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Quality evaluation of chicken patties marinated with roselle (*Hibiscus sabdariffa* L.) calyx extract

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ABSTRACT

The potential of extract from roselle calyx on quality attributes of chicken patties marinated without extracts [plain (P1) and prepared with 0.01% butyl hydroxyl anisole; BHA (P2)] and with extract [soaked in roselle calyx extracts concentrations at 0.005% (P3), 0.01% (P4), 0.015% (P5) and 0.02% (P6)] were evaluated. Sensory qualities, cooking loss, product yield and colour [lightness (L*), redness (a*) and yellowness (b*)] were determined on freshly prepared patties and the production cost was evaluated. Total bacterial count, TBC (log_{10} CFU/g), water holding capacity; WHC (%), pH and lipid oxidation (mg MDA/kg) were determined on days 0, 7, 14 and 21 of cold (4 °C) storage. Patties flavour of 5.65±0.01 (P6) was higher (p<0.05) than in other treatments and the least in P1 (3.96±0.23). Cooking loss ranged from 20.24± 0.11% (P6) to 26.55± 0.01% (P1). Product yield of 79.8±0.7% (P6) was the highest, which varied significantly from other treatments. Lightness in P1 - P6 was darker than normal, with the highest L* = 42± 2.43 (P1) and the least L* = 36.44± 0.15 (P6). Redness was the least in P1 (a* = 16.85± 1.32), which varied significantly (p<0.05) from other treatments. Yellowness in P2 (b* = 54.14±1.35) was the highest, which differs significantly (p<0.05) from other treatments. Production cost varied insignificantly (p>0.05) among the treatments, with (P2 - P6) being significantly (p<0.05) higher than P1, with increasing percentage gain ranging from 0.02% (P2) to 0.78% (P6) relative to P1. On day 21, there were variations (p<0.05) in range for TBC [0.30±0.03 (P6) to 0.48±0.03 (P1)], and WHC [68.78±0.27 (P1) to 80.96±0.37 (P6)], pH [5.21±0.13 (P6) to 5.70±0.18 (P1)]. Lipid oxidation of 0.39±0.04 (P2) and 0.41±0.04 (P6) was similar, but significantly lower than 0.61±0.01 (P3), 0.59±0.04 (P4) and 0.46±0.01 (P5). Thus, among all patties marinated with extracts, those with 0.02% roselle calyx extract maintained better quality, inhibited lipid oxidation and bacteria during storage.

Introduction

There have been growing concerns among consumers regarding the use of synthetic antioxidants to mitigate lipid oxidation in meat and its products due to health implications (Kumar et al., 2015). Synthetic antioxidants such as butylated hydroxyl anisole (BHA), butylated hydroxyl toluene (BHT) and tertia butyl hydroxyl quinone (TBHQ), commonly used in the meat industry, have been criticised as posing health hazards such as impared blood clotting, lung damage and tumor (Thorat et al., 2013). Even so, mitigating lipid oxidation in meat is necessary, because the products of lipid oxidation, such as the formation of malondialdehydes (MDA), are harmful in the way that they cause pathological changes in the mucous

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membrane of the digestive tract, increase the cholesterol and peroxides in the blood stream as well as reduce nutritional quality of meat and meat products (Babatunde and Adewumi, 2015).
Hence, the use of botanicals with antioxidative properties or plant extracts as natural sources of antioxidants have been considered as a safer intervention in mitigating lipid oxidation in meat and meat products (Zhang et al., 2016). Among the natural sources of antioxidants are plant extracts such as roselle calyx extract, which antioxidant capacity and antibacterial potentials have been established (Shruthi and Ramachandra, 2019; Onibi and Osho 2007). Synthetic antioxidants are scarce and expensive in comparison to natural antioxidants, which are readily available, cheap and affordable (Adeyemi et al., 2013).
The intervention of using botanicals with antioxidative properties to inhibit lipid oxidation and microbial growth in meat and its products will encourage the consumption of stored meat and its products, as botanicals are considered as a safe alternative, while enhancing meat quality attributes (Olusola et al., 2018). Also, most botanicals (natural sources of antioxidant) are edible and naturally consumed by human and livestock (Owosibo et al., 2018).
Extracts from botanicals with antioxidative properties used in controlling lipid oxidation in stored meat and its products enhance meat quality attributes, especially when marinated (Vlahova-Vangelova et al., 2016). Due to the adverse effects of lipid oxidation, such as unattractive meat colour, off-flavour development, rancid taste, negative textural changes and nutrient loss in stored meat and its products which are reduced by the addition of plant extract (Wazir et al., 2019).
Freezing is known to be a good method of preservation for meat products, but it does not completely inhibit oxidative changes (Leygonie et al., 2012). Besides, freezing is adversely affected by erratic electric power supply in countries like Nigeria, and this hastens oxidation (through repeated thawing and re-freezing) in frozen stored meat and meat products (Okolie et al., 2009).
Considering the various interventions employed in mitigating lipid oxidation and bacterial growth in meat and meat products, the aim of this study was to investigate the quality in terms of oxidative processes, microbial activities, sensory and some other technological properties (pH and water holding capacity) in chicken patties marinated with roselle calyx extract at varying concentrations. These concentrations were compared with non-extract chicken patties and the use of butylated hydroxyl anisole in chicken patties as an industrial referee.

Materials and methods

Meat source and experimental treatment

Twelve seven weeks old broiler chicken were obtained from Institute of Agricultural Research and Training, Moor Plantation, Nigeria. These were slaughtered by cutting through the jugular vein with a sharp knife and scalded manually by dipping into hot water for a minute, de-feathered, washed, eviscerated and de-skinned.
The breast-meat from the 12-broiler-chickens was cut into 16 slices of meat per broiler and were soaked (15 minutes) in water (P1), 0.01% BHA (P2) and also in P3, P4, P5 and P6 containing concentrations of 0.005, 0.010, 0.015 and 0.020% roselle calyx extract-RCE, respectively. The marination was done by soaking the meat slices from each treatment into their respective RCE for 15 minutes. The six (6) treatments were then processed further into chicken patties.

Product preparation and evaluation

Chicken patties: The marinated boneless chicken breasts from each of the six treatments were mixed with spices, salt and lards and ground to the desired particle size (1-5 mm). The ground mixtures were spread in a rectangular tray to a thickness of 10mm. Patties were cut out using a patty molder and breaded with corn flour. The breaded patties were pasted with whisked egg and coated with wheat breadcrumbs. The patties were placed into air-fryer at 200 ºC for 20 minutes until the chicken patties were golden brown with an internal temperature of 72 ºC. The formulation of the experimental chicken patties is shown in Table 1. The chicken patties were kept for 21 days at 4 ºC.
The chicken patties from each treatment were evaluated for (i) proximate composition, (ii) physical traits [cooking loss, product yield, minolta chroma reading (lightness, redness and yellowness) and cost of production], (iv) physicochemical traits, pH and water holding capacity (WHC), (v) organoleptic/ sensory evaluation (vi) lipid oxidation and (vii) microbiological assessment [TBC in coliform unit per gram (Cfu/g) of meat samples] at day 0, 7, 14 and 21 at 4 ºC storage.

Table 1. Meat and ingredient composition of experimental chicken patties

	Treatments					
			Roselle calyx extract levels (%)			
	No Extract	0.01% BHA	0.005% RCE	0.01% RCE	0.015% RCE	0.02% RCE
Ingredients	P1	P2	P3	P4	P5	P6
Breast muscle	75.00	75.00	75.00	75.00	75.00	75.00
[1]Binder	10.00	10.00	10.00	10.00	10.00	10.00
[2]Fat	7.00	7.00	7.00	7.00	7.00	7.00
[3]Spices	5.00	5.00	5.00	5.00	5.00	4.00
Monosodium glutamate	1.00	1.00	1.00	1.00	1.00	1.00
Salt	2.00	2.00	2.00	2.00	2.00	2.00
Total	100	100	100	100	100	100

RCE: Roselle Calyx Extract. **BHA**: Butylated Hydoxyl Anisole. [1]**Binder**: Wheat breadcrumbs (40%), whole egg (30%) and Corn flour (30%), [2]**Fat**: Lard, [3]**Spices**: Red chilli paste (20%), green pepper (30%), powdered nutmeg (20%), lemon juice (30%).

Table 2. Nine-point hedonic scale

Point	Quality attributes						
	Colour	Flavour	Taste	Texture	Tenderness	Juiciness	Overall acceptability
1	Extremely dark	Not perceptible	Extremely non-tasty	Extremely coarse	Extremely tough	Extremely dry	Dislike extremely
2	Just dark	Just perceptible	Just non-tasty	Very coarse	Very tough	Very dry	Dislike very much
3	Moderately dark	Moderately perceptible	Moderately non-tasty	Moderately coarse	Moderately tough	Moderately dry	Dislike moderately
4	Slightly dark	Slightly perceptible	Slightly non-tasty	Slightly coarse	Slightly tough	Slightly dry	Dislike slightly
5	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
6	Slightly light	Slightly strong	Just tasty	Slightly fine	Slightly soft	Slightly juicy	Like slightly
7	Moderately light	Moderately intense	Moderately tasty	Moderately fine	Moderately soft	Moderately juicy	Like moderately
8	Very light	Strongly intense	Very tasty	Very fine	Very soft	Very juicy	Like very much
9	Extremely light	Extremely intense	Extremely tasty	Extremely fine	Extremely soft	Extremely juicy	Like extremely

Proximate composition of chicken patties

Patties from each of the 6-treatment were assessed for moisture content, crude protein, crude fat and ash content following the procedures of AOAC (2000).
The moisture content assessment involved weighing 10 g of patties into a silica dish. Thereafter, the weighed patties are dried at 100 – 105 °C oven temperature for 24 h to a constant weight. Each treatment patty sample was cooled for 10 min. After the cooling, patties were reweighed and, subsequently, moisture content was obtained being expressed in percentages as:

$$\%\,Moisture = \frac{patties\ weight\ before\ drying\ (g) - Patties\ weight\ after\ drying\ (g)}{patties\ weight\ before\ drying\ (g)} \cdot 100$$

The crude protein was assayed in 10 g of ground patties using Khjedahl methods. The distillate obtained was titrated with 0.01 N HCl. The derived crude protein was deduced by the conversion of nitrogen (% N) content of patty obtained when titrated with a constant (6.25). Thus, it was expressed as (6.25 x % N).
The crude fat was assayed in 10 g of patties using a Soxhlet extractor with petroleum ether as solvent. The apparatus containing the solvent was heated over a

bursen burner and with a siphoning movement occurring 8 – 10 times in the flask to enable oil to be released. The released oil and the flask itself were weighed and to achieve a constant weight, the flask was dried in a preheated oven. The percentage crude fat was derived from this formula:

$$\%\, Crude\ Fat = \frac{oil\ weight\ (g)}{patties\ weight\ (g)} \cdot 100$$

The ash content, assessed from 10 g of ground patty in crucibles, was placed into a muffle furnace, set between 550 – 600 ºC for 4 h. The crucibles and their contents were cooled in a desiccator to about (270 ºC) and reweighed.

$$\%\, Ash = \frac{ash\ weight\ (g)}{patties\ weight\ (g)} \cdot 100$$

Physical traits of patties and production cost of chicken patties

The cooking loss was determined using freshly cut patties (by a patty moulder) which was weighed before it was air-fried in an air fryer for 20-min at 200 ºC in order to achieve an internal temperature of about 72 ºC doneness and then cooled to a room temperature. The weight of the patties after cooling was measured. The cooking loss was obtained by deducting the weight of patties after the cooking from the weight of patties before cooking. Percentage cook loss was calculated as stated below:

$$\%\, Cooking\ loss = \frac{patties\ weight\ before\ frying\ (g) - patties\ weight\ after\ frying\ (g)}{patties\ weight\ before\ frying\ (g)} \cdot 100$$

The patties' yield was obtained in line with the formula used by El-Nashi et al. (2015). This was expressed as:

$$Patties\ yield\ \% = (100\% - Cooking\ loss\%)$$

Colour of patties: The Minolta Chroma was used to assay lightness (L*), redness (a*) and yellowness (b*) for chicken patties from each of the 6-treatments using the method adopted by Radha krishnan et al. (2014).

Patties pH: The pH as a measure of the acidity and alkalinity (a physicochemical trait) of the chicken patties was assessed by the use of the pH meter using a buffer of 4.

Water Holding Capacity (WHC) was assessed using press method as used by Mallikarjuman and Mittal (1994). Approximately 10 g of meat sample from the chicken patties was placed between two previously weighed Whatman filter papers and pressed between two 10.20 x 10.20 cm^2 plexiglas using a vice for 60s. The weight of wet filter paper was taken and water holding capacity of meat samples was obtained as:

$$\%\, WHC = \frac{wet\ paper\ weight\ (g) - dry\ paper\ weight\ (g)}{weight\ of\ patty\ sample\ (g)} \cdot 100$$

The production cost of the chicken patties, based on each treatment (i.e. chicken patties with neither RCE or BHA, patties marinated with graded levels of RCE), was calculated in naira (₦) per kilogram (kg) of patty. The percentage gain for each treatment of the patties was derived from the formula expressed below:

$$\%\, Gain = \frac{product\ yield\ (g) - cooking\ loss\ (g)}{production\ cost\ (₦)} \cdot 100$$

Organoleptic/Sensory evaluation

The organoleptic/sensory traits of colour, flavour, taste, juiciness, texture, tenderness and overall acceptability of the samples were evaluated by 30 panelists from the Animal Products and Processing Unit at the Department of Animal Science, University of Ibadan. The panelists were trained to evaluate the patties samples independently, following specific rules, such as rising the mouth before and after having a taste of one sample, before evaluating the other sample in a well-lighted room Thus, the chicken patties were put (each treatment separately) into a clean saucer and the panelist distributed randomly to each treatment. Patties samples were rated using a 9-point hedonic scale (Table 2) for colour (1: Extremely dark – 9: Extremely light), flavour (1: Not perceptible – 9: Extremely intense), taste (1: Extremely non-tasty – 9: Extremely tasty), texture (1: Extremely coarse – 9: Extremely fine), tenderness (1: Extremely tough – 9: Extremely fine), juiciness (1: Extremely dry – 9: Extremely juicy) and overall acceptability (1: Dislike extremely – 9: Like extremely), according to the method of AMSA (2015).

Lipid oxidation of the chicken patties

The oxidative stability was monitored on chicken patties from each of the 6-treatment at day 0, 7, 14 and 21 of cold (4 °C) storage. Evaluation of lipid oxidations in the patties was assayed in 2-thiobarbituric acid (TBA). Measurements were taken twice on 10 g samples at each sampling day for values of thiobarbituric acid reactive substance (TBARS), using the methods of Adeyemi et al. (2013) with some modifications, which involved

homogenizing the sample with 50 mL distilled water instead of 47.5 mL of distilled water as used by Adeyemi et al. (2013) in a specimen bottle using glass pestle.
The 10 g of sample from each of the 6treatments was mixed with 25% tricholoroacetic acid (TCA) and 20 mL of deionized water. The mixture was homogenized for 2 min and thoroughly filtered using Whatman filter paper. The filtrate was mixed with an equal volume of 0.02 M TBA at 100 °C for 35 minutes. A running tap was used to cool the filtrate for 10 min. The solution of the absorbance was measured and TBARS was derived reading from spectrophotometer at 532 nm x 7.8 and expressed in mg MDA/kg.

Microbiological assessment of the chicken patties

Total bacterial count or the total bacterial load of the chicken patties: The culture medium used was nutrient agar for the overall bacterial load. The growth was evaluated at 0 day on fresh chicken patties, from each of the 6 treatments. Subsequently, the evaluation was carried out on day 7, 14 and 21 in a cold (4 °C) storage. Ten grams (10 g) of the patty from each of the 6treatments were homogenized with 90 mL of 0.1% (w/v) peptone for 1 min at room temperature using a blender.
Appropriate serial dilution was prepared in 0.1% (w/v) peptone water solution. A spread on petri plate was done using a 1 mL of the mixture of each sample and was incubated at 37 ºC for 24 hours as used by Heinz and Hautzinger (2007). All colonies that appeared afterwards were counted and expressed as Cfu/g-colonies forming unit per gram.

Results and discussion

The moisture content (MC), crude protein (CP) and ash content (AC) of the concentration's levels from 0 to 0.02% roselle calyx extract (RCE) marinated chicken patties for MC (45.55 – 46.05%), CP (21.38 – 22.05%) and ash (2.10 – 2.90%) had a direct proportional relationship as presented in Table 3. MC, CP and ash content increase as the concentration levels increase from 0 to 0.02% RCE used in marinating the chicken patties.
Notably, the MC of chicken patties marinated with RCE was significantly (p>0.05) higher than those without RCE (0% RCE and 0.01% BHA) and this could have had a positive impact on the product yield and water holding capacity of the RCE marinated chicken patties observed in this study. This inference harmonized with Kim et al. (2015), where the moisture content of citric acid treated chicken breast was in direct proportional relationship with its product yield.
The moisture content of the RCE marinated chicken patties had a range from 12.55% to 13.55% higher than that of chicken patties treated with 0.05% roselle extract by Babatunde and Adewumi (2015). This range of percentage differences in the moisture content could have contributed to the higher water holding capacity (WHC: 69.09 – 90.29%) of the RCE marinated chicken patties observed in this study, than the WHC of 47.19% for the chicken patties treated with 0.05% roselle extract by Babatunde and Adewumi (2015).
The crude protein of chicken patties marinated with RCE (0.01%, 0.015% and 0.02%) was significantly (p>0.05) higher than those of 0% RCE, 0.01% BHA and 0.005% RCE and this could have accounted for the higher product yield observed in 0.01%, 0.015% and 0.02% RCE than the other treatments.
Comparing the crude protein (CP) content of the concentration levels from 0 to 0.02% RCE, marinated chicken patties (CP: 21.38 – 22.05%) were lower than the crude protein (CP: 28.78%) content obtained for chicken patties treated with roselle extract by Babatunde and Adewumi (2015). These differences in the crude protein content could have contributed to the lower product yield (PY: 74.52 - 79.76%) of the RCE marinated chicken patties observed in this study than the PY of 86.85% for the chicken patties treated with 0.05% Roselle extract by Babatunde and Adewumi (2015). Thus, supporting the phenomenon that the higher the crude protein the higher the product yield and that at a higher concentration of extracts used in meat marination, product yield is greatly improved (Gamage et al., 2017).
The crude fat (CF) content observed in this study among the chicken patties marinated with 0.005, 0.01, 0.015 and 0.02% RCE had a decreasing crude fat content with an increasing level of the roselle calyx extracts used in marinating the chicken patties. The least crude fat content was observed in chicken patties marinated with 0.02% RCE.
The chicken patties marinated with 0% RCE (no extract) had significantly higher crude fat than those from the other treatments. This implies that at a higher concentration of RCE used in marinating chicken patties can be associated with reduction of fat deterioration in meat and its products such as rancidity (Possamai et al., 2018).
Conversely, the trend observed for the ash content among the chicken patties marinated with 0.005, 0.01, 0.015 and 0.02% RCE was increasing with an increasing concentration of the RCE used in marinating the chicken patties, with the highest been at 0.02% RCE marinated chicken patties.
However, the chicken patties with no extract (0% RCE) had significantly (p>0.05) lower ash content

than the other treatments. The range of value for the ash (2.10 - 3.04%) content among the chicken patties marinated with 0.005, 0.010, 0.015 and 0.02% RCE was similar to 2.68 – 3.01% ash content of cooked patties treated with extracts from ginger, garlic and roselle as documented by Babatunde and Adewumi (2015).

The percentage product yield significantly (P<0.05) higher in marinated chicken patties at concentrations of 0.005, 0.010, 0.015 and 0.02% RCE than those of the non-RCE [plain (0% RCE) and 0.01% BHA] marinated chicken patties (Table 4). This observation implies that the product yield of patties marinated even with a lower concentration of 0.005% RCE (PY: 74.52%) were more appreciable than those marinated with the non-RCE [0% RCE (PY: 73.45%) and 0.01% BHA (PY: 74.10%)]. Although at lower concentration of 0.005% RCE an appreciable amount of product yield can be obtained. However, it is noteworthy that as the concentrations of RCE increase the best concentration for product yield was at 0.02% RCE (PY: 79.76%).

This was implicated by the increased moisture content (MC) and crude protein (CP) of the marinated chicken patties, which increased as the concentration of RCE increases 0.005% (MC: 45.55%; CP: 21.38%), 0.010% (MC: 45.80%; CP: 21.60%), 0.015% (MC: 46.01%; CP: 21.98%) and 0.02% (MC: 46.05%; CP: 22.05%) more than those of the non-RCE [0% (MC: 42.89%; CP%: 21.06%) and 0.01% BHA (MC: 44.32%; CP: 21.34%)] marinated chicken patties.

This phenomenon of direct proportional relationship among product yield, moisture content and crude protein content of chicken marinated with RCE observed in this study was in harmony with the report of Babatunde and Adewumi (2015), where the chicken patties treated with the extract from roselle calyx had higher product yield (86.85%), moisture content (33.00%) and crude protein (28.78%) than the non-extract treated chicken patties with [product yield (84.39%), moisture content (32.50%) and crude protein (28. 12%)].

The percentage of cooking loss decreases with increasing concentrations of RCE in the marinated chicken patties.

Subsequently, an opposite trend in the product yield was observed for percentage cooking loss in the chicken patties marinated with RCE and the non-RCE (0% RCE and 0.01% BHA) marinated chicken parties (Table 4). It implies that chicken patties marinated in 0.02% RCE with the highest product yield (79.76%) had the least percentage cooking loss (20.24%).

This inverse relationship of the percentage product yield and the percentage cooking loss was consistent with El-Nashi et al. (2015) and Olusola et al. (2018). Therefore, plant extracts used in meat marination has been reported to have improved product yield or cooking yield and thereby reduced cooking loss in cooked chicken breast meat (Latif, 2010). The colour (Table 4) had a trend of lower lightness (L*): 42.30 (0% RCE), 36.79 (0.01% BHA), 41.44 (0.05% RCE), 41.01 (0.01% RCE), 36.44 (0.015% RCE) and 36.69 (0.02% RCE) values in the chicken patties were , for all the treatments considered, darker than normal, using the truncation values of Qiao et al. (2001) as follows: lighter than normal (lighter, L*>53), normal (48 < L* <53), and darker than normal (dark, L* < 46).

The trend of lower lightness (L*) with a range from 36.44 to 42.30 in this study was comparatively lower than 81.64 to 82.89 L* of Kim et al. (2015). Also, low lightness (L*) values in this study were associated with a high redness (a*) value and low yellowness (b*) with increasing level of RCE in the marinated chicken patties.

This was similar in trend to research findings of Petracci et al. (2004) and Bianchi et al. (2007), where breast meat with a higher-a* showed a lower lightness-L*.

The range value in redness (a*: 16.85 – 24.24) and in yellowness (b*: 44.36 – 54.14) of the chicken patties observed in this study was comparatively higher than the redness (a*: 2.72 – 5.16) and the yellowness (b*: 10.15 – 13.66) in Kim et al. (2015). However, the observation made on chicken patties marinated with and without RCE as darker than normal (L* < 46) on Minolta Chroma machine was not perceived by the sensory panelist who in this study adjudged the colour of the patties as 'Slightly light" (rated on average as 6.38) on the 9-point hedonic scale. The production cost per kg for patties marinated with 0.005, 0.01, 0.015 and 0.02% RCE and 0.01% BHA was higher than for patties untreated with extracts (Table 4), meaning that the extracts used in the preparation incurred more cost.

However, the percentage marginal gain relative to the patties untreated with extract increased with increasing level of the RCE. The improvement in the sensory quality traits of the chicken patties was enhanced only in flavour and taste, while in the others (colour, juiciness, texture and tenderness) no enhanced improvement was observed (Table 5).

The panelist preferred the flavour of chicken patties marinated with 0.02% RCE (rated as "Slightly strong") to those of 0% RCE (rated as "Slightly perceptible"), 0.005% RCE (rated as "Slightly perceptible"), 0.01% RCE (rated as "Intermediate"), 0.015% RCE (rated as "Intermediate") on the 9-point hedonic scale.

Table 3. Proximate composition of chicken patties with and without roselle calyx extract

	Treatments					
			Roselle calyx extract levels (%)			
	No extracts	0.01% BHA	0.005% RCE	0.01% RCE	0.015% RCE	0.02% RCE
Variable (%)	P1	P2	P3	P4	P5	P6
Moisture	42.89^{c}	44.32^{b}	45.55^{a}	45.80^{a}	46.01^{a}	46.05^{a}
Crude Protein	21.06^{b}	21.34^{b}	21.38^{b}	21.60^{a}	21.98^{a}	22.02^{a}
Crude Fat	11.36^{a}	6.78^{d}	9.80^{b}	9.35^{bc}	7.92^{c}	7.82^{c}
Ash	1.42^{c}	3.01^{a}	2.10^{b}	2.40^{b}	2.90^{a}	3.04^{a}

Table 4. Physical traits and cost of chicken patties marinated with and without RCE

	Treatments					
			Roselle calyx extract levels (%)			
	No Extracts	0.01% BHA	0.005% RCE	0.01% RCE	0.015% RCE	0.02% RCE
Variable	P1	P2	P3	P4	P5	P6
Cooking loss (%)	26.55± 0.01^{a}	25.90± 0.06^{ab}	25.48± 0.02^{ab}	24.20± 0.11^{c}	21.81± 0.01^{cd}	20.24± 0.11^{d}
Product Yield (%)	73.45± 0.01^{e}	74.10± 0.06^{d}	74.52± 0.02^{c}	75.80± 0.11^{b}	78.19± 0.01^{ab}	79.76± 0.11^{a}
Lightness (L*)	42.30± 2.43^{a}	36.79± 2.55^{b}	41.44± 4.81^{ab}	41.01± 4.12^{ab}	36.69± 2.34^{b}	36.44± 0.15^{b}
Redness (a*)	16.85± 1.32^{b}	24.24± 0.45^{a}	21.01± 1.05^{a}	22.66± 0.75^{a}	22.19± 1.30^{a}	23.11± 1.03^{a}
Yellowness (b*)	48.95± 0.98^{b}	54.14± 1.35^{a}	45.58± 0.67^{bc}	44.36± 0.98^{c}	45.56± 1.22^{bc}	46.12± 1.71^{bc}
Production Cost (₦/kg)	1450.00± 0.08^{b}	1485.00± 0.05^{a}	1470.00± 0.01^{a}	1475.00±0.02^{a}	1480.00±0.07^{a}	1485.00±0.06^{a}
Gain (%)	3.23± 0.03	3.25± 0.02 (0.02)	3.34± 0.08 (0.09)	3.50±0.06 (0.27)	3.81±0.03 (0.58)	4.01±0.02 (0.78)

Mean±SE on the same row with different letters differ significantly (p<0.05). Values in parenthesis represent marginal percentage increase in gain relative to the no extract samples (P1).

The enhanced improvement in flavour of the chicken patties marinated with RCE collaborate the report of Omojola et al. (2007) that injecting $CaCl_2$, a form of marination, at 1 hour postmortem improves flavour of cooked meat of old layers Also, Gao et al. (2015) made a similar observation that marinating improves meat flavour in pork chops. The taste as sensory quality attribute in this study was significantly (p>0.05) preferred in chicken patties marinated with 0.02% and 0.015% RCE (rated as “almost moderately tasty”) to those of chicken patties without RCE (0% RCE and 0.01% BHA) rated as intermediate. There is a direct proportional relationship between flavour and taste. For this reason, flavour has been described as comprising mainly of taste and aroma (Jayasena et al., 2013). This phenomenon was observed in this study as the panelist adjudgment for flavour and taste were preferred in chicken patties marinated with 0.02% and 0.015% RCE (rated as “almost moderately tasty”) to those of chicken patties without RCE (0% RCE and 0.01% BHA) rated as intermediate.

The effect of RCE in marinating the chicken patties on lipid oxidation observed at seven days intervals from 0 to day 21 in cold storage (4 °C) exhibited reduction in meat oxidation as RCE concentration increases in allthe treatments (Table 6). This could be attributed to the previously established fact that roselle calyx is very rich in vitamin C (ascorbic acid), flavonoids and phenols (Wang et al., 2007; Chumsri et al., 2008; Okereke et al., 2015; Aminul Islam et al., 2016; Jamini et al., 2019). These antioxidant constituents found in roselle calyx could have accounted for the reduction of lipid oxidation in the chicken patties as the concentrations of RCE increase. Besides, the incorporation of some amount of ascorbic acid, flavonoids and phenols from RCE into the chicken patties during marination could confer oxidative stability, which was in this study best at 0.02% RCE (0.41 mg MDA/kg) with similar reduction in lipid oxidation compared to 0.01% BHA- marinated chicken patties (0.39 mg MDA/kg) as an "industrial referee" up to 21 days of cold (4 °C) storage. This observation could be compared with the report made by Hwang et al. (2013) on the use of various concentrations of extract from ganghwayakssuk in mixture with ascorbic acid in raw and deep-fried chicken nuggets. It was concluded that the combination of ascorbic acid and the extract of ganghwayakssuk had better efficiency than other antioxidant combinations in limiting lipid-oxidation of nuggets in uncooked and deep-fried state.

Also, a similar observation was reported by Blackhurst et al. (2011) on the utilization of South African red wine to inhibit lipid oxidation of cooked beef.

The trend of decreasing lipid oxidation in the chicken patties with increasing concentrations RCE used in marinating the chicken patties gave rise to increased percentage reduction as observed in this study (Table 6). The range value for lipid oxidation among the marinated chicken patties with RCE concentration levels was from 0.07 to 0.61 mg MDA/kg with percentage reduction range from 9.52% to 66.67% relative to the control [the non-RCE (0%) marinated chicken patties) for 21 days of storage, while for 14 days of storage it was from 0.07mg MDA/kg to 0.41 mg MDA/kg with percentage reduction range from 9.52% to 66.67%. The deduction was that beyond 14days of storage there might not be a significant percentage decrease in lipid-oxidation of chicken patties marinated with the RCE levels. This observation was similar in trend to the report made by Babatunde and Adewumi (2015), where the range value from 0.56mg MDA/kg to 1.52 mg MDA/kg with percentage reduction range from 7.69% to 35.79% were observed for cooked patties from chicken treated with garlic, ginger and roselle extracts and stored for 14 days at 4 °C.

The reduction in lipid oxidation at (4 °C) storage at day 0, 7, 14 and 21 gave evidence that the intervention of using RCE (0.005, 0.01, 0.015 and 0.02%) as antioxidant in chicken patties was efficient in a way that there was high percentage reduction of lipid oxidation of the RCE levels relative to the non-extract marinated samples. The percentage reduction in lipid oxidation observed in this study was best at 0.02% RCE (38.81%) up to day 21 in the chicken patties with similarity in reduction of lipid oxidation reckoned at 0.01% BHA (41.79%) as an industrial reference. Applying the minimum threshold of 0.50 to 1.0 mg MDA/kg observed in cooked meat lipid oxidation during cold storage by Tarladgis et al. (1960) to this study, it was observed that in both the RCE (at 0.015 and 0.02%) and the non-RCE (0.01% BHA) marinated chicken patties, the lipid oxidations were below the minimum threshold value until day 21 of cold (4 °C) storage.

However, the RCE concentration levels (0.05, 0.01, 0.015 and 0.02%) and the non-RCE (0% RCE and 0.01% BHA) marinated chicken patties were within the minimum threshold of 0.50 to 1.0 mg MDA/kg by Tarladgis et al. (1960). Although, the lipid oxidation in the chicken patties increased with the increasing period of cold (4 °C) storage in this study, but did not exceed the maximum permissible limit of 2 mg MDA/kg (Possamai et al., 2018). The total bacterial count (TBC) of stored chicken patties marinated with and without RCE is presented in Table 7. On days 0, 7, 14 and 21 the differences observed among the treatments were not significant (p>0.05).

There were no microbial growth in the TPC observed in all the treatments on day 0. This could be attributed to the hygienic way the chicken patties were prepared, since most bacteria could be introduced into the patties when there is unhygienic handling (coughing, sneezing and talking over the patties) and processing (contaminated water) of the patties (Javadi and Safarmashei 2011).

Also, there were no microbial growth ($\log_{10}$ Cfu/g) among the patties marinated with RCE (i.e., P3, P4, P5 and P6) and these were insignificantly (p>0.05) different from those of P1 and P2 on day 7. However, the same level of TBC ($\log_{10}$ 0.30 Cfu/g) was observed among the treatments in P2, P3, P4 and P6 which were insignificantly (p>0.05) lower than that of P1 on day 21. There were no improved changes in microbial load observed among the RCE (0.005, 0.01, 0.015 and 0.02%) and non-RCE (0% RCE and 0.01% BHA) marinated chicken patties for TBC during the storage periods. Also, the increase at a slightly decreasing rate of TBC from day 0 to day 21 across the chicken patties marinated with and without RCE observed in this study were within the minimum threshold value of < 4 $\log_{10}$ Cfu/g (Heinz and Hautzinger, 2007). This observation gave evidence of good microbiological standard maintained during handling and processing of the patties.

There were similarities in pH observed among the RCE (0.005, 0.01, 0.015 and 0.02%) and non-RCE (0.01% BHA) marinated chicken patties except for 0% RCE with the least pH of 5.14 on day 0. There were no improved changes in pH in the chicken patties marinated with or without RCE on day 7 and day 14, respectively. The observed trend in this study for days 7 and 14 was similar to the report of Olusola (2018), where pH of broiler chicken was unaffected by extract from onion skin. Also, a similar trend was documented in the report of Malav et al. (2013), where storage period did not bring about any significant change in pH of restructured chicken meat blocks.

Table 5. Sensory evaluation of chicken patties marinated with and without roselle calyx extract

Variables	Treatments					
			Roselle extracts levels			
	No Extract	0.01% BHA	0.005% RCE	0.01% RCE	0.015% RCE	0.02% RCE
	P1	P2	P3	P4	P5	P6
Colour	6.70± 0.14	6.25± 0.20	6.60± 0.55	6.75± 0.59	5.75± 0.59	6.25± 0.10
Flavour	3.96± 0.23^{c}	4.45± 0.23^{bc}	4.75± 0.41^{b}	4.80± 0.52^{b}	4.85± 0.41^{b}	5.65± 0.02^{a}
Taste	5.30± 0.02^{b}	5.05± 0.58^{b}	5.75± 0.58^{ab}	6.04± 0.66^{ab}	6.45± 0.06^{a}	6.53± 0.10^{a}
Texture	4.80± 0.58	5.00± 0.20	4.90± 0.08	4.80± 0.61	4.79± 0.07	5.55± 0.06
Tenderness	5.55± 0.64	5.85± 0.08	5.75± 0.06	5.60± 0.51	5.50± 0.10	5.70± 0.02
Juiciness	4.85± 0.08	5.20± 0.42	4.80± 0.41	5.60± 0.02	5.10± 0.04	5.40± 0.10
Overall acceptability	6.50± 0.59	6.50± 0.63	6.80± 0.45	6.95± 0.09	6.55± 0.24	7.00± 0.20

Mean±SE on the same row with different letters differ significantly (p<0.05)

Table 6. Lipid oxidation (mg MDA/kg) of chicken patties marinated with and without RCE stored for 21 days at 4 °C

Storage (days)	Treatments					
			Roselle calyx levels			
	P1 (No extract)	P2 (0.01% BHA)	P3 (0.005% RCE)	P4 (0.01% RCE)	P5 (0.015% RCE)	P6 (0.02% RCE)
0	0.21± 0.01^{a}	0.07±0.02^{c} (66.67)	0.18±0.01^{a} (14.29)	0.12±0.01^{b} (42.86)	0.11±0.01^{b} (47.62)	0.07±0.02^{c} (66.67)
7	0.31± 0.01^{a}	0.21±0.01^{c} (32.26)	0.29±0.01^{a} (6.45)	0.26±0.01^{b} (16.13)	0.25±0.01^{b} (19.35)	0.22±0.01^{c} (29.03)
14	0.42± 0.01^{a}	0.29±0.01^{d} (30.95)	0.41±0.01^{ab} (2.38)	0.38±0.01^{b} (9.52)	0.33±0.06^{c} (21.43)	0.31±0.00^{cd} (26.19)
21	0.67± 0.01^{a}	0.39±0.01^{d} (41.79)	0.61±0.01^{b} (8.96)	0.59±0.01^{b} (11.94)	0.46±0.02^{c} (31.34)	0.41±0.01^{d} (38.81)

Mean±SE on the same row with different letters differ significantly (p<0.05). Values in parenthesis represent percentage reduction in lipid oxidation relative to the no extract (P1)

Table 7. Total bacterial count (log_{10} Cfu/g) of chicken patties marinated with and without RCE stored for 21 days at 4 °C

Storage (days)	Treatments					
			Roselle calyx extract levels			
	P1 (No extract)	P2 (0.01% BHA)	P3 (0.005% RCE)	P4 (0.01% RCE)	P5 (0.015% RCE)	P6 (0.02% RCE)
0	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
7	0.15±0.02^{a}	0.15±0.02^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
14	0.30±0.03^{a}	0.15±0.02^{a}	0.30±0.02^{a}	0.30±0.02^{a}	0.15±0.02^{a}	0.15±0.02^{a}
21	0.48±0.03^{a}	0.30±0.03^{a}	0.30±0.03^{a}	0.30±0.03^{a}	0.30±0.03^{a}	0.30±0.03^{a}

Mean±SE on the same row with same letters are not statistically significantly (p<0.05)

Table 8. The pH of chicken patties marinated with and without RCE stored for 21 days at 4 °C

Storage (days)	Treatments					
			Roselle calyx extracts			
	P1 (No extract)	P2 (0.01% BHA)	P3 (0.005% RCE)	P4 (0.01% RCE)	P5 (0.015% RCE)	P6 (0.02% RCE)
0	5.14±0.15^{c}	5.60±0.10^{a}	5.28±0.15^{bc}	5.58±0.05^{a}	5.43±0.09^{ab}	5.47±0.09^{ab}
7	5.42±0.17	5.52±0.09	5.55±0.09	5.60±0.05	5.68±0.05	5.73±0.15
14	5.90±0.18	5.83±0.12	6.03±0.10	5.85±0.07	5.70±0.10	5.65±0.14
21	5.70±0.18^{a}	5.36±0.09^{bc}	5.60±0.12^{ab}	5.57±0.04^{ab}	5.53±0.09^{ab}	5.21±0.13^{c}

Mean±SE on the same row with same letters are not statistically significantly (p<0.05).

Furthermore, pH of chicken patties marinated with 0.005, 0.01, 0.015 and 0.020% during the 21 days of cold storage (with a range from 5.21 to 6.03), compared to that of Babatunde and Adewumi (2015), was similar with the pH range of 5.91 to 5.92 in Roselle extract treated cooked chicken-patties. The pH ranges from 6.37 to 6.54 of Olusola et al. (2018) were comparatively higher than those recorded in this study (pH range from 5.42 to 6.03) for day 7 and day 14, respectively. A known protein which generates force and movement is myosin which has an isoelectric point or pH value of 5.2- 5.3, in chicken meats it helps in water binding stability. Furthermore, enhancement in water binding stability in chicken meat and its products can be achieved by using mariandesAlvarado and McKee et al., 2007). This phenomenon is similarly observed in this study where on day 21 of storage the chicken meat patties marinated with 0.02% RCE had a pH of 5.21 with water holding capacity of 80.96%. However, the pH changes observed was in a decreasing orders RCE levels used in marinating chicken patties increased with the least reckoned at 0.02% RCE having a pH of 5.21, which was similar to the pH of 5.36 (0.01% BHA) on day 21. This observation could have been due to the acidic nature of RCE since roselle calyx is very rich in ascorbic acid (Carvajal-Zarrabal et al., 2012). Also, Del Rio et al. (2007) documented that dipping of chicken meat in citric acid significantly decreased the pH value after marination. The reduction in pH value of meat products is known to affect factors such as low redness value, shelf life stability, good water binding capacity, and texture during storage (Sammel and Claus, 2003). Applying the acceptable range value from 4.0 to 7.0 for pH in meat processing used by Heinz and Hautzinger (2007) in this study, it was observed that the chicken patties marinated with or without RCE had pH-value that did not exceed the maximum acceptable limit.

The water holding capacity (WHC) observed in this study was best in chicken patties marinated in 0.02% RCE on each of the storage periods [day 0 (90.29%), day7 (86.86%), day 14 (85.15%) and day 21 (80.96%)], respectively (Table 9). A contributory impact to this outcome could be the increased ascorbic acid content which increases as the concentrations of RCE used for the marination of the chicken patties increased. This observation is consistent with Hosseini and Esfahani (2015) that the WHC of beef meat patties increases when marinated in citric acid. The chicken patties marinated with 0.02% RCE resulted in higher water holding capacity, moisture content and product yield. This observation in the present study could be due to the influence of the acidic nature of RCE which encourages the uptake of water (Ke et al., 2009). Several other studies also documented that the acidic nature played an important positive correlation with the water holding capacity of meat products (Aktas and Kaya, 2001; Aktas et al., 2003, Serdaroglu et al. 2006). Also, Latif (2011) reported that acidic marination increases WHC of cooked chicken breast meat range from 21.17% to 40.96%, which was comparatively lower than the range value of 68.78% to 90.29% obtained in this study. A similar study by Babatunde and Adewumi (2015) on cooked chicken patties treated with 0.05% ethanolic extracts from garlic, roselle and ginger had water holding capacity (WHC) with a range value from 44.36% to 52.20%, which was comparatively lower than the range value of WHC (85.00 – 90.29%) in chicken patties marinated with 0.005, 0.01, 0.015 and 0.02% RCE. However, there were similarities observed for WHC between chicken patties marinated with 0.02% RCE (80.96%) and 0.01% BHA (78.33%) on day 21. The implication was that the best replacement for 0.01% BHA was at 0.02% RCE in the chicken patties margination.

Table 9. WHC of chicken patties marinated with and without RCE stored for 21 days at 4 °C

	Treatments					
			Roselle calyx extract			
Storage (days)	**P1 (No extract)**	**P2 (0.01% BHA)**	**P3 (0.005% RCE)**	**P4 (0.01% RCE)**	**P5 (0.015% RCE)**	**P6 (0.02% RCE)**
0	80.61±0.37^{c}	87.00±0.41^{b}	85.00±0.41^{b}	87.13±0.17^{b}	87.49±0.38^{b}	90.29±0.69^{a}
7	73.20±0.27^{c}	81.33±0.35^{b}	75.35±0.32^{c}	79.59±0.19^{c}	79.41±0.32^{b}	86.86±0.56^{a}
14	70.87±0.27^{d}	80.59±0.35^{b}	74.49±0.32^{c}	77.78±0.18^{bc}	81.19±0.35^{b}	85.15±0.52^{a}
21	68.78±0.27^{c}	78.33±0.32^{a}	69.09±0.27^{c}	71.92±0.19^{bc}	73.91±0.28^{b}	80.96±0.37^{a}

Mean±SE on the same row with same letters are not statistically significantly ($p<0.05$).

Conclusions

The product yield and sensory or eating qualities of chicken patties marinated with roselle calyx extract were more desirable than the non-roselle calyx extract marinated chicken. Chicken patties marinated with roselle calyx extract and stored at 4 °C for 21 days had higher and better oxidative stability than the non-roselle calyx extract, while limiting the total bacterial count on patties. The best oxidative stability conferred to the patties among the roselle calyx concentrations was at 0.02% and this was comparatively similar to the use of butylated hydroxyl anisole in chicken patties as a synthetic source of antioxidant used in the meat industry. Thus, it is recommended that roselle calyx extract as a natural herb could be used to improve quality attributes of chicken patties and extend their shelf life without raising consumers' worries concerning safety.

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