Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan
ISSN 2303-2227 eISSN 2615-594X
Accredited by National Journal Accreditation No. 105/E/KPT/2022

Vol. 11 No. 1 Januari 2023, Hlm: 27-33
DOI: https://doi.org/10.29244/jipthp.11.1.27-33
Available online at https://journal.ipb.ac.id/index.php/ipthp/index

Improving The Quality of Sweet Duck Jerky from South Kalimantan through Modification of Antioxidant-Rich Spices

Peningkatan Kualitas Dendeng Itik Manis Khas Kalimantan Selatan Melalui Modifikasi Bumbu Kaya Antioksidan

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(Received 22-10-2022; Revised 03-11-2022; Accepted 13-12-2022)

ABSTRACT

Various processed duck meat generally still uses rejected duck meat. The weakness of rejected duck meat is its tough texture, fishy smell, and high-fat content. Fat content increases the possibility of lipid oxidation and the formation of free radicals. The effort to overcome this is by adding antioxidant-rich spices during processing, one of which is sweet duck jerky from South Kalimantan. The research aimed to analyze the effect of modification of antioxidant-rich spices and obtaining the best spice formula in the manufacturing process. The study used a 3x3 factorial completely randomized design (CRD) with three replications. First factor was three different spice formula (formula A, formula B, and formula C), and the second factor was three different storage times (0 week, two weeks, and four weeks). Data were analyzed using analysis of variance, and significant results were then tested using the Tukey test. The results showed that the spice formula had a significant effect ($p<0.05$) on malondialdehyde (MDA) content, DPPH inhibition, and antioxidant capacity. There was an interaction between spice formulas and storage times on microbiological characteristics, MDA content, DPPH inhibition, and antioxidant capacity. The study concludes that the modification of spices increases the quality of duck jerky, especially from antioxidant activity and ability to maintain low MDA content. B spice formula showed the best formula than other spice formulas.

Keywords: duck jerky, quality, rejected duck, spice formula, storage

ABSTRAK

Berbagai olahan daging itik umumnya masih menggunakan daging itik afkir. Kelemahan daging itik afkir adalah teksturnya alot, bau yang amis dan kandungan lemak tinggi. Kandungan lemak meningkatkan kemungkinan terjadinya oksidasi dan pembentukan radikal bebas. Upaya mengatasinya adalah dengan pemberian bumbu kaya antioksidan pada saat pengolahan, salah satunya menjadi dendeng itik manis khas Kalimantan Selatan. Tujuan penelitian adalah untuk menganalisis pengaruh modifikasi bumbu kaya antioksidan terhadap peningkatan kualitas dendeng itik manis dan mendapatkan formulasi bumbu yang terbaik dalam proses pembuatannya. Penelitian menggunakan Rancangan Acak Lengkap (RAL) faktorial 3x3 dengan 3 ulangan. Faktor pertama adalah tiga formula bumbu yang berbeda (formula A, formula B dan formula C) dan faktor kedua adalah tiga lama penyimpanan (0 minggu, 2 minggu, 4 minggu). Data dianalisis menggunakan analisis ragam dan hasil signifikan selanjutnya diuji menggunakan uji Tukey. Hasil penelitian menunjukkan bahwa formulasi bumbu berpengaruh nyata ($p<0,05$) terhadap kandungan malondialdehida (MDA), daya hambat DPPH dan aktivitas antioksidan. Terdapat interaksi antara formulasi bumbu dan lama penyimpanan terhadap karakteristik mikrobiologis, kandungan MDA, penghambatan DPPH dan aktivitas antioksidan. Kesimpulan penelitian yaitu modifikasi bumbu meningkatkan kualitas dendeng terutama dari aktivitas antioksidan dan kemampuan untuk mempertahankan kadar MDA tetap rendah. Formula bumbu terbaik ditunjukkan oleh formula B dibandingkan dengan formula bumbu lainnya.

Kata kunci: dendeng itik, formulasi bumbu, itik afkir, kualitas, penyimpanan

INTRODUCTION

Demand and production of duck meat continue to increase yearly, even though the amount only fulfills 1% of the national meat demand (DITJENNAK 2021). The low demand for duck meat is also because there are still many consumers who need to get used to eating duck meat because of its distinctive flavor, especially those that give a distorted off-flavor/odor sensation, namely a fishy/rancid smell. Rejected duck meat is redder and tougher than chicken meat, influencing consumer preference for duck meat. So far, duck meat in the community comes from young male ducks and old and rejected females (Matitaputty and Suryana 2010). Rejected duck has the advantage of high protein content and low-calorie content. However, it has drawbacks such as a fishy smell, toughness, and higher fat content (Zulfahmi *et al. 2013)*.

Apart from being used directly as the main ingredient in dishes, rejected duck meat is also partly processed and preserved. For example, the people of North Hulu Sungai Regency, South Kalimantan, process rejected duck meat into sweet duck jerky. Jerky is a traditional Indonesian processed meat product in which, in the manufacturing process, is added sugar, salt, and spices and then dried in the sun to dry. Processing meat into jerky will increase the intensity of malondialdehyde (MDA) formation as a secondary product of lipid oxidation. Using spices from spices that contain antioxidants in jerky processing can reduce MDA levels produced during processing and storage. Antioxidant compounds contained in spices inhibit lipid oxidation reactions, thereby inhibiting the formation of MDA.

Lipid oxidation occurs in polyunsaturated fatty acids. According to Sinabang *et al.* (2021) duck meat cut at 12 weeks of age has a total unsaturated fatty acid content of 51% with 31% monounsaturated fatty acids and 18% polyunsaturated fatty acids. The problem that often arises in the storage of duck jerky is rancidity due to fat oxidation accelerated by the presence of pro-oxidants (Purnamasari *et al.* 2013). Kusnandar (2006) stated that storage at low temperatures could reduce the intensity of chemical reactions. A chemical reaction is thought to also occur in sweet duck jerky, produced from rejected female duck meat, that causes the product range to be limited. This study aimed to analyze the effect of modification of antioxidant-rich spices on improving the quality of sweet duck jerky typical of South Kalimantan, as well as to obtain the right spice formula in sweet duck jerky production to improve its quality and shelf life.

MATERIALS AND METHODS

Material

The materials used in the research can be categorized into ingredients for sweet duck jerky and materials used for analysis. The material for making duck jerky is rejected duck carcasses obtained from local laying ducks with an age of more than 14 months which have passed one production period. The jerky spice includes salt, galangal, ginger, coriander, garlic, brown sugar, white sugar, tamarind, pepper, and pineapple. The chemical used in the analysis is distilled water, $CuSO_4$, K_2SO_4, H_2SO_4, H_3BO_3, propyl gallate (PG), ethylenediaminetetraacetic (EDTA), 1,1,3,3-tetraethoxypropane (TEP) solution, thiobarbituric acid (TBA) solution, methanol, 1,1-diphenyl 2 picrylhydrazyl (DPPH), vitamin C, Buffered Peptone Water (BPW), Plate Count Agar (PCA), Baird-Parker Agar (BPA), Eosin Methylene Blue Agar (EMBA), Xylose Lysine Deoxycholate Agar (XLDA) and trichloroacetic acid.

Methods

Duck Jerky

The first step in making duck jerky is separating the meat and bones from the duck carcass. The meat is completely separated from the bone to produce boneless sheets of meat and duck skin. The duck meat sheets were then marinated using three kinds of spice formulas, namely spices according to what was practiced in the community (Formula A), as well as two introduced spice formulas (Formulas B and C) (Table 1). The marination was carried out for 12 hours at room temperature. The marinated duck meat is then pressed using a weight. After marinating, the duck meat is dried in an oven for 24 hours at 60 °C.

Table 1. Spices and ingredients used in making sweet duck jerky

Ingredients	Formula A[a]	Formula B	Formula C[b]
Duck meat (g)	500	500	500
Garlic (g)	25	25	25
Ginger (g)	15	15	-
White sugar (g)	82.5	82.5	82.5
Brown sugar (g)	-	82.5	82.5
Salt (g)	12.5	12.5	12.5
Coriander (g)	5	5	5
Tamarind (g)	-	1.5	1.5
Galangal (g)	-	-	42.5
Pepper (g)	-	-	1.5
Pineapple (g)	-	25	25

[a]Source: Direct Interview

[b]Source: Suryati *et al.* (2014) with the modification of the use of duck meat and the addition of pineapple juice

Analysis Procedure

Fat Content (AOAC 2005)

Two grams of sample was spread on cotton based on filter paper, rolled up to form a thimble, then put into a Soxhlet glass. Then extraction was carried out for 6 hours using 150 mL of hexane solvent. The extracted fat is then dried in an oven at 105 °C for 1 hour. Fat content is calculated using the formula:

$$\text{Fat Content (\%)} = \frac{\text{Fat Weight}}{\text{Sample Weight}} \times 100\%$$

Protein Content (AOAC 2005)

A sample of 0.25 g was placed in a 100 mL Kjeldahl flask and added with 0.25 g of the mixture (5 g K_2SO_4, 0.25

g $CuSO_4$, 0.1 g selenium) and 3 mL H_2SO_4. Destruction was carried out for 1 hour until a clear liquid was obtained. After cooling, 50 mL of distilled water and 20 mL of 40% NaOH were added, then distilled. The distillation results were collected in an Erlenmeyer containing 10 mL of H_3BO_3 solution and two drops of green bromine cresol. After the distillate volume becomes 25 mL and has a bluish color, the distillation is stopped, and the distillate is titrated with 0.02 N HCl until it is pink. The same treatment was also applied to blanks. Nitrogen levels can be calculated using the formula:

$$\text{Nitrogen} = \frac{(S - B) \times N\ HCl\ x\ 14}{w \times 1000} \times 100\%$$

Protein content can be calculated by the formula: Protein Content = 6.25 × % Nitrogen
With:
S = Sample Titrant Volume
W = Dry Sample Weight
B = Blank Titrant Volume
N = Normality

Moisture Content (AOAC 2005)

The porcelain cup is dried in an oven at 105 °C, removed, and cooled in a desiccator. Samples were weighed in duplicate, 5 g each in a cup. The porcelain cup containing the sample is dried in an oven at 105 °C until the weight is constant. The difference in sample weight before and after drying is calculated, and then the percentage of moisture content is calculated.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight (g)} - \text{Final Weight (g)}}{\text{Initial weigth (g)}} \times 100\%$$

Microbial Analysis

Total plate count (TPC) was analyzed using the BSN method (2008), *Staphylococcus aureus* analysis using the spread method according to BSN (2008), *Salmonella sp* analysis using BSN (2013), *Escherichia coli* analysis using the pour plate method (Yusuf *et al.* 2016). Calculation of microbes using BAM Bacteriological Analytical Manual (2016).

MDA Content

MDA was measured by testing the number of thiobarbituric acids reactive substances (TBARS) with distillation and spectrophotometry methods following the procedures of Sørensen and Jørgensen (1996). Weight 10 g of the sample was homogenized with 50 mL of distilled water containing 0.1% propyl gallate (PG) and 0.1% ethylenediaminetetraacetate (EDTA) for 1 minute. The mixture was then transferred quantitatively into a distillation tube by washing with the addition of 47.5 mL of distilled water containing 0.1% PG and 0.1% EDTA. The mixture was acidified with 2.5 mL of HCl solution (HCl : distilled water = 1:2), and five drops of antifoam were added. Distillation was carried out to obtain 50 mL for each sample. TBARS determination was carried out using a spectrophotometer at 532 nm. Approximately 5 mL of sample distillate was mixed with 5 mL of 0.02 M TBA solution in a glass tube, then incubated in a 100 °C water bath for 40 minutes before cooling to room temperature and running water. All samples were analyzed in duplo. Standard curves were prepared from a series of 0.002 M 1,1,3,3-tetraethoxypropane (TEP) stock solutions into the range 2×10-6 to 10×10-6. TBARS was expressed as mg of malondialdehyde (MDA) per kg DM of duck jerky using TEP as a standard.

Antioxidant Activity

Antioxidant activity was determined according to Tangkanakul *et al.* (2009). Pure methanol was added to the sample extract and stored at room temperature measurement of DPPH radical scavenging activity. Sample extraction of 0.15 was added to 0.9 mL of 0.1 mM DPPH methanol solution, then incubated for 30 minutes at 37 °C, then the absorbance of the mixture was measured at a wavelength of 517 nm. The control used was pure methanol. Antioxidant capacity was seen based on the ability of duck jerky extract to reduce DPPH free radicals compared to antioxidants. Antioxidant activity is expressed as equivalent mg of vitamin C (VCE) per 100 g of duck jerky.

Trimethylamine (TMA) Content

Trimethylamine in duck jerky was determined according to SNI (2009) methods. A 25 g sample was weighed, and 75 mL of 7 % TCA solution was added. The sample was then pureed until homogeneous, filtered with coarse filter paper, followed by the addition of K_2CO_3 solution (1:1), 2 % H_3BO_3, concentrated formalin, conway indicator into the cup conway was then incubated. Titrate the incubation results using 0.02 N HCl solution, and the formation of a pink color marks the endpoint of the titration.

Experimental Design and Data Analysis

This study used a completely randomized design with 3 × 3 factorial design with three replications for microbiological analysis variables, MDA levels, TMA levels and antioxidant activity. The first factor is the spice formula (formula A, formula B, and formula C). The second factor is storage time (0 weeks, 2 weeks, and 4 weeks) at room temperature. Moisture content variables were measured at the beginning and end of the study (0 weeks and 4 weeks). Meanwhile, protein and fat content were only measured at the beginning of the study using a completely randomized non-factorial design. The data obtained were analyzed by analysis of variance to determine the effect of the treatment on the observed variables. If there is a difference between the treatments, it was further tested with the Tukey test (Montgomery 1991). Data processing is done using the Microsoft Excel program.

RESULTS AND DISCUSSION

Fat and Protein Content

The formula did not significantly affect duck jerky protein and fat content (Table 2). The protein content shown by duck jerky is in the range of 24 - 27%. This value is higher when compared to the protein content in duck meat cooked by roasting in the oven, which is around 21.56% (Nurmala *et al.* 2014). The fat content of duck jerky produced is in the range of 22.99 - 28.08%. The formula does not significantly

Table 2. Protein and fat content of duck jerky using different spice formulas and storage times

Variables	Formula		
	A	B	C
Protein (g/100 g)	25.29 ± 2.80	24.72 ± 1.77	27.73 ± 2.77
Fat (%)	28.08 ± 2.39	22.99 ± 4.71	25.34 ± 2.72

affect the fat content because the feed generally influences the fat content. The fat content of meat is related to the feed consumed by ducks. Ducks use the fat contained in duck feed as a source of energy; if fat consumption is excessive, the fat will be stored in the body's tissues (Hidayati *et al.* 2016).

Moisture Content

The moisture content of duck jerky was significantly affected by storage time ($P<0.05$) and was not affected by differences in formulas and interactions between spice formulas and storage time. Storage for up to four weeks showed a decreasing moisture content value (Table 3). The moisture content decreases because microbes utilize water in metabolism and replication (Puspitasari *et al.* 2013). In addition, the decrease in moisture content in duck jerky can also be caused by evaporation during storage (Mahemba *et al.* 2014).

Total Plate Count (TPC)

The results showed that the number of microbial colonies based on TPC was significantly influenced by the interaction between spice formulas and storage time. Spice formulas B and C and duck jerky storage at week 0 showed the lowest number of microbes compared to other formulas and storage time. A low number of microbes is because the test was carried out shortly after the jerky was removed from the oven. So, the previously present microbes die due to heating, while the other microbes have not had time to contaminate it.

The highest number of duck jerky bacterial colonies was 5.06 Log/CFU, slightly higher than the safe limit according to SNI, which was 5.0 Log/CFU. Total microbial colonies up to four weeks of storage are generally still within safe limits for consumption. Low total bacteria is due to the addition of spices that contain antibacterial components, including garlic which is added fresh. Fresh garlic contains allicin and diallyl sulfide, which are strong antibacterial agents (Muthia and Huda 2014).

Staphylococcus aureus

Based on Table 3, it was shown that during the storage of jerky until the fourth week, no growth of S. aureus bacteria was found. Bacterial growth is strongly influenced by water content, Aw, pH, and the product's nutritional content. The non-development of S. aureus bacteria in duck jerky is due to the manufacturing and storage processes which minimize the chances of contamination.

Table 3. The moisture content of duck jerky with different spice formula and storage times (%)

Formula	Storage (Weeks)		Means	Water Content SNI (2013)
	0	4		
A	23.40 ± 0.03	17.11 ± 0.13	20.26 ± 0.04	12
B	20.01 ± 0.03	13.78 ± 0.03	16.90 ± 0.04	12
C	18.99 ± 0.07	9.96 ± 0.02	14.48 ± 0.06	12
Means	20.80 ± 0.02b	13.62 ± 0.03a		

Means in the same row with different superscripts differ significantly ($P<0.05$)

The moisture content of the duck jerky produced is still quite high compared to the SNI standard (2013), which is 12%. However, this is in line with what was conveyed by Hadiwiyoto (1994), which states that dried beef jerky, which is dried using an oven, has a higher moisture content than that which is dried using the sun. The high water content is also caused by added sugar concentration during beef jerky processing. According to Ina *et al.* (2019), soaking beef jerky with 30% coconut sugar has a higher moisture content than with a lower concentration of coconut sugar. High moisture content is due to the hygroscopic nature of sugar so that it can absorb water from the environment.

Microbial Characteristics

Duck meat is easily damaged and susceptible to contamination by microorganisms. The lower the contamination of microorganisms in a processed livestock product, the better the quality and the safer it is for consumption. The microorganisms observed in this study included *S. aureus, Salmonella sp*, and *Escherichia coli*. Data from observations of microbial characteristics in duck jerky with different spice formulas and storage times are presented in Table 4.

Another possibility for the non-development of *S. aureus* bacteria is the effectiveness of the phenolic compounds in jerky spice. One of the main components of jerky spice is garlic, which has been proven to inhibit microbial growth. According to Pajan *et al.* (2016), garlic juice (*Allium sativum* L.) can inhibit the growth of Staphylococcus aureus at a concentration of 3.12%, while the ability to kill *Staphylococcus aureus* at a concentration of 6.25%.

Escherichia coli* and *Salmonella sp.

The inhibition of the development of *E. coli and Salmonella sp.* is due to the production process, which minimizes the chances of contamination and the presence of phenolic compounds in jerky spice. Effective ingredients to inhibit bacterial growth in jerky spice are garlic and salt. According to Prihandani *et al.* (2015), garlic powder is effectively used as a decontaminant for *S. aureus, E. coli, S. typhimurium, P. aeruginosa* bacteria to maintain quality and improve food safety in food ingredients such as chicken

Table 4. Duck jerky microbiological characteristics with different spice formulas and storage times

Formula	Storage (Weeks)			Means
	0	2	4	
		Total Plate Count (Log/CFU)		
A	3.15 ± 2.80b	1.90 ± 3.30ab	1.33 ± 2.30ab	2.13 ± 0.93
B	0.00 ± 0.00a	5.06 ± 1.60b	3.23 ± 2.90b	2.76 ± 2.56
C	0.00 ± 0.00a	1.23 ± 2.10ab	4.09 ± 0.40b	1.77 ± 2.10
Means	1.05 ± 1.82	2.73 ± 2.04	2.89 ± 1.41	
		S. aureus (Log/CFU)		
A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
B	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Means	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
		E. coli (Log/CFU)		
A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
B	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
C	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Means	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	
		Salmonella (Log/CFU)		
A	negatif	negatif	negatif	
B	negatif	negatif	negatif	
C	negatif	negatif	negatif	
Means				

Means with different superscripts differ significantly (P<0.05)

meat. Garlic contains the active compound allicin, which can damage the cytoplasmic membrane and interfere with protein metabolism (Pajan *et al.* 2016). Ratnasari *et al.* (2014) stated that adding salt, sucrose, and lime can inhibit microbial growth in snakehead fish fillets.

MDA Content

The results of measuring MDA levels in duck jerky were significantly affected by the length of storage (p<0.05). MDA levels were not significantly affected by the spice formula used, and there was no interaction between the spice formula and storage time of duck jerky in Table 5.

MDA compounds correlate with rancidity. The higher the amount, the more rancid the product smells. MDA levels in duck jerky tended to decrease in the second week and then increased again in the fourth week of storage. Low MDA content shows that the antioxidant compounds contained in the spice are effective in inhibiting the formation of MDA due to lipid oxidation. Suryati *et al.* (2014) conveyed that adding spices rich in antioxidants can reduce MDA levels in beef jerky products. Based on the expert panelist's assessment, the oxidation threshold in beef was at a value of 2.28 mg/g (Campo *et al.* 2006). The MDA value of duck jerky, which is still below this threshold until the four weeks of storage, indicates that the jerky product is still safe for consumption.

TMA Content

The spice formula used did not significantly affect the results of measuring trimethylamine levels in duck jerky. Trimethylamine levels were also not significantly affected by the duck jerky storage length. There was no interaction between the spice formula and storage time in Table 6.

The TMA content will increase as the decay rate increases. The addition of compounds containing antioxidants can slow down the rate of formation of TMA compounds. According to Idakwo *et al.* (2016), adding glucose and cloves to processed fish products reduced the rate of TMA formation up to the 32nd week of storage compared to the control.

Table 5. Malondialdehyde levels in duck jerky with different spice formulas and storage times (mg/kg)

Formula	Storage (Weeks)			Means
	0	2	4	
A	3.33 ± 1.67	0.61 ± 0.49	1.55 ± 0.88	1.83 ± 1.38
B	2.22 ± 1.09	0.76 ± 0.52	1.55 ± 0.63	1.51 ± 0.73
C	2.74 ± 1.90	1.84 ± 0.67	2.38 ± 1.79	2.32 ± 0.45
Means	2.76 ± 0.56b	1.07 ± 0.67a	1.83 ± 0.48ab	

Means in the same row with different superscripts differ significantly (P<0.05)

Table 6. Trimethylamine content of duck jerky with different spice formulas and storage times (mg/g)

Formula	Storage (Weeks)			Means
	0	2	4	
A	3.70 ± 2.91	5.53 ± 2.47	1.57 ± 1.99	3.60 ± 1.98
B	1.05 ± 0.97	0.22 ± 0.22	4.71 ± 2.14	1.99 ± 2.39
C	4.82 ± 2.20	3.29 ± 3.79	5.38 ± 3.35	4.49 ± 1.08
Means	3.19 ± 1.94	3.01 ± 2.66	3.88 ± 2.03	

Table 7. DPPH scavenging activity and antioxidant capacity of duck jerky with different spice formulas and storage times

Formula	Storage (Weeks)			Means
	0	2	4	
	DPPH scavenging activity (%)			
A	44.94 ± 0.82ab	64.33 ± 6.15ab	39.14 ± 19.76a	49.47 ± 13.19
B	57.80 ± 16.09ab	69.38 ± 13.31b	77.55 ± 1.67b	68.24 ± 9.92
C	79.23 ± 7.44b	55.42 ± 5.70ab	56.31 ± 13.56ab	63.65 ± 13.50
Means	60.65 ± 17.32	63.05 ± 7.07	57.66 ± 19.24	
	Antioxidant capacity (mg VCE/g)			
A	139.93 ± 2.31a	194.44 ± 17.28bc	183.55 ± 89.98 bc	172.64 ± 28.84
B	176.06 ± 45.21b	208.63 ± 37.40c	358.47 ± 7.62e	247.72 ± 97.28
C	236.30 ± 20.92d	169.39 ± 16.02ab	261.74 ± 61.75d	267.92 ± 87.63
Means	184.10 ± 48.68	190.82 ± 19.87	267.92 ± 87.63	

Means with different superscripts differ significantly (P<0.05)

Antioxidant Activity

Antioxidant activity in duck jerky was calculated through inhibitory activity against DPPH (1,1-diphenyl-2-picrylhydrazyl) and antioxidant capacity calculations. The test results in Table 7 show that the spice formula and the interaction between the spice formula and storage significantly affect DPPH inhibition (P<0.05). At the same time, the length of storage does not affect the rate of DPPH inhibition.

The use of spice formula B and storage at week 4 showed the highest percentage of DPPH inhibition and the best antioxidant activity among other spice formulas and storage time. The use of antioxidant-rich spices in spices for processing duck jerky inhibits oxidation reactions through their ability to scavenge free radicals.

Antioxidant capacity testing can be used as a parameter that describes the ability of a food ingredient to inhibit free radicals (Partayasa *et al.* 2017). The antioxidant capacity of duck jerky is in the medium-high group, according to Tangkanakul *et al.* (2009), because the value is above 100 mgVCE/g but not more than 500 mgVCE/g.

Storage until the four weeks, there has been no tendency to decrease antioxidant activity. This indicates that the antioxidants contained in duck jerky are still active during storage. Jabbar *et al*. (2021) said that the inhibitory activity against DPPH and antioxidant capacity in palekko nasu products decreased on the fourth day of storage. This difference is thought to be caused by the amount and type of spices used, as stated by Tangkanakul *et al.* (2009), and different processing methods (Febriana *et al.* 2019).

CONCLUSION

Modification of the spice formula was able to improve the quality of sweet duck jerky from South Kalimantan, especially in terms of antioxidant activity and ability to maintain low malondialdehyde content. Formula B is the best formula resulting from this study.

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