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ANTIMICROBIAL ACTIVITY OF GUAVA LEAF ON CHICKEN MEATBALLS AND CHICKEN CHIPS AND COMPARATIVE STUDIES OF THEIR WATER ACTIVITY AND MONOLAYER MOISTURE

AUTHORS:
N. O. Alamuoye[1,*], and O. F. Alamuoye[2]

AFFILIATIONS:
[1]Food Science and Technology Department, School of Agriculture and Agricultural Technology, Bamidele Olumilua University of Education Science and Technology, Ikere Ekiti, Nigeria.
[2]Animal Science Department, Faculty of Agricultural Science, Ekiti State University, Ado Ekiti, Nigeria.

***CORRESPONDING AUTHOR:**
Email: alamuoye.nathaniel@bouesti.edu.ng

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Abstract

The antimicrobial activity of guava leaves on chicken meatballs and chicken chips and the comparative analysis of their water activity and monolayer moisture content were investigated. The objectives of this study were to determine the effects of guava leaf slurry and essential oils on the microbial load of chicken meatballs and chicken chips and to evaluate the products' water activity and monolayer moisture content. Five kilograms of boneless breast muscle from broiler chickens were ground, mixed with nonmeat ingredients manually for 5 minutes, and rolled into meatballs. Each meatball was rolled in succession in an already whisked raw whole egg and coated with wheat flour inside a round mixing bowl. The frozen breast muscle was slightly thawed and cut into thin slices of approximately 2 mm in thickness via a very sharp knife. Slices of chicken breast muscle were coated with a mixture of the prepared marinade. The coated chicken flat chips and chicken meatballs were chilled for 2 hours for the marinade to penetrate the muscles before they were fried in vegetable oil (canola oil) to produce chicken meatballs and chicken chips. Guava leaf slurry and essential oils were used for the antimicrobial tests. The results revealed that chicken chips and meatballs had 0.466 and 0.764 for water activity and 17.50 and 15.80 for monolayer moisture respectively, whereas the microbial load of chicken meatballs coated with guava leaf slurry was minimal to quantify until day 10, whereas from day 15, a microbial load of $3.3x10^5$ CFU/ml was enumerated and increased to $4.9x10^5$ on day 25. Chicken chips coated with guava leaf slurry were also found to be too small to quantify until day 25. In conclusion, the slurry and essential oil of guava leaves inhibited microbial growth in chicken meatballs and chicken chips.

1.0 INTRODUCTION

The guava leaf, scientifically known as *Psidium guajava*, is classified within a complex taxonomic system that organizes the plant on the basis of morphological attributes. Guava, which belongs to the Myrtaceae family, originates from tropical American regions. Guava leaves exhibit particular characteristics, such as oblong shapes, smooth surfaces, and marked veins. In terms of taxonomy, it is categorized under the order Myrtales and subfamily Myrtoideae [1-5]. The bioactive compounds present in guava leaves, such as tannins, flavonoids, and phenolic compounds, are believed to be responsible for their antimicrobial effects [6]. Guava leaf extract has demonstrated significant antibacterial activity against both gram-positive and gram-negative bacteria, including *Staphylococcus aureus*,

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Salmonella typhi, *Shigella boydii*, and *Enterococcus feacalis* [7].

The use of guava leaves as antimicrobial agents is promoted by their traditional use, safety profile, availability, and ease of accessibility, making them a viable option for natural meat preservation [8]. Recently, the attention given to guava leaves has increased. This might be related to its potential antimicrobial characteristics. Various studies have proposed that guava leaves contain a vast array of bioactive molecules, namely, quercetin and tannins, in addition to flavonoids, which have effects on bacteria, fungi, and viruses [9-11]. These attributes render guava leaf extract an intriguing natural contender against artificially concocted antimicrobial forms, revealing particular relevance within the realm of food production, wherein foodborne pathogen-related maladies present significant issues [12]. Empirical evidence frequently highlights the ability of guava leaf extract to thwart growth among diverse pathogenic bacteria, including *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* spp. [13-15]. Moreover, the extract is also has antioxidant and anti-inflammatory properties due to the presence of compounds such as β-caryophyllene and limonene in guava leaf essential oils [12, 16].

A shift in inclination among consumers towards safer and more natural means of food preservation has been observed, catalyzing the transition to the use of natural antimicrobial agents in meat storage. The integration of plant-origin antimicrobials into meat products delineates an auspicious route for increasing food safety and prolonging shelf-life, concurrently preserving the nutritional value of the products. Plants have long been recognized for their antimicrobial and antioxidant properties, making them a potential solution for combating microbial growth and oxidative deterioration in meat. *Yucca baccata* butanoic extract (YBE) contains saponins that inhibit microbial growth, extending the shelf-life of chicken and beef [17]. *Moringa oleifera* leaf extract (MLE) has been explored and found to reduce spoilage bacteria and pathogens such as *E. coli*, *Salmonella*, and *Staphylococcus* in ground beef without affecting sensory attributes [18]. The unique composition of banana plant extracts, which are rich in antimicrobial compounds such as dopamine and gentisic acid, has led to their use as natural preservatives in meat products [19]. Herbs and spices such as parsley, dill, basil, oregano, sage, coriander, rosemary, marjoram, tarragon, bay, thyme, and mint, which are commonly used, have antimicrobial traits documented, and these traits can impede the proliferation of pathogens and spoilage microorganisms within meat [20].

Earlier research endeavors have indicated that extracts derived from cranberry and pomegranate, whether utilized independently or in tandem with essential oils such as those from thyme and oregano, manifest significant antimicrobial properties against an assortment of pathogens typically present in pork meatballs [21]. Recent investigation have revealed that extracts from the *Cynara scolymus* plant, commonly known as artichoke, exhibit significant antimicrobial capabilities that strongly hinder the proliferation of diverse foodborne pathogens. The implemented natural extract has revealed encouraging outcomes relative to the prolongation of minced meat product shelf-life by efficaciously diminishing microbial contamination metrics [22]. Earlier research endeavors have highlighted the probable antimicrobial attributes of *Amaranthus tricolor* extract, highlighting its efficacy against *Staphylococcus aureus*. This extract has potential as a natural substitute for maintaining the quality of cooked pork commodities during storage [23]. Additionally, previous investigations have shown that the use of diverse plant powders, including apple, onion, blackcurrant berries, garlic, tomato, and rhubarb petioles, has a notable ability to impede microbial proliferation within minced pork and is applicable to both uncooked and cooked varieties [24]. Ethanolic extracts of *Thymus daenensis* and *Camellia sinensis* have demonstrated antimicrobial and antioxidant effects, making them effective natural preservatives for chicken meat during frozen storage [25].

Water activity, a key parameter influencing the stability and safety of food products, plays a vital role in determining the overall quality and shelf-life of meatballs and chicken chips. Understanding the water activity of these products is essential to avoid potential hazards related to microbial growth and spoilage [26, 27]. Additionally, monitoring water activity can help determine the optimal storage conditions to keep the product fresh properly [28]. The food industry has been constantly evolving to meet the demands of consumers for healthier and more convenient food options [29]. One area of interest in this evolution is the use of monolayer moisture technology in food products [30, 31]. Monolayer moisture refers to the minimum amount of moisture required for a food product to maintain its quality and freshness [32, 33]. Monolayer moisture also denotes the quantum of moisture present in a foodstuff wherein all potential binding sites within the food matrix are saturated with water molecules, resulting in a monolayer

configuration of water [34, 35]. This concept has critical importance in the comprehension of the physicochemical properties prevalent within foodstuffs, which impinge upon various attributes, including water activity, structural robustness, and microbial inhibitive capabilities. Empirical investigations have revealed that sustaining an ideal level of monolayer moisture within foodstuffs can augment their sensory properties and prolong their shelf-life sustainably [36, 37]. Moreover, the interrelationship between monolayer moisture and foodstuff quality remains intricate, and involves a myriad of interactions including moisture content, protein denaturation, and lipid peroxidation, among other variables. Hence, elucidation of the fundamental of monolayer moisture is indispensable for the optimization of the manufacturing and quality regulation of meat products such as chicken meatballs and chicken chips.

Despite these promising findings, considerable research gaps remain regarding the specific microbial growth inhibition effects of guava slurries and essential oils on meat products such as chicken chips and chicken meatballs. This research aimed to determine the effects of guava leaf slurry and essential oils on the microbial load of chicken meatballs and chicken chips. Additionally, comparative analyses of water activity and monolayer moisture content between chicken chips and chicken meatballs have not received the needed attention. This study aims to evaluate the water activity and monolayer moisture levels of chicken chips and meatballs and their implications for the stability of these products.

2.0 MATERIALS AND METHODS

2.1 Procedure for the Preparation of Chicken Meatballs

Five kilograms of boneless breast muscle from broiler chickens were procured from a reputable meat shop in Ibadan, Nigeria. The raw meat was thoroughly rinsed with running water. The boneless breast muscle of the broiler chickens was ground and mixed with nonmeat ingredients (Table 1) manually for 5 min. The mixture was rolled into meatballs of approximately 50 g each using a cookie scoop. Each meatball was rolled in succession in an already whisked raw whole egg and coated with wheat flour inside a round mixing bowl. The coated meatballs were separately set onto a plastic packaging film lined with parchment paper and chilled for 2 hours before cooking. The marinated meatball samples were fried in vegetable oil (canola oil) by deep-frying under low-medium heat to an internal temperature of 74 ℃ with the aid of a digital food thermometer probe, cooled, drained, dried, and weighed. The process was repeated three more times to produce replicates for the experiment.

2.2 Procedure for the Preparation of Chicken Chips

Five kilograms of procured boneless breast muscle from broiler chickens were thoroughly rinsed with running water. The muscle was allowed to freeze to facilitate easy cutting into slices. The frozen breast muscle was slightly thawed and cut into thin slices of approximately 2 mm in thickness via a very sharp knife. Slices of chicken breast muscle were coated with a mixture of the prepared marinades (Table 1). The coated chicken flat chips were packed into a plastic packaging film lined with parchment paper and chilled for 2 hours for the marinade to penetrate the sliced muscles before cooking. The marinated slices of chicken chips were fried in vegetable oil (canola oil) by deep-frying under low-medium heat to an internal temperature of 74 ℃ with the aid of a digital food thermometer probe. The fried slices were removed from the oil, cooled, drained, dried with a paper towel, and weighed. Three replicates were produced to obtain reliable data from the experiment.

Table 1: Dried nonmeat ingredient compositions of chicken meatballs and chicken chips

Ingredients	Composition (g/100g)
Onion powder	3.0
Ginger paste	1.0
Garlic paste	1.0
Bread crumbs	30.0
Chili pepper	2.5
Maggi Seasoning	1.5
Curry Powder	2.0
Skim milk Powder	15.0
Wheat flour	28.0
Salt	1.0
Egg white	15.0

2.3 Gathering of *Psidium guajava* Leaves

The acquisition of *P. guajava* foliage involved sourcing samples from fully-developed trees in their indigenous surroundings at the Afolu Farm Settlement, in Ise Ekiti, Ekiti State, Nigeria (longitude: *5.3945°E* and latitude: *7.4453°N*). The collected leaves were identified at the University Herbarium of Plant Science and Biotechnology Department, Bamidele Olumilua University of Education, Science and Technology, Ikere Ekiti.

2.4 Essential Oil Extraction

One hundred grams of identified *P. guajava* leaves were rinsed thoroughly, air-dried, and pulverized. This mixture was subjected to hydrodistillation for 4 hours with the aid of a Clevenger apparatus. A total of 0.56% of the collected essential oil was dried over

anhydrous sodium sulfate and stored in sealed vials at 4°C until further use.

2.5 Application of Guava Leaf Essential Oils to Chicken Meatballs and Chicken Chips

Five grams (5g) samples of chicken meatballs and chicken chip products were lightly coated with the essential oils of guava leaves. The coating was performed with a small artistic brush. The samples were wrapped in aluminium foil paper and stored at refrigeration and room temperature for 25 days. The microbial load was enumerated at five-day intervals. The control samples were left untreated with the essential oil of guava leaves.

2.6 Preparation of Guava Leaf Slurry

Fresh guava foliage was washed and cleaned thoroughly with deionized water to remove dirt and other contaminants collected from the field. Five hundred grams of rinsed guava leaves were milled into a slurry without the addition of water in a ball-bearing mill (IQ Mill-2070, Frontier Lab, Japan). The slurry was kept in the freezer before use.

2.7 Application of Guava Leaf Slurry to Chicken Meatballs and Chicken Chips

The chicken meatball and chicken chip products were coated at a ratio of 2 to 4 (slurry to product) with the prepared guava leaf slurry and immediately transferred into the dehydrator to dehydrate the moisture present in the slurry before being stored at refrigeration and room temperature for 25 days. The samples to be stored were wrapped in triplicate with aluminum foil paper. The control samples were not coated with a slurry of guava leaves.

2.8 Adsorption procedure for chicken meatballs and chicken chips

A structured experimental process utilizing the gravimetric method [38] was used to determine the sorption isotherms of chicken meatballs and chicken chips. This technique involves subjecting food samples to various relative humidities ranging from 8.5 to 98.2% RH created by different saturated salt solutions [39] within a controlled setting and then quantifying the resulting weight fluctuations as moisture is adsorbed. The exposure of the sample to progressive increases in humidity continued until equilibrium was attained. Guggenheim-Anderson-de Boer (GAB) models were employed to fit the experimental data, providing insights into the sorption parameters of the samples' water activity and monolayer moisture content specific to chicken meatballs and chips. The equilibrium moisture content was determined at 25°C as the methodical execution of triplicate experiments was maintained.

Table 2: Salt solutions used for the sorption isotherms

Salt	Aw (10^0C)
Zinc bromide ($ZnBr_2$)	0.085
Potassium Hydroxide (KOH)	0.123
Lithium Iodide (LiI)	0.206
Magnesium Chloride ($MgCl_2$)	0.335
Sodium Iodide (NaI)	0.418
Trisodium tribromide Br_3Na_3	0.622
Potassium Iodide (KI)	0.721
Potassium Chloride (KCL)	0.868
Potassium Nitrate (KNO_3)	0.960
Potassium Sulfate (K_2SO_4)	0.982

2.9 Determination of Equilibrium Moisture Content

When investigating the equilibrium moisture content (EMC) of chicken meatballs and chicken chips, a meticulous methodology was used to affirm the precision and dependability of the outcomes. The samples of known moisture content were subsequently positioned in a regulated setting with predetermined temperature and humidity parameters until equilibrium was attained. The moisture content was determined via samples of chicken meatballs and chicken chips that were dried to a fixed weight in an oven maintained at 105°C. The moisture content and equilibrium moisture content of the chicken meatballs and chicken chips were quantified in triplicate via computations with slight modifications, as described in equations (1) and (2).

$$\mathrm{MC} = \frac{Wi - Wf}{Wi} \text{ X } 100 \text{ [40]} \quad (1)$$

Where, MC = moisture content, wi = initial weight, wf = final weight

$$\mathrm{EMC} = \frac{Wy}{Wu}(\mathrm{Me} + 1) - 1 \text{ [41]} \quad (2)$$

Where, EMC is the equilibrium moisture content, Wy is the weight of the sample at equilibrium (g), Wu is the initial sample weight (g), and Me is the initial moisture content of the sample (g).

2.10 Determination of Water Activity and Monolayer Moisture

The methodology employed in this research involved the use of the GAB model to determine water activity and monolayer moisture content in chicken meatballs and chicken chips [42]. The reorganization of GAB models into second-degree polynomials was used for more accurate determination of water activity and monolayer properties.

$$\text{GAB Equation} = \frac{M}{M_m} = \frac{ABaw}{(1 - Baw)(1 - Baw + ABaw)} \text{ [43]} \quad (3)$$

$aw/M = Aaw^2 + Baw + C$ (4)
Where, aw = water activity, M_m = GAB Monolayer

$M_o - Monolayer\ value = {}^{1}/_{\sqrt{b^2}} - 4ac$ (5)

2.11 Enumeration of the Total Viable Counts

The antimicrobial effects of guava leaves on chicken chips and meatballs were determined as follows: Samples of processed chicken meatballs and chips were wrapped in aluminum foil and stored in a refrigerator 2-4°C and at room temperature (20-25°C) for 25 days. The total bacterial load was enumerated at five-day intervals. The agar medium was prepared by melting it and then cooling it to approximately 45-50°C to avoid thermal destruction of the organisms. Samples of both processed chicken chips and meatballs (10 g) were macerated in 90 ml of distilled water in a conical flask in triplicate and were adequately mixed and used as stocks. The pour plate approach for enumerating microbial load represents an extensively utilized procedure within the field of microbiology, as the formulation of agar plates incorporates diluted samples (serial dilutions of 10^{-1} to 10^{-10}) to promote the proliferation and subsequent tallying of viable bacterial entities [44, 45]. This method facilitates accurate quantification of microbial populations extant within the sample. One milliliter of each of the serially diluted samples was mixed with agar before being poured into Petri dishes and gently swirled to ensure even distribution of the microbes. The plates were then incubated at 37°C for 1 day and upside down to prevent condensation from dripping onto the agar surface, which could disrupt colony growth. After an appropriate incubation period, colonies were counted and recorded for further analysis.

$$\frac{CFU}{ml} = \frac{\text{Colonies formed}}{\text{Dilution factor X ml plated}} \quad [44] \qquad (6)$$

2.12 Statistical Analysis

IBM SPSS Statistics 20 was used to conduct the statistical analysis, particularly one-way ANOVA with post hoc multiple comparisons with Hochberg's GT2 at an alpha level of 0.05. [46]

3.0 RESULTS AND DISCUSSION

The samples of the produced chicken meatballs and chicken chips used for this study are shown in Figures 1 and 2.

The equilibrium moisture contents of the sorption isotherms of the chicken chips and chicken meatballs ranged from 7.78-27.89 and from 5.99-25.12 respectively, across the water activity experiments (Table 3).

Figure 1: Samples of chicken meatballs produced for the study

Figure 2: Samples of chicken chips produced for the study

The outcomes of this research yielded notable perspectives pertinent to determinants impacting the equilibrium moisture content within meat commodities. The elevated equilibrium moisture content discerned in chicken chips, contrast to meatballs, can be attributed to various primary elements, including the product surface area, structural variations, and processing methodologies. Compared with chicken chips, the use of minced chicken breast muscle for the production of meatballs may have caused chicken meatballs to lose the capacity to absorb moisture at an equilibrium state. The processing methodology adopted for chicken chips, which involves cutting chicken breast muscle into thin slices of approximately 2 mm in thickness, may also have engendered structural variation in the product, rendering it susceptible to increase moisture uptake [47].

Figure 3 shows the adsorption isotherm curves of chicken chips and chicken meatballs. The equations of the line of the second-order polynomial for chicken chips and chicken meatballs were $y = -0.0242x^2 + 0.0497x + 0.0091$ and $y = -0.0258x^2 + 0.0533x + 0.0113$ whereas, the fitness of the curve for chicken

chips and chicken meatballs, as denoted by R^2 was 0.9495 and 0.9677, respectively.

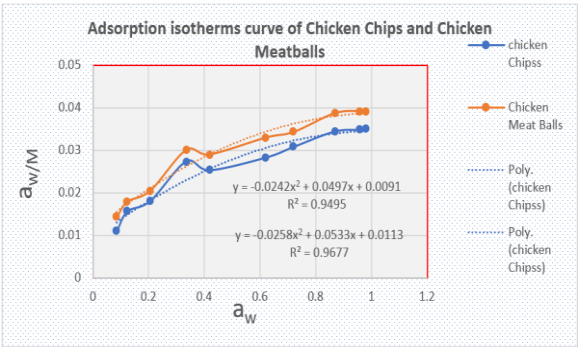

Figure 3: Adsorption isotherm curves of chicken meat balls

Table 4 shows the results of the sorption analysis of chicken chips and chicken meatballs fitted with the GAB model. The water activity and monolayer moisture content analyses of the chicken chips and chicken meatballs revealed that the chicken chips had 0.466 water activity and 17.5 monolayer moisture content, whereas the chicken meatballs had 0.764 and 15.80 water activity and monolayer moisture content. An examination of the sorption isotherms of chicken meatballs and chicken chips, clearly revealed, that the differences in water activity can be attributed to the varying structural compositions of the two products. Chicken meatballs, being a denser and more tightly packed product, have higher water activity, as they offer more opportunities for water molecules to interact and move within the product [48]. In contrast, chicken chips, with their more porous and less dense structure, limit water retention, free water availability, and movement of water molecules, resulting in lower water activity. This underscores the importance of comprehending the structural properties of food products terms of their water activity, as it directly impacts their value, safety, and life.

Sorption isotherm analysis, clearly revealed that the monolayer moisture content in chicken chips is greater than that in meatballs. The unique composition of chicken chips, with a relatively high surface area to volume ratio, allows for increased interaction with moisture molecules, leading to increased monolayer moisture content [49]. Understanding the differences in monolayer moisture content between these two popular snack foods is crucial for food scientists and manufacturers to optimize processing methods and packaging to maintain the standard of the product.

Table 3: Sorption isotherms of chicken chips and chicken meatballs

Water activity (a_w) (15^0C)	Adsorption			
	Chicken Chips		Chicken Meat Balls	
	EMC (M)	$a_{w/M}$	EMC (M)	$a_{w/M}$
0.085	7.78±0.05[a]	0.0109	5.99±0.02[a]	0.0142
0.123	7.86±0.03[a]	0.0156	6.87±0.05[b]	0.0179
0.206	11.34±0.02[b]	0.0181	10.05±0.03[c]	0.0205
0.335	12.24±0.03[c]	0.0274	11.13±0.01[d]	0.0301
0.418	16.53±0.05[d]	0.0253	14.41±0.02[e]	0.0290
0.622	21.95±0.01[e]	0.0283	18.84±0.05[f]	0.0330
0.721	23.4±0.05[f]	0.0308	21.02±0.07[g]	0.0343
0.868	25.24±0.02[g]	0.0344	22.45±0.03[h]	0.0387
0.96	27.58±0.04[h]	0.0348	24.52±0.03[i]	0.0392
0.982	27.89±0.03[i]	0.0352	25.12±0.02[j]	0.0391

EMC = M = Equilibrium moisture content

Table 4: Sorption analysis of chicken meatballs and chicken chips fitted with the GAB model

Sample name	Water activity (a_w)	Monolayer moisture content (Mo) (g H_20/g Solid)	R^2
Chicken Chips	0.466	17.5	0.949
Chicken Meatballs	0.764	15.80	0.968

The microbial load of chicken chips and chicken meatballs coated with slurry and essential oil from guava leaves and stored at refrigeration temperature for 25 days was so minimal to quantify (Table 5), whereas at room temperature (20-25°C) for the same number of days, the microbial load varied across products. The microbial load of chicken meatballs coated with guava leaf slurry was minimal to quantify until day 10, whereas from day 15, a microbial load of $3.3x10^5$ CFU/ml was enumerated and increased to $4.9x10^5$ on day 25. The number of chicken chips coated with guava leaf slurry was also minimal until day 25 (Table 6). Furthermore, the microbial load of chicken chips and chicken meatballs coated with the essential oil of guava leaves was too low to quantify throughout the 25 days of storage at room temperature (Table 6)

The findings of this research shed light on the impact of storage temperature on the microbial load in chicken chips and meatballs. These results demonstrate that higher storage temperatures lead to

increased bacterial growth in both products [50, 52]. This poses a significant food safety risk, as high levels of microbial contamination can result in foodborne illnesses [53, 54].

The results of the experiment further revealed that the microbial load of the uncoated chicken products was significantly greater than that of the chicken chips. The use of guava leaf slurry as a coating on chicken products significantly affects the microbial load during storage at room temperature. The results revealed that, compared with chicken chips, chicken meatballs presented a greater microbial load when coated with guava leaf slurry as the number of days of storage increased. This difference can be attributed to various factors, such as surface area, coating penetration into the meat [55], and the overall composition of the products. Additionally, it is important to consider the influence of the water activity of these products, as this factor also influences microbial growth [56, 57].

The results of the present study revealed interesting findings regarding the microbial load in chicken meatballs and chips coated with guava leaves. Compared with those of the control samples, the microbial counts of both types of food products significantly decreased after the application of the guava leaf slurry coating. These findings that the antimicrobial properties of guava leaves effectively inhibited the growth of bacteria in the food products. However, the reduction in microbial load was more pronounced in the chicken chips than in the meatballs. This difference could be attributed to the surface area and texture of the two food products, which may have influenced the interaction between the guava leaf coating and the microbes present.

Table 5: Microbial loads of chicken chips and chicken meatballs coated with slurries and essential oils from guava leaves and stored at refrigeration temperatures (2-4°C) for 25 days

Days	Products coated with guava leaf slurry and stored at refrigeration temperature			
	Chicken meatballs		Chicken chips	
	Control Log^{-4} cfu/ml	Treatment Log^{-4} cfu/ml	Control Log^{-4} cfu/ml	Treatment Log^{-4} cfu/ml
5	SMTQ	SMTQ	SMTQ	SMTQ
10	SMTQ	SMTQ	SMTQ	SMTQ
15	SMTQ	SMTQ	SMTQ	SMTQ
20	SMTQ	SMTQ	SMTQ	SMTQ
25	SMTQ	SMTQ	SMTQ	SMTQ
	Products coated with essential oil of guava leaves and stored at refrigeration temperature			
5	SMTQ	SMTQ	SMTQ	SMTQ
10	SMTQ	SMTQ	SMTQ	SMTQ
15	SMTQ	SMTQ	SMTQ	SMTQ
20	SMTQ	SMTQ	SMTQ	SMTQ
25	SMTQ	SMTQ	SMTQ	SMTQ

SMTQ = so minimal to quantify

Table 6: Microbial load of chicken chips and chicken meatballs coated with slurry and essential oil from guava leaves and stored at room temperature (20-25°C) for 25 days

Days	Products coated with guava leaf slurry and stored at room temperature			
	Chicken meatballs		Chicken chips	
	Control Log^{-4} cfu/ml	Treatment Log^{-4} cfu/ml	Control Log^{-4} cfu/ml	Treatment Log^{-4} cfu/ml
5	$4.2X10^5 \pm 2.0^a$	SMTQ	$3.2\ X10^5 \pm 2.0^a$	SMTQ
10	$6.4\ X10^5 \pm 1.0^b$	SMTQ	$4.5\ X10^5 \pm 1.0^b$	SMTQ
15	$8.7\ X10^5 \pm 2.0^c$	$3.3\ X10^5 \pm 1.0^a$	$5.5\ X10^5 \pm 2.0^c$	SMTQ
20	$1.15\ X10^5 \pm 1.0^d$	$3.4\ X10^5 \pm 1.0^a$	$7.7\ X10^5 \pm 1.0^d$	SMTQ
25	$1.54\ X10^5 \pm 4.0^e$	$4.9\ X10^5 \pm 2.0^b$	$1.12\ X10^5 \pm 2.0^e$	$3.15X10^5$
	Products coated with essential oil of guava leaves and stored at room temperature			
5	$4.2X10^5 \pm 2.0^a$	SMTQ	$3.2\ X10^5 \pm 2.0^a$	SMTQ
10	$6.4\ X10^5 \pm 1.0^b$	SMTQ	$4.5\ X10^5 \pm 1.0^b$	SMTQ
15	$8.7\ X10^5 \pm 2.0^c$	SMTQ	$5.5\ X10^5 \pm 2.0^c$	SMTQ
20	$1.15\ X10^5 \pm 1.0^d$	SMTQ	$7.7\ X10^5 \pm 1.0^d$	SMTQ
25	$1.54\ X10^5 \pm 4.0^e$	SMTQ	$1.12\ X10^5 \pm 2.0^e$	SMTQ

SMTQ = so minimal to quantify

4.0 CONCLUSION

Considering the outcomes of the present study on the comparative microbial load in chicken meatballs and chips with guava leaf coatings, the use of guava leaf coatings has a significant effect on reducing microbial contamination in these food products. The results clearly show that guava leaf coating not only inhibits the growth of pathogens but also improves the overall

microbial quality of the products. This is a promising development in the field of food hygiene and security, particularly for consumers who are concerned about the safety of their food choices. The potential for further research and development in the use of natural antimicrobial agents, such as guava leaves, holds great promise for enhancing the standard value and safety of food products in the future. Future studies should delve deeper into the mechanisms by which guava leaf coating exerts antimicrobial effects and explore its applications in diverse food products to ensure a safer food supply for consumers.

5.0 CONFLICT OF INTEREST

The authors declare that no conflicts of interest exist.

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