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Garlic and Ginger Pastes as natural Antioxidant in Spent Hen Meat Nugget

Olayemi R. Awodoyin and Oluwatobiloba D. Oyekunle

Department of Animal Science, University of Ibadan, Ibadan, Oyo State, Nigeria
Corresponding author. Telephone: +234(0) 8164193904; Email: olayemiawodoyin@gmail.com

Abstract

Economic value of spent hen can be improved through value addition. However, spent hen contain high fat and coupled with the fact that processed chicken meat is more susceptible to oxidative deterioration make spent hen meat products prone to oxidative degradation. Five spent hen chicken nugget emulsions were formulated (T1 ascorbic); T2 0.5% Garlic, T3 1.0% Ginger, T4 0.5% Ginger, T5 1.0%Ginger. The mixtures from each formulation were filled into boxes (20×10 cm) (approximately 40±1 g each), deep fried in Grand Soya oil® for 10 minutes at 190±2oC (frying temperature). The fried nuggets were allowed to cooled down to room temperature and a portion from each nugget was packaged in air tight zip loc bags and stored in a refrigerator (4oC). Frying yield (%), phenol content (GAEmg/g, flavonoid ((mg QE/g), cholesterol (%) and Thiobarbituric reactive substances (TBARS) mg MDA/kg). (Data generated were analysed using ANOVA@Pα0.05. Frying yield 92.29 (0.5% ginger) is similar to 88.62 (0.5% garlic) and significantly higher than 82.29 (ascorbic) and 85.72 (1.5% garlic) but significantly lower than 97.87 (1.5% ginger). Nugget with 1.5% ginger had 24.92 phenol content which is significantly lower (P<0.05) than 20.47 (0.5% ginger), 18.37 (1.5% garlic), 17.63 (0.5% garlic) and 16.06 (ascorbic). Flavonoid (9.34) and cholesterol (72.82) contained in ascorbic nugget is significantly higher than 8.20; 61.84 (0.5 ginger), 8.69; 57.09 (1.5% ginger), 4.71; 68.49 (0.5% garlic) and 6.32; 59.05 (1.5% garlic) for flavonoid and cholesterol respectively. Irrespective of the storage days, ascorbic nuggets had higher TBARS levels than nuggets with ginger and garlic pastes. The reduced cholesterol contents and low levels of TBARS in the spent hen chicken nuggets with ginger and garlic pastes elucidated that both spices can be part of spent hen chicken nuggets formulation.

Key Words: *Nuggets, Oxidative deterioration, Spent hen, Value addition, Scavenging radicals.*

Introduction

The egg industry, at the end of laying cycles produces a significant amount of spent hens as by product (Mahapatra, 1992; Chuaynukool et al., 2007). Spent hen meat is an excellent and cheaper source of animal protein, rich in fat, cholesterol (Sarkar et al., 2020) and similar to broiler meat in term of nutritional quality (Chueachuaychoo et al., 2011). However, despite of these beneficial qualities, spent hens have low economic value (Sarkar et al., 2020). They are most times underutilized and usually used in very low priced minced products (Chuaynukool et al. 2007). This is due to their poor functional characteristics and some sensory properties such as juiciness and tenderness all of which is attributed to the high collagen content they possess (Abe et al., 1996). For instance, spent hen meat still remains tough and fibrous even after cooking with high pressure for a long time (Mendiratta et al. 2012). However, their economic value can be improved through value addition by processing into convenient and shelf stable meat products (Sarkar et al., 2020).

The changing raw meat into to a high quality meat product through processing is usually referred to as value addition of meat. Chicken nugget is an example of food usually preferred by consumers because of its convenience (Sharima-Abdullah et al., 2018) and has been identified as one of the value added meat product that can be used to increase the consumption of poultry meat (Yogesh et al., 2013).

Nugget is a ready to cook and ready-to -eat deep fried meat product usually prepared with chicken meat (Hwuang et al., 2011). Its simple preparation makes it a generally acceptable fried meat products and a popular choice for a quick meal among consumers (Lukman et al., 2009).

Broiler chicken meat is usually used in the production of chicken nuggets because of its high quality characteristics such as high carcasses and better tenderness when compared to spent hen meat (Bhosale et al. 2011). However, throughout the world, broiler chicken meat is of economic importance and also have a good demand for direct meat consumption (Sabikun et al. 2019). It is therefore of utmost importance to find a way of converting the less palatable and tough meat of spent hen into attractive, convenient and more acceptable meat product using appropriate technology. The high fat content of spent hen together with the susceptibility of processed chicken meat to oxidative degradation (Xiao et al., 2011) make spent hen meat products prone to oxidative deterioration. Lipid oxidation in deep fried food has been reported as one of the important criteria that determine the quality and safety of the final product (Izaki et al., 1984). However, this can be reduced or inhibit with the inclusion of

antioxidants in the product during preparation. Antioxidant is one of the strategies and also an effective means used in controlling and reducing the oxidation in meat and meat products (Penchalaraju et al., 2017) as they are the first line of defence against free radicals (Ayoade et al., 2022). This implies that using spent hen meat in the formulation of nuggets will require the incorporation of antioxidant. Natural antioxidants are usually in the form of phenolic compounds such as flavonoids, phenolic acids, tocopherols commonly found in plants (Ali et al., 2008).

Phenolic compounds are group of plant secondary metabolites extensively found across diverse plant, including vegetables, fruits, cereals, legumes, spices and herbs (Balasundram et al., 2006; Zhang et al., 2022). Apart from their use as aroma additives in food many herbs and spices, are excellent sources of phenolic compounds with good antioxidant potentials. Examples of common and readily available spices with good antioxidant properties include garlic and ginger. They are common food spices that are used either singly or in combined form in the diet (Otunola and Afolayan, 2013).

Garlic (*Allium sativum* L.) is culinary spice rich in polyphenolic compounds (Awan et al., 2017; dos Santos et al., 2022) and other bioactive compounds such as flavonoids and organosulfur. These compounds are responsible for its biological activities (Shang et al., 2019; Tavares et al., 2021) such as antioxidant, anti-inflammatory, antimicrobial and immunomodulatory properties (Melguizo-Rodríguez et al., 2022). Fresh garlic bulb contains 65% water, 28% carbohydrates, 2.3% organosulfur compounds, 2% protein, 1.2% free amino acids and 1.5% fiber (Lidiková et al., 2022; Melguizo-Rodríguez et al., 2022).

Ginger (*Zingiber officinale* Roscoe) is usually use in food as a spice (Ali et al., 2008) or seasoning (An et al., 2016). It is composed of phenolic (gingerols, shogaols, and paradols), terpene, polysaccharides, lipids, organic acids and raw fibers (Mao et al., 2019). Fresh ginger contains 85% - 95% water (Prisacaru et al., 2023), 11.97 mg GAE/g total phenolic dry weight (An et al., 2016). This study therefore aimed at investigating the antioxidant potential of garlic and ginger pastes at different inclusion levels in the formulation of spent hen chicken nuggets

Material and methods

Food grade ascorbic acid was purchased from a standard and reputable food stall market. Fresh garlic bulbs were purchased from Bodija a local market within University of Ibadan environment. The garlic (*Allium cepa*) bulb dry skin was removed and the cloves peeled and finely crushed using a kitchen grater. For ginger (*Zingiber officinale* Roscoe), the peels were removed and the fingers cut into slices for easy grinding in the kitchen blender. After grinding, each paste was packed separately in different container until further use.

Sample preparation (raw and cooked nuggets)

Spent hen was obtained from a reputable farm in Ibadan. This was slaughtered, defeathered and cut into primal cuts. Meat was excised from all part of the chicken. All dirts and subcutaneous fat were manually trimmed off and the chicken meat cut into smaller chunks and minced (5mm plate) using a commercial meat grinder. The grounded meat was refrigerated at -4°C until further use. Five spent hen chicken nugget emulsions were formulated (Table 1), each emulsion was thoroughly mixed in an electric mixer for 5minutes to obtain a homogenous mix. The batter from each formulation was filled into boxes (20×20 cm) (raw nuggets) (individual nugget piece weighed 50±1 g/ piece). These were deep fried in Grand Soya oil® at 190±2ºC for 10 minutes with intermittent turning to an inner temperature of 75 °C (using a probe thermometer). The deep fried nuggets were arranged in a tray and placed on a rack and allowed (30 minutes) to cool down to room temperature. The fried nuggets were packaged and stored under refrigeration (4ºC) temperature for further study. The experiment was replicated three times.

Table 1. Ingredient formulation composition of nugget

Ingredients (%)	Ginger			Garlic	
	Ascorbic	0.5%	1.5%	0.5%	1.5%
Chicken meat	70.0	70.0	70.0	70.0	70.0
Ginger paste	0	0.5	1.5	0	0
Garlic paste	0	0	0	0.5	1.5
Ascorbic acid	1.5	0	0	0	0
Refined salt	1.5	1.5	1.5	1.5	1.5
Ice water	5.0	5.0	5.0	5.0	5.0
Pepper	2.0	2.0	2.0	2.0	2.0
0nion paste	2.0	2.0	2.0	2.0	2.0
Skim milk	9.0	10.0	9.0	10.0	9.0
Flour	9.0	9.0	9.0	9.0	9.0
Total	100.0	100.0	100.0	100.0	100.0

Design of the experimental

The study was a completely randomized design. Five different batches nugget were produced: ascorbic, 0.5% garlic, 1.5% garlic, 0.5% ginger and 1.5% and each batch was replicated three times

Parameters measured

pH

Samples (approximately 10g) of each nugget were weighed into a flask followed by addition of 50 mL of distilled water (Nopianti et al., 2012). The samples were then homogenised using an homogeniser (Model Stomacher® 400 Circulator). The pH of homogenized nuggets were measured using pH meter (Model Aqua Lab).

Frying Yield Percentage

Frying yield (%) was calculated, as follows (Naveena et al., 2006):

$$Frying\ yield\ (\%) = \frac{weight\ of\ freshly\ cooked\ spent\ hen\ chicken\ nugget}{weight\ of\ raw\ spent\ hen\ chicken\ nugget} X\ 100$$

Determination of cholesterol content of deep fried nugget

The spectrophotometric procedure was used in determining the cholesterol content of the nuggets as described by Egbert et al. (1991) with slight modifications. Five grams of each of the nugget sample was homogenized and lipid was extracted using the petroleum. The lipid residue was saponified by heating with 8ml of 15% potassium hydroxide in 90% ethanol and 2ml of 3% propyl gallate in water bath at 88°C for 10 minutes and the solvent is later evaporated in a water bath at 50°C. The solution was cool down, and 10ml of petroleum ether added and vortexed for 30 second. After separation, 2mls of the ether layer was pipetted into a clean test tube and evaporated in a water bath in a water bath at 50°C. After evaporation, 3ml of acetic acid saturated with ferrous sulfate and 1ml of concentrated sulphuric acid were added to develop the chromophore for colorimetric analysis of cholesterol. The absorbence was measured with a UV-VIS spectrophotometer at 490mm against a t blank and calculated as;

$$cholesterol\ (mg/g) = \frac{absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{weight\ of\ the\ sample\ taken}$$

Determination of total phenol and flavonoid contents

These were carried out on the raw garlic and ginger pastes and on the five different cooked Spent Hen Chicken Nuggets (SHCN). The phenol contents were determined using the procedure of Singleton *et al* (1999) through Follin-Ciocalteu reagent and expressed as Garlic Acid Equivalents (GAE). Each sample (200mg) was mixed with 10 ml acetone and extraction with ultrasonic extraction for 20 min (2×10 min, 5 min rest in between) carried out at room temperature. The extract was centrifuged for 10 min at 3000 rpm. One milliliter (1ml) of supernatant was mixed with 0.5 ml Folin-Ciocalteu 1 N and 2.5 ml sodium carbonate, vortexed, and then held for 40 min at room temperature. The absorbance was measured at 725 nm. A standard curve was plotted using different gallic acid concentrations, and the amount of total phenol was calculated as Gallic Acid Equivalents (GAE) in mg/g. The absorbance of both the samples and the standard concentrations were read on a Digital Spectrophotometer at a wavelength of 510 nm. The percentage of phenol is calculated using the formula:

$$phenol\ GAE(mg/g) = \frac{absorvence\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{weight\ of\ sample\ x\ 10{,}000}$$

The total flavonoids were determined spectrophotometrically following the procedure of Zhishen et al. (1999). Total flavonoids of each samples were determined by weighing 5g each of grounded samples into a 100ml beaker and 80ml of 95% ethanol was added and stirred with a glass rod to prevent lumping. The mixture was filtered into a 100ml volumetric flask (through a Whatman No.1. filter paper) and made up to mark with ethanol. One (1) ml of the extract was pipetted into 50ml volumetric flask and four drops of concentrated hydrochloric acid was added after which 0.5g of magnesium turnings was added to develop a magenta red coloration. Standard flavonoid solution of range 0-5ppm were prepared from 100ppm stock solution and treated in a similar way with the hydrochloric and magnesium turnings like sample. The absorbance of magenta red coloration of sample and standard solutions were read on a digital Jenway V6300 Spectrophotometer at a wavelength of 520nm. The percentage flavonoid was calculated using the formula;

$$flavonoids(QE) = \frac{Absorvence\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{weight\ of\ sample}\ x\ 10000$$

Determination of DPPH Radical scavenging activity of ginger, garlic and chicken nugget

Free radical scavenging activities of the garlic, ginger and nuggets were determined using a stable 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH) procedure described by Brand-William *et al*. (1995) and Puntel *et al*. (2005).

Assessment of Lipid oxidation in spent hen meat nugget

The extent of lipid oxidation was assessed using the level of thiobarbituric acid reactive substances in the nuggets at 0, 7 and 14 days. The procedure adopted was described by Radha Krishnan *et al*. (2014) with slight modification and each assessment was carried out in triplicates for each sample The amount of TBARS in the nuggets were expressed as milligrams of malonaldehyde per kilogram of chicken nugget (mg MDA/kg sample).

Statistical analysis

An analysis of variance (ANOVA) was performed on all the data generated and Duncan's multiple range tests at Pα 0.05 was used to determine differences between the treatment means.

Results

Ginger phenol (72.71) and flavonoid (21.06) contents (Table 2) were significantly higher (P<0.05) than 54.91 (phenol) and 18.65 (flavonoid) of garlic.

The DPPH percentage inhibition (Table 3) of ginger 93.68, 88.95, 84.92, 77.67, 71.42 at 5000, 2500, 1250, 625 and 312.5 µg/L were higher (P<0.05) than 90.46, 77.61, 70.39, 63.98 and 49.40 recorded for garlic.

The frying yield (92.20%) of nugget (Table 4) with 0.5% ginger is similar (P>0.05) with 88.62 (0.5% garlic) but significantly higher (P<0.05) than 82.29 (ascorbic) and 85.72 (1.5% garlic) and significantly lower (P<0.05) than 97.87 (1.5% ginger). pH 5.87(0.5% ginger) is similar with 5.43 (1.5% ginger) and 5.63 (0.5% garlic) but significantly higher than 5.33 (1.5% garlic) and lower than6.57 (ascorbic). Phenol (24.92) contained in 1.5% nugget is significantly higher P<0.05) than 16.06 (ascorbic), 20.47 (0.5%ginger), 17.63 (0.5% garlic) and 18.37 (1.5% garlic). Flavonoids (9.34) and cholesterol (72.82) of ascorbic nugget were higher (P<0.05) than 8.20; 61.84 (0.5% ginger), 8.69;57.09 (1.5% ginger), 4.71; 68.49 (0.5% garlic), 6.32; 59.05 (1.5% garlic) recorded for flavonoids and cholesterol contents respectively.

Displayed on (Table 5) is the radical scavenging potential 88.71, 88.51 and 71.86 of nugget with ascorbic at 5000, 2500 and 1250 µg/L were higher P<0.05) than 77.74; 68.71; 65.18 (0.5% ginger), 81.93;72.55; 68.24 (1.5% ginger), 76.00;66.50;53.31 (0.5% garlic), 79.18;71.81;63.20 (1.5% garlic) at concentration 5000, 2500 and 1250 µg/L respectively. At DPPH concentration of 625 µg/L, the inhibition % of nugget with 0.5% (60.88) and 1.5% (61.11) ginger paste were significantly higher (P<0.05) than 56.84 (ascorbic), 45.56 (0.5% garlic) and 54.17 (1.5% garlic). The inhibition % 47.50 of nugget with 1.5% ginger was significantly higher (P<0.05) than 40.90 (ascorbic), 44.32 (0.5% ginger), 36.60 (0.5% garlic) and 38.27 (1.5% garlic).

Table 2. Phenol and flavonoid contents of garlic and ginger used in this study

Parameters (%)	Ginger	Garlic	SEM	P-Value
Phenol GAE mg/g)	72.71^{a}	54.91^{b}	0.091	<.0001
Flavonoids (mg QE/g)	21.06^{a}	18.65^{b}	0.088	<.0001

$^{a,b:}$ Means of different superscripts on the same row signifies differences (P < 0.05)

Table 3. Percentage inhibition of ginger and garlic paste

% DPPH Inhibition				
Concentration (µg/L)	Ginger	Garlic	SEM	P-Value
5000	93.68^{a}	90.46^{b}	0.047	<.0001
2500	88.95^{a}	77.61^{b}	0.114	<.0001
1250	84.92^{a}	70.30^{b}	0.091	<.0001
625	77.67^{a}	63.98^{b}	0.120	<.0001
312.5	71.42^{a}	49.40^{b}	1.287	<.0001

$^{a,b:}$ Means of different superscripts on the same row signifies significant differences between values (P < 0.05).

Table 4. pH, Phenols, Flavonoids and Cholesterol contents of freshly prepared spent hen nugget incorporated with varying inclusion levels of ginger and garlic paste

Parameters	Ascorbic	Ginger		Garlic			
		0.5	1.5	0.5	1.5	SEM	P-value
Frying yield (%)	82.29^{c}	92.20^{b}	97.87^{a}	88.62^{bc}	85.72^{c}	1.931	<.0001
pH cooked nugget	6.57^{a}	5.87^{b}	5.43^{bc}	5.63^{bc}	5.33^{c}	0.223	0.0002
Phenols (GAE mg/g)	16.06^{e}	20.47^{b}	24.92^{a}	17.63^{d}	18.37^{c}	0.104	<.0001
Flavonoids (mg QE/g)	9.34^{a}	8.20^{c}	8.69^{b}	4.71^{e}	6.32^{d}	0.048	<.0001
Cholesterol (%)	72.82^{a}	61.84^{c}	57.09^{e}	68.49^{b}	59.05^{c}	1.931	<.0001

$^{a,b,c,d,e:}$ Means with different superscripts on the same row are significantly different (P < 0.05)

Table 5. Radical scavenging activity of freshly prepared spent hen chicken nugget with varying inclusion levels of ginger and garlic paste

Concentration(µg/L)	% DPPH Inhibition						
	Ascorbic	Ginger		Garlic			
		0.5	1.5	0.5	1.5	SEM	P-Value
5000.0	88.71[a]	77.74[d]	81.93[b]	76.00[e]	79.18[c]	0.170	<.0001
2500.0	88.51[a]	68.71[d]	72.55[b]	66.50[e]	71.81[c]	0.085	<.0001
1250.0	71.86[a]	65.18[c]	68.24[b]	53.31[e]	63.20[d]	0.302	<.0001
625.0	56.84[b]	60.88[a]	61.11[a]	45.56[d]	54.17[c]	0.142	<.0001
312.5	40.90[c]	44.32[b]	47.50[a]	36.60[e]	38.27[d]	0.135	<.0001

[a,b,c,d,e:] Means of different superscripts on the same row are significantly different (P < 0.05).

Table 6. Thiobabituric Acid Reactive Substances values during storage of spent hen meat nuggets with varying inclusion levels of ginger and garlic pastes

Storage days		Ginger		Garlic			
	Ascorbic	0.5	1.5	0.5	1.5	SEM	P-value
0	0.53[a]	0.20[d]	0.18[e]	0.28[b]	0.22[c]	0.025	<.0001
7	0.55[a]	0.24[d]	0.18[e]	0.39[b]	0.32[c]	0.017	<.0001
14	0.64[a]	0.45[b]	0.25[d]	0.40[b]	0.37[c]	0.012	<.0001

[a,b,c,d,e:] Means of different superscripts on the same row are significantly different (P < 0.05)

The TBARS (Table 6) at days 0 (0.53), 7 (0.55) and 14 (0.64) were significantly higher (P<0.05) than 0.20;0.24;0.45 (0.5% ginger), 0.18; 0.18;0.25 (1.5% ginger), 0.28; 0.39;0.40 (0.5% garlic) and 0.22;0.32;0.37 (1.5% garlic) recorded at 0, 7 and 14days respectively.

Discussion

The phenols and flavonoids results showed that ginger and garlic possess high amount of phenols and flavonoids with ginger containing higher amounts of both compounds. This result further confirm that ginger is one of the plants that is rich in phenolic compounds (Mahmudati et al., 2019).

Di-phenyl picry hydrazil (DPPH) is widely used as a free radical scavenging assay to evaluate the antioxidant activity of compounds (Ayoade et al., 2022). The DPPH assay is an easy, rapid and convenient method of evaluating antioxidants and radical scavengers (Bao et al., 2005). The percentage Hydroxyl (OH) radicals of ginger and garlic in this study although dose dependent were high indicating a high scavenging ability of hydroxyl radicals in both spices. This trend was also reported by Ayoade et al. (2022) who reported a DPPH of 85.358 and 87.694 for ginger and 83.956 and 79.751 for garlic from aqueous and ethanol extracts respectively.

The pH of the spent hen chicken nuggets with garlic and ginger in this study were lower than what was obtained in nugget with ascorbic acid. This low pH might be attributed to the rich bioactive compounds (Khatun et al., 2022) of both garlic and ginger. The pH of nuggets here was lower than 6.01 to 6.11 recorded by Khatun et al. (2022) in chicken nugget formulated with carrot and ginger.

The frying yield showed that as the inclusion of ginger paste increased the nugget yield increased while the reverse is observed in the nugget with garlic paste inclusion. This could be as a result of the higher water percentage (85-95%) contained in ginger (Prisacaru et al., 2023) when compared to 65% (Melguizo-Rodríguez et al., 2022) in garlic. The yield from garlic and ginger pastes nugget of this study was higher than 88.0-89.3% obtained in nugget with added fat and variable salt contents (Yogesh et al., 2013) and 76.5 - 85.6 g obtained in spent hen nuggets with milk fat and potato mash.

Normally, raw poultry meat usually has a cholesterol content of approximately 27- 90 mg/100 g while that of cooked poultry meat falls within the range of 59 to 154 mg/100g (Bragagnolo, 2009). Nugget samples formulated with various levels of ginger or garlic pastes significantly had lower levels of cholesterol than nuggets with food grade ascorbic acid. The cholesterol content of the spent hen nugget tends more to the lower limit of the required/permissible amount of cholesterol in meat products. This implied a healthier meat products as high cholesterol in food has been reported to have a negative effect on human health.

The higher level of phenol content recorded in the spent hen chicken nugget with ginger paste might be due to the ginger having a high phenolic content (Table 2). This same trend was also reported by Zhang et al. (2016) who opined that the high phenolic content in duck nugget with black garlic powder was due to the high phenolic content of the black garlic powder.

The DPPH scavenging activities of both ginger and garlic used in this study depict that they are dose responsive as scavenging activities increased with higher concentration of either compound. This same trend was also noticed with the spent hen nuggets as scavenging activity respond positively to increase concentration of the pastes in the spent hen nugget.

This further elucidated that scavenging radicals can be inhibited in meat and meat product by adding antioxidant compounds (Lishianawati et al., 2021). The result of the DPPH also revealed that ginger had a higher scavenging potential than garlic thus confirming that ginger had a high antioxidant capacity (Widayat et al., 2017). This also agreed with Ahmed et al. (2019) who reported that ginger exhibited higher scavenging activity than garlic and Nuutila et al. (2003) and Capasso (2013) who both reported lower antioxidant activity in garlic.

The high scavenging potential of the ginger was attributed to the high phenolic contents of ginger (Table 2). This is because phenolic compounds are phytochemicals found in plants and spices which account for most of their antioxidant activities (Ayoade et al., 2022). They are also the major primary antioxidant group of compounds or free radical terminators (Lishianawati et al., 2021) thus the high scavenging potential observed in ginger.

The lipid inhibition by ascorbic, garlic and ginger (Table 6) was obvious throughout the storage period (14 days) as all products did not exceed the permissible limits of TBARS value of 0.90 mg MDA/kg for meat and poultry products (Egyptian Organization for Standardization and Quality Control, 2005; El-Sohaimy et al., 2022). However, at the beginning (zero day) of the experimental storage, there was remarkable significant differences in TBARS levels among the different nugget's samples. The pre-treatment of the chicken nugget ingredients with garlic and ginger pastes reduced lipid oxidation drastically when compared with nugget with food grade ascorbic acid. The potency of ginger and garlic in retarding lipid oxidation in SHCN in the present study implied that there is low aldehyde compounds accumulation which further emphasizes the usefulness and importnace of utilizing ginger and garlic paste in processed meat products such as chicken nuggets.

Furthermore, the antioxidant effect of garlic and ginger paste on spent hen nugget at refrigerated storage was more pronounced with nugget with ginger paste having a lower TBARS value. This effect might be probably due to the fact the ginger contains higher content of phenol and flavonoid (Table 2). This is because linear correlation exists between phenolic content and antioxidant activity (Gheldof and Engeseth, 2002) thus high phenol content increases antioxidant activity (Velioglu et al., 1998; Holasova et al. 2002). Furthermore, higher flavonoids also indicate higher scavenging activity because flavonoids also function in scavenging free radicals, inhibition of peroxidants and chelating transition metals (Nickavar et al., 2007). The antioxidative effectiveness of ginger in reducing lipid oxidation was also reported by Baker and Alkas (2020) when ginger and rosemary extracts were compared on their potency in increasing meat quality. However, the TBARS of nugget with ginger and garlic paste inclusion at end of the storage period did not exceed 0.5 mg/kg reported to be the threshold at which rancid flavour can be detected by consumer (Choi et al., 2010). The obtained TBARS in either of the two spices pastes was lower than 0.46 mg MDA/kg reported in nugget with quinoa flour after 18 days of cold storage (El-Sohaimy et al., 2022).

Conclusion

Quality characteristics of fresh and stored spent hen chicken nuggets with ginger and garlic pastes were highly remarkable implying that both spices can be part of spent hen chicken nuggets formulation. This is evident in the reduced cholesterol contents of the freshly prepared deep fried spent hen chicken nuggets. Furthermore, ginger and garlic pastes were highly effective in reducing the rate oxidative deterioration of the nuggets which is exhibited in the low TBARS when compared with ascorbic acid marinated nuggets. This implied that addition of bioactive compounds such as ginger and garlic pastes up to 1.5% inclusion will be an effective functional ingredient for maintaining the quality attributes especially deterioration of lipid during storage of spent hen chicken nugget. The findings of this study elucidated that spent hen can be effectively utilized by processing into better-accepted, convenience ready-to-eat and shelf stable meat products such as chicken nugget.

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