Content lists available at PublikasiPolije

International Journal of Technology, Food and Agriculture (TEFA)

journal homepage : https://publikasi.polije.ac.id/index.php/tefa

Article

Antioxidative Effects of Muscovy Duck Meatballs with the Addition of Torch Ginger Flower Extract

Yudha Moningka[1], Chatarina Wariyah[2*], and Agus Slamet[3]

[1] Universitas Mercu Buana Yogyakarta , Jl Wates Km 10 Yogyakarta 55753, Indonesia; 235210003@student.mercubuana-yogya.ac.id

[2] Universitas Mercu Buana Yogyakarta, Jl Wates Km 10 Yogyakarta 55753, Indonesia; wariyah@mercubuana-yogya.ac.id

[3] Universitas Mercu Buana Yogyakarta, Jl Wates Km 10 Yogyakarta 55753, Indonesia; agus@mercubuana-yogya.ac.id

* Correspondence: wariyah@mercubuana-yogya.ac.id

Abstract: Muscovy duck meatballs are high-fat, wet foods that are susceptible to oxidation and microbial activity. Torch ginger flower extract (TFE) contains flavonoid compounds that can capture free radicals resulting from fat oxidation. The purpose of this study was to evaluate the antioxidative effect of Muscovy duck meatballs with the addition of TFE based on the changes in functional groups in meatballs. The materials used were male Muscovy duck meat and torch ginger flowers. This study used a Randomized Block Design with variations in the meat/tapioca ratio (250g/37.5g; 250g/62.5g; 250g/87.5g) and the amount of ginger torch extract (8.35ml; 17.7ml; 28.05ml), as well as controls without and with sodium benzoate. Analysis included chemical criteria of the meatballs, antioxidant activity, identification of functional groups with FT-IR, and microbiological tests. The results showed that meatballs with more TFE added had higher antioxidant activity. Meatballs with a ratio of 250g/15g and 8.35 ml TFE exhibited antioxidant activity of 18.49±0.84%. Based on the FT-IR spectrum, the functional groups in the meatballs were the same as those in the torch ginger flower extract, namely -OH, aromatic C=C, and C-O. Implementing this functional meatball processing technology can provide safe food and reduce the risk of oxidative stress.

Keywords: antioxidant; duck meatballs; torch ginger; functional group

Citation: Y. Moningka, C. Wariyah, and A. Slamet, "Antioxidative Effects of Muscovy Duck Meatballs With the Addition of Torch Ginger Flower Extract ", *TEFA*, vol. 3, no. 2, pp. 81–90, May 2026.

Received: 13-03-2026
Accepted: 30-03-2026
Published: 14-05-2026

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution-ShareAlike 4.0 International License (CC BY SA) license (http://creativecommons.org/licenses/by-sa/4.0/).

1. Introduction

The Muscovy duck (*Cairina moschata*) is a waterfowl cultivated for meat or egg production. Muscovy duck meat production has increased significantly alongside the development of duck-based food products. According to Indonesian Central Statistics Agency [1], national duck meat production in 2021 was 45,681.21 tons, and in 2023 it increased to 49,267.40 tons, an increase of approximately 8.0%, making duck meat a potential source of animal protein, which is very beneficial for health [2]. However, duck meat contains quite high fat, namely 8.58% with 66.80% unsaturated fatty acids, mainly oleic acid, linoleic acid, and palmitoleic acid [3], so it is easily oxidized, producing a rancid odor and free radicals that are not good for health.

Muscovy duck meat is tougher than chicken and has a darker color, which are barriers to consumer acceptance [4]. Processing duck meat into meatballs is an alternative to improve sensory properties by grinding the meat and adding starch, which can enhance elasticity and color [5]. However, as a wet food, meatballs are susceptible to oxidation. Unsaturated fatty acids will undergo autooxidation, producing free radicals such as alkyl radicals (R•) and peroxy radicals (ROO•). The primary products of autooxidation are hydroperoxides, which are unstable and readily break down into aldehydes, ketones, and alcohols, causing off-odor and off-flavor in meat [6]. Therefore, compounds that can scavenge free radicals are needed to inhibit fat oxidation.

Torch ginger flower (*Etlingera elatior*) is a plant from the *Zingiberaceae* family that is widely used as food or spice. Torch ginger flower extract contains phenolic compounds at 4.80±0.53% w/w (GAE) and total flavonoids at 2.60±0.04% w/w (CE), both of which are antioxidants with an IC_{50} of 251.40 ppm [7]. Flavonoids in torch ginger extract include myricetin, rutin, kaempferol-3-O-glucoside, quercetin, and kaempferol [8]. The implementation of using torch ginger flowers has been carried out in the storage of fresh chicken meat packaged with edible film containing starch with added torch ginger flower essential oil. The results showed that the number of TBARs (Thiobarbituric acid reactive substances) during six days of storage was 0.212 ± 0.31 mg MDA/kg, while the control (without essential oil) reached 0.350 ± 0.29 mg MDA/kg. In addition, flavonoids and phenols from torch ginger flowers exhibit antimicrobial activity [9].

Currently, research on the use of torch ginger flower extract as an antioxidant is limited to chicken meat and has not been found in products such as meatballs. However, [10] found that mutton meatballs with the addition of 6-gingerol, a source of antioxidants, were able to inhibit the increase in TBARs levels. TBARs is an indicator of aldehyde formation from fat oxidation, and aldehydes are secondary oxidation products resulting from the decomposition of peroxides [11].The 6-gingerol compound is found in ginger rhizomes and contains phenols between 130.77-195.25 g/mL and flavonoids between 6.74-11.62 g/mL, which can capture free radicals [12] thereby suppressing the formation of TBA. Therefore, it is necessary to evaluate the antioxidative effect of Muscovy duck meatballs containing torch ginger flower extract, and its effect on the meatball shelf life in the refrigerator.

2. Materials and Methods

2.1.Materials

The materials used in this study were 10-week-old male Muscovy duck meat weighing between 1.7 and 2.0 kg, breast part, purchased from Muscovy duck breeders in Palagan, Yogyakarta, Indonesia. Torch ginger flowers with bud-shaped flower specifications (Lanceolate), dark pink, 5-10 cm in diameter, 10-15 cm in width and length were obtained from farmers in Tlogodadi, Mlati, Sleman, Yogyakarta, Indonesia. Sodium benzoate preservative and ingredients for making meatballs, namely tapioca flour (Rose Brand), garlic powder (Koepoe-Koepoe), pepper (Ladaku), and salt (Dolpin) were purchased from Intisari store in Yogyakarta. Materials for chemical analysis with pro analysis qualifications were DPPH radicals (1,1-diphenyl-2-picrylhydrazyl) for antioxidant activity analysis from Sigma-Aldrich (Germany), materials for microbiological tests were Plate Count Agar (Oxoid) and *Salmonella-Shigella* Agar (SSA) from Merck.

2.2. Equipments

The equipment used for meatball production includes a meat grinder (Philips Food Processor HR7627/00), a set of dough preparation tools, and an electronic kitchen scale (Acis). Equipment for torch ginger flower extraction includes a set of preparation tools, a cabinet dryer, an oven (Memmert UM Gemini BV), and a rotary evaporator (IKA). For chemical analysis, the equipment includes a centrifuge (Eba Hettic), a UV-Vis spectrophotometer (Shimadzu UV-1800), a magnetic stirrer (Nouva II), and a vortex mixer (Thermo Scientific). For functional group testing of meatball samples and torch ginger flower extract, a Bruker Alpha II Fourier Transform Infrared (FTIR) spectrometer was used. Equipment for microbiological testing includes a sterilizer (EA Medical International), an incubator (Sanyo), and a colony counter (J-2, OEM) for total plate count (TPC). Glassware for chemical analysis is made from Pyrex (Iwaki).

2.3. Methods

This study used a randomized block design (RBD) with one treatment factor, namely the meat/tapioca ratio with the preservative (torch ginger flower extract, sodium benzoate, control/no preservative), with 9 variations in treatment levels (Table 1), and treatment replications as blocks. Data were statistically processed using SPSS 20 for Windows, and significant differences between samples were tested using Duncan's Multiple Range Test. The research stages were as follows:

Table 1. Muscovy duck meatball dough formulation variations

Ingredients (g)	**Dough formulation***								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Duck Meat	250	250	250	250	250	250	250	250	250
Tapioca	37.5	62.5	87.5	37.5	62.5	87.5	37.5	62.5	87.5
Ice cubes	100	100	100	100	100	100	100	100	100
Garlic	10	10	10	10	10	10	10	10	10
Pepper	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	10	10	10	10	10	10	10	10	10
Torch ginger flower extract (ml)	-	-	-	8.35	17.7	28.05	-	-	-
Sodium Benzoate	-	-	-	-	-	-	0.1	0.15	0.2

Data Source: The Orientation Before the Research.

2.3.1. Torch ginger flower extraction

Torch ginger flower extraction was carried out according to the method described by [13]. 1.0 kg of fresh torch ginger flowers were washed under running water, then sliced into 1-2 cm pieces, and dried in an oven at 50°C for 1 day (24 hours). The dried torch ginger flowers were ground using a blender and sieved through a 35-mesh sieve. The powder was then extracted using 70% ethanol with a powder/ethanol ratio of 1/5. The extract was left in a dark room for 24 hours, protected from light, and stirred every hour. The extract was separated from the pulp, filtered through filter paper, and evaporated using a rotary evaporator at 50°C at 60 rpm until a thick extract was obtained. The resulting extract was used for research. Torch ginger flower extract was analyzed for water content [14], and for phenol and flavonoid content [15].

2.3.2. Processing of Muscovy duck meatballs

The duck meatballs were made according to[16] with modifications, including the addition of torch ginger flower extract. The meat was first weighed, then 250g of ice cubes were added, and the meat was ground in a food processor for 1.5 minutes at medium speed. Then, tapioca starch, spices, and other ingredients were added according to the instructions (Table 1), and ground again for 3 minutes. The mixture was molded into balls, each weighing approximately 35g. The meatballs were placed in boiling water until they floated, then removed and drained. The Muscovy duck meat and meatball samples were used for testing.

2.3.3. Chemical analysis of duck meat and meatballs

Chemical analysis included moisture, ash, fat, and protein content [14], antioxidant activity, and identification of functional groups in the meatballs using a Fourier Transform Infrared (FT-IR) spectrophotometer. Moisture content was determined using the static gravimetric method, ash content using the dry combustion method at 550-600°C, fat content using the Soxhlet distillation method with hexane as the solvent, and protein using the micro-Kjeldahl method using digestion, distillation, and titration. Antioxidant

activity was analyzed based on the ability to scavenge DPPH radicals (Radical Scavenging Activity (%) [15].

2.3.4. Antioxidant activity analysis

Antioxidant activity was analyzed using the DPPH radical-scavenging method [17]. A DPPH stock solution was prepared in ethanol at 0.1 mM. A 1 ml sample of the extracted meatballs was added with 2.5 ml of DPPH solution and then thoroughly mixed using a vortex. The sample absorbance was measured using a spectrophotometer at 517 nm at t = 0 and t = 30 minutes after incubation in a dark room. Antioxidant activity was calculated as RSA (Radical Scavenging Activity (%), using the formula:

Radical Scavenging Activity (%) = [1-(At/Ao)] x 100%

Ao = absorbance value at t=0 minutes, and At = absorbance value at t=30 minutes

2.3.5. Microbiological testing

Meatballs with torch ginger extract and the addition of 8.35 ml of torch ginger flower extract (F4) were tested for Total Plate Count (TPC) during refrigerated storage (4-7°C) from day zero until the permissible TPC limit of a maximum of 1 x 10^5 colonies/g was reached. *E. coli* and *Salmonella* were tested on day zero and on the day when the TPC test results reached the maximum limit according to the SNI 3818 for meatballs.

- Total plate count (TPC) testing procedure

The TPC test follows [18], in which 10 g of the sample is diluted with 90 ml of Buffered Peptone Water (BPW) and then homogenized. The suspension is diluted 10-fold by aseptically adding 9 ml of BPW solution to 1.0 ml of the suspension. Further dilutions are performed to a concentration of 10^2-10^6, with 1 ml of each dilution being placed in a sterile petri dish containing agar medium. The petri dishes are placed upside down in an incubator at 10°C for 24 hours, and the bacterial colonies growing in each dish are counted.

- *Escherichia coli* testing

E. coli testing refers to the 2014 Indonesian National Standard (SNI) for meatballs [19]. The test is conducted as follows: 25 g of the meatball sample is ground, diluted 10-fold, then placed in an Erlenmeyer flask, and 225 ml of 0.9% NaCl is added. 10 ml of the sample solution is added to 90 ml of lactose broth, and the mixture is incubated at 37°C for 24 hours. After incubation, the sample is placed on solid endo agar media in a zigzag pattern, then incubated for another 24 hours at 37°C. Colony growth is then observed on the solid media.

- *Salmonella* sp. bacteria testing

The *Salmonella* sp. bacteria testing was carried out according to [20], using 35 g of Salmonella-Shigella Agar (SSA) dissolved in 1 liter of distilled water, then boiled and autoclaved for 30 minutes at 121°C and 1 atm pressure. Next, 10 g of the ground meatball sample was mixed with 90 ml of sterile distilled water at a 10^{-1} dilution and vortexed until homogeneous. 1 ml of the 10^{-1} dilution solution was taken and transferred to a test tube containing 9 ml of fresh sterile distilled water (10^{-2} dilution) using the pour plate method on the SSA media. Incubate the diluted sample at 35°C for 24 hours. Positive *Salmonella* colonies are transparent with a black spot in the center. Observe the growth of *Salmonella* colonies.

3. Results and Discussion

3.1. Chemical Components of Muscovy Duck Met and Torch Ginger Flower Extract

Table 2 shows the chemical components of Muscovy duck meat and torch ginger flower extract.

Table 2. Components of duck meat and torch ginger flower extract

Components	Muscovy duck meat	Torch ginger flower extract
Moisture (%)	74.47±2.57	92.47±0.85
Fat (%)	3.98±0.33	-
Protein (%)	21.67±3.11	-
Ash (%)	1.41±0.06	2.05±0.05
Phenol (μg/g dry matter)	-	38.93±5.19
Flavonoid (μg/g dry matter)	-	28.32±2.45

The chemical components of Muscovy ducks are water, protein, fat, and ash. According to [4], the water content of duck breast meat is between 77.08-77.20%, fat 0.90-2.32%, protein 19.41-22.96%, and ash 0.60-1.38%. High levels of fat in meat can increase the potential for fat oxidation. In a study of fresh chicken meat in a refrigerator without packaging, the TBARs number increased from 0.074 ± 0.05 mg MDA/kg on day zero to 0.475 ± 0.33 mg MDA/kg on day six [9], which indicates that fat oxidation occurs producing peroxides which are then decomposed into aldehydes [6]. Therefore, antioxidants are needed to capture free radicals. Table 2 shows that the torch ginger flower extract contains phenols and flavonoids, both of which are antioxidants.

3.2. Chemical Criteria of Muscovy Duck Meatballs

The chemical criteria of the Muscovy duck meatballs with the addition of torch ginger flower extract are shown in Table 3.

Table 3. Chemical Criteria of Muscovy duck meatballs*

Duck Meat/Tapioca Ratio (g/g):Preservative**	Moisture (%)	Ash (%)	Protein (%)	Fat (%)
250/37.5: -	72.92±0.06^{g}	2.72±0.03^{e}	14.96±2.22^{bc}	1.51±0.13^{e}
250/62.5: -	67.29±2.02^{bc}	2.47±0.02^{d}	14.43±1.74^{bc}	0.27±0.05^{a}
250/87,5: -	64.06±1.92^{a}	2.25±0.02^{b}	13.54±1.53^{ab}	0.86±0.04^{cd}
250/37.5: TFE 8.35mL	72.70±0.72^{fg}	3.04±0.04^{f}	15.05±1.06^{bc}	2.40±0.15^{g}
250/62.5:TFE 17.70 mL	68.35±1.02^{d}	2.41±0.05^{cd}	13.55±3.42^{ab}	0.81±0.05^{c}
250/87.5: TFE 28.05 mL	66.41±0.87^{b}	2.35±0.03^{c}	12.28±1.39^{a}	0.48±0.03^{b}
250/37.5: SB 0.1 mg	71.79±2.26^{f}	2.67±0.05^{e}	15.73±1.52^{c}	1.87±0.02^{f}
250/62.5:SB 0.15 mg	70.15±0.13^{e}	2.47±0.07^{d}	14.80±2.53^{bc}	0.94±0.06^{d}
250/87.5: SB 0.20 mg	68.17±1.37^{cd}	2.12±0.01^{a}	13.42±1.12^{ab}	0.79±0.01^{c}

*Numbers followed by different letters in the same column indicate significant differences ($p<0.05$).
** TFE : Torch ginger flower extract, SB : Sodium benzoate

3.2.1. Moisture

The analysis of Muscovy duck meatball moisture content showed a significant difference. The more tapioca added, the lower the water content. Tapioca is a cassava starch that is physically white and solid, so the more tapioca added, the more solids in the dough, and the lower the water content. Table 3 shows that the moisture content of duck meatballs ranges from 64.06±1.92 % to 72.92±0.06 %. According to SNI-3818-2014, the maximum water content of meatballs is 70.00%. Meatballs with a meat/tapioca ratio of

250/37.50 show a figure slightly above standard. However, according to [21], the results of the preference test showed that the meatball with a duck meat/tapioca ratio of 250/37.50 g/g and 8.35 ml of torch ginger extract was preferred, and the more torch ginger extract added, the less the meatball was liked.

3.2.2. Ash

The ash content of Muscovy duck meatballs showed a significant difference. The ash content of the meatballs showed that the higher the tapioca content, the lower the ash content. According to SNI Tapioca [22], the maximum ash content of tapioca is 0.5 (w/w), very low compared to the Muscovy duck meat used in this study, which was 1.41±0.06%. Therefore, the more tapioca, the lower the ash content. However, in meatballs containing torch ginger flower extract, the higher the extract concentration, the higher the ash content. This increase in ash content is due to the torch ginger flower extract, which has an ash content of 2.05±0.03% (Table 2), thereby increasing the ash content of the meatballs. According to SNI-3818-2014 [19], the maximum ash content in meatballs is 3.0% w/w. In Muscovy duck meatballs, the ash content is between 2.12±0.01 – 3.04±0.04%.

3.2.3. Protein

The protein content of Muscovy duck meatballs showed a significant difference. The protein content of Muscovy duck was 21.67±3.11% (Table 2). According to [2], the protein content of Muscovy duck meat was 21.11±0.09%. The protein content increased with a lower meat/tapioca ratio or with a higher meat content. This increase was due to Muscovy duck meat being the main source of protein. The use of torch ginger flower extract and sodium benzoate did not show a significant difference in the protein content of the duck meatballs, as these ingredients are not considered protein sources.

3.2.4. Fat

The fat content of Muscovy duck meatballs shows a significant difference. The fat content increases with a higher duck meat/tapioca ratio, or with greater amounts of duck meat. [2] reported a fat content of 1.99±0.03% in duck meatballs. The fat content of Muscovy duck meat used is 3.66±0.45%. According to [23], the composition of duck meat is influenced by the type of duck and carcass. In this study, breast meat was used. The results showed that the more duck meat used to make meatballs and the less tapioca, the higher the fat content. The quality requirements for meatballs, as specified in SNI-3818-2014, require a maximum fat content of 2.0% w/w. Tingginya kadar lemak dalam meatballs berpotensi terjadinya oksidasi selama penyimpanan.

3.3. Antioxidant Activity

Antioxidant activity is expressed as the sample's ability to capture DPPH free radicals, as in Table 4. The statistical analysis shows differences in antioxidant activity among

Table 4. Antioxidant activity of Muscovy duck meatballs

Duck Meat/Tapioca Ratio (g/g): preservative	**Antioxidant Activity (%)* (Radical Scavenging Activity)**
Torch ginger flower extract (TFE)	90.00±0.08
250/37.5: - (control)**	7.21±0.34[a]
250/62.5: - (control)	-
250/87.5: - (control)	-
250/37.5: TFE 8.35 mL	18.49±0.84[b]
250/62.5: TFE 17.70 mL	42.20±0.41[c]
250/87.5: TFE 28.05 mL	44.72±0.25[d]
250/37.5: SB 0.10 g**	7.04±0.56[a]
250/62.5: SB 0.15 g	-
250/87.5: SB 0.20 g	-

*Numbers followed by different letters indicate significant differences ($p<0.05$).
**Meatballs without preservatives and with sodium benzoate preservative, one sample was taken as a control, based on the level of preference, which was not significantly different from the other samples [21].

In the control meatballs and in the meatballs with sodium benzoate, the antioxidant activity is almost identical, with RSA values between 7.04% and 7.21%. Meatballs containing torch ginger flower extract exhibit higher antioxidant activity than the control or those containing sodium benzoate. The high antioxidant activity is because torch ginger flower extract contains phenolic compounds of 38.93±5.19 μg/g dry matter, one of which is flavonoids of 28.32 ± 2.45 μg/g dry matter (Table 2), so the antioxidant activity of meatballs with torch ginger flowers is high. According to [8], flavonoid compounds in torch ginger flowers can function as antioxidants.

3.4. Functional Groups of Muscovy Duck Meatballs

The results of the FT-IR absorption spectrum test of torch ginger flower extract, Muscovy duck meatballs with 8.35 ml of torch ginger extract (F4), meatballs with 0.1 g of sodium benzoate (F8), and meatballs without preservatives (F1-control) can be seen in Figure 1. Meanwhile, Table 5 shows the FTIR spectrum of the samples.

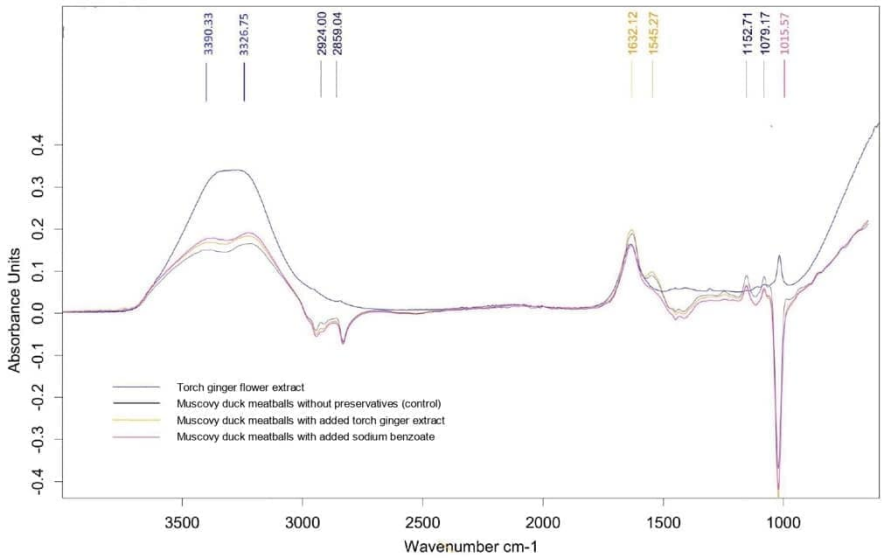


Figure 1. FT-IR spectra of torch ginger flower extract and Muscovy duck meatballs.

Table 5. FTIR Spectra of Torch Ginger Flower Extract and Muscovy Duck Meatballs with the Addition of Torch Ginger Flower Extract

No.	Active fraction of Muscovy duck meatballs (cm^{-1})	Torch ginger flower extract (cm^{-1})	Functional group*
1	3390.33-3226.00	3302.33	-OH
2	2942.00-2859.04	-	C-H (CH_2)
3	1632.12-1545.27	1636.00	C=C aromatic
4	1152.71-1015.57	1015.57	C-O

* Data Source : [24]; [25].

Based on Figure 1 and Table 5, the FT-IR spectrum of torch ginger flower extract has 3 peaks. The peak at 3390.00 cm^{-1} is attributed to the -OH group, extending to 3226.00 cm^{-1} [26]. The peak at a wavelength of 2871.73 cm^{-1} is identified as the organic compound C-H

(CH_2), the peak at a wavelength of 1630.69 cm^{-1} is the absorption of the aromatic C=C group, and the peaks at wavelengths of 1436.69 cm^{-1} and 1306.33 cm^{-1} are the absorption of the C-H group [25]. Flavonoid compounds in torch ginger extract include quercetin and kaempferol. Both compounds consist of two benzene rings (C6) connected by a carbon atom (C3). In quercetin, there are three -OH (hydroxyl) groups on the benzene ring at C5-C7-C4′, while in kaempferol there are four -OH groups at C5, C7, C3′ and C4′ which are shown in the FT-IR spectra at a wavelength of 3,400-3,200 cm^{-1} [27]and a bend at 1,504-1,160 cm^{-1}. Figure 1 also shows the FT-IR spectrum of Muscovy duck meatballs added with torch ginger flower extract, which has 3 peaks at a wavelength of 3390.33-3226.00 cm^{-1}, 1632.12 - 1545.27 cm^{-1}, and 1152.71-1015.57 cm^{-1}. The peak at 3390.33 cm^{-1} was identified as the -OH group absorption, extending to 3226.00 cm^{-1}. The presence of spectra with a wavelength similar to that of the torch ginger flower extract in duck meatballs indicates that the addition of torch ginger flower extract to meatballs can produce meatballs that have functional groups. According to [28], the functional group that acts as an antioxidant is -OH; the more -OH groups, the higher the antioxidant activity.

3.5. Microbiology of Muscovy duck meatballs during storage

Penambahan The results of the Total Plate Count (TPC) test for Muscovy duck meatballs with 8.35 ml of torch ginger extract are shown in Table 6.

Table 6. Microbiological test results of Muscovy duck meatballs

Parameter	SNI-3818-2014	Meatballs shelf life in the refrigerator (days)				
		0	4	8	12	16
TPC (Colony/g)	Max. 1.10^5	$<1.0.10^3$ - $1.10.10^3$	$2.20.10^3$ - $2.30.10^3$	$2.1.10^3$ - $2.60.10^4$	$2.10.10^3$ - $2.30.10^4$	$3.9.10^4$ - $3.5.10^5$

Table 6 shows that the TPC value of meatballs with the addition of torch ginger flower extract, stored in a refrigerator and packaged in 0.50 mm polyethylene plastic, increased. According to meatballs SNI 3818-2014, the maximum TPC level for meatballs is 1×10^{-5} colonies/g. In this study, the maximum limit occurred on the 16th day; during storage, the number of *E. coli* remained zero, and *Salmonella* was negative. The normal Muscovy duck meatballs stored at refrigerator temperatures only lasted for 3-9 days [29]. The previous study showed that flavonoids can inhibit bacterial growth through various mechanisms, including disruption of cell wall synthesis, prevention of biofilm formation, disruption of cell membrane integrity, and inhibition of bacterial efflux pumps [30]. Therefore, adding torch ginger extract can extend the shelf life of Muscovy duck meatballs.

4. Conclusions

This study concluded that adding torch ginger flower extract can produce Muscovy duck meatballs with antioxidative effects, as evidenced by their ability to scavenge DPPH radicals. The antioxidative properties of the meatballs are determined by the presence of functional groups derived from the torch ginger flower extract. Functional meatballs packaged in 0.5 mm polyethylene can be stored for 16 days at 4°C. Therefore, the application of this technology is important for providing safe, functional foods that serve as nutrient sources.

Author Contributions: Conceptualization, C.W. and Y.M.; methodology, Y.M. and A.S.; software, Y.M.; validation, C.W., Y.M. and A.S.; formal analysis, Y.M and C.W.; investigation, Y.M.; resources, C.W.; data curation, Y.M.; writing—original draft preparation, C.W. and Y.M.; writing—review and editing, Y.M. and A.S; visualization, C.W.; supervision, C.W.; project administration, Y.M.; funding acquisition, C.W. All authors have read and agreed to the published version of the manuscript

Funding: This research was funded by the DIRECTORATE OF RESEARCH AND COMMUNITY SERVICE, DIRECTORATE GENERAL OF RESEARCH AND DEVELOPMENT OF THE MINISTRY

OF HIGHER EDUCATION, SCIENCE, AND TECHNOLOGY, REPUBLIC OF INDONESIA, grant number "SP DIPA- 139.04.1.693320/2025 revision 04 dated April 30, 2025, Master's Research scheme with research implementation contract No. 66/C.05/H.1/2025, dated June 4, 2025"

Conflicts of Interest: The authors declare no conflict of interest

References

[1] BPS, "Produksi Daging Itik/Itik Manila menurut Provinsi (Ton), 2024." 2025. [Daring]. Tersedia pada: https://www.bps.go.id/id/statistics-table/2/NDg5IzI=/produksi-daging-itik-itik-manila-menurut-provinsi.html

[2] P. Ungkusonmongkol dan S. Wattanachant, "Carcass characteristics and meat quality of spent laying ducks for potential additional supply to the duck meat market," *Journal of Applied Poultry Research*, vol. 33, no. 3, hlm. 100450, Sep 2024, doi: 10.1016/j.japr.2024.100450.

[3] D.-M. Shin, Y. J. Kim, Y.-S. Choi, B.-K. Kim, dan S. G. Han, "Duck fat: Physicochemical characteristics, health effects, and food utilizations," *LWT*, vol. 188, hlm. 115435, Okt 2023, doi: 10.1016/j.lwt.2023.115435.

[4] D. S. J. Costa, W. M. Dos Santos, I. M. T. Lemos, B. S. Dos Santos Braga, M. A. S. Dos Santos, dan E. D. A. De Araújo Guimarães, "Nutritional aspects and commercial challenges of Muscovy duck meat (*Cairina moschata*)," *World's Poultry Science Journal*, vol. 79, no. 3, hlm. 513–533, Jul 2023, doi: 10.1080/00439339.2023.2234347.

[5] M. Y. Yasin, N. Haryuni, dan A. Lidiyawati, "Duck Meatballs With Various Tuber Flour Quality Based on Organoleptic," *JURNAL TERNAK*, vol. 14, no. 1, hlm. 24–30, Apr 2023, doi: 10.30736/jt.v14i1.157.

[6] Cheng Jh, "Lipid Oxidation in Meat," *J Nutr Food Sci*, vol. 06, no. 03, 2016, doi: 10.4172/2155-9600.1000494.

[7] U. Safrina, W. Wardiyah, dan H. Cartika, "Evaluation of Total Flavonoid, Total Phenolic, and Antioxidant Activity of Etlingera elatior (Jack) R.M.Sm Flower, Fruit, and Leaf," *Trad.Med.J*, vol. 27, no. 1, hlm. 50, Apr 2022, doi: 10.22146/mot.72210.

[8] H. M. Zendrato dan N. Masruchin, "Trends and multidisciplinary research of torch ginger [Etlingera elatior (Jack) R.M.Sm.]: A systematic review," *Journal of Ethnopharmacology*, vol. 360, hlm. 121160, Apr 2026, doi: 10.1016/j.jep.2026.121160.

[9] A. A. Marzlan *dkk.*, "Incorporating torch ginger (Etlingera elatior Jack) inflorescence essential oil onto starch-based edible film towards sustainable active packaging for chicken meat," *Industrial Crops and Products*, vol. 184, hlm. 115058, Sep 2022, doi: 10.1016/j.indcrop.2022.115058.

[10] J. Li *dkk.*, "Effect of 6-gingerol on oxidative stability and quality characteristics of mutton meatballs during refrigerated storage," *Food Chemistry: X*, vol. 24, hlm. 101865, Des 2024, doi: 10.1016/j.fochx.2024.101865.

[11] M. Zhao *dkk.*, "Advance in aldehydes derived from lipid oxidation: A review of the formation mechanism, attributable food thermal processing technology, analytical method and toxicological effect," *Food Research International*, vol. 203, hlm. 115811, Feb 2025, doi: 10.1016/j.foodres.2025.115811.

[12] D. A. Widyastuti, S. Fatimah, T. R. Nuringtyas, D. Santosa, dan A. Rohman, "Total phenolic and flavonoid contents and antioxidant activity of red ginger (Zingiber officinale var. rubrum) rhizomes from seven different regions in the island of Java, Indonesia," *Food Research*, vol. 9, no. 6, hlm. 79, Nov 2025, doi: 10.26656/fr.2017.9(6).296.

[13] N. C. Endriyatno, M. Walid, K. Nurani, dan R. Evi Ulfiani, "Penentuan Nilai SPF Ekstrak Bunga Kecombrang (Etlingera elatior) Secara In Vitro," *IJPE*, vol. 4, no. 2, Jul 2024, doi: 10.37311/ijpe.v4i2.26846.

[14] AOAC, "Official Methodsof Analysisof AOAC International." Diakses: 19 September 2025. [Daring]. Tersedia pada: https://www.researchgate.net/publication/292783651_AOAC_2005

[15] A. T. M. Abdullah, M. M. Rahman, M. Sharif, T. A. Khan, S. N. Islam, dan K. M. R. Karim, "Edible flowers efficiency to boost the thermal oxidation stability of soybean oil: Polyphenolic and antioxidant insights," *Future Foods*, vol. 9, hlm. 100338, Jun 2024, doi: 10.1016/j.fufo.2024.100338.

[16] C. Wariyah dan R. Riyanto, "Efek Antioksidatif dan Akseptabilitas Bakso Daging Ayam Ras dengan Penambahan Gel Lidah Buaya," *Agritech*, vol. 38, no. 2, hlm. 125, Jul 2018, doi: 10.22146/agritech.31850.

[17] P. Galaz, M. Valdenegro, C. Ramírez, H. Nuñez, S. Almonacid, dan R. Simpson, "Effect Of Drum Drying Temperature On Drying Kinetic And Polyphenol Contents In Pomegranate Peel," *Journal of Food Engineering*, vol. 208, hlm. 19–27, Sep 2017, doi: 10.1016/j.jfoodeng.2017.04.002.

[18] H. Desvita, M. Faisal, M. Mahidin, dan Suhendrayatna, "Natural antimicrobial properties of liquid smoke derived from cocoa pod shells in meatball preservation," *South African Journal of Chemical Engineering*, vol. 46, hlm. 106–111, Okt 2023, doi: 10.1016/j.sajce.2023.08.003.

[19] BSN, "SNI bakso daging : SNI : 3818: 2014." 2014.

[20] A. Fatiqin, R. Novita, dan I. Apriani, "Pengujian Salmonella Dengan Menggunakan Media SSA Dan E. Coli Menggunakan Media Emba Pada Bahan Pangan," *indobiosains*, vol. 1, no. 1, Feb 2019, doi: 10.31851/indobiosains.v1i1.2206.

[21] Y. Moningka, Ch. Wariyah, dan A. Slamet, "Kualitas Fisik dan Sensoris Bakso Itik dengan Penambahan Pengawet Alami Ekstrak Bunga Kecombrang," *PSPFS*, vol. 8, hlm. 207–212, Mar 2025, doi: 10.30595/pspfs.v8i.1496.

[22] BSN, "Kadar abu tapioka : SNI tapioca: SNI 3451:2011." 2011.
[23] K. Kususiyah, D. Kaharuddin, H. Hidayat, dan T. Akbarillah, "Performa, Kualitas Karkas dan Persentase Organ Dalam Itik, Entok dan Tiktok," *Bul. Pet. Trop.*, vol. 3, no. 1, hlm. 42–49, Mei 2022, doi: 10.31186/bpt.3.1.42-49.
[24] I. D. P. Subamia, N. N. Widiasih, I. G. A. N. Sri Wahyuni, dan P. L. Pratami Kristiyanti, "Optimasi Kinerja Alat Fourier Transform Infrared (FTIR) Melaui Studi Perbandingan Komposisi dan Ketebalan Sampel-KBr," *JPLP*, vol. 5, no. 2, hlm. 58–69, Jul 2023, doi: 10.14710/jplp.5.2.58-69.
[25] O. Kombongkila, H. Taunaumang, dan F. R. Tumimomor, "Analisis Struktur Film Tipis Disperse Orange-3 Hasil FTIR," *fista*, vol. 5, no. 1, hlm. 45–50, Apr 2024, doi: 10.53682/fista.v5i1.305.
[26] R. R. Sable, D. G. Thite, P. B. Udavant, E. D. Ahire, dan S. J. Khairnar, "Isolation and identification of flavonoids compounds and formulation of tecoma undulata (Sm.) seem. Herbal ointment," *Materials Today: Proceedings*, hlm. S2214785323052410, Des 2023, doi: 10.1016/j.matpr.2023.11.135.
[27] M. Krysa, M. Szymańska-Chargot, dan A. Zdunek, "FT-IR and FT-Raman fingerprints of flavonoids – A review," *Food Chemistry*, vol. 393, hlm. 133430, Nov 2022, doi: 10.1016/j.foodchem.2022.133430.
[28] R. K. Sari, S. Susilowati, dan D. Wahyudi, "Phytochemical Analysis, FTIR Spectroscopic of Flavonoid and Antibacterial Activity of Crassocephlum Crepidiodes (Benth.) S. Moore Leaf and Herbs Extract," *Indonesian Journal of Global Health Research*, vol. 6, no. S5, hlm. 419–426, Okt 2024, doi: 10.37287/ijghr.v6iS5.4540.
[29] N. D. Anggraini, K. M. Kartika, dan E. P. Sari Tambunan, "Uji Efektivitas Antibakteri Ekstrak Etanol Bunga Kecombrang (Etlingera elatior) Terhadap Pertumbuhan Klebsiella pneumoniae," *KLOROFIL:JIBT.jurnal. ilmu. biologi. dan. terap.*, vol. 6, no. 1, hlm. 38, Agu 2022, doi: 10.30821/kfl:jibt.v6i1.11648.
[30] Y. Liu, J. Zhu, Z. Liu, Y. Zhi, C. Mei, dan H. Wang, "Flavonoids as Promising Natural Compounds for Combating Bacterial Infections," *IJMS*, vol. 26, no. 6, hlm. 2455, Mar 2025, doi: 10.3390/ijms26062455.