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Effect of the incorporation of graded levels of turmeric (*Curcuma longa)* on different qualities of stirred yoghurt

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There is an increasing trend in yoghurt consumption due to the health benefits from the gut bacteria present in yoghurt. However, there is need to evaluate other inexpensive nutrient sources such as spices (turmeric) which contain a lot of phytochemicals to make yoghurt more nutritious. Fresh turmeric rhizome was sorted, washed, peeled and milled. Ethanol was added to obtain turmeric extract. The turmeric extract was added to the yoghurt before (YTBF) and after fermentation (YTAF) at different ratios of yoghurt: Turmeric (95:5, 90:10, 85:15, 80:20, 75:25 and 100:0). Proximate composition and sensory characteristics of the blends were determined using standard procedures. Results obtained show that the addition of turmeric extract to the yoghurt had significant ($p < 0.05$) effect on the parameters analyzed. The protein, fat, ash and carbohydrate content of YTBF samples ranged from 2.70 - 3.98, 1.56 - 1.74, 0.20 - 0.38 and 7.69 - 8.25%, respectively while that of sampled YTAF ranged from 2.64 - 3.85, 1.53 - 1.69, 0.24 - 0.54 and 7.87 - 8.26%, respectively. From the sensory scores, sample with the lowest level of turmeric extract (YTBF1) (95:5) was most preferred and compared favorably with the control sample based on colour, taste and overall acceptability. The incorporation of turmeric extract in yoghurt improved the nutrient content of the yoghurt samples. Increased levels above 10% (90:10) led to a more intense colour and spicy taste which did not appeal to the panelists.

Key words: Yoghurt, turmeric, fermentation, proximate composition, sensory characteristics.

INTRODUCTION

Yoghurt is a product of the lactic acid fermentation of milk by addition of a starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. bulgaricus.* In some countries, less traditional microorganismms such as *Lactobacillus helveticus* and *Lactobacillus delbrueckii* ssp*. lactis,* are sometimes mixed with the starter culture (McKinley, 2005).Yoghurt is valued for controlling the growth of bacteria and in

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Plate 1. Turmeric rhizome.

curing of intestinal disease such as constipation, diarrhoea and dysentery, anti-carcinogenic effect and lowering of blood cholesterol (Kamruzzaman et al., 2002). Due to the aforementioned health benefits, there is an increasing trend for yoghurt consumption and is the fastest growing dairy sector in the market, in particular, standard yoghurt and yogurt drinks. Yoghurts come in a variety of textures (e.g. liquid, set and stirred curd), fat contents (e.g. regular fat, low-fat and fat-free) and flavours (e.g. natural, fruit, cereal, chocolate), and can be consumed as a snack or part of a meal, as a sweet or savoury food.

Yoghurt is generally considered as a safer product and its unique flavour, is so appealing that consideration is being given by nutritionists to incorporate inexpensive source of nutrients in order to make it an almost complete food (Boghra and Mathur, 2000). Nowadays, yoghurts are being sold with different flavours. For instance, ginger and herbs are added to the fresh milk before fermentation or served with sugar syrup. Various fruits, vegetables and spices e.g. turmeric are being incorporated into yoghurts to give them desirable flavours. Turmeric (*Curcuma longa L.*) is a rhizomatous herbaceous perennial plant of the ginger family (Zingiberaceae) originated in tropical South Asia but is now widely cultivated in the tropical and sub-tropical regions of the world (Jurenka, 2009).It has a warm, bitter taste and is frequently used to flavour or colour curry powders, mustards, butters, and cheeses. It contains a yellow-coloured chemical substance called curcumin, which is often used to colour foods and cosmetics (Akande and Adegoke, 2018).

Curcumin is the main active ingredient in turmeric responsible for turmeric's numerous activities. It is known to possess anti-oxidative (Cousins et al., 2007), anti-microbial (Cho et al., 2006) and anti-inflammatory properties as well as having radio-resistant and chemo-preventive properties (Bar-sela et al., 2010).

Yoghurt is naturally produced from milk which contains a reasonable amount of live cultures mainly bacteria. Milk, from which yoghurt is made, contains a reasonable quantity of fat globules referred to as milkfat. Yoghurt therefore is prone to oxidation and can produce off-flavor. However, there are some spices that possess anti-oxidative, anti-microbial and anti-inflammatory properties which if incorporated in yoghurt, can help avert the off-flavour. However, it is most likely that the main reason that spices are being used is because, they help keep the foods free of unwanted microorganisms and thus contribute to health (Brul and Coote, 1999). However, spices such as turmeric are known to contain proteases and to have proteolytic activity (Nagarathnam et al., 2010).

Therefore, a yoghurt product with spice extract should serve to provide the combined health benefits from the spice plus those from the gut healthy bacteria present in the yoghurt. The objective of this study was to produce stirred yoghurt with graded levels of turmeric and evaluate the effect of turmeric in the yoghurt before and after fermentation on the physicochemical, microbiological and sensory characteristics of the yoghurt.

MATERIALS AND METHODS

Procurement of raw materials

The turmeric rhizome (Plate 1), skimmed powdered milk, starter

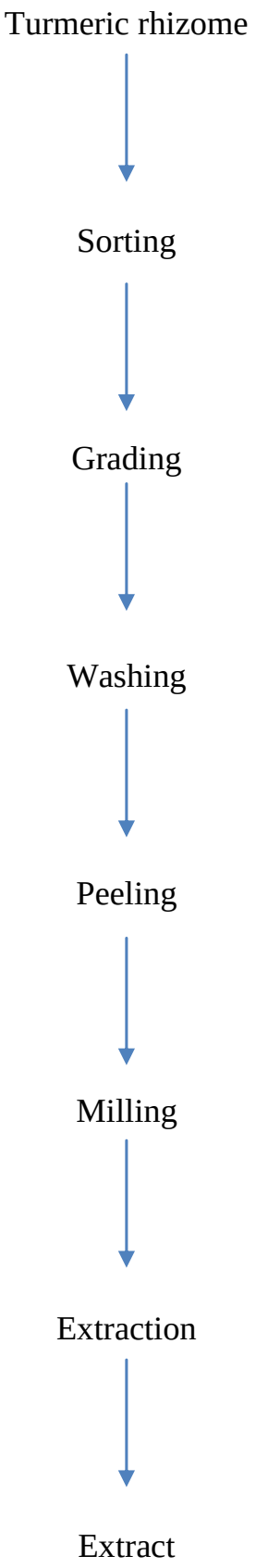

Figure 1. Preparation of turmeric extract

culture (Yoghurmet) and granulated sugar (Dangote Sugar Company) were purchased from Ogige main market in Nsukka local Government area of Enugu State, Nigeria.

Sample preparation

Preparation of turmeric extract

The turmeric was sorted, graded, washed thoroughly with water and the peel was separated from the flesh, milled and water was added for extraction as shown in Figure 1.

Preparation of ethanolic turmeric extract

180 g of ground spice was transferred to a 250ml conical flask. 200ml of 95% ethyl alcohol (ethanol) was added. The flask was covered, mixed, and stored overnight for 16 h at room temperature. The solution was filtered using a dry Whatman No. 1 filter paper. The ethyl alcohol was allowed to evaporate in a hot air oven at 110^{o}C until a constant weight of the extract was obtained as shown in Plate 2A.

Preparation of aqueous turmeric extract

180 g of ground sample was weighed into a 500ml of conical flask. 200ml of water was added, covered and shaken vigorously. The flask was covered, mixed, and stored overnight for 16 h at room temperature. The solution was filtered using Whatman No. 1 dry filter paper, then dried in a hot air oven at 110^{o}C until constant weight of extract was obtained as shown in Plate 2B.

Production of yoghurt

Yoghurt was produced as described by Lee and Lucey (2010) with slight modification. The milk mix was pasteurized at 80^{o}C for 20 to 30 min to inactivate the pathogens in a Gallenkamp (220/240V, 50 Hz) water bath and homogenized at pasteurization temperature. The milk was cooled to inoculation temperature of 40 to 45^{o}C and then inoculated with 2 to 3% starter culture (Yoghurmet consisting of *Lactobacillus bulgaricus and Streptococcus thermophilus*). The yoghurt was fermented for 12 h at incubation temperature of 43 to 45 ^{o}C in a water bath after which it was homogenized and divided into six portions. Thereafter, six sample blends of 95:5, 90:10, 85:15, 80:20, 75:25, 100:0 (Table 1) indicating the ratio of Yoghurt to Turmeric, were formulated as shown in Figure 2 and 3.

Sample analysis

Proximate composition of turmeric and formulated yoghurt

The moisture, crude protein (N x 6.25), crude fat, crude ash and crude fibre contents were determined using standard Association ofOfficial Analytical Chemists (AOAC, 2010).

Determination of total carbohydrate content

Total carbohydrate content was determined by difference (AOAC, 2005). This was simply carried out by subtracting the value of other food components (moisture, ash, fibre and protein) from 100 as shown in the Equation (1).

% Carbohydrate = 100 - (% fat + % protein + % moisture + % ash+% crude fibre) (1)

Table 1. Proportion of turmeric and yoghurt used in the formulation of yoghurt incorporated with turmeric.

Sample	Yoghurt (ml)	Turmeric (ml)
PY +TM (95:5)	95	5
PY +TM (90:10)	90	10
PY +TM (85:15)	85	15
PY +TM (80:20)	80	20
PY +TM (75:25)	75	25
PY +TM (100:0)	100	0

Turmeric was added before fermentation and after fermentation. PY = Plain yoghurt, TM = Turmeric extract.

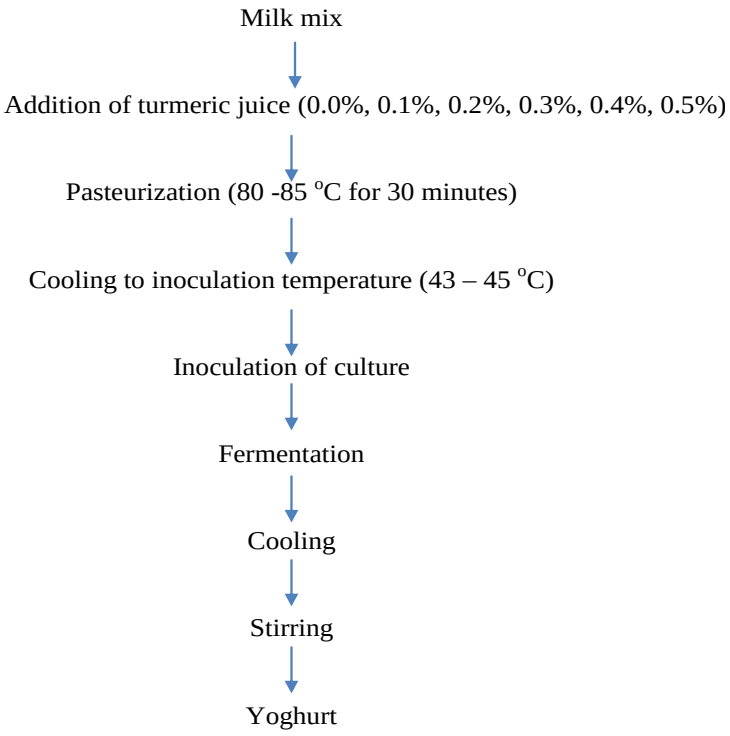

Figure 2. Modified production of yoghurt with turmeric extract before fermentation.
Source: Lee and Lucey (2010)

Determination of ash content

The ash content of the freshly prepared yoghurt and turmeric samples was determined according to the standards of AOAC (2010). A preheated and cooled crucible was weighed (W_1) and 2 g of each of the samples was weighed into two preheated cooled crucibles (W_2). The samples were charred on a Bunsen flame inside a fume cupboard. The charred sample in the crucible was then transferred into a preheated muffle furnace at 550°C for 2 h until a white or light grey ash was obtained (W_3). It was then cooled in a dessicator, weighted and documented. The ash content of the samples was calculated using Equation 2

$$\%\ \text{Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

Where $W_1 = Weightofemptycrucible$; $W_2 = Weightofcrucible + Weightofsamplebeforeashing$; $W_3 = Weightofcrucible + Weightofthesampleafterashing$

Determination of moisture content

The moisture content of the samples was determined according to the standard method of Association of official Analytical Chemist (AOAC, 2010). The crucibles were washed thoroughly and dried in the oven at 100°C for 1 h. The hot dried crucibles were cooled and weighed and value noted down (W_1). The samples (2 g) each were weighed into the crucibles (W_2) and dried at 110°C until a constant weight (W_3)was obtained. The moisture content of the samples was calculated as given in Equation (3).

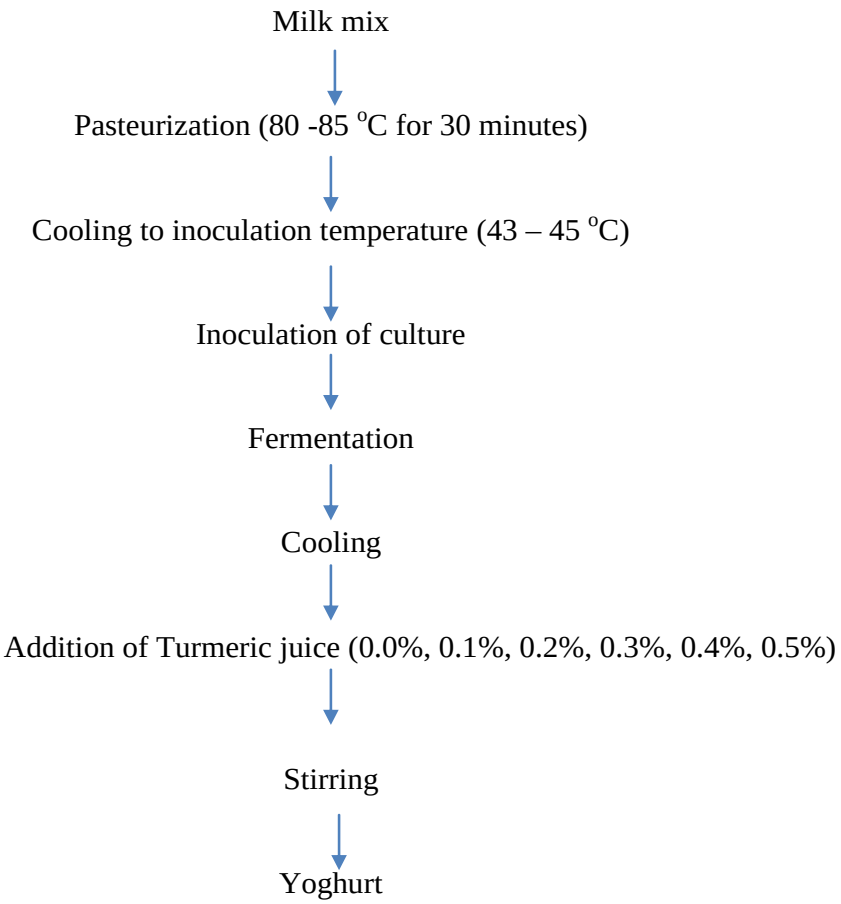

Figure 3. Modified production of yoghurt with turmeric extract after fermentation".
Source: Lee and Lucey (2010)

$$\%\ MoistureContent\ = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (3)$$

Where $W_1 = Initialweightofemptycrucible$;
$W_2 = Weightofcrucible + Weightofsamplebeforedrying$; $W_3 = Weightofcrucible + Weightofthesampleafterdrying$

Determination of fat content

The fat content of the yoghurt samples was determined using standard AOAC (2010) method. A Soxhlet extractor with a reflux condenser and a 500 ml round bottom flask was fixed. The yoghurt sample (2 g) was weighed into a labeled thimble and petroleum ether (300 ml) was filled into the round bottom flask. The extraction thimble was sealed with cotton wool. The Soxhlet apparatus was allowed to reflux for about 6 h. The thimble was removed with care and the petroleum ether was collected on the top and drained into a container for reuse. As soon as the flask was free of ether, it was removed and dried at 70°C for 1 h in an oven. It was cooled in desiccators and then weighed.The fat content of the samples was calculated using Equation (4).

$$\%\ fatcontent = \frac{Weightoffat}{Weightofthesample} \times 100 \quad (4)$$

Determination of crude protein

The protein content of the samples was determined according to the standard methods of AOAC (2010) using Kjeldahl`s method.

Digestion of the sample

The yoghurt sample (5 ml) was weighed into Kjeldahl digestion flask, and 1 tablet of Kjeldahl catalyst was added. Twenty-five milliliters (25 ml) of concentrated H_2SO_4 was added with few boiling chips. The flask with its content was heated in a 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 a known level with distilled water.

Distillation

The distillation unit was cleaned and the apparatus set up.A 100 ml conical flask (receiving flask) containing 5 ml of 3% Boric acid was placed under the condenser and 2 drops of methyl red indicator was added. A digest of 5 ml was pipetted into the apparatus through a small funnel and washed down with distilled water. This was followed by the addition of 5ml of 60% sodium hydroxide solution (NaOH).Heat was applied to the digestion flask until 100 ml of distillate (ammonium sulphate) was collected in the receiving flask.

Titration

The solution in the receiving flask was titrated with about 0.04 M HCl to get pink colour. The same procedure was carried out on the blank. The percentage Nitrogen was evaluated as given in Equation 5.

$$\% \text{ Nitrogen} = \frac{V_s - V_b \times N_{acid}}{W} \times 0.0401 \times 100 \quad (5)$$

Where $V_s = Volume(ml) of the acid required to titrate the sample$; $V_b = Volume(ml) of the required base to titrate the blank$; $N_{acid} = Normality of acid$ and W = Weight of sample (g)

The percentage crude protein of the samples was determined using Equation 6 as shown below.

$$\% \text{ Crude protein} = \% \text{ N} \times 6.25\ (ConversionFactor) \quad (6)$$

Micronutrient analysis

Determination of vitamin B_{12} (Cyanocobalamine)

The fat content of the yoghurt samples was determined using the method described by AOAC (2010) was used. 1 g of the sample was weighed into a flat-bottom flask and 50 ml of 0.1 N HCl was added to it. The flask was thoroughly swirled and allowed to stand for 2 h. The mixture was then filtered and 10 ml aliquot taken in a test tube for spectrophotometric reading. Then 0.5 ml, 0.2 % alpha-alpha dipyridyl were added to the sample which was read within 10 min in a spectrophotometer at 550 nm.

Determination of calcium content

Calcium content of the samples was determined by the Ethylene diamine tetra acetic acid(EDTA) complexiometric titration of AOAC (1990) as described by Hussain et al. (2010). 20ml of sample was taken in a conical flask and 2 to 3 pellets of KOH were added. After shaking the solution 1 g of Patton and reeder indicator (calcon 3-carboxylic acid) was added and the sample was titrated against 0.01M EDTA solution until a colour change from wine red to blue appeared. The volume of EDTA is the equivalent volume of calcium in the sample.

Determination of phosphorus content

Phosphorus in the sample was determined by Molybdate method as described by Onwuka (2005). Hydroquinone was used as a reducing agent. A mixture of 1.0 sodium sulphate (Na_2SO_4), 1.0 ml hydroquinone and 0.5 ml of the mineral digest was agitated and allowed to stand for 30 min. The blue colour developed was quantified using a colorimeter at 660 nm against a standard. The Phosphorus in the sample was calculated using the following Equation 7.

$$\text{Phosphorus} = \frac{Absorbance of test \times Dilution Factor}{W \times 5} \quad (7)$$

Where W = Weight of the sample.

Determination of vitamin C (ascorbic acid) content

Vitamin C content was determined according to the method described by Onwuka (2005). Five grams (5 g) of the sample and 2.5 ml of 20% metaphosphoric acid (as a stabilizing agent) was diluted with distilled water and weighed into a 100ml volumetric flask. Ten milliliters (10 ml) of the solution was mixed with 2.5ml acetone and homogenized. The absorbance reading wasobtained using an Ultra-violet (UV) spectrophotometer to ascertain the Vitamin C content at 264 nm wavelength. Vitamin C content of the samples was calculated using the Equation 8.The calibration curve was constructed by plotting the concentration against the corresponding absorbance. The molar absorptivity was found usingthe Beer-Lambert's law.

$$\text{Vitamin C} = \frac{Absorbance \times dilution factor}{Slope\ (from Standard curve)} \quad (8)$$

Determination of vitamin B_2(Riboflavin) content

AOAC (2005) standard method was used. A 2 g sample of the yoghurt was placed in a conical flask and 50 ml of 0.2 N HCl added. The solution was boiled for 1 h and cooled. The pH was adjusted to 6.0 using Sodium Hydroxide (NaOH). Also 1 N HCl was added to the solution of the sample to lower the pH to 4.5. The solution was filtered into 100 ml volumetric flask and made up to the required volume with distilled water. In order to remove interference, two tubes were taken and labelled 1 and 2. Ten millilitres (10 ml) of water was added to tube 1. Another 10 ml of filtrate and 1 ml of Riboflavin standard were added to test tube 2. Then 1 ml of glacial acetic acid was added to each tube and mixed 0.5 ml of 3% $KMnO_4$ solution was added to each tube. The test tube was allowed to stand for 2 min after which 0.5 ml 3% H_2SO_4 was added ad solution mixed well. The fluorimeterwas adjusted to an excitation wavelength of 470 nm and emission wavelength of 525 nm. The fluorimeter was adjusted to zero deflection against 0.1 N $H_2SO_4$and 100 against tube 2 (standard). The fluorescence of tube 1 was added to both tubes and the fluorescence measured within 10 s.

Riboflavin (Vitamin B_2) was calculated as shown in Equation 9:

$$\text{Riboflavin (mg / g)} = \frac{Y}{Y - X} \times \frac{1}{W} \quad (9)$$

WhereW = Weight of sample; X = Reading of sample - Blank reading; Y = Reading of sample + standard (tube 2) – reading of sample - standard blank.

Determination of vitamin B_6 (pyridoxal phosphate) content

The method described by AOAC (2010) was used. 1 g of each sample was weighed separately into a 100 ml conical flask and extracted with 10 ml 0.1 M HCl with vigorous shaking for 10 min. The sample was ten filtered through Whatman No. 1 filter paper. The filtrate was then made up to 10 ml with distilled water. 5 ml of the slightly acidic filtrate was treated with 1 ml 0.40% Ferric Chloride. The optical density of the resultant brown solution was measured in a spectrophotometer at 450nm. The absorbance obtained from the sample extract was converted to pyridoxine concentration by means of a calibration curve generated using different standard concentrations. Vitamin B_6 was calculated as shown in Equation 10:

$$\text{Vitamin } B_6 \text{ (mg / 100 g)} = \frac{Absorbance of sample \times \text{Conc. of standard}}{Absorbance of Standard \times \text{Sample size}} \quad (10)$$

Determination of vitamin B_3 (Niacin) content

This was done using Pearson (1976) spectrophotometric method.

Table 2. Proximate analysis on turmeric extract of water and ethanol extraction.

Constituent	Water extraction (%)	Ethanol extraction (%)
Moisture	80.5	50.2
Protein	2.5	7.0
Fat	4.2	10.8
Ash	3.0	1.5
Carbohydrate	15.8	30.5

A 2 g portion of yoghurt sample was weighed into a conical flask and 20 ml of 0.5 MNaOH added. The contents of the flask were stirred with a magnetic stirrer for 30 min. The resulting solution was filtered into a clean container and 5 ml was transferred into a test tube. Four milliliter (4 ml) of 0.1 N KCl and 0.1 N NH_4Cl solutions were added into the extract and allowed to stand for yellow colourdevelopment. The absorbance was measured at 261 nm. Astandard and blank solution was also prepared.

Nicotinic acid (Niacin) was calculated as given in Equation 11:

$$\text{Niacin (mg / g)} = \frac{Absorbance of test sample \times Conc.\ of standard\ (5\ mg/dl)}{Absorbance of standard} \quad (11)$$

Physicochemical analyses of stirred yoghurt samples

Determination of pH

A standard pH meter (model 20 pH Conductivity Meter, Denver Instrument, United Nations Inventory Database), was standardized using buffer solutions of pH 4.0 and 9.0. The pH electrode was dipped into the yoghurt and after a few minutes of equilibration, the pH of the yoghurt sample was taken (AOAC, 2010).

Determination of apparent viscosity

The viscosity of yoghurt samples was determined by using Ostwald viscometer according to AOAC (2010). 20 g of each of the samples was taken and made Newtonian by dissolving in 50 ml of water to obtain the density of each sample. 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 samples. The apparent viscosity was calculated in Centipoise (cP) using Equation 12.

$$\text{Apparent viscosity (cP)} = \frac{n2 \times \rho1 \times t1}{\rho2 \times t2} \quad (12)$$

Where n_2 = Viscosity of water (0.89); ρ_1 = Density of sample; t_1 = time taken for the sample to fall back on its own (seconds); ρ_2= Density of water (1g / cm^3); t_2 = time taken for water to fall back on its own (2.5 s).

Determination of total titratable acidity

The total titratable acidity was determined using the method of AOAC (2010). The sample (5 ml) at 25^{o}C 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 0.1 M NaOH to the first permanent pink colour. The total titratable acidity was calculated as the percentage lactic acid by weight using Equation 13:

$$\text{Titratable acidity (\%)} = \frac{Quantity of yoghurt sample}{Quantity of NaOH(ml) \times 0.009 \times 100} \quad (13)$$

Microbial analysis of yoghurt samples

Microbiological analysis was carried out on the yoghurt samples. A serial dilution of the sample was done. The sample was placed at ambient temperature. Total viable count (TVC) and mould count was determined by pour plate method on nutrient agar and Saboroud Dextrose Agar (SDA) respectively as described by Prescott et al. (2005).

Sensory evaluation

The sensory evaluation was carried out according to Ihekoronye and Ngoddy (1985) using a 20- man semi-trained panelist consisting of students and lecturers of Food Science and Technology Department, University of Nigeria Nsukka. The panelists were instructed to indicate their preference of the samples using a nine-point Hedonic scale (where 9 signifies *extremely like* and 1 signifies *extremely dislike*) for each characteristic such as colour, flavour, mouth feel, taste after taste, consistency and overall acceptability being determined.

Data analysis and experimental design

The experiment was one in triplicates. Data obtained were subjected to analysis of variance (ANOVA) using split-plot in completely randomized design according to the methods of Gomez and Gomez (1985). Least significant difference was used to compare the treatment means and significance difference was used to compare the treatment means and significance was accepted at $p< 0.05$.

RESULTS

Comparison of the extract of aqueous and ethanolic extraction

Tables 2 and 3 shows selected chemical components and characteristics of turmeric extracted with ethanol and water (as shown in Plate 2A and B). Turmeric extracted with ethanol had higher chemical composition and

Table 3. Micronutrient analysis on turmeric extract of water and ethanol extraction (As shown in Plate 2).

Constituent	Water extraction	Ethanol extraction
Vitamin B_2	19 mg	39 mg
Vitamin B_{12}	2.10 μg	5.10 μg
Vitamin B_6	0.80 mg	1.80 mg
Vitamin B_3(µg/ml)	ND	0.233 mg
Vitamin C	4.5 mg	25.9 mg
Phosphorus	65.9 mg	268 mg
Calcium	3.10 mg	183 mg

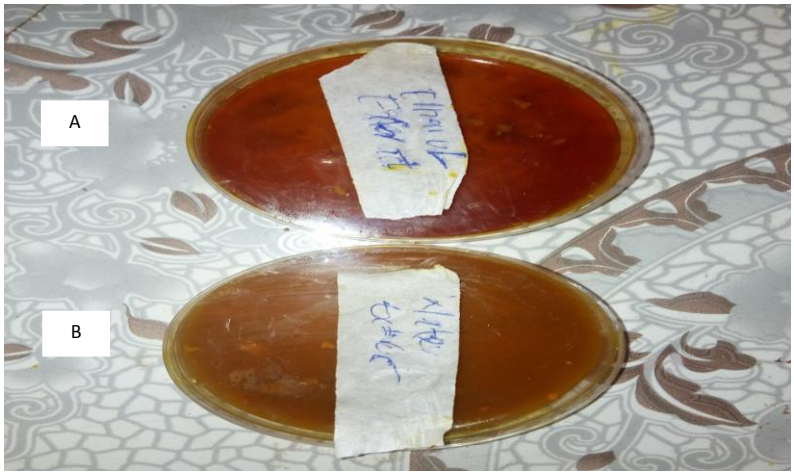

Plate 2. (A) Turmeric extracts using ethanol; (B) Turmeric extracts using water**.**

characteristics than the turmeric extracted with water. This could be attributed to the fact that curcumin ($C_{21}H_{20}O_5$), the major bioactive compound in turmeric, is highly soluble in ethanol, acetone and dimethysulfoxide (Remadevi et al., 2007). It can then be inferred that turmeric is an oil-soluble, hydrophobic pigment which is practically insoluble in water (Tonnesen, 2002). Hence turmeric extracted with ethanol was used for the production.

Proximate composition of yoghurt graded with different levels of turmeric

Effect of turmeric extract on the moisture and protein contents of the stirred yoghurt

Table 4 shows that the moisture content values of plain yoghurt sample (without turmeric) were found to be 8.55±0.01%. Generally, there were significant ($p<0.05$) differences between the moisture content of the stirred yoghurt at different levels of turmeric incorporated. The moisture contents of samples ranged from 8.55±0.01 to 87.29±0.01%. Sample YTB5 (75:25) yoghurt to turmeric ratio before fermentation had the highest moisture content while the control Yoghurt (100:0) had the lowest moisture content. There was significant ($p<0.05$) difference in the protein content of the stirred yoghurt formulated with different amount of turmeric (Table 4). The values ranged from 2.64±0.05 to 4.13±0.01%. Sample YTB5 (75:25) yoghurt to turmeric ratio before fermentation had the lowest protein content while theplain yoghurt had the highest protein content. The effect of the different amount of turmeric also shows significant ($p<0.05$) differences at different levels. This is evident that protein content decreased with increase in the amount of turmeric added due to the fact that turmeric contains low protein content.

Effect of turmeric extract on the ash and fat contents of the stirred yoghurt

Data presented in Table 4 illustrated that there were significant ($p<0.05$) difference in the ash content of the stirred yoghurt at different levels of turmeric incorporated into the product. The ash content values were within the range of 0.20±0.01 to 1.81±0.01%. Yoghurt sample

Table 4. Proximate composition (%) of yoghurt graded with different levels of turmeric.

Sample (ml)	Moisture	Protein	Ash	Fat	Carbohydrate
YTA1(95:5)	86.05^{d}±0.07	3.98^{b}±0.13	0.38^{d}±0.07	1.70^{c}±0.06	7.89^{a}±0.15
YTA2(90:10)	86.30^{c}±0.03	3.84^{c}±0.02	0.27^{f}±0.03	1.63^{e}±0.01	7.69^{g}±0.10
YTA3(85:15)	86.98^{b}±0.06	3.10^{e}±0.00	0.25^{g}±0.01	1.61^{f}±0.00	8.06^{e}±0.07
YTA4(80:20)	87.18^{a}±0.08	2.85^{f}±0.01	0.21^{h}±0.02	1.56^{g}±0.01	8.17^{c}±0.13
YTA5(75:25)	87.29^{a}±0.01	2.70^{h}±0.01	0.20^{h}±0.01	1.74^{b}±0.01	8.25^{b}±0.09
YTB1(95:5)	85.87^{d}±0.05	3.85^{c}±0.08	0.54^{b}±0.01	1.69^{c}±0.00	7.87^{i}±0.03
YTB2(90:10)	85.81^{d}±0.01	3.61^{c}±0.01	0.50^{c}±0.00	1.65^{d}±0.01	7.96^{g}±0.01
YTB3(85:15)	86.24^{c}±0.03	3.09^{d}±0.03	0.33^{e}±0.01	1.57^{g}±0.03	8.03^{f}±0.03
YTB4(80:20)	87.28^{a}±0.01	2.78^{e}±0.01	0.27^{f}±0.03	1.57^{g}±0.00	8.12^{d}±0.07
YTB5(75:25)	87.33^{a}±0.08	2.64^{i}±0.05	0.24^{g}±0.03	1.53^{h}±0.02	8.26^{a}±0.04
Yoghurt	8.55^{e}±0.01	4.13^{a}±0.01	1.81^{a}±0.01	1.81^{a}±0.02	7.82^{j}±0.01

Values are mean ± standard deviation of triplicate readings. Means on the same column with different superscripts are significant (p< 0.05) different. YTA=yoghurt with turmeric after fermentation; YTB=yoghurt with turmeric before fermentation.

YTA5(75:25), that is, yoghurt samples with 0.5% turmeric extract after fermentation, had the lowest ash content while Yoghurt (100:0), the control sample, had the highest fat content. Notably, the ash contents of the yoghurt samples before and after fermentation decreased with increasing levels of turmeric extracts in the formulation. The effect of turmeric extracts incorporated on fat contents of the yoghurt samples was studied at different levels (0.1, 0.2, 0.3, 0.4 and 0.5%). The results revealed that significant (p<0.05) difference between the fat contents of the stirred yoghurt with different amount of turmeric existed (Table 4). The fat contents were within the range of 1.53±0.02 to 1.81±0.02%. Sample YTB5 (75:25) had the lowest fat content while Yoghurt (100:0) had the highest fat content.

Effect of turmeric extract on the carbohydrate content of the stirred yoghurt

Table 4 showed that there was significant (p< 0.05) difference between the carbohydrate contents of the stirred yoghurt samples and the different amount of turmeric extracted added (Table 4). The carbohydrate content ranged from 7.82±0.01 to 8.26±0.04%. The obtained results showed that sample YTB5(75:25) before fermentation had the highest carbohydrate content while the plain yoghurt (100:0), that is, the control sample, had the lowest carbohydrate content. In general, the effect of the different amount of turmeric also showed significant (p <0.05) differences at different levels.

Effect of turmeric extract on micronutrient contents of the stirred yoghurt

Effect of different amount of turmeric on vitamin B_3 and vitamin B_{12} content of the stirred yoghurt: Table 5 showed that there was significant (p< 0.05) difference in vitamin B_3 content of the stirred yoghurt with different amount of turmeric (Table 5). The samples ranged from0.12±0.00 to 1.72±0.01 mg. Sample YTA5(75:25) before fermentation had the highest vitamin B_3 content while sample YTB1(95:5) had the lowest vitamin B_3 content. Generally, the yoghurt samples formulated with turmeric before and after fermentation (YTB and YTA) have higher vitamin B3 content than the plain yoghurt (YOGHURT). There was a significant (p<0.05) difference in the vitamin B_{12} content of the stirred yoghurt with different amount of turmeric (Table 5). The samples ranged from 8.42±0.04 to 34.30±0.01µg.Sample YTA5(75:25) yoghurt to turmeric ratio before fermentation had the highest vitamin B_{12} content while plain yoghurt had the lowest Vitamin B_{12} content.

Effect of turmeric extract on vitamin C and vitamin B_2 of the stirred yoghurt: There was a significant (p< 0.05) difference between vitamin C content of the stirred yoghurt and different levels of turmeric incorporated (Table 5). The samples ranged from 42.5±0.06 to 66.15±0.10 mg. Sample YTA1 (95:5) had the highest vitamin C content while the control sample (YOGHURT) had the lowest vitamin C content. The effect of the different amount of turmeric also shows significant (p <0.05) differences at different levels. Vitamin C content decreased with increase in the amount of turmeric. There was significant (p<0.05) difference in the vitamin B_2 content of the stirred yoghurt with different amount of turmeric (Table 5). The samples ranged from 6.30±0.01 to 14.40±0.02 mg. Sample YTB5 (75:25) had the highest vitamin B_2 content while plain yoghurt had the lowest vitamin B_2 content.

Effect of turmeric extract on vitamin B_6, calcium and phosphorus of the stirred yoghurt: There was significant (p<0.05) difference in the vitamin B_6 content of

Table 5. Micro-nutrients of yoghurt graded with different level of turmeric.

Sample (ml)	VitaminB_3 (mg/100 g)	VitaminB_{12} (µg/100 g)	Vitamin C (mg/100 g)	Vitamin B_2 (mg/100 g)	Vitamin B_6 (mg/100 g)	Calcium (mg/100 g)	Phosphorous (mg/100 g)
YTA1(95:5)	1.01^{e}±0.06	9.77^{g}±0.00	66.15^{a}±0.10	7.25^{j}±0.05	0.23^{c}±0.01	92.70^{g}±0.01	87.29^{a}±0.00
YTA2(90:10)	1.09^{d}±0.01	10.52^{h}±0.01	60.12^{b}±0.07	7.42^{i}±0.02	0.21^{d}±0.01	93.20^{f}±0.01	79.78^{c}±0.00
YTA3(85:15)	1.12^{c}±0.06	24.26^{a}±0.01	58.26^{h}±0.10	8.01^{h}±0.00	0.20^{a}±0.01	99.24^{e}±0.03	71.45^{e}±0.01
YTA4(80:20)	1.42^{b}±0.03	25.15^{a}±0.02	57.21^{e}±0.07	9.24^{d}±0.01	0.18^{e}±0.01	105.35^{b}±0.03	67.64^{g}±0.01
YTA5(75:25)	1.72^{a}±0.01	34.30^{a}±0.01	56.44^{f}±0.07	9.77^{c}±0.02	0.16^{f}±0.01	110.09^{a}±0.01	61.04^{i}±0.02
YTB1(95:5)	0.12^{j}±0.00	9.99^{i}±0.03	59.42^{c}±0.04	8.45^{g}±0.01	0.60^{f}±0.01	87.32^{j}±0.03	84.73^{b}±0.03
YTB2(90:10)	0.22^{i}±0.03	15.10^{g}±0.03	49.30^{h}±0.01	8.80^{f}±0.01	0.40^{b}±0.01	88.10^{c}±0.00	78.60^{d}±0.01
YTB3(85:15)	0.40^{h}±0.01	24.53^{e}±0.00	48.50^{h}±0.01	9.01^{e}±0.02	0.30^{e}±0.01	89.24^{i}±0.02	70.90^{f}±0.02
YTB4(80:20)	0.50^{g}±0.01	26.20^{c}±0.01	46.51^{j}±0.06	10.24^{b}±0.05	0.20^{g}±0.01	100.12^{h}±0.01	66.42^{i}±0.00
YTB5(75:25)	0.63^{f}±0.02	27.20^{b}±0.00	44.21^{j}±0.07	14.40^{a}±0.02	0.12^{g}±0.01	100.42^{d}±0.01	60.53^{h}±0.03
YOGHURT	0.21^{l}±0.01	8.42^{k}±0.04	42.50^{h}±0.06	6.30^{f}±0.01	0.13^{g}±0.01	85.90^{c}±0.01	25.60^{j}±0.01

Values are mean ± standard deviation of triplicate readings. Means on the same column with different superscripts are significant ($p<0.05$) different. YTA=yoghurt with turmeric after fermentation, YTB=yoghurt with turmeric before fermentation.

Table 6. Functional properties of the effect of stirred yoghurt.

Sample	pH	Viscosity(cP)
YTA1(95:5)	4.72^{e} ± 0.02	118.89^{f} ± 0.23
YTA2(90:10)	4.75^{d} ±0.05	114.87^{g} ± 0.17
YTA3(85:15)	4.78^{c} ± 0.03	101.01^{d} ±0.10
YTA4(80:20)	5.00^{b} ± 0.08	96.18^{a} ±0.25
YTA5(75:25)	5.21^{a} ± 0.07	90.94^{e} ±0.29
YTB1(95:5)	4.68^{g} ±0.02	115.94^{de} ±0.10
YTB2(90:10)	4.71^{f} ± 0.02	110.03^{a} ± 0.21
YTB3(85:15)	4.72^{e} ± 0.06	100.96^{d} ± 0.17
YTB4(80:20)	4.75^{d} ± 0.03	95.94^{b} ± 0.21
YTB5(75:25)	4.79^{c} ±0.00	90.92^{e} ± 0.17
YOGHURT(100:0)	4.70^{f} ±0.01	120.65^{d} ±0.20

Values are mean ± standard deviation of triplicate readings. Means on the same column with different superscripts are significant ($p<0.05$) different.YTA=yoghurt with turmeric after fermentation, YTB=yoghurt with turmeric before fermentation.

the stirred yoghurt with different amount of turmeric (Table 5). The vitamin B6 content of the samples were within the range of 0.12±0.01 to 0.60±0.01 mg. Sample YTB1 (95:5) had the highest vitamin B_6 content while plain had the lowest vitamin B_6 content. The values of Calcium in the samples ranged from 85.90±0.01to 110.09±0.01mg.The calcium content of the stirred yoghurt showed significant ($p< 0.05$) difference at different levels of turmeric extract incorporated (Table 5). It was observed that sample YTA5 (75:25) had the highest calcium content as compared to sample yoghurt (100:0) which was found to have the lowest calcium content. This equally shows that yoghurt itself contains high amount of calcium which is necessary in young and adult for good bone and teeth development. Based on data presented in Table 5, there were significant ($p<0.05$) difference in the phosphorus content of the stirred yoghurt at different levels of turmeric extracts added. The phosphorus in the yoghurt samples ranged from25.60±0.01 to 87.29±0.00 mg. Sample YTA1 (95:5, that is, yoghurt to turmeric ratio before fermentation) had the highest phosphorus content while the control sample (Yoghurt) had the lowest phosphorus content. It was noted that for all samples in which turmeric extract was added, the phosphorus content decreased with increased level of turmeric before and after fermentation.

Effect of turmeric extraction on the physicochemical properties of the stirred yoghurt

Effect of turmeric extract on the pH and viscosity of the stirred yoghurt: Table 6 shows the pH and viscosity of the yoghurt samples in which turmeric extract was

Table 7. Microbial count (cfu/ml) of the stirred yoghurt.

Sample	Mould count (cfu/ml)	Total viable count (cfu/ml)	Lactic acid bacteria (LAB)count (cfu/ml)	Coliform count (cfu/ml)
YTA1(95:5)	$5.0x10^1$	$2.0 x10^5$	$2.1 x10^5$	$1.0 x10^1$
YTA2(90:10)	$4.0x10^1$	$2.0 x10^5$	$2.0 x10^5$	$0.5 x10^1$
YTA3(85:15)	ND	$1.9 x10^5$	$1.9 x10^5$	ND
YTA4(80:20)	ND	$1.8 x10^5$	$1.5 x10^5$	ND
YTA5(75:25)	ND	$1.7 x10^5$	$10.0 x10^5$	ND
YTB1(95:5)	$2.1x10^1$	$1.9 x10^5$	$2.0 x10^5$	$1.0 x10^1$
YTB2(90:10)	$0.1x10^1$	$1.7 x10^5$	$1.8 x10^5$	$0.4 x10^1$
YTB3(85:15)	ND	$1.6 x10^5$	$1.5 x10^5$	ND
YTB4(80:20)	ND	$1.4 x10^5$	$1.3 x10^5$	ND
YTB5(75:25)	ND	$1.2x10^5$	$1.1x10^5$	ND
Yoghurt (100:0)	$3.0x10^1$	$2.2 x10^5$	$2.3x10^5$	$1.4 x10^1$

Values are mean ± standard deviation of triplicate readings. Means on the same column with different superscripts are significant ($p< 0.05$) different. YTA=yoghurt with turmeric after fermentation, YTB=yoghurt with turmeric before fermentation, ND = Not Detected.

incorporated and the pH and viscosity of yoghurt sample without turmeric (that is, the control). The values for pH ranged from 4.68±0.02 to 5.21±0.07 (Table 6). Within the yoghurt, the pH increased with increase in the amount of turmeric added. This indicates that the addition of turmeric significantly increased the pH of the stirred yoghurt. Data presented in Table 6 also showed that all samples except sample YTB1 (95:5) had pH values significantly higher than that of the plain yoghurt. Considerable increase in pH of the yoghurt samples was also observed when pH of the samples before and after fermentation was compared. The values for viscosity ranged from 90.92± 0.17to 120.65 ± 0.20cP.Within the yoghurt, the viscosity decreased with increase in the amount of turmeric added.

Effect of turmeric extract on the microbial characteristics of the stirred yoghurt: Table 7 shows the total viable count, lactic acid bacteria, mould and coliform counts of the formulated stirred yoghurt.The mould count ranged from 3.0 $x10^1$cfu/ml in the plain yoghurt to a non-detectable (ND) amount in the sampleYTB5(75:25) where turmeric extract was added before fermentation. The plain yoghurt, that is, Yoghurt (100:0) had the highest mould count while sample YTB5(75:25) had the lowest mould count. The total viable count (TVC) was within the range of $1.2×10^5$to$2.2 ×10^5$cfu/ml. The plain yoghurt was found to have the highest TVC ($2.2×10^5$cfu/ml) while sample YTB5 (75:25) gave the lowest total viable count. Also, the Coliform Count of the yoghurt samples ranged from 0.4×10 to 1.4×10cfu/ml. The lactic acid bacteria (LAB) Count of the samples ranged from 1.0 $x10^5$ to 2.1 $x10^5$cfu / ml. Generally, total viable count (TVC), mould count, and coliform count decreased with increase in the amount of turmeric added this could be attributed to anti-oxidant properties of turmeric extract.

Effect of different amount of turmeric on the sensory scores for stirred yoghurts: There were significant ($p<0.05$) differences in colour, taste aftertaste, consistency, firmness and overall acceptability (Table 8). The plain yoghurt was most appealing (8.23±1.45) as having the highest score while sample YTA5 (75:25) had the lowest score (5.43±0.91).Data obtained also revealed that there was a decrease in the acceptability of colour as the level of turmeric added increased (Table 8).

This could be attributed to high intense colour in the samples due to the effect of curcumin, a colouring agent in the turmeric extract. The sample YTB1 (95:5) scored the highest for taste (8.87±0.49), while the sample YTA5 (75:25) within the stirred yoghurt group had the lowest score (5.23±1.07).The plain yoghurt scored (7.23±1.48) for taste. There was a decrease in the overall acceptability of taste as higher amount of turmeric was incorporated. This could be traceable to a very characteristic spicy taste of turmeric in the samples thus changing the samples' taste from sweet to somewhat bitter taste. The sample YTA1(95:5) scored the highest in consistency (8.45±1.26) and the sampleYTA5 (75:25) had the lowest in consistency (5.21±1.57). The panelists rated sample YTB1 (95:5) highest (8.43±0.98) while sample YTB5(75:25) had the lowest score (5.21±0.26) for firmness. This was so evident that the higher amount of turmeric reduced the consistency and firmness of the stirred yoghurt. The plain yoghurt (100:0) sample had the highest score in the overall acceptability (8.86±0.84) while sample YTB5 (75:25) had the lowest score (5.67±1.00). Samples YTB5 (75:25) and YTB3 (85:15) had the lowest (5.24±0.50) and highest score

Table 8. Sensory scores of the formulated stirred yoghurt.

Sample	Colour	Taste	Aftertaste	Consistency	Firmness	Overall acceptability
YTA1(95:5)	7.40^{c} ± 1.26	8.80 ^{b}± 0.49	7.24^{c} ± 0.50	8.45^{a} ± 1.26	7.98 ^{c} ± 0.44	8.21 ± 0.80
YTA2(90:10)	7.01^{d} ± 1.04	7.52 ^{d} ± 1.91	7.02 ^{d} ±1.91	7.42 ^{d} ±1.35	7.44 ^{d} ±0.38	7.77±1.84
YTA3(85:15)	6.21^{h}±0.77	6.97^{f}±1.14	7.23^{c} ±1.63	6.41^{g}±0.99	6.43 ^{g} ±0.09	7.03±1.10
YTA4(80:20)	6.01 ^{i} ±0.85	6.42 ^{g} ±1.05	6.15 ^{f} ±1.28	5.98 ^{g} ±1.39	5.22^{j}±0.52	6.67±1.24
YTA5(75:25)	5.43^{k}±0.91	5.23 ^{j} ±1.07	5.90^{g} ±1.33	5.21 ^{j} ±1.57	5.53 ^{g} ±0.37	5.77^{i}±0.75
YTB1(95:5)	7.54 ^{b} ±1.26	8.87 ^{a} ±0.49	7.23^{c} ±0.50	8.23 ^{b} ±1.35	8.43 ^{b} ±0.98	8.39 ^{a} ±1.13
YTB2(90:10)	7.03^{c} ±1.64	7.91^{c} ±2.03	7.41^{c} ±0.89	7.6 ^{c} ±1.81	7.43 ^{d} ±0.57	7.55 ^{d} ±1.01
YTB3(85:15)	6.45 ^{e} ±1.14	6.43 ^{g} ± 1.45	7.44 ^{a} ± 1.29	6.98 ^{f} ± 1.26	6.77 ^{e} ± 0.36	6.87 ^{f} ± 1.57
YTB4(80:20)	6.23 ^{f} ±1.07	6.00 ^{h} ± 1.49	6.43 ^{e} ± 0.89	5.55 ^{h} ± 1.51	5.41 ^{i} ±0.81	6.33 ^{h} ± 1.45
YTB5(75:25)	5.47 ^{j} ±0.49	5.43 ^{i} ± 0.46	5.24 ^{h} ±0.50	5.24^{j} ±0.47	5.21 ^{j} ±0.26	5.67 ^{j} ± 1.00
Yoghurt	8.23^{e}±1.45	7.23 ^{e} ±1.48	7.41^{b} ± 1.63	7.13 ^{e} ± 0.28	7.21 ^{e} ± 0.51	8.86 ^{a} ± 0.84

respectively for after taste.

DISCUSSION

Effect of different levels of turmeric on the proximate composition of formulated stirred yoghurt

The significant ($p < 0.05$) increase in the moisture content of yoghurt samples formulated with graded levels of turmeric extracts when compared to the moisture content of the control sample (YOGHURT) could be traced to the reduction in the water holding capacity of milk by the extracts before fermentation. This observation was in agreement with the result obtained by Akande and Adegoke (2018) in which there was increase in moisture content of spiced yoghurt. According to Ammon et al. (1992), the marked increase in the moisture content of yoghurt formulated with spices could be attributed to the antibacterial mechanism exhibited by the spices involving formation of water in the electron transport system. For the yoghurt samples examined in this research, the protein contents of those samples with turmeric extracts (before and after fermentation) were lower than that of the plain yoghurt. This significant ($p < 0.05$) decrease could be traced to the presence of proteolytic enzymes (proteases) in the turmeric extract incorporated in the yoghurt samples which degrade proteins into peptides and amino acids. This assertion was in agreement with Nagarathnam et al. (2010). Altogether, the protein contents of the yoghurt samples did not exceed the commercial yoghurts' recommended range (11-18%) of proteins prescribed by the National Yoghurt Association. Yoghurt, like ice cream, is a milk-and-water-based dairy product which is poor in fibre level (Cheeseman and Lean, 2000). Result showed that ash content decreased with increase in the amount of turmeric added. This is attributed to low ash content of the turmeric extract. The ash contents of the turmeric-containing yoghurt samples before and after fermentation were low compared to the plain yoghurt sample (without turmeric extract). This finding was in agreement with Akande and Adegoke (2018).According to U.S. Food and Drug Association, low fat yoghurt must contain 0.5 to 2% fat while regular yoghurt must be no less than 3.25% fat (Food Source Information – Colorado, 2018). The yoghurt samples examined in this study had low fat contents. This was attributed to the low fat content of the skimmed milk which was used as a major ingredient for yoghurts.The carbohydrate content of the yoghurt samples containing turmeric extracts increased with increase in the amount of turmeric added when compared to the carbohydrate content of plain yoghurt. This increase could be traced to carbohydrate present in the turmeric (Table 2).

Effect of different levels of turmeric on the physicochemical properties of the stirred yoghurt

The incorporation of turmeric extract in yoghurt before and after fermentation showed significant ($p < 0.05$) increase in pH leading to decrease in acidity. This observation could be attributed to the alkaline nature of turmeric itself. Decrease in viscosity was observed in the viscosity of stirred yoghurt formulated with turmeric extract as compared to the value obtained for the plain yoghurt sample. This observation correlates with high moisture content of the yoghurt samples in which turmeric extracts were incorporated. Thus, the higher the moisture content, the less viscous the samples become (and vice-versa).

Effect of different levels of turmeric on the micronutrient composition of the stirred yoghurt

The incorporation of turmeric extract (before and after fermentation) at different levels in the stirred yoghurt samples showed significant ($p < 0.05$) improvement in the vitamin B_2, B_3, and $B_{12.}$ However, vitamins C and B_6 contents of each of the stirred yoghurt samples

Plate 3. Formulated Yoghurt samples.

formulated with turmeric extracts (Plate 3) significantly decreased with increase in the levels of turmeric. The significant increase ($p < 0.05$) in vitamins B_2, B_3, and B_{12} could be attributed to the starter culture used in the stirred yoghurt samples. Lactic acid producing bacteria have been reported to produce or utilize B-group vitamins to meet their nutritional requirement during fermentation (Snell, 1993). The turmeric extract incorporated in the stirred yoghurts have been discovered to be rich in B-group vitamins especially vitamins B_2, B_3, and B_{12} and some mineral elements (Table 2). So, the contributions from turmeric extract in the stirred yoghurt and starter culture during fermentation could be categorically pointed to as the factors leading to the significant ($p < 0.05$) improvement of vitamins B_2, B_3, and B_{12}in the stirred yoghurt samples. Calvince et al. (2019) reported that fermentation caused marked increase in niacin (vitamin B_3) of milk. This is consistent with the result of Gu and Li (2016).

Capozzi et al. (2012) explained that B-group vitamins are present in a number of foods but are easily destroyed or removed during food processing and that succinctly explains why their deficiencies are commonly found a large population. Vitamins C and B_6 decreased with increasing concentration of turmeric in the stirred yoghurt samples. These vitamins are heat-labile and can be destroyed or removed during pasteurization (80 to 85^{o}C) and inoculation (40 to 45^{o}C). Moreso, vitamins C and B_6 are vital nutritional requirements for lactic acid bacteria (LAB). The more the lactic acid bacteria present in the sample, the less the amount of vitamins C and B_6 turnout.

From the mineral analysis of the samples, there were significant ($p < 0.05$) improvement in the Calcium (Ca) and Phosphorus (P) of the stirred yoghurt samples wherein turmeric were incorporated. The aforementioned deductions corroborate with the reports of Hale et al. (2010), Ihemeje et al. (2015) and Mbaeyi and Anyanwu (2010). The results agreed with the assertion of Gray (2007) in which the author reported that yoghurt is a good dairy product and a source of indispensable minerals required for human metabolism and cells' functionality.

Effect of different levels of turmeric on the Microbial qualities of the stirred yoghurt

The total viable count, coliform count, Lactic Acid Bacteria (LAB) count and mould count of the stirred yoghurt samples formulated with turmeric extracts were compared to study the effect of addition of turmeric extract before fermentation and after fermentation, with the plain yoghurt sample. When compared with the plain yoghurt sample, the mould count of the yoghurt-turmeric samples before fermentation decreased from $2.1 \times 10^{1}$to 0.1×10^{1}then became undetectable as the levels of turmeric increased. Similar trend was observed after fermentation where the mould count decreased from $5\times 10^{1}$to 4×10^{1}then became not detectable (ND) at 0.3, 0.4

and 0.5% of turmeric extract incorporated. This could be traced to the antimicrobial effect of turmeric extract on the samples. This finding was in line with the report by Akande and Adegoke (2018) on production, microbiological and quality evaluation of low-fat spiced yoghurts with low glycemic loads. The total viable count of the samples decreased far more before fermentation (1.9×10^5 to 1.2×10^5)than what it was after fermentation (2.0×10^5 to 1.5×10^5). Fermentation increased the amount of viable microorganisms in the samples. The total viable count levels are very much below the acceptable range (0.0 - 8.7 cfu) according to National Yoghurt Association (NYA, 2000).Similar trend as the mould count was obtained for the coliform count of the samples. Upon the incorporation of turmeric extract, the samples' coliforms decreased to a non-detectable level before and after fermentation. It has been suggested that yoghurt should contain abundant and viable organisms of starter origin or above 1.0×10^4cfu/ml of the starter culture organisms (FAO and WHO, 2003) and, whichever format is adopted, there is a general agreement that yoghurt should contain live bacteria unless specifically designated as pasteurized or heat treated (Tamime and Robinson, 2007). 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.

Effect of different levels of turmeric on the sensory characteristics of the stirred yoghurt

There were significant ($p<0.05$) differences in colour, taste aftertaste, consistency, firmness and overall acceptability (Table 7). The sample YTB1 (95:5) scored the highest for colour (8.24±0.01), while the sample YTA5 (75:25) within the stirred yoghurt group, had the lowest score (5.43± 0.01).The plain yoghurt scored (7.93±0.01).There was a decrease in the acceptability of colour as higher amount of turmeric added this is attributed to high intense of colour in the sample due to the effect of curcumin a colouring agent in the turmeric extract. The sample YTB1 (95:5) scored the highest for taste (8.87± 0.01), while the sample YTA5 (75:25) within the stirred yoghurt group had the lowest score (5.63± 0.01).The plain yoghurt scored (7.23± 0.01) for taste. There was a decrease in the acceptability of taste ashigher amount of turmeric was added. This could be attributed to high intense of the spice taste of turmeric impacting a bitter taste in the sample. The plain yoghurt scored the highest in consistency (8.13± 0.01) and firmness (8.21± 0.01), and the sample YTA5 (75:25) had the lowest in consistency (5.28± 0.01) and firmness (5.53± 0.01). This was evident in that, higher amount of turmeric reduces the consistency and firmness of the stirred yoghurt. The sample YTB1 (95:5) has the highest score in the overall acceptability of the whole samples.

Conclusion

This study shows that turmeric extracted with ethanol have higher nutrient composition than turmeric extracted with water. The different concentrations of turmeric affected the nutritional composition of the yoghurt. pH increased with increase in concentration of the turmeric due to the alkalinity of the turmeric. The use of turmeric affected the colour of the yoghurt, changing it from white to yellowish-orange due to the curcumin in the turmeric. Although the protein and carbohydrate contents of the yoghurt samples formulated decreased with increasing concentrations of turmeric, the minerals (calcium and phosphorus) and vitamins (B_2, B_3, and B_{12}) improved significantly ($p < 0.05$) between the range of 100:0 to 75:25 before and after fermentation. There was a decrease in microbial load of the yoghurt as the concentration of turmeric increases due to the fact that turmeric possesses antimicrobial ability thus increasing the keeping quality of the yoghurt. In terms of overall acceptability, the stirred yoghurt sample with 0.1% turmeric (that is, YTB1 (95:5) was most preferred sample. Therefore, the yoghurt: turmeric concentration of 90:10 and less should be used to achieve the taste effect and colour of the stirred yoghurt.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

Ammon HP, Anazodo M, Safayh H, Dhawan BN, Srimal RC (1992). Curcumin: A potent inhibitor of Leukotriene B4formation in rat peritoneal polymorphonuclear neutrophils (PMNL). PlantaMed 58:226.

Akande AA, Adegoke GO (2018). Production, Microbiological and Quality Evaluation of Low-fat Yoghurts with Low Glycemic Loads. African Journal of Food, Agriculture, Nutrition and Development 18(2):13287-13303.

AOAC (2005).Official Methods of Analysis, 18thEd.Association of Official Analytical Chemists. Washington DC, USA.

AOAC (2010).Official Methods of Analysis.Association of Official Analytical Chemists.18th Ed. Gaithersburg, Maryland, USA.

Bar-sela G, Epelbaum R, Schaffer M (2010).Curcumin as an anti-cancer agent: review of the gap between basic and clinical applications. Current Medicinal Chemistry 17:190-197.

Boghra VR, Mathur ON (2000). Physico-chemical status of major milk constituents and minerals at various stages of shrikhand preparation.

Journal of Food Science and Technology 37:111-115.
Brul S, Coote P (1999). Preservative agents in foods: mode of action and microbial resistance mechanisms. International Journal of Food Microbiology 50(1-2):1-17.
Calvince A, Arnold O, Samuel I, Julius M (2019). Effect of Lactic Acid Bacteria Starter Cultures on Vitamins and Oligosaccharide Composition of ilk extracted from Three Common Bean (*Phaseolous vulgaris L.*) varieties. Journal of Food Research Archives 8:3.
Capozzi V, Russo P, Dueñas MT, López P, Spano G (2012). Lactic Acid Bacteria producing B-group vitamins: A great potential for functional cereal products. Applied Microbiological Technology 96:1383-1394.
Cheeseman GC, Lean MC (2000). Yoghurt Nutritional and Health Properties. Journal of National Yoghurt Association 3:35.
Cho JY, Choi GJ, Lee SW, Lim HK, Jang KS, Lim CH, Cho KY, Kim JC (2006).*In vivo* antifungal activities against various plant pathogenic fungi of curcuminoids isolated from the rhizomes of *Curcuma longa*. Plant Pathology Journal 22:94-96.
Cousins M, Adelberg J, Chen F, Rieck J (2007).Antioxidant capacity of fresh and dried rhizomes from four clones of turmeric (Curcuma longa L.) grown in vitro. Industrial Crop Production 25:129-135.
FAO, WHO (2003).CodexAlimentarius: abridged version. Joint FAO/WHO Food Standards Programme: Codex Alimentarius Commission. Smith BL (Ed). Food and Agricultural Organization of the United Nations, Rome.
Food Source Information- Colorado (2018). Yoghurt / Types of Yoghurts. Available at: www.fsi-colostate.edu/yoghurt.
Gomez KA, Gomez AA (1985). Statistical Procedures for Agricultural Research, 2nd Edition. Wiley and Sons Publishers, New York, pp. 45-67.
Gu Q, Li P (2016). Biosynthesis of vitamins by Probiotic Bacteria.In Probiotics and Prebiotics in Humans and Health, pp.136-148. China: INTECH: Open Science Open Mind.
Gray C (2007). Yoghurt and Your Health. Star Base Publishers, Washington. pp. 6-8.
Hussain JA, Bahader N, Rehman AL, Khan W, Ullah SZK (2010). Proximate And Nutrient Analysis of the Locally Manufactured Herbal Medicines and its Raw Material. Journal of America Science 6(5):91-96.
Ihekoronye AI, Ngoddy PO (1985).Integrated Food Science and Technology for the Tropics. First edition Macmillan Publishers, pp. 383.
Ihemeje A, Nwachukwu CN, Obi KC, Ekwe CC (2015). Production and Quality Evaluation of flavoured Yoghurts using Carrot, Pineapple and Spiced Yoghurts using Ginger and Pepper fruit. African Journal of Food Science 9(3):163.
Jurenka JS (2009). Anti-inflammatory Properties of Curcumin, a Major Constituent of Curcuma longa: A Review of Preclinical and clinical research, Alternative Medicine Reviews 14(2):141-153.
Kamruzzaman M, Islam MN, Raman MM, Parvin S, Rahman MF (2002).Evaporation Rate of Moisture from Dahi (Yoghurt) during Storage at Refrigerated Condition, Pakistan Journal of Nutrition 1:209-211.
Lee WJ, Lucey JA (2010). Formation and physical properties of yoghurt. Asian-Australian Journal of Animal Science 23(9):1127-1136
Mbaeyi IE, Anyanwu LN (2010). Production and Evaluation of Yoghurt flavoured with Solar-dried Bush Mango (*Irvingiagabonensis*) Pulp. Journal of Tropical Agriculture, Food, Environment and Extension 9(2):137-146.
McKinley MC (2005). The Nutrition and Health Benefits of Yoghurt – Review, Society of Dairy Technology 58:1-12.
Nagarathnam R, Rengasamy A, Balasubramanian R (2010). Purification and Properties f Cysteine Protease from Rhizomes of Curcuma longa (Linn). Journal of the Science of Food and Agriculture 90(1):97-105.
National Yoghurt Association, NYA (2000). Yoghurt Varieties. Available at http://about yogurt.com/index.
Onwuka GJ (2005). Food Analysis and Instrumentation Theory and Practice. Naphthali Prints, Lagos, Nigeria, pp. 64-76.
Pearson DA (1976). Chemical Analysis of Foods. 7th Ed. Churchill Livingstone, New York, pp. 218-336.
Prescott LM, Harley JP, Klein OA (2005). Microbial Nutrition: Types of Media. Microbiology 6th edition. McGraw Hill Publishers, New York, pp. 93-105.
Remadevi R, Surendra E, Kimura T (2007). Turmeric in Traditional Medicine. In: Turmeric: the genus Curcuma, Ravindran PN, Nirmal BN, Sivaraman K Ed. CRC press: Boca Raton, London New York. pp. 409-436.
Snell EE (1993). From Bacterial Nutrition to Enzyme Structure: A Personal Odyssey. Annual Review of Biochemistry 62:1-27.
Tamime AY and Robinson RK (2007).Yoghurt: Technology and Biochemistry. Journal of Food Protection 43:939-977.
Tonnesen HH (2002). Alginate in Drug Delivery Systems. Drug Development and Industrial Pharmacy 28(6):621-630.