Comparative Studies on the Production and Evaluation of Yoghurt Enriched with Different fruits

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Abstract: - This study investigates the quality and physicochemical composition of yoghurt produced and fortified with different fruit puree using standard methods. Sample B (yoghurt fortified with carrot) had the highest protein and fat content (6.39±0.00a, 9.38±0.00a) and higher than other samples. The Ash and carbohydrate content of sample A (yoghurt fortified with apple) had the values of (0.25±0.02a and 13.55±0.05a) respectively. The moisture content of yoghurt fortified with banana (sample E) had the highest value (82.52±0.05a). The result of the physicochemical revealed that Sample B (yoghurt fortified with carrot) has the lowest pH value (2.50). TTA result showed that sample D (yoghurt fortified with grape) had the highest TTA (1.40%) when compared with the control (sample C) (0.60%). There were significant difference in the result of total Dissolved solid TDS with sample E (yoghurt fortified with banana) having the highest TDS value. Enriched yoghurt showed increase in the vitamin C content (5.78, 6.52, 7.82, 8.12 mg/100g) than in the control (5.58 mg/100g). Mineral composition result for Ca, Na, K, Mg, Zn, Mn, Fe, Cu, Se, and P were significantly different from each other. A significant increase was observed in the Na content of sample B (104.30 mg/100g) when compared with the control sample C (85.50 mg/100g). Total viable count which ranged from 3.20 × 105 cfu/mL to 5.40 × 102 cfu/mL was higher in the enriched yoghurt when compared with the control (3.20 × 105 cfu/mL). Conclusively, enrichment of yoghurt with different fruit puree improved its nutritional qualities.

Key-Words: - Yoghurt, Fruits, Nutritional content, Physicochemical

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1 Introduction

Yoghurt is acidified, custard like semisolid dairy product produced by fermenting pasteurized milk with starter culture containing lactic acid producing bacteria (Munzur et al., 2004). Yoghurt is nutritionally balanced containing almost all the nutrients present in milk in a more assimilable form. It is obtained by lactic acid fermentation of milk through the action of a starter culture containing Streptococcus thermophilus and Lactobacillus bulgaricus. Yoghurt is believed to promote good gum health and facilitate the absorption of calcium, thus preventing osteoporosis, possibly because of the probiotic effect of lactic acid bacteria present in it (Ezeonu et al., 2016). Because of its probiotic characteristics (Lourens-Hattingh and Viljoen, 2001), yoghurt boosts the immune system and provides resistance to infections in addition to regulating intestinal flora (Hove et al., 1999; Plessas et al., 2012). Human consumption of yoghurt has been associated with tremendous health benefits due to the improvement of gastrointestinal functions and disease risk reduction following its daily consumption (Hadjimbei et al., 2022). Yoghurt is also very effective in curing diarrhea, dysentery, constipation, lowing blood cholesterol and carcinogenesis (Kamruzzaman et al., 2002).

In recent years, various additives such as fruits, vegetables, coffee, oats, almonds e.t.c has been added to yoghurt in order to improve its flavour and enhance consumption. Fruits (apple, grapes, banana, and carrots e. t. c) and vegetables are rich sources of vitamins, minerals, fibres and can be used as value-added yoghurt. Pectin and fructose of fruits improve consistency and viscosity of yoghurt by getting mixed with it, and the mouth-feel is improved (Nongonierma et al., 2007; Tromp et al., 2004). Addition of fruits to yoghurt will not only improve its nutrient content but also reduce post-harvest loss. With increasing consumer awareness of healthy eating, expectations have gone beyond simply meeting basic nutritional needs. Food preferences and consumer demand are primarily based on sensory characteristics such as taste, texture, and flavour (Lesme et al., 2020). In particular, adding natural functional ingredients such as fruit and fruit seeds has attracted increasing interest due to their contribution to the nutritional value and increased yoghurt consumption (Pramanik et al., 2025). The sensory qualities of yoghurt can change due to the addition of fruit (Najgebauer-Lejko, 2014). Since ingredients added to yoghurt during production can affect the yoghurt microflora, they may also have a positive or negative effect on the quality of the yoghurt. Hence the aim of this research is to evaluate the nutritional and physicochemical properties of yoghurt produced and enriched with different fruit puree.

1.1 Materials and Methods

Evaporated milk, fruits (banana, apple, carrot and grape), starter culture were purchased from supermarket and reagents were obtained in the Microbiology laboratory of the Federal Polytechnic of Ado Ekiti.

2 Preparation of fruit pulps

Fruits (apple, banana, grapes, and carrots) were washed, peeled, cut into pieces and seeds were removed. The fruit pieces were blended by mixer for 5 minutes to obtain fine puree, heated at 85°C for 3 min, cooled to 5±1°C, and the puree were divided into five portions and kept in sterilized plastic containers at 5°C until used.

2.1 Sample Preparation

The sample of yoghurts were produced according to International standard of yoghurt as described by Guler and Mutlu (2005). 500g of skimmed powdered milk was reconstituted with water and heated to 80^0C for 15mins for pasteurization and then allowed to cool to 42-43^0C before inoculation with starter culture (Roy, et al., 2015). During heating, milk was stirred continuously with the help of a stirrer to avoid formation of cream layer. The milk mixture was divided into five portions. 10ml of the already prepared portions of fruit puree: apple (Sample A), carrot (sample B), plain yoghurt (sample C) which served as control, grape (sample D), and banana (sample E) were added to the warm milk separately. They were incubated at 37^0C for 10-12 hours (overnight) until a pH of about 4.3-4.5 is attained (Roy, et al., 2015). Sugar was added after inoculation. The yoghurt samples were kept in a refrigerator at 4^0C until used for analysis.

2.2 Proximate Analysis

The moisture, ash and crude protein content of the yoghurt samples were determined according to AOAC (2022). The fat content was determined on wet weight basis by soxhlet's method as described by Suzanne, 2003. Carbohydrate content of the sample was determined as the nitrogen free extraction calculated as the formula below:

% Carbohydrate = 100% - % (protein + fat + fibre + ash + moisture)

Also the analysis of ascorbic acid (Vitamin C) in the prepared yogurts was performed using the tirimetric method based on 2,4 dichlorophenol indolphenol (Mbaeyi-Nwaoha and Iwezor-Godwin, 2015).

2.3 Microbial Culture

The different batches of yoghurt were inoculated on growth media (Nutrient agar) and incubated aerobically at 37^0C for 18-24 hours, so as to determine the growth of bacteria according to the method of Olutiola et al. (2000). Microbial colonies were observed morphologically and counted using standard methods. The growth in the different plates were counted and recorded and compared between groups.

3 Physicochemical Analysis

3.1 Determination of Total Titratable Acidity (TTA)

This was determined by the method described by AOAC (2022). The sample was dissolved in distilled water and mixed thoroughly. 1ml of phenolphthalein indicator was introduced into 10ml of the mixed solution. It was titrated against standard sodium hydroxide solution until pink colour persisted for about 10-15 seconds for compete neutralization. The end point was taken and the TTA expressed as % lactic acid was calculated using the relationship:

% TTA as lactic acid = (n (NaOH) × N (NaOH) × 0.09 / Volume of sample) X (100 / 1)

Where;
n = volume of titre
N= number of moles

3.2 Determination of Total Dissolved Solids

The total dissolved was measured by a refractometer following the method from the Nigerian Industrial standard (2004). A small amount (1-2 drops) of the sample was put into the refractometer's prism, which was previously calibrated with distilled water. The prism end of the refractometer was pointed toward a light source, and the eyepiece was focused until the scale was visible. Then the scale in °Brix was read as the total amount of dissolved solids. The refractometer was rinsed with distilled water after each sample change

3.3 Determination of pH

pH was determined using a pH meter which was previously standardized with buffer solutions of pH 4 and pH 9 by dipping the electrode into the samples and then the pH was read.

Results and Discussion

Table 1. Proximate composition of yoghurt enriched with fruits (%)

Samples	Protein	Fat	Moisture	Ash	Fibre	Carbohydrate
A	5.23 ± 0.01^{c}	7.85 ± 0.01^{b}	72.65 ± 0.02^{c}	0.25 ± 0.02^{a}	0.38 ± 0.01^{b}	13.55 ± 0.05^{a}
B	6.39 ± 0.00^{a}	9.38 ± 0.00^{a}	76.13 ± 0.01^{b}	0.19 ± 0.01^{b}	0.41 ± 0.01^{a}	7.52 ± 0.01^{d}
C	3.17 ± 0.01^{c}	6.89 ± 0.02^{c}	80.22 ± 0.02^{a}	0.15 ± 0.00^{c}	0.21 ± 0.01^{c}	9.31 ± 0.00^{c}
D	5.84 ± 0.01^{b}	7.61 ± 0.01^{b}	73.68 ± 0.02^{c}	0.24 ± 0.02^{a}	0.43 ± 0.00^{a}	12.23 ± 0.02^{b}
E	3.48 ± 0.01^{c}	7.12 ± 0.01^{bc}	82.52 ± 0.05^{a}	0.20 ± 0.01^{b}	0.26 ± 0.01^{b}	6.38 ± 0.02^{d}

Keys:
Sample A: Yoghurt fortified with apple
Sample B: Yoghurt fortified with carrot
Sample C: Plain yoghurt
Sample D: Yoghurt fortified with grape
Sample E: Yoghurt fortified with banana

Table 2. Mineral composition of yoghurt enriched with different fruits (mg/100g)

Samples	Ca	Na	K	Zn	Mg	Mn	Fe	Cu	Se	P
A	103.40	92.40	76.50	0.37	9.23	0.02	0.17	0.18	0.02	20.62
B	181.30	104.30	82.50	0.25	7.85	0.15	0.74	0.32	0.06	35.72
C	106.00	85.50	54.00	0.63	5.94	0.30	0.54	0.15	0.01	16.59
D	122.70	86.20	84.70	0.82	8.96	0.50	0.62	0.23	0.05	29.77
E	115.20	90.50	62.30	0.64	6.12	0.27	0.52	0.52	0.04	14.23

Table 3. Total viable count of plain yoghurt and yoghurt enriched with different fruit puree

Samples	**TVC (cfu/mL)**
A	5.40×10^{2}
B	4.30×10^{3}
C	3.20×10^{5}
D	4.80×10^{4}
E	5.20×10^{3}

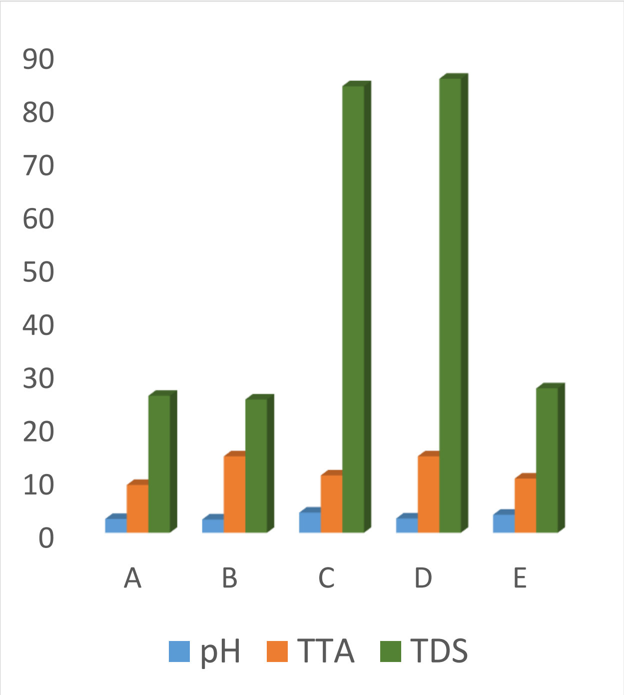

Fig. 1: Physicochemical properties of yoghurt fortified with fruits puree

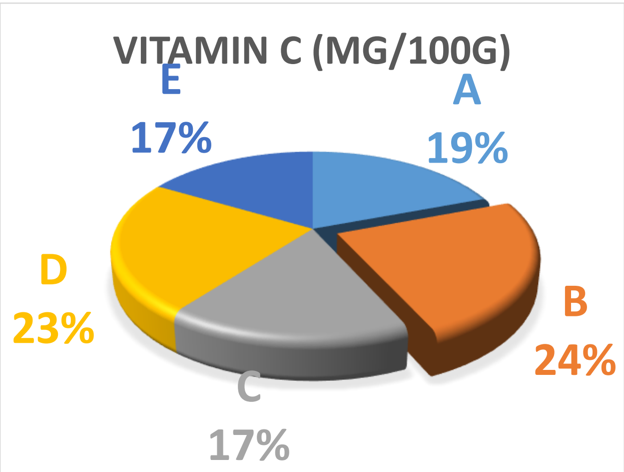

Fig. 2: Vitamin C composition of yoghurt enriched with fruits puree (mg/100g)

4 Discussion

The research was conducted to develop fortified fruit yoghurt with acceptable nutritional, physicochemical and microbiological quality. Four different fruits types (Apple, carrot, grape and banana) were used in this study to fortify yoghurt.

The result of proximate composition of yoghurt fortified with different fruit puree is presented in Table 1. Moisture content is very important in the determination of durability, storage conditions, safety and shelf life of the food. This is because microbial growth in food is enhanced by the amount of moisture present in them. The addition of fruit puree increased the moisture content of the yoghurt from 72.65±0.02[c] - 82.52±0.05[a]. The results of moisture content in the samples were similar to those reported by Osman (2004) who indicated a range of 78.62 to 82.41%. In principle, the texture of the yoghurt is influenced by the moisture content, moreover, the firmness of the yoghurt increases if the moisture content is low (Amal et al., 2016). There was no difference in the protein content of the yoghurt after the addition of the fruits puree. Protein is known to enhance the formation of antibodies which helps the body fight infections and also, it helps to build, maintain and repair new tissues especially in infants (Ajanaku et al., 2017).The ash and fibre content were remarkably higher than the control which is the plain yoghurt. The crude fat content of the yoghurt sample enriched with fruit puree ranged from 6.89±0.02[c]-9.38±0.00[a]. The highest fat content was observed in sample B (yoghurt fortified with carrot) (9.38±0.00[a]) while the highest ash content was observed in sample A (yoghurt fortified with apple) (0.25±0.02[a]) as compared with the control (6.89±0.02[c], 0.15±0.00[c]) respectively. This agrees with the report of cheeseman and Lean (2000) that generally, yoghurt has poor fibre level because they are milk and water based product. Yoghurts generally are known to have a low percentage of carbohydrate and this is due to the conversion of carbohydrates (lactose) to lactic acid during fermentation. This particular property of yoghurt makes it an ideal dairy product for patients who cannot tolerate lactose (Ehirim and Ndimantang, 2004).

The mineral analysis of the samples as presented in Table 2 revealed that the yoghurts fortified with different fruit puree increased favorably when compared with the plain yoghurt. Although yoghurt is a very good source of essential minerals needed for human metabolism and functionality of cells. However, the addition of fruits increases the essential minerals thereby improving the health of the consumers.

Table 3. shows the total viable count of fortified yoghurt enriched with different fruit puree. The total viable count ranged from 3.20 × 105 cfu/mL to 5.40 × 102 cfu/mL. Microorganisms used as starter culture may have contributed to the total viable count of the yoghurt samples. Also, the source of the fruits used as for fortification may have contributed to the total bacteria count which is above the control (Ihemeje et al., 2015). Very high count however is used as an indication of post-pasteurization contamination (Tamine and Robinson, 2004). The plain yoghurt, sample C (control) had lower viable count (3.20 × 105) than enriched yoghurts. Ogunlade et al., 2019 in

a study suggested that the source of raw ingredients and its handling could be the main factors responsible for the high microbial loads which might affect the quality of the product

Figure 1 shows the results of physicochemical analysis of the fortified yoghurt. The Titratable acidity (TTA) content indicating the extent of lactic acid fermentation, ranged from 0.09 to 0.11%. These values reflect the acid content, which is essential for the preservation and tangy flavour of yoghurt. The TTA values observed are in line with those required for a balanced flavour and good shelf-life (Tamime & Robinson, 2007). Titratable acidity is the total amount of acid in a sample determined by titration using a standard solution in NaOH. This parameter also determines the freshness of the yoghurt which is a function of the absorption of hydroxyl ions by the protein or salts in the yoghurt. The titratable acidity increases with bacterial acidification and the release of fatty acid, which is due to the breakdown of fats and other lipids by hydrolysis. This result shows that the titratable acidity increased with the addition of fruit puree due to the multiplication of lactic bacteria present in it. The product with the highest acidity was the yoghurt fortified with carrot, followed by grape, then banana and the least was apple as compared with the plain yoghurt which was the control. Organic acids produced during fermentation are what gives the yogurt its sour flavour. As metabolites, Setiarto and Widhyastuti (2017) demonstrated that lactic acid bacteria produce organic acid components such as lactic acid, acetaldehyde, propionic acid, butyric acid, and volatile compounds. The initial pH of the plain yoghurt was 3.80. According to Roy et al. (2015), lactic acid bacteria have the ability to ferment the sugar (lactose) in milk into lactic acid. The pH values of all the yoghurts fortified with fruit puree were lower than that of control. Addition of fruit puree decreased significantly the pH values of yoghurt as result of low pH of fruits. Tanwar et al. (2014) and Souza et al. (2018) reported similar results. The lowest pH value was recorded in sample B (yoghurt fortified with carrot). Decrement in the pH values of functional yoghurt is reflected by the high activity of starter culture. This phenomena was due to the growth of lactic acid bacteria and produced lactic acid which was due to the special synergism between Streptococcus sp. and Lactobacillus sp. These results were in agreement with Matter et al. (2016). pH is a crucial factor for dairy products such as yoghurt because it significantly influences consumer acceptance and microbiological quality. This lower pH is beneficial as it inhibits the growth of pathogenic microorganisms, thus ensuring the safety and shelf-life of the yoghurt. The highest total dissolved solids value was found in sample D (yoghurt fortified with grape). Because of the ability to hold water, addition of grape to the yoghurt can raise the total value of dissolved solids. Sugar is hygroscopic, which means it dissolves more easily in water; the more bound water, the higher the total dissolved solids (Meikapasa and Seventilofa, 2016). Total dissolved solids are also frequently used to determine a product's sugar amount. It is possible to calculate the product's total dissolved solids to analyze the total amount of sugar still present after lactic acid bacteria fermentation (Sintasari et al., 2014). Sugar in the form of simple carbohydrates will be transformed into lactic acid throughout the fermentation process by the metabolism of lactic acid bacteria, hence this examination is required to find out how much sugar is still present. The total dissolved solids will decrease as the amount of sugar used to grow lactic acid bacteria decreases during fermentation (Bayu et al., 2017). Based on this, sample D has the highest sweetness level due to the addition of grape to the yoghurt. The ascorbic acid (vitamin C) content of the yoghurts fortified with fruit puree as revealed in figure 2 increased (5.78, 6.52, 7.82, 8.12 mg/100g) when compared with the control (5.58 mg/100g). This is probably due to the high ascorbic acid content of the fruits used for fortification. The flavoured yoghurt samples with carrot contained higher amount of ascorbic acid compared with others. Studies had shown that ascorbate favours iron absorption by reducing the inorganic iron III (ferric) complexes in food to iron II (ferrous), a form in which it is more readily absorbed according to (Onimawo et al., 2003). Similar trend of increased in vitamin content of flavoured yoghurt was recorded by Ihemeje et al., 2015

5 Conclusion

In conclusion, this study shows that fortification of yoghurt with fruit puree at moderate proportions proves to be highly beneficial with improved nutritional values and retained probiotic activities. Although medicinal properties of the fortified yoghurt was not directly tested, it can be inferred based on several antioxidants present in the fruits and the probiotic properties of yoghurt that this yoghurt samples will provide many health benefits which is safe and easily digestible for adults, ill, malnourished children or lactose intolerant persons.

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