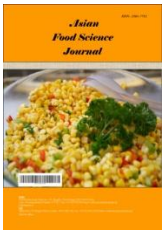

Asian Food Science Journal

21(10): 122-130, 2022; Article no.AFSJ.95136
ISSN: 2581-7752

Effect of Natural Antioxidants on Nutrients, Sensory and Keeping Quality of Suya from Mutton Subjected to Different Processing Methods

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2022/v21i10613

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95136

Original Research Article

Received: 13 July 2022
Accepted: 16 September 2022
Published: 17 September 2022

ABSTRACT

This study evaluated the effect of breeds, processing methods, natural antioxidants and storage period of *Suya* from mutton. A total of 12 sheep (six each from Balami and Ouda) were weighed, slaughtered and allotted to three processing methods which are scalding, singeing and skinning. They are processed into *Suya* meats prepared with 4 different natural antioxidants (black pepper (*Piper nigrum*), green tea (*Camellia sinensis)*, roselle (*Hibiscus sabdariffa* L.) and clove (*Syzygium aromaticum*) and preserved for four weeks. The samples were evaluated for chemical composition, organoleptic properties, microbial loads and storage period. Data collected were analysed using a factorial arrangement of 2x3x4. The results showed that natural antioxidants significantly (P<0.05) influenced all parameters measured except dry matter with the highest value of CP (60.28%) observed in *Suya* samples spiced with black pepper. There were significant (P<0.05) in all the parameters evaluated using different processing methods. Breed had no significant (P>0.05) on organoleptic properties. Significant (P<0.05) effect was observed on colour for processing methods with the highest value 5.18 in scalding. Natural antioxidants had significant (P<0.05) on organoleptic properties except for flavor while *Suya* spiced with clove was rated highest on overall acceptability (6.60). However, breed had no significant (P>0.05) on all the microbial counts of *Suya*

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samples. Scalding had the lowest (P<0.05) values for all the microbial parameters measured. Natural antioxidants significantly (P<0.05) affect all the parameters evaluated with the highest total bacterial count (TBC) $9.34x10^6$, total coliform count (TCC) $9.21x10^4$ and total yeast count (TYC)$10.23x10^3$ in the control while the lowest counts of TBC, TCC and TYC in the samples spiced with clove were found as ($4.31x10^6$), ($5.26x10^4$) and ($5.46x10^3$), respectively. Storage for four weeks had higher significant (P<0.05) values in all the parameters measured than those evaluated for microbial loads at 0 day. It is therefore concluded that, samples spiced with clove had lower microbial loads which tend to enhance shelf-life and were most acceptable for consumption.

Keywords: Microbial loads; mutton; natural antioxidants; scalding; suya.

1. INTRODUCTION

Meat and meat products are major source of protein and an important source of vitamins for most people in many parts of the world, thus they are essential for the growth, repair and maintenance of body cells which is necessary for our everyday activities. The biological and chemical characteristics of meat make it an excellent medium for the growth of microorganisms that produce undesirable sensory changes, which is why processing and preservation methods are aimed at delaying or inhibiting microbial growth to increase the shelf life of fresh meat [1]. Singeing, scalding, and skinning are the processing methods that are extensively used for dressing animal carcass post-mortem [2] while processed meat is any meat which has been modified in order to either improve its taste or extend its shelf life [3].

Suya is primarily prepared from the boneless meat of animals [4]. Muscles meat of almost any kind can be used to increase its keeping quality. It is a popular, traditionally processed, ready to eat Nigerian meat product, which may be served or sold along the streets, in club houses, at picnics, parties, restaurants and within institutions. *Suya* is one of such intermediate moisture product that is easy to prepare and highly relished [5]. There are three types of suya namely; *Tsire*, *Kilishi*, *Balangu*. The process of preservation commences after the whole period of dressing i.e Scalding, singeing, decapitation, evisceration etc. have been completed [6]. Today, *Suya* meat has gained wide popularity and it is been consumed by majority. Most of the sellers of this processed meat were found in strategic locations and were people who does not have much formal education and as a result still uses traditional methods of handling, processing and packaging the products, which are considered to be unhygienic, unsafe and can result in rapid deterioration of the processed meat if not consumed within a short period of time [7].

The intentions of preservation methods are to inhibit the microbial spoilage and to minimize the oxidation and enzymatic spoilage. Since meat has a high nutritive value, microorganisms could easily grow on it. The possible sources of contamination are through slaughtering of sick animals, washing the meat with dirty water, handling by butchers, contamination by flies, processing close to sewage or refuse dumps environment, spices, transportation and use of contaminated equipment such as knife and other utensils [8]. Jackson and Mcgowan [9] stated in their work that microorganisms grow on meat causing visual, textural and organoleptic changes when they release metabolite while Nester et al [10]. Listed factors affect the growth of microorganisms on meat as temperature, pH, water availability and presence of nutrients, moisture, acidity (intrinsic factors), gaseous requirement, and atmosphere of storage (extrinsic factors).

Antioxidants are substances that delay or prevent the oxidation of biomolecules in meat. Antioxidants are added to different meat products to prevent lipid oxidation, and improve quality along with nutritional value of meat. They can be classified into natural and synthetic antioxidants. To avert the effects of oxidation in meat, chemical antioxidants are extensively used. However, because of the possible health risk and toxicity, natural antioxidants are extensively used due to increased demand by consumers. Natural antioxidants are plant derived antioxidant which includes Rosemary Black pepper, Roselle, Green Tea, Clove, Ginger and others [11]. Therefore, this study evaluated the effect of natural antioxidants on nutrients and keeping quality of suya from mutton subjected to different processing methods.

2. MATERIALS AND METHODS

2.1 Experimental Samples

Twelve sheep (six each for Balami and Ouda) were purchased from a reputable ruminant animal market in Ibadan and transported to the Livestock unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State. Ingredients such as ginger, red pepper, salt, seasoning, vegetable oil, and groundnut cake powder, and test ingredients such as (Black pepper (*Piper nigrum*), Green tea (*Camellia sinensis)*, Roselle (*Hibiscus sabdariffa* L.) and Clove (*Syzygium aromaticum*) were purchased from a reputable market in Ogbomosho, Oyo State. The animals were stabilized for optimum condition for two weeks before slaughtering. The experimental animals (six per breed) were slaughtered and processed using three different methods (Scalding, Skinning, and Singeing) as described by Omojola and Adesehinwa [6].

2.2 Suya Preparation

The raw meats were washed and cut into thin fillets. The ingredient was spread on a clean, dry tray and each sheet of meat was properly dusted and soaked with the ingredient according to methods of [12]. The sticks of meat were labeled and about 5–10 ml of groundnut oil was sprinkled on each meat stick before roasting using traditional suya smoker. The meats were allowed to stay on the fire at 90°C for 20 minutes with the distance of 22–23 cm from the center of the fire and intermittent turning of the product. Additional groundnut oil was sprinkled on the meat while roasting continued [12]. The suya prepared from the 3 dressing methods were labeled accordingly for easy identification. The ingredients composition as described by Omojola, [12] was used for the production of suya while ginger was replaced with the different natural antioxidants at 10% each (Table 1). All necessary hygienic precautions were observed in the laboratory.

2.3 Data Collection

2.3.1 Proximate composition

The proximate composition of dry matter, crude protein, and ether extract and ash contents was determined for *suya* samples using standard analytical methods of AOAC [13], while the amount of nitrogen-free extract was calculated by differences.

Table 1. Ingredients Composition of Spices and Condiment for Suya Production

Ingredients (%)	Control	Black pepper	Green tea	Roselle	Clove
Groundnut powder	52.00	52.00	52.00	52.00	52.00
Ginger	10.00	10.00	10.00	10.00	10.00
Dried pepper	10.00	10.00	10.00	10.00	10.00
White pepper	5.00	5.00	5.00	5.00	5.00
Salt	8.50	8.50	8.50	8.50	8.50
Curry	5.00	5.00	5.00	5.00	5.00
Maggi seasoning	7.50	7.50	7.50	7.50	7.50
Groundnut oil	2.00	2.00	2.00	2.00	2.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Raw meat→ washed → sliced → skewed in thin stick → spiced → kept in transparent plastic container for 30-60 minutes → roasted → spiced → heated for 5-8 minutes → sprinkled vegetable oil → packaged.

Fig. 1. Flow chart for suya preparation

Table 2. Main effect on chemical composition of suya with different antioxidant subjected to different processing methods

Parameters	DM(%)	CP(%)	EE	Ash	NFE	CHO	TAG	HDL	LDL	MDA
Breeds										
Balami	76.84	59.18	10.49	4.52	2.62	299.65^{a}	127.25^{a}	71.70	202.50^{a}	10.95
Ouda	77.59	59.32	10.28	5.08	2.91	262.00^{b}	113.90^{b}	70.21	169.00^{b}	10.22
SEM	3.92	2.52	1.32	0.52	0.65	3.21	3.01	1.24	3.42	1.40
Processing methods										
Scalding	71.46^{c}	55.91^{c}	7.45^{c}	3.79^{b}	4.30^{a}	276.40^{b}	107.82^{b}	70.95^{b}	183.89^{b}	11.57^{a}
Singeing	79.88^{b}	60.43^{b}	11.62^{b}	5.66^{a}	2.27^{b}	282.28^{b}	133.40^{a}	74.54^{a}	181.06^{b}	11.05^{a}
Skinning	83.02^{a}	63.51^{a}	13.88^{a}	5.00^{a}	0.55^{c}	305.60^{a}	127.00^{a}	64.53^{c}	215.70^{a}	8.05^{b}
SEM	2.31	2.11	1.32	1.02	0.34	3.41	2.32	2.10	2.31	1.23
Natural antioxidants										
Control	77.83	60.09^{a}	10.99^{a}	4.61^{b}	2.11^{b}	184.20^{e}	131.90^{b}	61.03^{b}	96.81^{d}	11.68^{b}
Black Pepper	78.77	60.28^{a}	11.27^{a}	4.79^{b}	2.42^{b}	231.20^{d}	130.40^{b}	74.96^{b}	130.20^{c}	8.27^{c}
Green Tea	76.02	57.60^{b}	10.39^{b}	4.61^{b}	3.37^{a}	306.10^{c}	81.37^{c}	39.13^{c}	250.70^{a}	7.70^{d}
Roselle	76.24	58.64^{b}	9.21^{c}	4.66^{b}	3.74^{a}	332.80^{b}	129.30^{b}	99.04^{a}	207.90^{b}	12.73^{a}
Clove	76.86	59.56^{a}	10.17^{b}	5.03^{a}	2.04^{b}	368.60^{a}	136.60^{a}	81.35^{ab}	259.90^{a}	12.90^{a}
SEM	2.13	2.11	1.34	1.21	0.21	4.21	3.21	2.13	2.12	2.31

^{abc} Means on the same row with different superscripts are statistically significant ((p<0.05). SEM: Standard Error of Mean.

DM – Dry Matter, CP – Crude Protein, EE – Ether Extract, NFE – Nitrogen Free Extract, CHO – Cholesterol, HDL – High Density Lipoprotein, LDL – Low Density Lipoprotein, MDA – Malondialdehyde

Table 3. Main effect on organoleptic properties of *suya* with different natural antioxidants subjected to different processing methods

Parameters	Colour	Flavour	Juiciness	Tenderness	Overall Acceptability
Breeds					
Balami	4.25	4.49	4.66	4.90	5.72
Ouda	4.32	5.17	5.14	4.73	6.34
SEM	0.17	0.19	0.16	0.16	0.19
Processing methods					
Scalding	5.18^{a}	4.66	4.98	5.74	5.96
Singeing	3.78^{b}	4.83	4.66	4.73	6.04
Skinning	3.48^{b}	4.84	4.95	4.62	5.84
SEM	0.24	0.28	0.23	0.23	0.27
Natural Antioxidants					
Control	4.32^{a}	4.52	4.88^{ab}	4.36^{b}	5.56^{b}
Black pepper	4.71^{a}	4.77	4.47^{b}	5.04^{ab}	5.56^{b}
Green tea	5.00^{a}	5.12	5.20^{a}	5.00^{ab}	6.20^{ab}
Roselle	3.08^{b}	4.48	5.08^{ab}	5.24^{a}	5.92^{ab}
Clove	4.28^{a}	4.92	4.63^{ab}	4.50^{ab}	6.60^{a}
SEM	0.23	0.27	0.22	0.23	0.27

^{abc} *Means on the same row with different superscripts are statistically significant ((p<0.05). SEM: Standard Error of Mean*

Table 4. Main effect on microbial loads of *suya* with different natural antioxidant subjected to different processing methods

Parameters	Mean Total Bacterial Count cfu/g x10^{6}	Mean Total Coliform Count cfu/g x 10^{4}	Mean Total Yeast and Mould cfu/g x 10^{3}
Breeds			
Balami	7.35	8.03	7.23
Ouda	6.13	7.91	8.28
SEM	0.63	0.21	0.33
Processing Methods			
Scalding	7.15^{c}	7.12^{b}	8.34^{c}
Singeing	8.72^{b}	7.82^{b}	10.36^{a}
Skinning	10.3^{a}	10.36^{a}	12.53^{a}
SEM	1.29	1.03	0.92
Natural Antioxidants			
Control	9.34^{a}	9.21^{a}	10.23^{a}
Black pepper	6.32^{b}	7.56^{b}	7.21^{b}
Green tea	6.62^{b}	7.39^{b}	6.76^{b}
Roselle	5.27^{c}	6.16^{c}	6.01^{c}
Clove	4.31^{d}	5.26^{d}	5.46^{d}
SEM	1.29	1.03	0.92
Storage			
0 day	6.52^{b}	6.01^{b}	7.02^{b}
4 weeks	9.39^{a}	9.25^{a}	10.21^{a}
SEM	0.34	0.21	0.45

^{abc} *Means on the same row with different superscripts are statistically significant ((p<0.05). SEM: Standard Error of Mean*

2.3.2 Sensory evaluation

Suya samples were cut into uniform size, coded and served warm for organoleptic properties assessment. A 9-point hedonic scale was used to assess the following categories of the *suya* samples: colour, flavour, tenderness, juiciness and overall acceptability. Scores were assigned with 9 being ''like extremely'' and 1 ''dislike extreme''. Semi-trained panelist received a piece

of *suya* samples with a different tag for sensory evaluation. Water and cream cracker biscuits were provided for each panelist to freshen their mouth between each sample assessment [14].

2.3.3 Microbiological load

The microbiological quality and safety of *suya* were assessed on the basis of Total Bacterial Count (TBC), Total Coliform Count (TCC) using Nutrient agar and MacConkey agar, respectively. The swabs from the samples were taken to the laboratory where samples were evaluated at 0 days and four weeks for microbial assay. Gram-staining, motility test, and biochemical test techniques were conducted for clear identification as described by [15] while fungi identification was carried out as described by [16].

2.4 Statistical Analysis of Data

Data collected were subjected to One-way ANOVA using SAS [17]. Significant means were separated by Duncan option of the same statistical software. A probability of 5% was considered significant (P<0.05).

3. RESULTS

3.1 Chemical Composition

Chemical composition as affected by breeds; processing methods and natural antioxidants on *suya* meat product is presented in Table 2. The results showed that the CHO, TAG and LDL were significantly (P<0.05) were the highest for balami breed. Although, ouda breed had the values for dry matter, ash and NFE. Furthermore, processing methods significantly (P<0.05) influenced the chemical composition of *suya* with different antioxidants. Highest DM, CP, EE, CHO, LDL and MDA were observed in skinning processing method. Although, natural antioxidant did not have significant (P>0.05) effect on DM whereas other parameters were significantly (P<0.05) affected by the natural antioxidants. Highest value of DM, CP and EE were observed in *suya* processed with black pepper. However, highest CHO, TAG, LDL and MDA were recorded for *suya* processed with clove.

3.2 Sensory Evaluation

Organoleptic properties of *suya* with different antioxidant subjected to different processing methods are presented in Table 3. Breeds had no significant (P>0.05) influence on the *suya* prepared with different natural antioxidants. Though, the taste panelist scored *suya* obtained from ouda breed the highest in terms of flavour, juiciness and overall acceptability. Only flavour was significantly (P<0.05) influenced by processing methods. Meat samples (*suya*) processed by scalding was rated the highest for colour, juiciness and tenderness. However, natural antioxidants significantly (P<0.05) influenced organoleptic properties except flavour. The panelists rated colour the lowest in *suya* prepared with Roselle while the highest overall acceptability was observed in *suya* processed with Clove.

3.3 Microbial Load Counts

Table 4 shows microbial loads count of *suya* with different natural antioxidants subjected to different processing methods. Breed of the animals did not significantly (P<0.05) influenced the microbial load of the *suya.* However, balami breed had the highest total bacterial and coliform counts while highest total yeast and mould counts was observed in *suya* obtained from ouda breed of sheep. Processing methods, natural antioxidants and storage significantly (P<0.05) affected the microbial counts of the *suya.* Skinning method was observed to have the highest total bacterial, coliform, yeast and mould counts while lowest values were observed in scalding processing method. The *suya* prepared without any natural antioxidant (control) was observed to have the highest microbial load counts while the lowest values were obtained from *suya* prepared with clove. *Suya* stored for four weeks had significant (P<0.05) highest microbial counts and the lowest values were recorded those with 0 day storage.

4. DISCUSSION

The chemical composition of *Suya* with different natural antioxidants subjected to different processing methods is as shown in Table 2. According to Akinleye et al. [18] protein is the most important muscle constituent of which is made up of myofibrilla, sarcoplasmic and connective tissues. Highest CP (60.28%) was recorded in samples prepared with black pepper while lowest CP (57.60%) in *Suya* sample prepared with green tea. Ether extract of *Suya* prepared with black pepper was higher than other prepared with other natural antioxidants. The MDA of *Suya* processed by skinning is the

lowest among the processing methods (scalding, singeing and skinning). Malondialdehyde is the most abundant aldehyde that results from lipid peroxidation and highly toxic molecule. *Suya* prepared with green tea had lower MDA which is an indication of reduced level of toxicity molecule in the *Suya* samples. This report agreed with the findings of McCarthy et al. [19] who stated that the catechins present in green tea leaves was the most effective in reducing lipid oxidation frozen and fresh pork patties. Although, black pepper tended to decrease the LDL but lowest value of LDL was observed in the control. However, highest level of ash content was observed in *Suya* prepared using clove is in agreement with the report of Akinola et al. [20]. Ash content is often seen as an index of mineral content in biological mass [21]. With the highest DM observed in *Suya* processed by skinning shows that the meat can be stored for a longer period [20].

From Table 3, the significant effect observed in *Suya* samples prepared with clove is in consonance with the report of Abubakar et al. [22] who asserted similar scoring by the panelist for juiciness, tenderness and acceptability. The highest level of juiciness observed in *Suya* prepared with Roselle is an impression of moisture released during chewing and salivation produced by flavour factor [23]. Numerically, *Suya* obtained from Ouda breed had higher values of colour, flavour, juiciness, tenderness and overall acceptability. The result obtained for the overall acceptability shows that the consumers (panelists) prefer *Suya* prepared with clove.

The microbial load of *Suya* with different natural antioxidant subjected to different processing methods is presented in Table 4. Meat contains all the nutrients necessary for microbial growth and metabolism, making it susceptible to microbial contamination [24]. *Suya* stored for 4 weeks had higher Total Bacterial Counts (TBC), Total Coliform Counts (TCC) and Total Yeast Count (TYC) than those assessed for microbial load count at 0 day. Mandee et al. [25] stated that the kind and number of micro organisms found on frozen meat is as a result of the freezing temperature of storing which can lead to death of the micro organisms. According to Kamala-Kumari et al. [26] natural antioxidants have tendencies to reduce microbial growth, lipid peroxidation and improve product shelf-life. The *Suya* prepared with clove has the lowest TBC, TCC and TYC. This report is in line with the report of Jayathilakan et al. [27]. The TBC obtained in this study for Ouda (6.13) falls below the report of Salihu et al. [28] who reported 8.90 TBC. Meanwhile, the TBC for Balami in this study (7.35) is higher than what was reported (4.60) by the same author. Although, higher TCC were reported for Ouda (7.91) and Balami (8.03) than what was reported by Salihu et al. [28] for Ouda (3.46) and Balami (1.10). All these are still within the acceptable range for human consumption.

According to International Commission on Microbiological Specifications for Food Microorganisms in Foods ICMSF [29] and London Health Protection Agency, LHPA [30] spoilage in meat products becomes evident when the bacterial counts exceed international guidelines of good manufacturing practice 10^7 cfu/g. For this study, meat products prepared from three processing methods (Skinning, Singeing and Scalding) did not exceed threshold levels for bacteria count, coliform count and fungal count that could cause microbiological spoilage of the meat products. Natural antioxidants have abilities to retard microbial growth, lipid oxidation and prolong product shelf-life [26] which was evident in this study. The samples with clove have the lowest counts. This result agreed with that reported by [25] who stated that microbes are sensitive to clove, and other antimicrobial activities as clove and its essential oil were among the most capable antioxidants for controlling bacteria such as *Escherichia coli* [25]. Storage effect resulted in higher TBC, TCC and TYC. This agrees with the report of Mandee et al., [25] that the kind and number of microorganisms found in frozen meat depend on freezing temperature during storage and severity of the freezing process with respect to the lethality to microorganisms. Complete death of all the microorganisms does not occur merely due to low temperatures and when the food is thawed there can be a rapid multiplication of microorganisms [31].

5. CONCLUSION

Skinning is a suitable processing method because it had higher level of DM and CP. Though, green tea reduced the malondialdehyde in the *Suya* samples. The overall acceptability for the *Suya* prepared with clove is the highest. All the natural antioxidants reduced the microbial loads of the samples, thereby improving the quality and shelf-life but storage of the *Suya* product could be deleterious.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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