



Cured characteristics of non-nitrite-ham produced with *Ocimum gratissimum* as additive

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ABSTRACT

Cured meats are desirable to consumers across the world. Unfortunately, the use of nitrite to obtain cured characteristics has health implications for consumers. Three (3) kg each of ham were produced and labeled as H0, H1, H2, H3 and H4, respectively. H0 represented traditional ham produced with nitrite-curing salt and H4 contained common salt alone. H1, H2 and H3 were produced with 15.0 mg kg⁻¹, 30.0 mg kg⁻¹ and 60.0 mg kg⁻¹ *Ocimum gratissimum* leaf extract as an additive with common salt. Proximate composition, pH, water activity and residual nitrite levels in treatments as well as color profiles were studied. The percentage contents of moisture, fat, protein and ash ranged from 40.02 (H3) to 41.20 (H4), 2.05 (H0) to 2.61 (H2), 19.37 (H4) to 20.83 (H3) and 2.27 (H4) to 2.69 (H2), respectively. Residual nitrite levels reduced significantly ($P < 0.05$) with increased use of OG as an additive in ham production. Lightness, redness and yellowness characteristics of OG-common-salt-cured ham were not significantly different ($P > 0.05$) from nitrite-cured ham, but redness of common-salt cured ham was significantly lower ($P > 0.05$) compared to 60.0 mg kg⁻¹ *Ocimum gratissimum*-common-salt-cured and conventionally cured types of ham. It was concluded that *Ocimum gratissimum* leaf extract as an additive can potentially influence the development of desirable characteristics in ham.

Keywords: Nitrite cured meat, Ham, Consumer health implication, Residual nitrite, *Ocimum gratissimum*, Cured characteristic

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Introduction

The use of nitrite as a cure additive in meat processing results in enhanced color, flavor and taste characteristics, which are acceptable to consumers. Nitrites also have antioxidant and antimicrobial properties, especially against the growth of *Clostridium botulinum* in processed meat products. However, the continued use of synthetic additives in food processing in general has received negative dialogues concerning health issues due to the potential risks associated with them. Nitrites have the potential to produce nitrosamines, which can be carcinogenic to biological organs, systems, tissues and cells. There is therefore an urgent need not only to reduce the levels of synthetic food additives used in meat processing, but also to provide alternatives, which can provide similar product characteristics desirable by consumers across the world.

Several studies have focused on the use of plant or vegetable sources to effect curing reactions with some desirable results because of their contents of nitrates which when converted to nitrite through microbial interactions could produce desirable cured effects. Such natural plant sources also can function as antioxidants due to their contents of phytochemicals (Akinmoladun *et al.*, 2007). Farombi *et al.* (1998) reported that phytochemicals have disease preventing abilities due to their biologically active compounds with antimicrobial and antioxidant properties, for which reasons they are employed in several health promoting and disease fighting functions in humans.

Ijeh *et al.* (2005) and Prabhu *et al.* (2009) provided a list of several plants including *Ocimum gratissimum*, as examples used in



herbal medicine or as spices and food condiments. According to Prabhu *et al.* (2009) *Ocimum gratissimum* is herbaceous and belongs to the family *Lamiaceae*. This plant is commonly known differently in different locations where it is found. It is called “effirin-nla” by the Yoruba speaking tribe in Nigeria, while Hausa’s in northern Nigeria call it “daidoya” (Effraim *et al.*, 2003). The Akan tribes in Ghana call it “nunum”, Ewes call it “dzofotsi” and Gas refer to it as “shoon”. Akwetey *et al.* (2021a) screened *Ocimum gratissimum* leaf extracts for their phytochemical contents and antioxidant properties and recommended its potential use in food. This study therefore seeks to produce ham with or without using *O. gratissimum* as a cure additive. The specific objectives were to determine physicochemical properties, including pH, water activity, residual nitrite and colour profile ($L^* a^* b^*$) in ham produced with or without using *O. gratissimum*.

Materials and Methods

Ingredients used and procedure for ham production

Fresh ham cuts from 6-month old hogs slaughtered on the same day were obtained from the Kumasi Abattoir Company Limited and transported on ice to the Meat Science and Processing Unit at the Departments of Animal Science, KNUST, Kumasi. Upon arrival, the fresh hams were taking to safe storage facility with a temperature of 2°C overnight. Five cure solutions comprising of nitrite curing salt, three (3) *Ocimum gratissimum*-common-salt mixtures and common salt alone were prepared for curing ham by immersion for 72 h. All immersed fresh hams were kept in a room at 16°C in order to facilitate the curing process. Cured fresh ham were washed with tap water and hung individually by means of stainless steel hooks for hot smoking for 3 h using fire wood as fuel in a traditional smoke chamber. Smoked hams were cooked to attain core temperatures of 71°C after which they were chilled at 2°C overnight and packaged separately in zip-lock bags for frozen storage at -18 °C and further analysis. The experimental treatments were all repeated 3 times.

Parameters determined

Proximate composition and colour profile

The procedures recommended by AOAC (2012) were used in the determinations of percentage moisture, fat, protein and ash. The Hunter colour system was used to determine colour profile ($L^* a^* b^*$) of cooked ham using the Meat Colour Measurements Guidelines suggested by AMSA (2012). Three (3) measurements were taken from different position of the lean portions of each cooked treatment sample.

Water activity and pH

Water activity (a_w) was determined using the methods of Kuo and Ockerman (1985) and a pH-meter (FC-200, HI9024C, Hanna Instruments, Singapore) fitted with a probe was employed to measure pH of mashed treatment samples in distilled water.

Residual Nitrite

Methods of AOAC (1990) were used in the determination of residual nitrite. Finely ground treatment samples (5g) were used for all residual nitrite assays in triplicate at the same time to minimize variation in analysis due to time.

Design of experiment and statistical analysis

The experiment was conducted in a completely randomized design; comprising of 5 treatments (H0-H5) with 3 replications. Each treatment was repeated 3 times to obtain 45 experimental units. Data generated were subjected to one-way analysis of variance (ANOVA) using Minitab version 18.1 software. Significance differences in treatments means were determined at 5% using Duncan’s test of homogeneity.

Results and Discussion

Proximate composition

Results of proximate compositions of ham produced with either nitrite salt, OG-common salt or common salt alone are shown in Table 1.

Table 1. Proximate composition of ham produced with and without nitrite salt, OG and or common salt.

Type of ham	Percentage proximate composition			
	Moisture	Fat	Protein	Ash
H0	40.93	2.05	19.67	2.72
H1	41.01	2.46	20.33	2.64
H2	40.78	2.61	20.10	2.69
H3	40.02	2.52	20.83	3.12
H4	41.20	2.22	19.37	2.27
<i>P-value</i>	0.91	0.18	0.26	0.19
<i>SE</i>	0.203	0.103	0.254	0.135

H0 is 12 g nitrite salt/kg H1, H2, H3 contain 12 g common salt/kg +OG at 15.0 mg, 30 mg and 60 mg respectively, and H4 is 12 g common salt/kg; SE= standard error.

No significant ($p>0.05$) differences were recorded for all the proximate components evaluated. The percentage contents of moisture, fat protein and ash ranged from 40.02 (H3) to 41.20 (H4), 2.05 (H0) to 2.61 (H2), 19.37 (H4) to 20.83 (H3) and 2.27 (H4) to 2.69 (H2), respectively. These observations suggested that the levels of OG used were probably not high enough to influence any significant changes in the proximate compositions in ham. Akwetey

et al. (2021b) reported similar findings when frankfurters were produced with and without using *Ocimum gratissimum* up to 50 mg/kg in frankfurter-type sausage formulations.

Colour profile of ham

The L* a* b* colour measurements for ham in this study are reported in Table 2.

Table 2. Colour measurements of ham produced with and without nitrite salt, OG and or common salt.

Type of ham	Colour profile		
	L*	a*	b*
H0	55.51 ^a	23.64 ^a	20.98 ^{ab}
H1	55.73 ^a	22.73 ^{ab}	19.28 ^{ab}
H2	55.77 ^a	21.44 ^{ab}	19.85 ^{ab}
H3	55.00 ^a	23.78 ^a	17.02 ^b
H4	51.92 ^b	20.70 ^b	21.55 ^a
P-value	<0.001	<0.001	0.02
SE	0.729	0.606	0.788

^{abc}Means with same superscripts in same column are not significantly different ($p>0.05$). H0 is 12% nitrite salt only, H1, H2, H3 contain 12% common salt+OG at 15.0mg, 30mg and 60mg respectively, and H4 is 12% common salt only; SE= standard error.

Significant ($p<0.05$) differences were observed in all the colour coordinates studied. Lightness profile (L*) was lower in H4 compared to all other treatments, redness (a*) in H0 was not different significantly ($p>0.05$) from H1, H2 and H3. Treatment H4 was also not significantly ($p>0.05$) different from H1 and H2 however, a* in H4 was significantly ($p<0.05$) lower compared to H0 and H3. Yellowness (b*) in H4 was significantly ($p<0.05$) higher compared to treatment H3, but the observed differences in yellowness of H0, H1, H2 and H4 were not statistically different. Sindelar (2006) investigated several brands of ham and reported that uncured, no-nitrate/nitrite-added ham had better cured colour than nitrite-added control;

and concluded in general that, the uncured types were comparable to traditional nitrite-cured control in terms of colour and residual nitrite.

Sullivan (2011) observed increased redness for natural nitrate and nitrite-cured hams, but suggested that the differences would probably not be detectable by consumers. The objective color measurements in this study do not show any marked differences between the nitrite-cured ham and *Ocimum gratissimum*-treated counterparts.

Water activity, pH and residual nitrite in ham

Table 3. Water activity, pH, residual nitrite and nitrate (mg kg⁻¹) in ham produced with and without *O. gratissimum*.

Type of ham	Chemical property		
	Water activity	pH	Residual nitrite (ppm)
H0	0.950 ^b	5.76 ^a	5.71 ^a
H1	0.955 ^b	5.62 ^{ab}	4.00 ^b
H2	0.952 ^b	5.57 ^{ab}	3.97 ^b
H3	0.951 ^b	5.55 ^b	2.40 ^c
H4	0.969 ^a	5.72 ^{ab}	3.86 ^{bc}
P-value	<0.001	0.02	<0.001
SE	0.004	0.041	0.525

^{abc}Means with same letter within a column are not significantly different ($p>0.05$). H0 is 12% nitrite salt only, H1, H2, H3 contain 12% common salt+OG at 15.5 mg, 30 mg and 60 mg, respectively, and H4 is 12% common salt only; SE= standard error.

Table 3 shows results obtained for determinations of water activity, pH and residual nitrite in ham. Water activity ranged from 0.951 (H3) to 0.969 (H4), and values observed for H4 were significantly ($p<0.05$) higher compared to all other treatments. These observations could be useful in preventing growth or spoilage by

microbiota, which may require a_w in the range of 0.970 to 0.990 to proliferate in food (ICMSF, 1996). The levels of pH recorded were from 5.55 (H3) to 5.76 (H4), and H0 was significantly ($p<0.05$) higher compared to H3. However, treatments H0, H2, H3 and H4 were not significantly ($p>0.05$) different. In a previous

study using the same cure ingredients, pH in frankfurters were not influenced by treatment (Akwetey *et al.*, 2021b). The observed differences in pH of ham cured with OG-common salt could be responsible for their improved hunter a^* compared to ham cured with common salt alone (Table 3). In addition, the observed reductions in pH could be beneficial in ensuring some degree of microbiological safety of hams cured with OG during storage. ICMSF (1980) and Jay (2000) indicated a pH range of 5.9 and 6.1 to be beneficial for growth and proliferation of most microorganisms in cooked meat and meat products, however pH values of ham in this study were <5.90 in all treatments.

Residual nitrite levels reduced significantly ($p < 0.05$) with increased use of *Ocimum gratissimum* leaf extract as additive in ham production and higher residual nitrite was recorded in conventionally cured ham (H₀) compared to all other treatments. This observation results from the fact that unlike H₀, no nitrite was initially added to treatments H₁, H₂, H₃ and H₄. Thus, the use of *Ocimum gratissimum* in ham curing operations has promising potential to assist in reducing residual nitrite levels.

Conclusions and Recommendations

Increasing the use of *Ocimum gratissimum* up to 60 mg kg⁻¹ in ham production was not high enough to influence any significant changes in their proximate compositions. Residual nitrite levels reduced with increased use of *Ocimum gratissimum* leaf extract in ham production compared to conventionally cured hams. It is recommended to conduct further studies and determine shelf stability of ham produced with *Ocimum gratissimum*. Such studies should focus on effects of using *Ocimum gratissimum* on storage characteristics of cured meat products.

Conflict of interest

The authors have no conflicts of interest to declare.

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