial Analysis of Yoghurt Samples

Sample	Total bacterial/ counts (log_{10}cfu/mL)	Yeast &Mould /(cfu/ml)	Coliform /(cfu/mL)
T0	7.15^{c}±1.18	NIL	ND
T1	6.95^{c}±1.23	NIL	ND
T2	7.30bc±0.57	NIL	ND
T3	7.50^{b}±1.28	NIL	ND
T4	7.95^{ab}±0.75	NIL	ND
T5	8.20^{a}±0.61	NIL	ND

Values are means of triplicate determinations ± S.D Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

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Table 4 shows the results of microbial analysis of yogurt samples. The total bacterial count ranged from 6.95 to 8.20 with significant difference between the samples. Yeast and mould were not detected, and no coliform found in any of the yoghurt sample.

The investigation of total bacterial count is an important parameter for the assessment of microbiological quality of a sample. The results show a significant increase ($p<0.05$) between samples with sample T1 having the least value and T5 recording the highest value. The increase in total plate count in T0 is as a result of the production of lactic acid by starter cultures during fermentation. The result also indicated that the substitution of date syrup in coconut milk significantly increase the total plate count of bacteria in the samples. This is because date contains simple sugars (glucose and fructose) which simulate the growth and activity of bacterial. The result is in line with the report of (Shahein et al., 2022) who found out that the adding of date syrup to fermented camel milk increased the total bacterial count.

Yeasts and moulds are undesirable microorganisms that cause food spoilage and are also pathogenic to man after consuming a certain quantity. In this study yeasts and moulds were not found. This may be due to the heat treatment given to the yoghurt during production which inhibits their growth. The antimicrobial properties produced by some bacterial in the yoghurt (bifidobacteria) also inhibits the growth of yeast and moulds (Tawab, 2012).

Coliforms bacteria are organisms present in the environment and in the faeces of animals and humans. Their presence in food or water indicates that the food or water is contaminated with pathogens. However, no coliform was detected in all the samples. This implies that the products were prepared under high hygienic conditions.

3.4 Sensory attributes of the coconout Yoghurt samples

Table 5: Sensory Attributes of Coconut Yoghurt Fortified with Date Syrup

samples	Appearance	Aroma	Taste	Consistency	Acceptability
T0	8.40^{b}±0.68	7.60^{b}±0.68	6.95^{c}±1.23	7.80^{ab}±0.41	7.60^{bc}±0.50
T1	8.95^{a}±0.22	8.40^{a}±0.75	7.50^{bc}±1.27	6.70^{c}±1.62	7.80^{abc}±1.00
T2	8.00^{bc}±1.15	7.85^{ab}±1.34	7.30^{bc}±0.57	7.15^{bc}±0.93	7.50^{bc}±1.39
T3	7.45^{d}±0.60	7.35^{b}±0..87	7.15^{c}±1.18	7.40^{ab}±0.68	7.40^{c}±0.75
T4	7.65^{cd}±0.48	7.35^{b}±0.87	8.20^{a}±0.61	7.45^{ab}±0.68	8.30^{a}±0.47
T5	7.57^{cd}±0.67	7.50^{b}±0.51	7.95^{ab}±0.75	8.00^{a}±1.29	8.15^{ab}±0.74

Key: values are means of triplicate determinations ± S.D Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

The sensory attribute results of various yoghurt samples are presented in Table 5. The sensory evaluation was carried out using 9 point hedonic scale (9 = extremely like and 1 dislike extremely). Sample T1 scored the highest in terms of appearance 8.95^{a}±0.22, while sample T3 scored the least 7.45^{d}±0.60. For aroma sample T1 has the highest score (8.40^{a}±0.75) and was significantly different from other samples. The score for the taste of the yoghurt samples ranged from 8.20^{a}±0.61 (T4) to 6.95^{c}±1.23 (T3). For consistency, sample T1 recorded the lowest value 6.70^{c}±1.62 while sample T2 recorded the highest 8.00^{a}±1.29. All yoghurt samples were generally accepted by the panellist with T5 and T4 having the highest scores.

Appearance is the look and colour of the sample of any product. Sample T1 has the best appearance while sample T3 has the least in appearance. The result of the sensory score for appearance shows that all the samples were generally accepted by the panellists. There was a significant different ($p<0.05$) between sample T1 and the other samples. The colour preference might be influence by the pure white colour of the coconut milk. From sample T2 the colour of the yoghurt changed from white to brown as date syrup was added, reflecting the brownish colour of date syrup. However this result agrees the one reported by (Amerinasab et al., 2015) where date liquid was used in dairy yoghurt.

As concern aroma all the samples were generally accepted by panellists but with preference for sample T1 (100% coconut yoghurt) which was significantly different from other samples. This is because coconut has a natural flavour which enhances the aroma and the taste of the yoghurt. This agrees with the result obtained by(Ndife, 2014) who reported that enriching functional yoghurt with coconut increase the aroma and the taste of the yoghurt. (Sanful, 2009) also reported that flavour and aroma scored higher rating for increased coconut-milk input in the production of yoghurt. There was significant difference between sample T0 and the other samples.

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In terms of taste sample T4 (75% coconut and 25% date syrup) and T5 (70% coconut and 30% date syrup) were the most preferred samples, and were significantly different from other samples. This results agreed with the report of (Amerinasab et al., 2015). This is because increased in the percentage of date syrup increased the sweetness of the yoghurt. There was no significant different among the other samples yet the samples still scored within the acceptable limit.

For overall acceptance, sample T4 (75% coconut and 25% date syrup) and T5 (70% coconut and 30% date syrup) were the most acceptable samples. Their preference can be attributed to the sweetness of the yoghurt sample was because of the increase percentage of date syrup. All the other samples scores show no significant difference and were within the acceptable limit (7, like moderately). This study shows that coconutyoghurt fortified by date syrup do not differ organoleptically from those produced from pure coconut milk and cow milk.

3.5 Storage studies on coconut yoghurt samples

The storage stability of the yoghurt samples was studied using pH, total titratable acidity, and viscosity of the samples stored for a period of 4 weeks (Figure 2).
For week 0, the pH of various yoghurt samples ranged from 4.49 to 4.50, T1 has the lowest value with T2 having the highest value. There was no significant difference within the samples. For week 1, pH values ranged from 4.30 to 4.46. Week 2 shows the same trend with values ranging from 4.46 to 4.30. At week 3, there was a noticeable decrease in pH value; from 3.96 to 4.30 with T0 significantly decreasing than other samples. For week 4 values ranged from 3.33 to 4.30 with significant different between samples. During storage it was observed that the pH values of samples fortified with date syrup decrease from week 0 to week 4. This agrees with the results of (D. Ibrahim & Salman, 2019). They reported that the use of starter culture *Streptococcus* and *Lactobacillus* microorganism in yoghurt is responsible for the increased of acidity during storage. It can also be noted that at week 4, the pH values were still within standard values (3.7 - 4.5) except sample T0 with the pH of 3.33. This shows that sample T1 to T5 were still good under the storage period of 4 weeks under the stated conditions. This may be attributable to the antimicrobial properties of date and coconut that turn to limit the activity of lactic acid bacteria hindering the process of continuous fermentation of yoghurt.

The results of total titratable acidity (TTA) of yoghurt sample during four weeks of storage are presented in Figure 3. Generally, it was observed that the total titratable acidity of the yoghurt sample increased significantly ($p < 0.05$) from week 0 to week 4 with sample T1 recording the lowest value (0.49) and sample T0 the highest value (1.52). It was also noted that the total titratable acidity increased with increased percentage of date syrup from T2 to T5. This is due to increase in glucose and fructose in the yoghurt sample fortified with date syrup which intern increased the activity of starter culture which is responsible for acid production. This result agrees with the report of (D. Ibrahim & Salman, 2019) Comparing the result with Nigerian yoghurt standard which stipulated that the maximum acidity of yoghurt is 1.5max, all the values were still within ranged except sample T0(100% cow milk). This may be becauseof the antimicrobial properties found in coconut and date fruit that inhibit the growth of microbes(Debmandal & Mandal, 2011),(Ali et al., 2018)

The apparent viscosity of yoghurt sample during 4 weeks of storage is presented in figure 4. For week 0 the viscosity of the samples ranged from12.00 to 72.40 cp with significant difference between samples. For week 1 viscosity ranged from 24.00 to 104.66cp with sample T1 having the lowest value and sample T5 having the highest value. Week 2 follow the same train with values varying from 36.00 to 106.00cp respectively. For week 3 the viscosity value varies from 40.00 to 144.66 cp. At week 4 there was a significant increase in viscosity from 72.40 to 192.00 with T5 recording the highest value and T1 the lowest value.

Comment [DV20]: Check the sentence

Generally, there was a significant increase ($p<0.05$) in viscosity from week 0 to week 4 during storage. It could be observed that the viscosity of samples with the addition of date syrup (T2, T3, T4, T5) increase significantly with the corresponding percentage of date syrup being added to it (15, 20, 25, 30%). This is because of the increase in total solid and low moisture content which further increased the consistency of the product. The increased in viscosity also improved the thickness of the yoghurt which is one of the sensory quality consumers looked for in yoghurt. Also, coconut and date contain fiber which improved viscosity by binding to water molecules. This result is in agreement with the reports of (Shahein et al., 2022)and (D. Ibrahim & Salman, 2019)who also recorded an increased in viscosity during storage of yoghurt fortified with date fruits.

Comment [DV21]: Rewrite

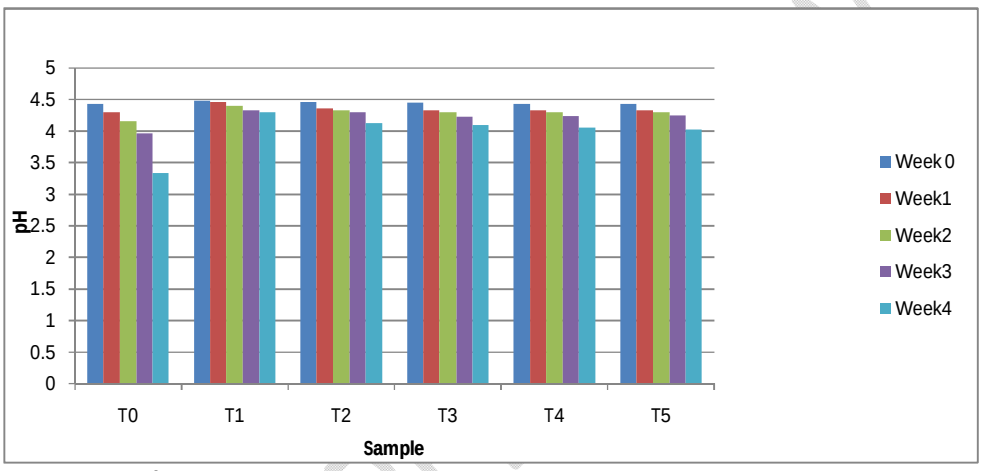

Figure 2: pH of yoghurt sample during storage

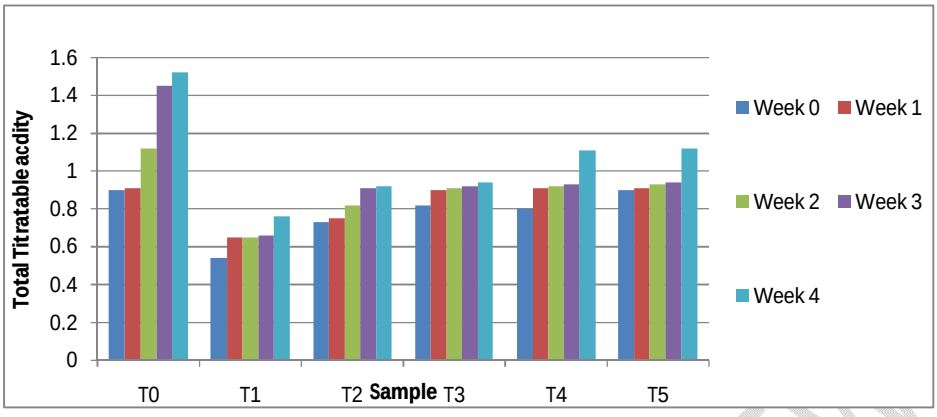

Figure 3; Titratable acidity of yoghurt sample during storage

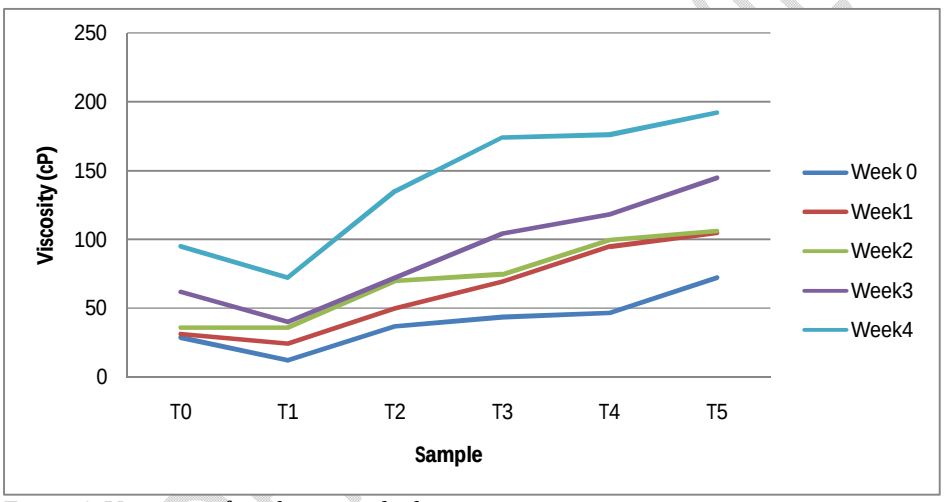

Figure 4; Viscosity of yoghurt sample during storage

IV. CONCLUSION

In this work, yoghurt was formulated from plant-based milk, coconut milk, and fortified with date syrup. The results obtained show that coconut milk and date syrup blends can replace dairy milk in the production of yoghurt product, as the products have comparable attributes with yoghurt from animal milk. Producing plant-based dairy alternative yoghurt from coconut and date syrup blend has shown anincrease in nutritional properties, thus served as a functional food to consumers. It also has a good storage stability which shelf-life can be sustainable.

Generally the sensory quality of the product was acceptable, samples containing 25% and 30 % date syrup haveimproved organoleptic and chemical characteristic of the yoghurt. From our findings, it can therefore be said that fermentation of coconut milk and date syrup with LAB starters for the production of coconut yoghurt can be encouraged as the coconut yoghurt has better nutritive and sensory properties, and improved shelf-life. We, therefore, suggest

that T4 and T5 can be adopted as the best formulation in an option to replace dairy milk yoghurt for vegetarians, lactose intolerance people, milk allergic, and people suffering from high level of cholesterol and hypertensive patients. Also the use of natural sugar and flavourants from date and coconut should be encouraged in yoghurt producing industry.

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