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Meat quality and consumers acceptability of meat balls treated with different plant extracts

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Abstract
The study investigated the effect of plant extracts (garlic, African walnut seed, avocado seed) used as marinade on physicochemical, proximate and sensory properties of meat balls made from *Bicep femoris* muscle of matured bull. The extracts were incorporated into ingredients used for marination to constitute four treatments viz treatment 1(control, no extract was added), treatment 2 (50% garlic extract), treatment 3 (50% African walnut seed extract) and treatment 4 (50% avocado seed extract). Minced meat was introduced into the treatments in a Completely Randomized Design. Raw meat balls were analyzed prior to cooking (pan fry and oven cook). The result showed that the pH, chilling loss, cooking loss and cooking yield of meat balls differ significantly ($p<0.05$) among treatments. The results of the proximate composition for the raw and cooked were significantly influenced ($p<0.05$) by the treatments. The sensory evaluation showed that the oven cooked meat balls of treatment 2 were generally preferred over other method of cooking. The study showed that garlic, African walnut seed, avocado seed extracts enhanced the qualities, nutritional and sensorial properties of meat ball.

Keywords: cooking methods, meat balls, meat quality, marinade, plant extracts

Introduction
The consumption of a healthy red meat remains a major factor to be considered in meat production. Animal protein being very crucial in the daily diets accounts for reason meat products should be safe for consumption. The consumers' demand for nutritionally improved, low-cost and as ready to eat meat products, must be meet for the benefits of the consumers (Gurikar *et al.*, 2014) [1]. Globally, non meat ingredients of low cost had been used to improve yield and consumers' acceptability (Arun *et al.*, 2008) [2]. Meatball is meat- based muscle food; it is an easy to prepare meat product which can be gotten from various animal species (Putra *et al.*, 2011; Evive *et al.*, 2015) [3,4]. Marination is a popular technique used to tenderize and improve the quality characteristics of meat products (Popat *et al.*, 2018) [5]. It is imperative to incorporate substances that will contribute to better quality of meat products which are suitable for the consumers' health as well as sustained the nutritive values. Antioxidants are substances that occur naturally in plants, known to inhibit formation of free radicals in foods, help to prolong shelf life, maintain quality in food products, protecting consumers' health and preventing diseases (Pokorny, 2001) [6]. Several plant extracts had been investigated but non has been reported on the use of African walnut seed and avocado (pear) seed as natural ingredients in the preparation of muscle food products. Therefore the study was designed to investigate the impact of garlic, African walnut seed, avocado seed extracts used as marinade ingredients on physicochemical, proximate and sensory properties of meat balls made from *Bicep femoris* muscle of a matured bull.

Materials and methods
Plant extract preparation
Raw garlic cloves and African walnut were chopped into small sizes, sun dried up to 9% moisture content and milled to powder using hammer mill machine. Avocado seeds were grated, air dried and milled into powder. All milled plant products were kept in a sealed container to prevent moisture absorption. The plant extraction was done by cold aqueous method of Abah and Egwari (2011) [7].

Sample Preparation
Eight kilogram (8Kg) of *Bicep femoris* muscle of a-two year old bull was purchased from the municipal abattoir in Ado, Ekiti State. The meat was trimmed of all adhering fats and excess connective tissues, chopped, minced using a mixer grinder (USHA, MG 2053N). Minced meat was divided into sixteen portions of equal weight of 500g and randomly allocated to the constituted ingredients (Table 1). Meat samples were manually massaged by hand to allow even distribution of ingredients. These were then rolled into circular ball shape of 50g. Samples were placed in labeled flat trays, covered with aluminum foil and kept at 4ºC for 24 hours. Samples were analyzed for the pH, dripping and chilling loss determined. Meat samples were cooked by two methods viz oven cook and pan fry until an internal temperature of 70 °C was reached. The meat ball samples were oven cooked at 155ºC for 50 minutes while meat balls were pan fried in unsaturated oil at 85ºC for 30 minutes.

Table 1: Ingredients composition (g/100g) 3

Ingredients	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Brown sugar	15.00	12.0	12.0	12.0
Dry red pepper	10.00	6.0	6.0	6.0
White pepper	10.00	6.0	6.0	6.0
Bread crumbs	20.00	6.0	6.0	6.0

Powdered thyme	10.00	6.0	6.0	6.0
Curry	10.00	6.0	6.0	6.0
Rosemary	10.00	6.0	6.0	6.0
Common Salt	2.00	2.00	2.00	2.00
Orange juice(ml)	25	-	-	-
Vinegar (ml)	0.0	-	-	-
Onion	10.00			
Garlic extract	-	50.00	-	-
African walnut extracts	-	-	50.00	-
Avocado seed extract	-	-	-	50.00
Total	100	100	100	100

Proximate analysis

The AOAC method (AOAC, 2005) [8] was used to determine the proximate content of the meatballs: The moisture content was determined by drying the samples overnight at 105ºC, the crude protein content was determined using the Kjeldahl method, the Soxhlet method was used to determine fat content and ash content was determined by using blast furnace to ash the samples overnight at 550ºC.

PH

Meat ball samples were homogenized with distilled water at a ratio of 1:5 (w/v) and the pH value was measured using a digital pH meter.

Cooking loss

Cooking loss was evaluated by the method of Komoltri and Pakdeechanuan (2012) [9]. The raw meat balls samples were weighed, and cooked to an internal temperature of 70 °C. The oven cooked meat balls were allowed to cool to room temperature, while pan fried meats were drained and dried with paper towels and weighed.

Cooking loss was calculated as % cooking loss = $[(W_1-W_2)/W_1]$ x100

Where W_1 = weight before cooking, and W_2 = weight after cooking.

Cooking yield

Cooking yield was evaluated by method of Komoltri and Pakdeechanuan (2012) [9] as:

% cooking yield = (W_4/W_3) x100 where W_3 = initial weight of meat ball and W_4 = final weight of meat balls.

Sensory evaluation

The sensory attributes were accessed for aroma, tenderness, juiciness, texture and overall acceptance. Sensory evaluation of cooked meatballs was performed by twelve-member panelists who were served warm meatballs using nine hedonic scales (Omojola, 2008) [10].

Experimental design and statistical analysis

4 x 2 factorial arrangements in a Completely Randomized Design were used for the study. All data were obtained in triplicates and analyzed using ANOVA and mean difference were separated using the Tukey test at a confidence level of 5% of Minitab software v16 (Minitab, 2007) [11].

Results and discussion

The result of the quality of meat balls treated with different plant extracts is shown on Table 2. The pH value of raw meat balls was significantly higher ($p<0.05$) in treatment 3 (50% African walnut seed extracts than other treatments and control. The pH of meat ball samples were within the normal value for meat, an evidence that the muscle undergone complete rigour mortis during conversion to meat after slaughter (Ekiz *et al*., 2012) [12] which also accounts for meat quality attributes such as water binding capacity and texture (Shirimaa and Mteng, 2012) [13]. Chilling loss varied between 7.97 and 10.28% in samples. This low chilling loss indicates that the meat balls have ability to retain water and no shrinking of muscular structure which may let loose of moisture during chilling (Beshir and Babiker, 2009) [14]. Cook yield expresses loss of meat mass during cooking (Gustavson *et al*., 2011) [15]. The highest cook yield values were recorded in treatment 2 (50% garlic extract) of both oven-cooked and pan fried meat ball samples which indicates that the plant extracts probably contains substances that could keep meat mass intact during cooking. Treatment 2 (50% garlic extracts) had the least cooking loss values of 31.67% and 31.33% in oven- cooked and pan-fried meat respectively. The exposure of treated meat balls to thermal processing may results into denaturation of myofibrillar protein in cooked samples, this leads to loss of moisture and meat constituents (Toohey and Hopkins, 2006) [16].

Table 3 shows the results of the proximate composition of meat ball samples treated with plant extracts. The proximate composition of the raw meat ball showed that the moisture content was significantly higher ($p<0.05$) in treatment 3. This high moisture content accounts for meat qualities such as appearance, tenderness and texture. The highest value of crude protein was observed in treatment 2 samples, ash content ranged from 2.81% (treatment 3) and 4.00% (treatment 2); the lowest fat content was found in treatment 2 (50% garlic extracts).

The proximate composition of oven-cooked meat ball samples revealed that the least moisture content was obtained in treatment 2 (8.6%) while the highest value of 14.51% recorded in control samples. Generally, moisture contents of oven-cooked samples were extremely lower than pan-fried samples this makes the product more shelf-stable. The crude protein of treatment 2 was significantly ($p<0.05$) higher than other treatments and control. Ash content ranged from 2.39% (treatment 1) to 3.61% (treatment 2). The lowest fat content value of 0.87% was recorded in treatment 2 samples while treatment 4 (50% avocado seed extract) had the highest value of 1.26%.

The proximate composition of pan-fried meat ball samples show that moisture content values varied between 50.2% (treatment 2) and 52.64% (treatment 1); crude protein was significantly lower ($p<0.05$) in control than the treated samples; Highest ash content was observed in treatment 4 and lowest fat content was recorded in treatment 2.

The plant extracts (garlic, African walnut and avocado) may contain fat degradation substances and these substances may be more in garlic extracts as lowest fat content was recorded in samples treated with garlic extract (Konjufca *et al*., 1997) [17], also the plant extract added to the increment in the

nutritional value such as crude protein and ash (minerals) contents as recorded in raw and cooked meat balls in this study (Sacks *et al*., 2006) [18].

The result of sensory evaluation of cooked meat balls shown in Table 4 revealed that aroma and tenderness were significantly influenced ($p<0.05$) in treatment 2 than other treatments in both oven-cooked and pan-fried samples, treatments 2 and 3 samples were similar for juiciness in both oven-cooked and pan fried samples respectively. Tenderness of control sample was significantly high in oven-cooked samples while treatment 2 (50% garlic extract) had the highest score for texture in pan fried samples. Treatment 2 of oven-cooked was most accepted as shown by highest score for overall acceptability while treatment 1(control) sample had overall best for pan-fried samples. Garlic extract influenced better aroma of meat ball samples irrespective of methods used for the processing. It shows that garlic extract may contain allicin and organosulphur compounds (Chang and Cheong, 2008)[19] more than other extracts. The rating for tenderness was high (moderately liked) in both oven and pan fried products but garlic extract had better rating than African walnut and avocado extracts, an indication that bioactive substances in the plant extracts may have reacted with moisture, fat and other muscle constituents which facilitate succulence during mastication and chewing of meat (Omojola *et al.*, 2003)[20].

Juiciness rating were similar in both oven cooked and pan fried methods of cooking across the treatment groups. Treatments 1 and 2 were rated moderately dry while treatments 3 and 4 were rated very dry which shows that methods of cooking may have resulted in the dryness of products observed in this study as these methods did not support water retention due to increase in temperature that enhanced loss of moisture (Cross *et al*., 1986; Aberle *et al*. 2001) [21, 22]. Texture which depends on tenderness and juiciness plays a vital role in organoleptic determination of meat products. Texture was rated to be slightly coarse in treatments 1 and 2, moderately coarse in treatments 3 and 4 of oven-cooked while pan fried were intermediately fine. The overall acceptability showed that the consumers preferred garlic treated oven cooked meatball to African walnut and avocado treated pan fried meatballs.

Table 2: Meat qualities of raw and cooked meatballs treated with different herbal extracts

parameter	Treatment1 (control)	Treatment 2 50% garlic extract	Treatment 3 50% African walnut extract	Treatment 4 50% avocado seed extract	p-value
pH@ 24h raw meat ball	5.57±0.15 ^{b}	5.50±0.10^{c}	5.70±0.06 ^{a}	5.50±0.10^{c}	0.77
Chilling loss raw meatball	10.28±1.61 ^{a}	7.83±0.58^{c}	7.97±0.06^{c}	8.83±0.29^{b}	0.03
Cook yield oven cooked meatball	63.33±2.89^{b}	65.00±5.00 ^{a}	61.67±5.69^{c}	61.67±1.533^{c}	0.73
Cook yield pan-fried meatballs	69.00±1.00 ^{a}	68.67±0.58 ^{a}	64.00±1.00^{c}	63.33±2.89^{d}	0.004
Cook loss oven-dried meatballs	36.67±2.89^{b}	31.67±5.77^{d}	38.33±5.69 ^{a}	36.33±4.04^{c}	0.41
Cook loss pan-fried meatballs	31.00±1.00^{c}	31.33±0.58^{c}	35.33±0.58^{b}	36.67±2.89 ^{a}	0.01

*Means with different small letters among rows are significantly different ($p<0.05$).

Table 3: Proximate composition raw and cooked meatballs (%)

Proximate composition	Methods of cooking	Treatment 1 (control no extracts)	Treatment 2 (50% garlic extracts)	Treatment 3 (50% African walnut seed extracts)	Treatment 4 (50% Avocado seed extracts)
Moisture	Raw meatball	76.00±2.85^{b}	73.49±0.84^{d}	77.54±1.40^{a}	75.38±1.81^{c}
	Oven-cooked	14.51±3.76^{a}	8.63±1.52^{d}	10.50±1.32^{b}	9.17±1.16^{c}
	Pan-fried	52.64±2.68 ^{a}	50.21±0.30^{d}	51.37±1.01^{b}	50.85±2.02^{c}
Protein	Raw meatball	15.42±1.01^{a}	21.20±0.26^{b}	18.07±0.75^{c}	18.27±0.03^{c}
	Oven-cooked	43.33±1.53^{d}	46.17±1.61^{a}	44.67±4.20^{b}	44.50±3.50^{c}
	Pan-fried	28.45±0.44^{d}	32.55±3.51^{a}	31.14±4.94^{b}	29.46±5.53^{c}
Ash	Raw meatball	3.00±1.00^{c}	4.00±1.00 ^{a}	2.18±0.74^{d}	3.63±0.15^{b}
	Oven-cooked	2.39±0.53^{d}	3.61±0.09^{a}	2.88±0.16^{b}	2.99±0.32^{c}
	Pan-fried	1.83±0.01^{d}	2.33±0.29^{b}	2.30±0.06^{c}	2.48±0.06 ^{a}
fat	Raw meatball	5.02±0.98 ^{a}	1.72±0.15^{d}	2.21±0.01^{c}	3.63±0.15^{b}
	Oven-cooked	1.81±0.06^{a}	0.87±0.59^{c}	1.23±0.04^{b}	1.26±0.05^{b}
	Pan-fried	1.69±0.06^{c}	1.62±0.04^{d}	1.73±0.03^{b}	1.87±0.12 ^{a}

*Means with different small letters among rows are significantly different ($p<0.05$).

Table 4: organoleptic properties of cooked meat balls

Sensory properties	Methods of cooking	Treatment 1 (control no extracts)	Treatment 2 (50% garlic extracts)	Treatment 3 (50% African walnut seed extracts)	Treatment 4 (50% avocado seed extracts)
Aroma	Oven-cooked	6.67±0.82^{b}	7.17±1.72^{a}	6.50±1.87^{c}	6.67±1.03^{b}
	Pan-fried	6.17±0.75^{b}	6.83±0.75^{a}	6.17±0.75^{b}	5.67±1.21^{c}
Tenderness	Oven-cooked	6.17±1.17^{c}	7.00±0.63^{a}	6.50±1.38^{b}	5.83±1.33^{d}
	Pan-fried	6.33±0.52^{d}	7.50±1.05^{a}	6.67±0.52^{b}	6.50±0.55^{c}
Juiciness	Oven-cooked	4.33±0.82^{a}	4.33±1.21^{a}	3.83±1.17^{b}	3.83±0.75^{b}
	Pan-fried	4.33±0.82^{a}	4.33±1.21^{a}	3.83±1.17^{b}	3.83±0.75^{b}
Texture	Oven-cooked	4.17±0.41^{a}	4.00±0.89^{b}	3.67±0.82^{c}	3.50±1.05^{d}
	Pan-fried	5.00±0.63^{c}	5.33±1.03^{a}	5.17±0.75^{b}	5.00±0.63^{c}
Overall acceptability	Oven-cooked	6.33±0.52^{b}	6.67±1.21^{a}	5.83±1.47^{d}	6.00±0.63^{c}
	Pan-fried	6.33±0.52^{a}	6.17±0.75^{b}	5.67±0.82^{d}	6.00±0.00^{c}

*Means with different small letters among rows are significantly different ($p<0.05$).

Conclusion

The study concluded that extracts of garlic, African walnut and avocado used as marinade in meat ball preparations enhanced better qualities such as reduction of chilling loss, cooking loss increase of cooking yield, nutritional value and good sensorial properties.

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