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Antioxidant activity of galangal powder and the effect of addition on some quality characteristics of meatball

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ABSTRACT

In this research, the effect of dried galangal powder addition (% 0.1, % 0.25, % 0.5 w/w) on oxidative stability as measured by thiobarbituric acid-reactive substances (TBA) and conjugated diene of meatballs were investigated at different days (Day 0, 3, 7). There was no significant difference were found between the TBA values of control and BHT added samples at the end of the storage but significant difference ($p<0.05$) were found the galangal added samples. The lowest TBA value observed at % 0.5 galangal powder added samples (0.2 mg malonaldehyde/ kg meat sample). When the conjugated dienes results were examined, it was determined that the highest value was obtained at % 0.5 galangal powder added group (0.0273 µmole/mg meat) and there was no significant difference ($p>0.05$) were found between the other galangal powder added samples. There was a significant difference ($p<0.01$) was found between the % 0.5 galangal added and control or BHT added samples (0.0151 and 0.017 µmole/mg meat respectively). Also color analysis and sensorial evaluations of the meatball samples were done.

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1. Introduction

Buckley, Morissey, & Gray [1] concluded that lipid hydroperoxides formed during the propagation phase of the process are unstable and are reductively cleaved by the trace elements to give a range of free radicals and other non-radical compounds including alkoxyl, alkyl radicals, aldehydes, ketones and a range of carboxyl compounds. These compounds adversely affect the texture, color, flavor, nutritive value and safety of muscle food. Addition of antioxidative compounds required for preserving the food quality [2]. Synthetic antioxidants are widely used in the food industry such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propile gallate (PG), tert-butyl hydroquinone (TBHQ) [2-3]. Synthetic antioxidants have long been used but their use has recently come into the dispute to a suspected carcinogenic potential [4] and the general rejection of synthetic food additives by consumers [2]. A multitude of natural antioxidants has already been isolated from different kinds of plant materials such as; oilseeds, cereal corp, vegetables, fruits, leaves, roots, spices, herbs [5]. Currently, there is an increasing demand for new ethnic foods. Some of the popular emerging ingredients for developing these foods include galangal, cardamom, lemongrass, etc. [6].

Lu, Yuan, Zeng, & Chen [7] studied the antioxidant capacity and phenolic compounds of spices used in China. They found that galangal has the highest antioxidant capacity between the 19 dried culinary spices. Galangal (Alpinia galanga), a rhizome related to the ginger family and used for stir-fries, curries, soups of South East Asia [6].

The study aimed to determine the effects of dried galangal powder addition on oxidative stability of meatballs as measured by thiobarbituric acid reactive substances, conjugated dienes during storage at 4°C. Also, some quality characteristics of meatballs were determined

2. Materials and methods

Galangal rhizomes were purchased from a supermarket in Afyonkarahisar/ Turkey. Beef meat was purchased from local butchers in Afyonkarahisar. The rest of the chemicals and standards were analytical grades and obtained from Sigma or Merck (Darmstadt, Germany) unless otherwise stated. Duplicate determinations were carried out for all analysis.

Rhizomes were cleaned and cut into small pieces and ground by using a grinder (Bosch, MKM6000), and stored at

refrigerated conditions in an airtight, screw-capped plastic container until use.

Phenolic isolation of samples was done by the method of Shahidi, Chavan, Naczk, & Amarowicz [8]. According to this method, one gram sample extracted 3 times with 10 mL of aqueous methanol (70%) using a homogenizer (Daihan HG-15D) at 11.000 rpm for 1 min. Then the slurry centrifuged at 4000 rpm for 15 min. Supernatants were collected and evaporated by the rotary evaporator (Scilogex- RE100) at 45 °C under vacuum. Extracted phenolics were dissolved in 25 mL of methanol and filtered by filter paper (Whatmann No:1). Methanolic solutions of extracted materials were then used for further analysis.

Total phenolic contents were determined according to Kaur & Kapoor [9]. The methanolic solution of extracts (0.5 mL), distilled water (7 mL) and Folin Ciocalteu reagent (0.5mL) were added to the test tube and mixed. After 3 min, 2 mL of sodium carbonate (20%) was added and mixed again. The solution was read at 720 nm after 1 h standing at 25°C in a water bath. Results were expressed as mg catechin of kg weight sample using a standard calibration curve of catechin ($r2>0.99$).

The DPPH radical scavenging assay with some modifications was used Choi, Kozukue, Kim, & Friedman [10]. The methanolic DPPH solution was prepared and 1.6 mL of sample was added to DPPH (0.4 mL, 96mg/L). After 30 min incubation period at room temperature, the absorbance was measured by UV-Vis spectrophotometer at 517 nm against the blank. Antioxidant activity (AA) (%) was calculated according to the equation given below;

Antioxidant activity (%)= [(Ablank-Asample)/Ablank]x100

Duplicate treatments were done for the meatball dough preparation. Meat divided into 5 groups. Control, BHT added and 3 different galangal added meat doughs prepared. Galangal powder (previously ground galangal powders) added to meat at a concentration of 0.1% (P1), 0.25 % (P2) and 0.5 % P3) of the meat weight. Each group sample was divided into 25 g of meatballs on a plastic tray and sealed with stretch film and stored in a refrigerator at 4°C. Meat samples were evaluated at 0, 3, 7 days for TBA, Conjugated dienes, color values. Also, sensory parameters evaluated on Day 0.

Table 1. *Meatball preparation*

Ingredients	Control	BHT	P1	P2	P3
Meat (g)	1000	1000	1000	1000	1000
Salt (g)	20	20	20	20	20
BHT (ppm)	-	200	-	-	-
Galangal Powder (g)	-	-	1	2,5	5

CIE color values (L*, a*, b*) of the meatballs were determined by X-Rite (Ci6X) colorimeter. The colorimeter was calibrated using a standard white plate. The color was measured at three positions of the samples. The color was measured from uncooked meatball samples during the storage and cooked meatballs on day 0.

To determine lipid oxidation, a 10 g sample was homogenized with 97.5 mL distilled water at 50°C and put into a Kjeldahl flask. The volume was completed to 100 mL by adding a 2.5 mL 4 N HCl solution (1:2 37% HCl : distilled H2O) to it. Soybean oil was used as the antifoaming agent. Fifty mL of distillate was collected with steam distillation in a precise manner. Five mL was taken from the distillate and 5 mL 0.02 M TBA reactive was added to it; it was kept in a boiling water bath for 35 min. The absorbance values of the cooled samples were read in the UV spectrophotometer at 538 nm wavelength. The amount of malondialdehyde (MDA) (mg MDA/kg sample) formed in the product was calculated by multiplying the absorbance values by the factor 7.8 [11].

The formation of conjugated dienes was determined according to the procedure described by 2. Meat samples (0.5 g) were suspended in 5 mL of distilled water and homogenized to form a smooth slurry. A 0.5 mL aliquot of this suspension was mixed with 5 mL of extracting solution (3:1 hexane: isopropanol) for 1 min. after centrifugation at 2000 g for 5 min, the absorbance of the supernatant was measured at 223 nm. The concentration of conjugated diene was calculated using the molar extinction coefficient of 25.200/Mcm and the results were expressed as µmole per mg meat sample.
Sensory evaluation was conducted according to IFT (Institute of Food Technologists) [12]. Meatball samples were grilled at 80°C internal temperature and served in random order. The serving temperature was approximately 60°C. Water and bread were served for cleaning the mouth between samples. Consumer panelists were 12 volunteers from the Nutrition and Dietetics department and a nine-point hedonic scale was used.

The obtained data were presented as means and standard deviation (mean±SD) and subjected to analysis of variance (one way/ two way-ANOVA). Means were compared with Tukey test.

3. Results and discussion

The total phenolic content of galangal rhizomes was 17,729.16 mg catechin equivalent/ kg sample and antioxidant activity was 89.62 %. These results showed that the galangal methanolic extracts have strong antioxidant activity.

Table 2. *Color values of Stored Meatballs*

Treatment	L*	a*	b*
Control	44.45± 4.41	12.42^{a}±4.57	13.09±1.37
BHT	43.64±2.73	11.25^{ab}±4.38	13.01±2.14
P1	47.55±5.25	8.41^{b}±6.49	12.37±3.94
P2	41.22±2.02	10.34^{ab}±5.23	11.88±3.64
P3	41.85±3.69	11.45^{ab}±5.04	12.61±3.18
Sig	n.s.	*	n.s.
Day			
0	44.30±1.71	15.66^{a}±1.55	15.84^{a}±1.06
3	43.40±5.01	5.69^{c}±1.95	11.33^{b}±1.20
7	43.53±5.3	10.98^{b}±4.42	10.61^{b}±2.32
Sig	n.s.	**	**
Treatment* Day Interaction			
Sig	n.s.	*	*

$^{a–c}$ Means in the same column with different superscripts are significantly different.
* p<0.05, **p<0.01

When the L* values of meatballs were compared, results showed that there was no significant (p>0.05) difference found between treatment groups, days and "Treatment*Day" interactions. Also, treatment does not affect the b*values of meatballs. Table 3 shows that the a* value of the meatballs significantly affected a partial the treatment (p<0.05) and storage (p<0.01). The highest a* value was seen in the control group (12.42±4.57) but there was no difference seen between the other groups except P1. Maybe the quantity of galangal powder in the meat matrix is inadequate for the prevention of color.

Discoloration in meat is interrelated with lipid oxidation and metmyoglobin production through the action of free radicals [13]. Cheah & Abu Hasim [3] concluded that samples with galangal extract showed increasing a* values with increasing concentration. Addition of BHT or alfa-tocopherol didn't affect the L* and b* values.

According to Tironi et al. [14] The red color decreased in both untreated and rosemary extract-treated samples as a function of storage time; a minor decrease was observed in treated muscles, as evidenced by the increase in a*. These results indicate partial red color preservation by the rosemary extract. Rosemary extract produces only partial preservation of red color because there are other causes for color modification in addition to the oxidative processes investigated in this work. Possible causes for the decrease of a* include the conversion of oxy- and deoxyhemoglobin to methemoglobin, denaturation of myofibrillar proteins that produce a change upon interaction with hemoglobin, and surface dehydration.

Table 3. *Color values of Cooked Meatballs*

Treatment	L*	a*	b*
Control	33.48±2.09	6.82±0.06	9.28±0.52
BHT	29.95±1.40	5.63±0.51	6.84±1.14
P1	32.16±0.55	6.86±0.51	8.90±0.64
P2	28.76±2.41	6.59±0.30	7.55±1.08
P3	30.27±0.74	5.79±0.49	7.17±1.28

a–c Means in the same column with different superscripts are significantly different.
* p<0.05, **p<0.01

There was no significant (p>0.05) difference found between the color values of cooked control and treatment groups of meatballs. The highest L* value (33.48±2.09) was seen in the control g highest a* (6.86±0.51) and the highest b* values (8.90±0.64) were seen in the P1 group.

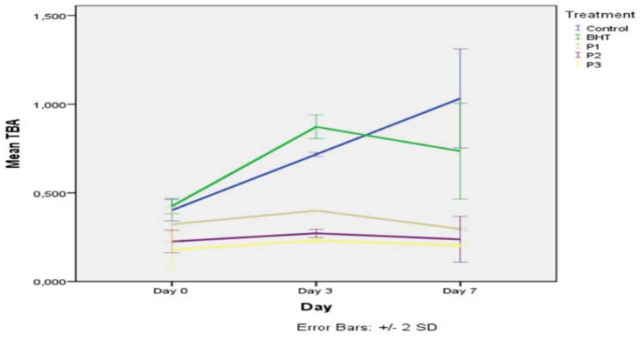

Figure 1. *TBA values (mg MDA/kg meat) of meatballs*

TBA values, which can be used as a measure of the concentrations of secondary lipid oxidation products such as aldehydes or ketones in samples. Many spices contain phenolic substances which exhibit antioxidant activities. Several studies showed the antioxidant effect of galangal extract in model systems. Cheah & Abu Hasim [3] also showed the galangal extracts at higher concentrations (like 5-10 %) retarded the lipid oxidation in meat. But 1% concentration of galangal extract was not effective on retarding the lipid oxidation (Fig. 1). In this research, TBA values decrease by the dose increase. The TBA value of the control group increases linearly by the storage time. BH added groups TBA value increase during the beginning of the storage and then decrease by the time. At the same time, galangal powder added samples lowers the TBA values by the increase of their concentration. That can be said the inhibitory effect of galangal powder is dose-dependent.

Table 4. *Conjugated dienes values of meatballs*

Treatment	Conjugated Dienes (µmole/mg meat)
Control	0.0162^{c}±0.001
BHT	0.0170^{bc}±0.004
P1	0.0213^{abc}±0.012
P2	0.0250^{ab}±0.018
P3	0.0273^{a}±0.026
Sig	**
Day	
0	0.0143^{b}±0.002
3	0.0133^{b}±0.001
7	0.0359^{a}±0.018
Sig	**
Treatment*Day Interaction	
Sig	**

[a–c] Means in the same column with different superscripts are significantly different (**p<0.01)

Lipid oxidation in meat can result in quality deterioration and decreases in sensory and nutritional factors [2]. Unsaturated lipids that have non-conjugated double bonds transform into conjugated dienes after peroxides are formed during lipid oxidation. Hydroperoxides hardly decompose during the early stage of lipid oxidation and decompose into secondary products at the later stage [15].

Table 4 shows that there was a significant (p<0.01) difference found between the conjugated diene values of galangal added meatballs compared with the control group. But there was no difference found between each other. At the beginning of the storage, the conjugated dienes value lowers but increase by the time. The effect of time on the conjugated dienes values of the samples was significant (p<0.01) different.

Conjugated dienes values of the galangal powder added samples have an opposite situation with the TBA results. Meatball samples which have the lowest TBA value have the highest conjugated diene value. This can be explained with the transformation of the lipid peroxidation products during the storage because the compounds don't stable.

Table 5. *Sensorial values of Meatballs*

Treatment	Appearance	Color	Odor	Taste	Texture	Overall Acceptabil
Control	5.73±1.10	6.82±1.08	4.73±1.49	5.00±1.79	6.09±0.70	5.72±1.10
BHT	4.91±1.22	6.73±1.10	4.28±2.24	4.55±1.51	5.64±1.03	4.90±1.22
P1	4.27±1.42	6.64±1.36	3.45±1.97	3.73±1.62	5.45±1.44	4.27±1.42
P2	5.09±0.83	6.64±1.03	3.90±1.76	4.36±1.75	6.09±1.04	5.09±0.83
P3	5.36±1.43	6.55±1.13	5.27±1.80	4.82±1.99	5.55±0.93	5.36±1.43

[a–c] Means in the same column with different superscripts are significantly different. * p<0.05, **p<0.01

Sensorial analysis results (Table 5) indicate that there was no significance (p>0.05) difference found between appearance, color, odor, taste, texture, overall acceptability values of the control and the treatment groups.

4. Conclusion

Generally dried galangal powder has a protective effect against lipid oxidation of meatballs during storage at 4 °C for 7 days. These results suggest that the addition of galangal powder to meatballs enhance the oxidative stability of meat or other lipid-containing food systems.

Dried galangal powder addition to meatballs lowers the TBARS values. Galangal, used in Asian countries cuisine for centuries. But some countries like Turkey don't use in their cuisine especially in their meatballs. Sensory analysis showed that no differences were found between control and galangal added samples. The consumer wants to use natural ingredients in their foods. Galangal can be used as a natural antioxidant without any known toxic effects. In this research, only galangal usage showed the antioxidant activity but the consumer will use the spice with other spices. As conclusion, further investigations are needed.

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