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EFFECT OF TURMERIC (*CURCUMA LONGA*) SPICE ON NUTRITITIONAL, MICROBIAL CONTENT OF MOIN-MOIN AND EFFICACY OF SPICE AGAINST SELECTED FOODBORNE PATHOGENS

Ajayi Olasunmbo A.* **and Segun-Taiwo B. A.**

Food Science and Technology, College of Agriculture, engineering and Science, Bowen University, P. M. B. 284, Iwo, Osun State, Nigeria.

*E-mail: olasunmbo.ajayi@bowen.edu.ng

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ABSTRACT: *Turmeric (Curcuma longa) impacts flavor, organoleptic quality of foods and contributes to the preservation of foods. Moin-moin is an indigenous food made from beans (Vigna unguiculata) and highly perishable. This study investigated the effect of turmeric spice on quality of moin-moin, and the efficacy of turmeric on selected foodborne pathogens. Three samples were prepared with (0; 2.5 and 5g) of turmeric. Nutritional, microbial, sensory and efficacy of spice against microorganisms were performed. Moisture content ranged from (1.35 to 1.48%), protein (38.9 to 44.9%), ash (6.2 to 7.4%), fat (11 to 11.8%) and fibre (6.9 to 7.7%). TVC of samples for day zero was (3.1 to 6.8 x 10^5CFU/g); Enterobacteriaceae (1.1 to 2.1x10^5CFU/g); Staphylococcal (2.7 to 4.6 x10^5CFU/g); and Coliform (6.4 to 8.3x10^5CFU/g). After 48 h, sample with 5g of spice and refrigeration had reduced microbial load. Moin-moin with 2.5g of turmeric was generally accepted and considered the best sample. Turmeric spice was observed to be more effective against Salmonella spp. Conclusively, addition of turmeric to moin-moin was able to reduce the microbial load and improve the shelf-life of the product.*

KEYWORDS: Turmeric, Moin-Moin, Preservative, Cowpea

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INTRODUCTION

Turmeric (*Curcuma longa*) is a perennial plant, belonging to the family Zingiberaceae, along with other members like ginger, cardamom and galangal (Kandiannan *et al.,* 2008). Turmeric is a native to South East Asia, an ancient spice used in medicine, in many religious observances as a cosmetic, as a dye, as food additives. It belongs to the genus Curcuma, derived from the Arabic word "turmeric" which means yellow (Ravindran, 2007), and the part of turmeric used in food and medicine is the rhizome. Curcumin, an orange-yellow crystalline powder, it is the most important fraction which is responsible for the biological activities of turmeric, it is a potent antioxidant, in that it scavenges damaging particles in the body known as free radicals, and has been reported to possess potential health benefits for numerous inflammatory diseases such as arthritis and cardiovascular disease, as well as for cancer and diabetes (Singletary, 2010).

Furthermore, turmeric has a high nutritional status that can be exploited it contains vitamins or vitamin precursor which produces vitamin C, beta - carotene as well as polyphenol coupled with fatty acid and essential oil. Turmeric is an important component of curry and popularly consumed in Africa and some sub - Saharan countries (Chattopadhyan *et al.,* 2004).

Cowpea (*Vigna unguiculata*) is a cheap source of protein, consumed as a vegetable often in combination with cereals or grains and are incorporated into a variety of recipes which are processed into various products (Odedeji *et al*., 2011) including akara and moin-moin (Olopade *et al.,* 2004).

Moin-moin is an important dietary staple traditionally produced from steamed cowpea paste and popular in Nigeria and other West African countries (Ngoddy *et al.,* 1986). Moin-moin can be consumed alone as part of diet or with other cereal based foods such as Akamu, Agidi (fermented maize porridge) with rice or gaari (cassava). It is usually packaged in different materials such as leaves, milk tin, plastic or polyethylene bags before steaming (Olayiwola *et al.,* 2012).

The preparation of moin-moin from fresh cowpea seed is labour intensive and time consuming. Besides that, moin-moin has a short shelf life of 18-24 h (Olapade, 2004; Ayoade et al., 2012), and highly prone to spoilage.

Spices may contribute piquancy to foods and beverages (Praween and Nazia,2006), and are commonly used as natural antimicrobial agents in foods (Indu *et al.,* 2006). Turmeric extracts have been shown to have medicinal effects such as anti-fungal activities, it is also expedient to determine the efficacy of turmeric on selected foodborne bacteria. It is believed that turmeric does not only contribute to the taste and aroma of food products it also has preservative properties. Therefore, the focus of this study is to investigate the preservative effect of turmeric in foods and its efficacy against selected foodborne pathogens.

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MATERIALS AND METHODS

Source of Plant Material

About 8.0 kg of harvested rhizomes of turmeric plant (*Curcuma longa*) and 2.0 kg of red beans (*Vigna unguiculata*) were obtained from Ojee market, Ibadan Oyo state and transported to the Food Science Department of Technology Iwo, Osun State until used. Leaves *(Thaumatococcus danielli)* were also procured on production day.

Preparation of Turmeric (*Curcuma longa*) powder

Turmeric rhizomes were cleaned, sorted, to remove dirt, debris and damaged ones and were washed with running potable water. Rhizomes were peeled, crushed and dried in the cabinet (Model F300, Chris Alex Engineering, Ibadan, Nig.) drier at 65 ^{0}C for 5 h. After drying, the turmeric rhizome was milled using a blender (Master Chef blender MC-BL1544, China) until a smooth powder was obtained in order to ensure high surface area for increased diffusion (Manju *et al*., 2005). The resulting dried turmeric powder was stored in a clean air tight container in the laboratory at room (25±2 ^{0}C) temperature until used.

Preparation of Bean pudding (Moin-moin)

The red beans (*Vigna unguiculata*) were cleaned and sorted to remove dirt and debris. About 1.5 kg of red beans sample was soaked in 2 L of potable water for 20 minutes after which it was dehulled. After dehulling, 1 L of water was added to the beans which was then wet milled in a blender (Bottom discharge hammer mill Tw- 48BD, India). Further, 2 L of water was added after blending and the resulting bean paste weighed 3.9 kg. The pre-cooked cowpea paste was divided into three equal parts of 1.3 kg each, namely moin-moin without spice (MWOT); moin-moin with 2.5 g of turmeric spice (MWT1) and moin-moin with 5 g of turmeric spice (MWT2). Further, 25 g of salt and 50 mL of vegetable oil were added to each sample and mixed thoroughly. About 15 mL of the bean paste was then packaged into leaves *(Thaumatococcus daniellii*) for steaming. All samples were steamed for about 45 minutes then removed and left to cool. After cooling, samples were divided into two batches for storing at room (25±2 ^{0}C) and refrigeration (4±2 ^{0}C) temperatures in order to monitor shelf life/spoilage according to Ogundele *et al.,* (2015).

Proximate Analysis of Moin-moin Samples

All chemical analyses were performed in triplicates

Proximate composition (Moisture, protein, ash, crude fibre and fat) was determined according to AOAC (2005). Carbohydrate was determined by difference as follows: % carbohydrate = 100 – [% moisture + % fat + % ash + % protein + %fibre]

Determination of Mineral Content of Moin-moin Samples

The minerals analyzed were calcium, potassium, sodium, iron and magnesium. Mineral ash content was determined according to (AOAC, 2005). The elements, calcium (Ca) and magnesium (Mg) were determined using Atomic Absorption Spectrometer (PG 990, United Kingdom) at wavelength of 422.7nm and 285.2nm respectively. The element, sodium (Na) and potassium (K) were determined by flame photometry method using a flame photometer (Jenway PFP7, United Kingdom) at wavelength of 589.0 nm and 766.4 nm respectively.

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Physical Analysis (Colour Determination)

The colour of the samples was assessed by the method described by Hongbete *et al* (2009). The Hunter Lab colour coordinates system, L*(Lightness) a*(redness), b*(yellowness) values were recorded. The Commission Internationale de l' Eclairage (CIE) tristimulus L*a*b*parameters were determined using a colour meter CR-410 (Konica Minolta, Inc., Japan). Multiple measurements (10 points) of L*, a*and b* parameters were determined by placing the sensor of the colorimeter on the sample. All measurements were done in triplicate.

Microbiological Analyses

The microbiological analyses of the dried turmeric spice and Moin-moin samples were performed on production day and 48 h after production and storage. The dried turmeric powder was assessed for total viable, Enterobacteriaceae and Staphylococci counts. While the moin-moin samples were assessed for total viable, Enterobacteriaceae, coliform and Staphylococci counts on production day and 48 h after production. Briefly, for the microbial load of the spice, 10g of spice was mixed with 90 mL of peptone water (Himedia Lab., India) and further serially diluted up to 10^{-4}. Using the pour plate method, 1 mL of last dilution was plated in plate count agar, MacConkey and Baird Parker agar (Lab. M, United Kingdom) for total viable, Enterobacteriaceae and Staphylococci counts respectively (AMPH, 1992). Similar process was followed for the moin-moin samples except Eosin methylene blue agar for Coliform count was also inoculated. Plates were incubated at 37 ^{0}C overnight and enumerated.

Sensory Evaluation Test

All samples were cut into bite size after cooling, coded and served randomly to 15-member untrained panelists. The participants were however familiar with the product and were instructed to score on a 5-point Hedonic scale, where 1 = dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately and 5 = like very much (Meilgaard *et al.,* 1991), based on the attributes such as appearance, aroma, taste, texture and overall acceptability. Water and crackers were made available for panel members to rinse their palates between samples to prevent carry over effect and to aid in removing flavour between tasting.

Preparation of methanol turmeric extracts

A 10 g of the powdered turmeric spice was soaked in 100 mL of mixture of methanol and water (4:1) for 96 hours. After the extraction, the mixture was filtered with muslin cloth and then concentrated to remove the entire methanol using rotary evaporator (Adebisi and Ojokoh, 2011).

Preparation of bacterial inoculum

Two Gram negative and 1 Gram positive (*Salmonella* spp., *E. coli* spp. *and Staphylococcus aureus*) bacteria isolates previously identified were sub-cultured in nutrient broth and incubated. Following incubation for 18 h, 5 mL portion of broth culture of *Salmonella* spp., *E. coli* spp. *and Staphylococcus aureus* was transferred into a set of eight sterile test tubes each.

Determination of efficacy of turmeric spice against selected foodborne pathogens

Following Adebisi and Ojokoh method (2011), different concentrations of the extract were prepared at 2.5, 5, 10 and 20 mg/mL. Using a sterile pipette, 1 mL of the different concentration

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of the extract was poured into the 5 mL broth culture and further incubated for 24 h at 30 ^{0}C. The tubes were observed for growth as indicated by turbidity and confirmed with the aid of a colorimeter at 540 nm wavelength.

Statistical Analysis

Data from proximate, colour, mineral and sensory analyses was analyzed using descriptive statistics, Analysis of variance (ANOVA) with a post-hoc Duncan New Multiple Range Test in IBM SPSS Statistics 23.0 version at ($p< 0.05$) significant level.

RESULTS AND DISCUSSION

Proximate Analysis

Nutritional composition of the moin-moin samples are presented in the Table 1. From the results, there were significant differences ($p< 0.05$) in moisture and protein contents of the samples. On dry weight basis, moisture content ranged from (1.35± 0.0 to 1.48± 0.01%) with MWOT, cowpea moin-moin (control) having the highest moisture content. Protein content ranged from (38.9± 2.8 to 44.9± 0.1 %). Ash content ranged from (6.2± 0.7 to 7.4± 1.3 %). The values for the crude fat ranged from (11.0± 1.2 to 11.8± 0.2 %). Crude fiber content ranged from (6.9± 0.5 to 7.7± 0.3 %) and carbohydrate content ranged from (27.7± 1.3 to 33.8± 5.9 %). The moisture content values are below the range of moin-moin samples (36.10 to 44.12%) reported by (Akusu *et al*., 2012). It was observed that as the concentration of turmeric powder increased, the protein, fat and crude fibre content also increased significantly ($p<0.05$), while moisture and ash contents decreased. The crude protein content of the samples in this study are contradictory to the values (17-27 %) reported by (Otunola *et al*., 2018), possibly due to their addition of water yam flour. Moin-Moin without turmeric (control sample) had the least protein content and the value increased as turmeric increased. Turmeric powder contains a significant level of protein (Ikpeama *et al.*, 2014), thereby increasing the protein level in moin-moin. The fat content in moin-moin samples corresponds to Otunola *et al* (2018) report of (9-10 %) , but contradicts the report (15.3 %) of Akusu and Kiin-Kabari (2012). The ash content in all the moin-moin samples in this study is not significantly different. Moin-moin without spice (MWOT) has higher ($7.41±1.3^{a}$) content. Ash content is an indication of mineral contents in food (Adelakun *et al.*, 2009). It is unclear why the ash content of samples with the addition of turmeric spice further decreased. Although ash content of turmeric has been documented to be low (Ikpeama *et al.*, 2014). The crude fiber content was within range of the report (6.30 to 8.40 %) of (Otunola *et al* (2018). Crude fiber was also observed to be highest in moin-moin (7.71±0.3 %) with high turmeric spice though, there were no significant difference between the samples. The highest value for carbohydrate was recorded in MWOT (33.75± 5.9 %). Legumes are valuable source of carbohydrates; hence blends of cereal legume diet will satisfy both the protein and carbohydrate requirements of man (Maphosa and Jideani, 2017).

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Table 1: Proximate Composition of Cowpea paste (moin-moin) samples with turmeric spice

	Proximate Content (%)							
Sample	**Moisture**	**DM**	**Protein**	**Ash**	**Fat**	**Fiber**	**CHO**	**Energy (Kcal)**
MWOT	1.48±0.01[a]	98.5	38.9±2.8[b]	7.4±1.3[a]	11.0±1.2[a]	7.5±0.6[a]	33.8±5.9[a]	389.15
MWT1	1.37±0.03[b]	98.6	40.9±0.9[b]	6.2±0.7[a]	11.6±0.5[a]	6.9±0.5[a]	33.1±2.1[a]	400.23
MWT2	1.35±0.00[b]	98.6	44.9±0.1[a]	6.5±1.0[a]	11.8±0.2[a]	7.7±0.3[a]	27.7±1.3[a]	397.04

Values are mean ± SD of triplicate; Duncan separation of means with same alphabets are not different ($p<0.05$) in each column. DM= Dry matter; MWOT= Moin-moin without turmeric; MWT1=Moin-moin with 2.5 g of turmeric; and MWT2= Moin-moin with 5 g of turmeric.

Mineral Composition

Mineral composition of the moin-moin samples are presented in Table 2. Inclusion of turmeric spice improved the mineral contents. There were significant differences ($p< 0.05$) in the calcium (Ca), magnesium (Mg), potassium (K), Iron (Fe) and sodium (Na) content. Calcium content ranged from (88.5± 0.01 to 204.3± 0.07 mg/kg); magnesium ranged from (207.8± 0.01 to 269.8± 0.07 mg/kg); potassium ranged from (291.8± 0.07 to 410.0± 0.07 mg/kg); iron content ranged from (151.8± 0.07 to 255.5± 0.01 mg/kg) and sodium ranged from (292.3±0.07 to 315.2± 0.07 mg/kg). Potassium content was observed to be the highest in the minerals analyzed and in agreement with the finding of Cardoso et al (2021). The calcium content from this study was low compared to Adeyeye *et al* (2012), who reported (460±0.71mg/kg). Moin-Moin with 5g inclusion of turmeric (MWT2) had the highest value of (204.3± 0.00 mg/kg) while the least value was in MWOT (88.5± 0.01 mg/kg). Calcium is one the most important mineral that the body requires and its deficiency is more prevalent than any other mineral (Kanu *et al.*, 2009). Moin-Moin with 5 g of turmeric had higher amounts of all the minerals analyzed followed by the sample with 2.5 g. Different minerals have been documented to be beneficial to human health. For example, magnesium acts as an activator of many enzyme systems (Adeyeye and Agesin, 2007), potassium binds to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrium (Adeyeye and Agesin, 2007). The iron content of the products ranged from (151.8±0.07 to 255.5± 0.01 mg/kg). The highest value of iron was recorded for MWT2 and within range of the results (119-327 mg/kg) of Adeyeye *et al* (2012). The sodium content in the moin-moin samples is high and could be attributable to the addition of salt in the sample preparation. But not more than the recommended average daily intake of 3,400 mg (CDC, 2017).

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Table 2: Selected mineral content of moin-moin samples with turmeric spice

	Mineral Content (mg/kg) of moin-moin samples				
Sample	Calcium	Magnesium	Potassium	Iron	Sodium
MWOT	88.5± 0.01^{c}	207.8± 0.01^{c}	291.8± 0.07^{c}	151.8± 0.07^{c}	292.3± 0.07^{c}
MWT1	96.0± 0.07^{b}	225.3± 0.2^{b}	404.8± 0.07^{b}	198.5± 0.1^{b}	302.3± 0.1^{b}
MWT2	204.3± 0.07^{a}	269.8± 0.07^{a}	410.0± 0.07^{a}	255.5± 0.1^{a}	315.2± 0.07^{a}

Values are mean ± SD of triplicate; Duncan separation of means with same alphabets are not different ($p<0.05$) in each column. MWOT= Moin-moin without turmeric; MWT1=Moin-moin with 2.5 g of turmeric; and MWT2= Moin-moin with 5 g of turmeric.

Colour Composition of Moin-Moin Samples

The mean values for the color intensity of the moin-moin samples are presented in Table 3. The L* values ranged from (63.6 ± 0.0 to 72.3 ± 0.3) The a* value ranged from (-0.69 ± 0.07 to -5.2 ± 0.07) and b* value ranged from (7.01 ± 0.4 to 21.5 ± 0.2). The L* values implies that most of the color of the moin-moin samples without turmeric (MWOT) was tending towards white while the other samples with turmeric were tending away from white (lightness) hence the b* value of MWOT is the lowest compared to the moin-moin samples with turmeric. The higher the concentration of turmeric used, the higher the b* value (Surojanametakul *et al.*, 2010). Furthermore, the addition of turmeric increased the curcuminoid content and redness as reported by Ajayi and Bankole (2020).

Table 3: Colour composition of moin-moin samples

Parameter	L*	a*	b*
MWOT	72.3 ± 0.3^{a}	-0.69 ± 0.07^{a}	7.01 ± 0.4^{c}
MWT1	67.8 ± 0.1^{b}	-4.2 ± 0.21^{b}	20.6 ± 0.6^{b}
MWT2	63.6 ± 0.0^{c}	-5.2 ± 0.07^{c}	21.5 ± 0.2^{a}

Values are mean ± SD of triplicate; Duncan separation of means with same alphabets are not different ($p<0.05$) in each column; MWOT= Moin-moin without turmeric; MWT1=Moin-moin with 2.5 g of turmeric; and MWT2= Moin-moin with 5 g of turmeric.

Microbial Load

The microbial (TVC; Enterobacteriaceae and Staphylococcal) load for the turmeric spice are presented in Table 4. The source of microbial contaminants could be from soils, dirt from harvesting environment and inadequate washing and cleaning before milling. Microbial loads of turmeric spice were ($1.2x10^{6}$ CFU/g); ($1.1x10^{6}$ CFU/g); and ($6.1x10^{5}$ CFU/g) for total viable, Enterobacteriaceae and Staphylococcal counts respectively.

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Table 4.: Microbial content (CFU/g) of turmeric spice

Sample	Total viable	Enterobacteriaceae	Staphylococcal
Turmeric spice	1.2×10^{6}	1.1×10^{6}	6.1×10^{5}

CFU=Colony Forming Unit

Microbial Load of Moin-Moin sample at Day 0 and 48 h

On production day, total viable count for the moin-moin ranged from (3.1 ± 2.1^{b} to $6.8\pm5.6^{a}x10^{5}$ CFU/g); Enterobacteriaceae count ranged from (1.1 ± 1.4^{b} to $2.1\pm4.2^{a}x10^{5}$ CFU/g). Staphylococcal count ranged from (2.7 ± 4.2^{b} to $4.6\pm2.8^{a}x10^{5}$ CFU/g). Coliform counts for the moin-moin were (6.4 ± 5.6^{b} to $8.3\pm4.2^{a}x10^{5}$ CFU/g) (Table 5). The presence of Enterobacteriaceae are usually indicators of post processing contamination of heat-treated food. With the addition of turmeric, it was observed that the microbial counts reduced, when compared to the control sample. After 48 hours of storage at varying temperatures, total viable count for the moin-moin sample kept at room (32 ± 2 ^{0}C) temperature ranged from ($7.9\pm1.4^{b}x10^{5}$ to $1.3\pm2.5^{a}x10^{6}$ CFU/g), and (6.4 ± 4.1^{b} to $8.9\pm1.4^{a}x10^{5}$ CFU/g). Enterobacteriaceae counts after storage were (1.5 ± 0.7^{b} to $3.5\pm4.2^{a}x10^{5}$ CFU/g) and ($4.5\pm0.7^{b}x10^{4}$ to $1.2\pm0.2^{a}x10^{5}$ CFU/g); Staphylococcal counts ranged from ($8.9\pm1.0^{c}x10^{5}$ to $2.6\pm0.8^{a}x10^{6}$ CFU/g) and ($4.1\pm2.1^{b}x10^{5}$ to $1.6\pm6.3^{a}x10^{6}$ CFU/g); and Coliform ranged from (7.0 ± 0.7 ^{c} to $9.0\pm0.7^{a}x10^{5}$ CFU/g) and (5.0 ± 2.8^{b} to $7.3\pm1.4^{a}x10^{5}$ CFU/g) for room and refrigeration temperatures respectively. Sample MWT2 showed a one log reduction in the microbial counts. This means the introduction of turmeric spice in moin-moin can prolong the shelf-life of the product and to further reduce the load, the moin-moin samples should be heated before consumption.

Table 5: Microbial Load (CFU/g) of moin-moin sample with turmeric during storage at room and refrigeration temperature

Sample	Microbial load (CFU/g)			
	TVC	**Enterobacteriaceae**	**Staphylococcal**	**Coliform**
Day 0				
MWOT	$6.8\pm5.6^{a}x10^{5}$	$2.1\pm4.2^{a}x10^{5}$	$3.5\pm4.2^{a}x10^{5}$	$8.3\pm4.2^{a}x10^{5}$
MWT1	$3.1\pm2.1^{b}x10^{5}$	$1.1\pm1.4^{b}x10^{5}$	$2.7\pm4.2^{b}x10^{5}$	$6.4\pm5.6^{b}x10^{5}$
MWT2	$5.8\pm2.8^{a}x10^{5}$	$1.1\pm1.4^{b}x10^{5}$	$4.6\pm2.8^{a}x10^{5}$	$6.6\pm2.1^{b}x10^{5}$
48 h storage @ (32 ± 2^{0}C)				
MWOT	$1.3\pm2.5^{a}x10^{6}$	$3.5\pm4.2^{a}x10^{5}$	$2.6\pm0.8^{a}x10^{6}$	$9.0\pm0.7^{a}x10^{5}$
MWT1	$1.0\pm5.6^{a}x10^{6}$	$1.7\pm1.4^{b}x10^{5}$	$1.5\pm0.8^{b}x10^{6}$	$7.5\pm1.4^{b}x10^{5}$
MWT2	$7.9\pm1.4^{b}x10^{5}$	$1.5\pm0.7^{b}x10^{5}$	$8.9\pm1.0^{c}x10^{5}$	7.0 ± 0.7 $^{c}x10^{5}$
48 h storage @ (4 ± 2 ^{0}C)				
MWOT				
MWT1	$8.9\pm1.4^{a}x10^{5}$	$1.2\pm0.2^{a}x10^{5}$	$1.6\pm6.3^{a}x10^{6}$	$7.3\pm1.4^{a}x10^{5}$
MWT2	$8.1\pm3.5^{a}x10^{5}$	$1.0\pm1.4^{a}x10^{5}$	$4.7\pm3.5^{b}x10^{5}$	7.0 ± 0.7^{a} $x10^{5}$
	$6.4\pm4.1^{b}x10^{5}$	$4.5\pm0.7^{b}x10^{4}$	$4.1\pm2.1^{b}x10^{5}$	$5.0\pm2.8^{b}x10^{5}$

MWOT: Moin-moin without turmeric; MWT1: Moin-Moin with 2.5g of turmeric; MWT2: Moin-Moin with 5g of turmeric; TVC: Total viable count CFU=Colony Forming Unit

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Sensory Evaluation

Sensory scores ranged from (2.9±0.46 to 3.6 ± 0.00); (3.3±0.81 to 3.7±0.88); (3.0±0.84 to 4.1± 0.79); (3.1± 0.63 to 3.4± 0.98) and (2.8± 0.87 to 3.9 ± 0.00) for colour, aroma, taste, texture and overall acceptability. These scores were significantly different (P<0.05). Bean cake (moin-moin) with 2.5 g of turmeric (MWT1) was scored higher in colour (3.8), aroma (3.7), taste (4.1), and overall acceptability (3.9). Moin-moin without turmeric (MWOT) was scored higher only in texture and MWT2 with 5 g turmeric was scored low consistently (Figure 1).

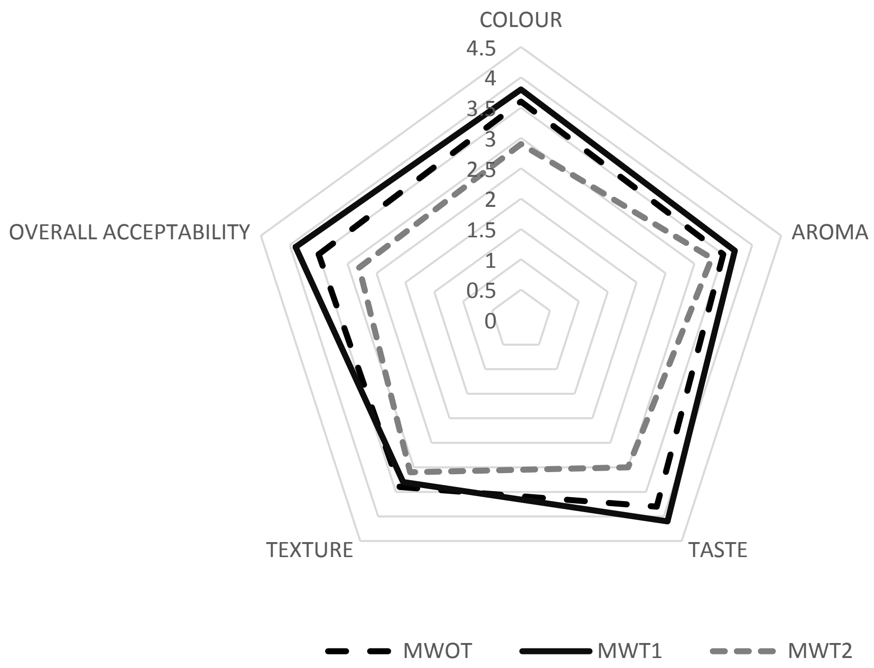

Figure 1: Values are mean scores of panelists for sensory attributes. MWOT= Moin-moin without turmeric; MWT1=Moin-moin with 2.5 g of turmeric; and MWT2= Moin-moin with 5 g of turmeric

Efficacy of Turmeric Spice Against Selected Microorganisms

Figure 2 shows the antimicrobial activity of turmeric spice extracted in methanol against *Salmonella* spp., *Escherichia coli* and *Staphylococcus aureus.* The spice extract minimum absorbance was (0.39); (0.38) and (0.35) at 2.5mg/mL and maximum absorbance was (0.88); (0.61) and (0.55) at 20mg/mL concentration of extract. Turmeric extract was slightly more effective against enteric microorganisms in this study, particularly *Salmonella* spp and less effective against *Staphylococcus aureus*.

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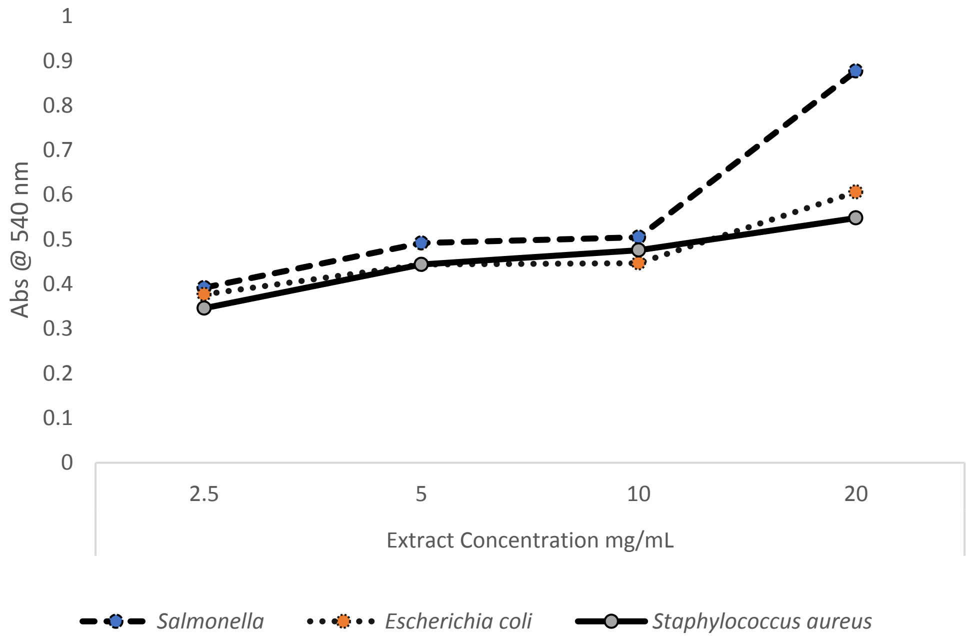

Figure 2: Efficacy of Turmeric spice against selected microorganisms at varying concentration

A Spearman *rho* correlation coefficient was calculated for the relationship between the various treatments and sensory attributes (colour, aroma, texture, taste and overall acceptability) of moin-moin samples. The correlation between various treatments of samples and sensory attributes was observed to be strong except aroma (ρ (45)=-.091 p<0.554) and texture (ρ (45)=-.232 p<0.126). There were strong positive correlations between colour (*rho* (45) =.644**, *p* .000); aroma (*rho* (45) =.385**, *p* .09); texture (*rho* (45) =.542**, *p* .000); taste (*rho* (45) =.767**, *p* .000); and overall acceptability (Table 6).

Table 6: Spearman's ρ correlation between overall acceptability of moin-moin and sensory attributes

	Sensorv Attributes				
	Colour	Aroma	Texture	Taste	Overall acceptability
Treatment	ρ(45)=-.408**	ρ(45)=-.091 p<0.554	ρ(45)=-.232 p<0.126	ρ(45)=-.359* p<0.15	ρ(45)=-.360* p<0.15
Colour	p<0.05	ρ(45)=.422** p<0.04	ρ(45)=.193 p<0.205	ρ(45)=.718** p<0.00	ρ(45)=.644** p<0.00
Aroma			ρ(45)=.366* p<0.13	ρ(45)=.468** p<0.01	ρ(45)=.385** p<0.09
Texture				ρ(45)=.471** p<0.01	ρ(45)=.542** p<0.00
Taste					ρ(45)=.767** p<0.00

** Correlation is significant at (p<0.01); * Correlation is significant at (p<0.05)

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CONCLUSION

Other spices such as onion and pepper were not used to season the moin-moin samples in this study, in order to observe the effect of turmeric on the quality of the food. Study showed that turmeric spice can serve as a substitute for natural preservative or added along the other spices in indigenous foods. The moin-moin samples contain desired amounts of nutrients such as protein, carbohydrates, minerals, fat, fibre and ash. The microbial contents were either unchanged or reduced by at least 1 log during storage. Furthermore, the most acceptable moin-moin samples as shown in the sensory analysis was the moin-moin sample containing 2.5g turmeric. Turmeric possesses antimicrobial activity and is more effective against various foodborne pathogens such as *Salmonella* spp. and *Staphylococcus aureus*. Further investigation on the preservative effect of turmeric spice on indigenous foods should be encouraged.

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