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Quality Characteristics of Chicken Burger Processed from Broiler Chicken Fed on Different Levels of Quinoa Seeds

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Abstract**—** *The study was carried out to evaluate the effect of feeding broiler chickens on different levels of quinoa seeds on the quality characteristics of chicken burger during frozen storage at -20°C for 90 days. A total of 480 one-day-old chicks of (Ross 308) were used for this study. Treatments were: (T1) control group fed on corn–soybean basal diet; (T2) fed on basal diet with 5 % quinoa seeds; (T3) fed on basal diet with 10 % quinoa seeds; (T4) fed on basal diet with 15 % quinoa seeds. Results showed that feeding broiler chickens on different levels of quinoa seeds had significant effects on pH values, cooking loss %, color measurements and shear force values. No significant differences were found in shrinkage measurements. Supplemented quinoa seeds in broilers diets can be potentially used for improving color stability and controlling TBA values in processed chicken burger during frozen storage at -20°C for 90days.*

Keywords**— Broiler feed, quinoa seeds, Chicken burger, frozen storage, Quality characteristics.**

I. INTRODUCTION

Lipid oxidation in foods specifically, meat and meat products is the major cause of quality deterioration. Chicken meat is subjected to quality deterioration caused by lipid oxidation because of its high content of polyunsaturated fatty acids and low natural antioxidants (Aziza et al., 2010). Synthetics antioxidants have been widely used in poultry diets to prevent the lipid oxidation and improved color stability in meat and its products (Avila-Ramos et al., 2013).

Many studies have revealed that using synthetics antioxidants have been found to exhibit adverse health effects because of their toxicity and carcinogenicity. This has led to growing interest in the use of natural antioxidants in meat and meat products because of their safety and consumer acceptability (Mokhtar et al., 2014).

Quinoa (*Chenopodium quinoa* Willd) belongs to Chenopodiaceae. Quinoa is unique seeds it has high ability to adapt different types of soil and climatic changes therefore, it could be cultivated in different environments. Quinoa is a grain with exceptional health benefits, nutritional and functional value (Gordillo-Bastidas et al., 2016). Quinoa seeds had large variety of bioactive compounds phenolic compounds include phenolic acids (rosmarinic and chlorogenic acids), flavonoids (quercetin and isoquercetin), and nitrogen-containing compounds (betacyanins, and betaxanthins). Most of the bioactive compounds in quinoa seeds are related to their antioxidant activity (Fernández-López et al., 2020).

Using quinoa seeds extract in broiler diet significantly affected on broilers performance and improved the meat quality. Quinoa extract had antioxidative properties which resulting in delaying the lipid oxidation of broiler meat during storage (Easssawy et al., 2016).

This study aimed to evaluate the effect of feeding broiler chicken on different levels of quinoa seeds on the processing and quality characteristics of chicken burger during frozen storage at -20° for 90 days.

II. MATERIAL AND METHODS

2.1. Preparation of quinoa seeds

Quinoa seeds (*Chenopodium quinoa* Willd*)* were supplied by the project of climatic smart agriculture entrepreneurship development of quinoa value chain in Egypt. The seeds were soaked in distilled water for 48 h thereafter the soaked seeds were washed with distilled water several times in a row, drained and dehulled, according to the method described by Udensi et al. (2008). Seeds were dried in a room with a temperature of 30 to 32ºC and a humidity of 15% with stirring until complete drying (about 8 days).

2.2. Experimental design

The experimental procedures were approved by the Animal Breeding Department, Animal and Poultry Production Division, Desert Research Center.

A total of 480 one-day-old chicks of (Ross 308) strain were used for this study, the chicks were randomly assigned to four treatment groups. Each group consisted of 6 replicates and each replicate was made up of 20 chicks. Treatments were: (T1) control group fed on corn–soybean basal diet; (T2) fed on basal diet with 5 % quinoa seeds; (T3) fed on basal diet with 10 % quinoa seeds; (T4) fed on basal diet with 15 % quinoa seeds. The basal diet was formulated to meet the nutrient requirements of broiler chicken following the National Research Council (NRC, 1994). Diets were offered in two feeding phase's starter: one-day-old till 21 days of age and grower: 22 days till 35 days. The composition and calculated analysis of basal diets are showed in Table 1. The chicks were raised at 33 ± 0.5 °C and then the temperature was gradually decreased until 28 ± 1 °C was reached by day 15 and then left with the case of natural temperature.

Table 1 Feed ingredients and chemical analyses of experimental diets

Ingredients (%)	Starter (1-21 d)				Grower (22-35 d)			
	Q0	Q5	Q10	Q15	Q0	Q5	Q10	Q15
Yellow corn	53.35	49.60	45.95	43.44	57.70	54.05	50.12	45.56
Soybean meal (44%)	33.14	32.14	31.00	29.50	28.65	28.26	27.34	26.8
Corn gluten meal (62%)	6.35	6.35	6.35	6.35	5.75	5.20	5.20	5.20
Quinoa	0.00	5.00	10.00	15.00	0.00	5.00	10.00	15.00
Soybean oil	3.00	2.70	2.39	1.40	3.95	3.50	3.28	3.30
Calcium carbonate	1.23	1.23	1.23	1.23	1.07	1.17	1.15	1.15
Di-calcium phosphate	1.93	1.93	2.03	2.03	1.98	1.85	1.88	1.90
Broiler premix*	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Salt	0.45	0.45	0.45	0.45	0.40	0.40	0.40	0.40
DL-methionine	0.20	0.20	0.20	0.20	0.15	0.17	0.20	0.22
L-lysine	0.00	0.05	0.05	0.05	0.00	0.05	0.08	0.12
Total	100	100	100	100	100	100	100	100
Chemical analysis								
ME (kcal kgG1)	3050	3050	3050	3050	3150	3150	3150	3150
Crude protein	23.00	23.00	23.00	23.00	21.00	21.00	21.00	21.00
Calcium	1.00	1.00	1.00	1.00	0.95	0.95	0.95	0.95
Av. phosphorus	0.48	0.48	0.48	0.48	0.45	0.45	0.45	0.45

*Premix: (1%) provided the following (per Kilogram of complete diets). 1400 IU vitamin A, 3000 IU Vitamin D3, 50 mg vitamin E, 4 mg vitamin K, 3 mg Vitamin B6, 6 mg Vitamin B12, 60 mg Niacin, 20 mg Pantothenic acid, 0.20 mg folic acid, 150 mg Choline, 48 mg Ca, 3.18 mg P, 100 mg Mn, 50 mg Fe, 80 mg Zn, 10 mg Cu, 0.25 mg Co, 1.5 mg Iodine.

2.3. Slaughtering of birds

At the end of the experiment (42 days), 80 birds (20 birds from each group) were selected based on similar body weight for slaughtering. Slaughtered birds were scalded in hot water bath, plucked and eviscerated manually. Chicken meat from thigh and abdominal muscles were collected, packed and frozen at -20ºC until further analyses and processing of chicken burger were completed.

2.4. Preparation of chicken burger

Chicken meat of thigh and abdominal muscles were collected from each experimental diet and separately ground through a 3mm plat meat grinder (K-R-SU, Model: KMG1700. China). Meat of each dietary treatment was formulated with 1.5% salt, 0.5% black pepper, 0.5% spices and 7.5% onion as describe by Mikhail et al. (2014). The formula of each dietary treatment was handily mixed and formed by using manual burger press machine (Metaltex No.25.17.25 Made in PRC). Chicken burgers (1cm thickness, 10cm diameter and 70±2g weight) were placed in plastic foam trays packed in polyethylene bags and frozen at -20ºC±1until further analysis.

2.5. Physical analysis

2.5.1. pH value

Raw chicken burger was measured for pH value as described by Hood (1980). Ten grams of sample were homogenized with 100ml distilled water and measured using a digital pH-meter Jenway 3310 conductivity and pH meter. Values of pH were determined in triplicate for each dietary treatment at 0, 30, 60 and 90 days of storage at -20°C.

2.5.2. Cooking measurements

Chicken burger samples of each treatment were cooked in preheated grill (at110°C for 10 min each side) to an internal temperature 70°C±1. Three replicates per treatment were done for cooking loss measurement. Cooking loss was calculated by using the following equation as reported by Naveena et al. (2006).

$$\text{Cooking loss (\%)} = \frac{(\text{Uncooked sample weight}) - (\text{Cooked sample weight})}{(\text{Uncooked sample weight})} \times 100$$

2.5.3. Shrinkage measurements

The reduction in diameter and thickness of chicken burger were measured as described by Berry (1993) using the following equation:

$$\text{Reduction in diameter (\%)} = \frac{(\text{Uncooked sample diameter}) - (\text{Cooked sample diameter})}{(\text{Uncooked sample diameter})} \times 100$$

$$\text{Reduction in thickness (\%)} = \frac{(\text{Uncooked sample thickness}) - (\text{Cooked sample thickness})}{(\text{Uncooked sample thickness})} \times 100$$

Shrinkage was calculated by using the following equation as reported by Murphy *et al.* (1975).

$$\text{Shrinkage (\%)} = \frac{[(\text{Raw thickness} - \text{Cooked thickness}) + (\text{Raw diameter} - \text{Cooked diameter})]}{(\text{Raw thickness} + \text{Raw diameter})} \times 100$$

2.5.4. Shear force value

Cooked chicken burger samples were sheared for three times at different positions by using Instron Universal Testing Machine (Model 2519-105, USA). The average shear force was calculated from the three obtained results ($Kg/_f$).

2.5.5. Color measurements

Color of raw chicken burger samples was measured by Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer (CIE, 1976). The color was expressed as lightness (L*), the redness (a*) and the yellowness (b*). The average of three spectral readings at different locations was obtained for burgers of each dietary treatment during storage periods 0, 30, 60 and 90 days of storage at -20°C.

2.6. T.B.A value

Measurement of lipid oxidation: The extent of lipid oxidation in raw chicken burger was assessed by measuring 2- thiobarbituric acid reactive substances (TBARS), as described by AOCS (1998). TBARS values were determined in triplicate for each sample at 0, 30, 60and 90 days of storage at -20°C.

2.7. Statistical analysis

All data generated from each treatment were analyzed using statistical analysis system (SAS, 2000). Two- way ANOVA was applied for pH, TBA and color measurements. In case of shrinkage measurements and physical analysis one – way ANOVA was applied.

III. RESULTS AND DISCUSSIONS

Physical properties of chicken burger

Physical properties (pH values, cooking loss, shear force values and color parameters) of chicken burger processed from broiler fed on different levels of quinoa seeds are shown in Table 2. The results of pH values of chicken burger indicated that feeding broilers on different levels of quinoa seeds had significant differences in pH values. Burger processed from control feeding group (T1) exhibited significantly higher in pH value followed by burger of T2 group. Burger from feeding groups of high levels of quinoa seeds (T3 and T4) showed lower pH values. In the same line, similar trends of pH values were found by Marino et al. (2018). Conversely, Shim et al. (2018) found that no significant difference were found in pH values of broiler meat fed on different levels of dried grains.

Table 2 Physical properties of chicken burger

Parameters	Treatments				
	T1	T2	T3	T4	SEM
pH	5.64[a]	5.59[b]	5.46[d]	5.54[c]	0.01
Cooking loss (%)	42.08[b]	40.83[b]	49.43[a]	47.64[a]	1.11
Shear force ($Kg/_f$)	2.08[a]	1.59[c]	1.62[bc]	1.99[ab]	0.11
Color parameters					
L	49.36[b]	51.47[a]	50.69[ab]	50.95[a]	0.79
a	4.71[ab]	4.44[b]	5.09[a]	4.26[b]	0.15
b	7.59[b]	8.30[ab]	8.73[a]	8.99[a]	0.33

[a-d] means within the same row with different superscripts letters are different ($p<0.05$).

T1: control diet, T2: diet contains 5 %, T3: diet contains 10 % and T4: diet contains 15 %.

SEM: standard error of means.

No significant differences were found in cooking loss between burger processed from control feeding groups (T1) and treated feeding group (T2). On the other hand, no significant differences were found in cooking loss between burger processed from (T3) and (T4) feeding groups. These results came in accordance with that obtained by Zaki et al. (2018) they found that no significant differences were observed in cooking loss of chicken burger processed from broiler fed on different types of diets and feed additives.

Results of shear force values of burger samples are revealed that feeding broilers on different levels of quinoa seeds had a significant effect on tenderness of processed chicken burgers. Burger of control group (T1) showed the higher shear force value (less tender) than the burger of quinoa seeds feeding groups. In this regard, our data reflect that the increasing of quinoa seeds level in broilers diet resulting in increasing in shear force values of processed chicken burgers. Burger of (T2) group which processed from broiler fed on the lowest level of quinoa seeds (5 %) showed the lowest shear force value (more tender) than the other quinoa feeding groups. Similar results were obtained by Marino et al. (2018) they found significant differences in WBSF values of meat fed on diets supplemented with quinoa. They found that control group showed the highest WBSF value (less tender) while; meat of quinoa feeding groups showed the lowest WBSF value (more ender).

Data of color measurements of chicken burger processed from different level of quinoa seeds showed that no significant differences were found in L* values of chicken burger samples of T2 and T4. Slight significant differences were found between burger of T1 andT3 and T4.

Supplemented broiler diet with different quinoa levels had significant effects on redness of processed burger (a* value). Burger of (T3) showed the highest *a value and no significant differences were found between T4 and T2. Chicken burger processed from broiler fed on different levels of quinoa seeds exhibited significantly higher in b* values than burger processed from control group (T1). View of the present data, it could be concluded that that the yellowness of chicken burger increased as feeding broiler on quinoa seeds levels increased. This finding came in accordance with the results obtained by Marino et al. (2018) they found that feeding on quinoa or/ and linseed showed a significant higher on color parameters (L* , a* and b* values) than meat feeding on control groups.

Shrinkage parameters of chicken burgers processed from broiler fed on different levels of quinoa seeds are shown in Table 3. Results of reduction in diameter % revealed that supplemented broiler diets with quinoa seeds had no significant effect on reduction in diameter % of burger, despite of burger of T2 had the lowest reduction in diameter % while, burger of T3 had the highest percentage but, the differences among burger groups were not significant . The same trends were found in data of reduction in thickness %.

View of the current results, it could be concluded that shrinkage measurements % of chicken burger did not affected by supplemented broiler diets with different quinoa seeds levels. These results are in line with that obtained by Zaki et al. (2018) they found that no significant differences were found in shrinkage measurements % of chicken burger processed from broilers fed on different feeding diets and feed additives. However, results of shrinkage measurements are consistency with data of cooking loss% and shear force values.

Table 3 Shrinkage parameters of chicken burgers

Treatments	Parameters		
	Reduction in diameter (%)	Reduction in thickness (%)	Shrinkage (%)
T1	21.23	19.44	21.69
T2	20.12	18.43	21.53
T3	22.37	22.22	22.73
T4	21.90	21.77	22.51
SEM	1.49	2.11	1.44
Sig.	NS	NS	NS

T1: control diet, T2: diet contains 5 %, T3: diet contains 10 % and T4: diet contains 15 %.

SEM: standard error of means. Sig : significant, NS: non significant.

Effect of frozen storage on the quality characteristics of chicken burger

Changes in pH values

Data in Table 4 showed the pH values of chicken burger processed from broiler fed on different levels of quinoa seeds during frozen storage at -20°C for 90 days. It can be noticed that a significant difference were found in pH values of burger treatments, the highest pH values found in burger of control feeding group (T1).While, slight significant differences were found among burgers of quinoa seeds feeding groups (T2, T3 and T4). Regarding frozen storage, during 30 days of storage no significant changes in pH values were found in both of burger of T1 (control feeding group) and burger of T2 (low level quinoa feeding group). Conversely, burger from higher quinoa levels feeding groups (T3 and T4) showed significantly decreased in pH values after 30 days of storage.

Table 4 Changes in pH values of chicken burger during frozen storage at -20°C for 90 days

Treatments	Storage periods (days)			
	0	30	60	90
	pH values			
T1	5.64^{Ac}	5.64^{Ac}	5.95^{Ab}	6.29^{Aa}
T2	5.59^{Bc}	5.57^{Bc}	5.84^{Bb}	6.16^{Ba}
T3	5.46^{Cc}	5.35^{Dd}	5.78^{Cb}	6.01^{Ca}
T4	5.54^{BCc}	5.44^{Cd}	5.85^{Bb}	6.03^{Ca}
SEM	0.02	0.02	0.02	0.02

$^{a-d}$ (→) means within the same row with different superscripts letters are different ($p<0.05$).

$^{A-D}$ (↓) means within the same column with different superscripts letters are different ($p<0.05$).

T1: control diet, T2: diet contains 5 %, T3: diet contains 10 % and T4: diet contains 15 %. SEM: standard error of means.

However, significant increased were found in pH values of all burger treatments during 60 and90 days of frozen storage. These discrepancies in pH values during frozen storage could be explained separately, the decreasing in pH values could be attributed to psychrophilic bacteria especially lactic acid bacteria which resulting in breakdown of glycogen during frozen storage; thereby increase in lactic acid which caused the reduction in pH values (Shelef, 1975). Conversely, the increasing in pH values may be due to the breakdown of protein in meat during frozen storage resulting in releasing of amino acids and accumulation of ammonia and consequently,

increasing in pH values (Jin et al., 2007). These results are consonance with that obtained by Alabdulkarim et al. (2012) they found that pH values of chicken patties significantly decreased after 20 days of frozen storage and then increased during the rest of frozen storage period (60 days). The same results were found by Ozer and Sariçoban (2010) they indicated that during frozen storage, pH values of chicken patties samples tended to decrease after 2 months of storage and significantly increased as the time of frozen period increased (6 months).

Color parameters

Effect of frozen storage on the color measurements of chicken burger processed from broiler fed on different levels of quinoa are shown in Table 5. It can be noticed that fresh burger (at zero time) showed slight differences in L* values of all burger samples. After 30days of storage L* values significantly decreased, followed by significant increased throughout the storage period (90 days of storage). Fernandez-Lopez et al. (2003) indicated that pH values are the most factor affected on meat color because of its effect on chemical state of meat pigments. In this regard, data of pH values are consistency with results of L* values which could be explained the changes in L* values during frozen storage. Similar trend were obtained by Ozer and Sariçoban (2010) they found that L* values of chicken patties significantly decreased during 4 months of frozen storage and then increased at the end of frozen period.

Table 5 Changes in color parameters of chicken burger during frozen storage at -20°C for 90 days

Treatments	Storage periods (days)				
	0	30	60	90	SEM
			*L**		
T1	49.36^{Ba}	46.39^{Bb}	46.84^{Bb}	48.79^{Ba}	0.65
T2	51.47^{Aa}	48.22^{ABb}	50.22^{Aab}	52.49^{Aa}	0.65
T3	50.69^{ABab}	49.72^{Ab}	48.60^{ABb}	52.28^{Aa}	0.65
T4	50.95^{Aa}	46.44^{Bb}	47.21^{Bb}	48.36^{Bb}	0.65
			*a**		
T1	4.71^{ABa}	4.41^{ABa}	4.46^{Aa}	3.55^{Bb}	0.19
T2	4.44^{Ba}	4.13^{Bab}	3.86^{Bb}	3.88^{ABb}	0.19
T3	5.09^{Aa}	4.74^{Aa}	4.53^{Aab}	4.34^{Ab}	0.19
T4	4.26^{Ba}	4.10^{Ba}	3.68^{Bab}	3.61^{Bb}	0.19
			*b**		
T1	7.59^{Bb}	10.04^{Aa}	10.49^{Aa}	9.94^{Aa}	0.42
T2	8.30^{ABb}	10.25^{Aa}	9.91^{Aa}	8.94^{Aab}	0.42
T3	8.73^{Ab}	10.28^{Aa}	9.98^{Aa}	9.92^{Aa}	0.42
T4	8.99^{Aa}	9.79^{Aa}	9.88^{Aa}	9.10^{Aa}	0.42

$^{a-b}$ (→) means within the same row with different superscripts letters are different ($p<0.05$).

$^{A-B}$ (↓) means within the same column with different superscripts letters are different ($p<0.05$).

T1: control diet, T2: diet contains 5 %, T3: diet contains 10 % and T4: diet contains 15 %.

SEM: standard error of means.

Burger of T3 showed the highest a*value (more red), followed by burger of control group (T1). No significant differences were found between burger of T2 and T4. Regarding frozen storage, decreasing trends were observed in (a*) values for all burger samples as the time of frozen storage increased. This may be attributed to the oxidation of oxymyoglobin to metmyoglobin which resulting in dark color (Ozer and Sariçoban, 2010). In addition, at any time of frozen storage burger of T3 showed the highest a* value (more red) than other burger samples. These results are in line with the results of Vieira et al. (2009) they found significant decreased were observed in a* of all beef

samples as the time of frozen storage increased. The same results were found by Fernandez-Lopez (2006) who found that a* values of burger decreased as the time of storage increased. Also, Gahruie et al. (2017) reported that significant decrease in a* values were found in all beef burger formulations during frozen storage.

The results revealed that a significant increased was found in b* values after 30days of frozen storage, after that b* values tended to decrease gradually with the time of storage increased up to 90days despite the fact that differences in b* values were not significant as the time of frozen storage increased. These results are consonance with Vieira et al. (2009) they found a significant decreased in b* values of meat after 90days of frozen storage. The same results were found by Ibrahim et al. (2011) they found that all chicken burger formulations tended to increased in b* values after 45 days of storage and slightly decreased after 90 days of frozen storage.

The results of the current study revealed that supplemented quinoa seeds in broilers diets resulting in increasing the antioxidant activity in chicken meat which can be potentially used as a natural antioxidant for controlling color parameters (L*, a* and b*) values in processed chicken burger during frozen storage.

Changes in TBA values

Table 6 showed the TBARS values of chicken burger during frozen storage at -20°C for 90 days. It can be noticed that at zero time burger of control group (T1) showed the lower TBA value and no significant differences were found between burger of T2 and T3 while, the highest TBA value were found in burger of T4. After 30 days of frozen storage significant decreased were found in all burger samples especially, in burger processed from chicken fed on high level of quinoa seeds (T4). On the other hand, the differences between burger treatments were not significant. After 60 days of storage TBA values increased for all burger treatments and such increase was continued as the time of frozen storage increased. These results are consonance with that obtained by Gahruie et al. (2017) they found that TBARS values of all burger treatments were significantly increased as the time of frozen storage increased.

Table 6 Changes in TBA values of chicken burger during frozen storage at -20°C for 90 days

Treatments	Storage periods (days)			
	0	30	60	90
	T.B.A value (mgMDA/kg)			
T1	0.209^{Ca}	0.029^{Bc}	0.105^{Bb}	0.111^{Bb}
T2	0.235^{Ba}	0.033^{ABd}	0.099^{Cc}	0.110^{Bb}
T3	0.239^{Ba}	0.034^{Ad}	0.109^{Bc}	0.116^{Bb}
T4	0.409^{Aa}	0.035^{Ad}	0.118^{Ac}	0.132^{Ab}
SEM	1.88	1.88	1.88	1.88

$^{a-d}$ (→) means within the same row with different superscripts letters are different ($p<0.05$).

$^{A-C}$ (↓) means within the same column with different superscripts letters are different ($p<0.05$).

T1: control diet, T2: diet contains 5 %, T3: diet contains 10 % and T4: diet contains 15 %.

SEM: standard error of means.

Also, Wei et al. (2017) found that TBA values of breast chicken meat were gradually increased during frozen storage period (0-5 months) but the significant increased was found during 7- 8 months of storage. Generally, it is clear that at any time of frozen storage, T.B.A. values of all burger samples remained lower than T.B.A. values at zero time. Based on the present data, it could be concluded that incorporation of quinoa seeds in broiler diets resulting in inhibited lipid oxidation of chicken burger during frozen storage. This is may be attributed to the higher antioxidant activity of quinoa seeds because of its remarkable content of phenolic and flavonoid compounds which play as a source of free radical scavenging agents. Thereby, addition of quinoa seeds in broilers diet resulted in increment of the antioxidative properties of chicken burger. This finding came in accordance with the results of Easssawy et al. (2016) they reported that addition of quinoa seeds extract in broiler diets can be successfully delayed the lipid oxidation of chicken meat during refrigerated storage for 7 days.

IV. CONCLUSION

The aim of the current study was to evaluate the quality characteristics of chicken burger processed from broiler chicken fed on different levels of quinoa seeds and stored under frozen storage. Addition of quinoa seeds in broiler diets has a positive effect on quality traits of chicken burger. Quinoa in broiler chicken diets would subsequently affect the oxidative stability during frozen storage and improving the color of burger during frozen storage.

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