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Value added beef meatballs using turmeric (*Curcuma longa*) powder as a source of natural antioxidant

M. Milon[1], M.H. Kabir[2], M.A. Hossain[1], M. Rahman[1], M.A.K. Azad[1], M.A. Hashem[1]*

[1]Department of Animal Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]BAU Extension Center (BAUEC), Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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***Corresponding Author**

M.A. Hashem
hashem_as@bau.edu.bd

ABSTRACT

The experiment was conducted to find out the effect of different levels of turmeric powder and synthetic antioxidant on fresh and preserved beef meatballs as a source of value added meat products. Ground beef samples were divided into five treatment groups viz. control, antioxidant (BHA), 0.1%, 0.2% and 0.3% turmeric powder as T_1, T_2, T_3, T_4 and T_5, respectively. Proximate analysis, sensory tests (color, flavor, tenderness, juiciness, and overall acceptability), cooking loss, pH value, free fatty acids (FFA), thiobarbituric acid values (TBARS), peroxide value (POV) and microbiological examination were determined. Days of intervals were on 0, 15^{th}, 30^{th} and 60^{th} days. DM content of all the treatment groups differ significantly ($p<0.05$), DM content increased significantly ($p<0.05$) with the advancement of different days of intervals. CP, EE, and Ash content of all treatments were increased significantly ($p<0.05$). FFA values, TBARS, POV were decreased significantly ($p<0.05$). Color, flavor, tenderness, juiciness, overall acceptability, raw P^H, cooked p^H were increased at different treatment levels significantly ($p<0.05$). The cooking loss at different treatment levels were differ significantly ($p<0.05$). TVC (*log* CFU/g), TCC (*log* CFU/g) and TYMC (*log* CFU/g) was decreased significantly ($p<0.05$) at different treatment levels. In conclusion on the basis of sensory evaluation, 0.2% turmeric powder group was more acceptable but on the basis of nutrient quality, physicochemical properties, biochemical, microbial analysis 0.3% turmeric powder group was more satisfactory than other treatments.

INTRODUCTION

Value added meat is the process of taking raw meat and changing its form to produce a high quality end product. Value added of meat is defined as the addition of time, place, and/or form utility to meet the preferences of consumers. In other words, value added meat is figuring out what consumers want. In recent years, natural antioxidants have increasingly replaced artificial preservatives in food products. Natural antioxidants like Turmeric (*Curcuma longa)* have many of the same functions as artificial antioxidants like butylated hydroxyanisole, can increase shelf life of stored products without affecting qualities. This research explores the effects of natural antioxidants on quality changes of beef meatball during refrigeration storage. Turmeric is the potential sources of natural antioxidants because they produce various ant oxidative compounds to counteract reactive oxygen species (ROS). In food, ROS can cause lipid per oxidation, which leads to the deterioration of food (Miller et al., 1997). The oxidative deterioration of lipid-containing food is responsible for the rancid odors and flavors that can develop during processing and storage; this deterioration decreases nutritional quality and safety of food due to the formation of secondary and potentially toxic compounds. The addition of turmeric powder as natural antioxidant can help prevent this process and increase shelf life of foods. Lipid oxidation promotes production of rancid flavors and odors while also reducing shelf-life, nutritional quality, and safety of food products. To prevent autoxidation process, antioxidants have been utilized for many years (Lahucky et al., 2010). Antioxidants have an ability to prevent oxidative damage of a tissue indirectly by enhancing natural defenses of cell and directly by scavenging free radical species.

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Fatty acids contribute to a wide range of quality attributes for meat such as color stability, drip loss and the development of oxidative rancidity (Kouba et al., 2003).

Over the years, synthetic antioxidants like hydroxyanisole, butylated hydroxytoluene and tertiary butyl hydroquinone have been widely used to preserve meatballs (Fasseas et al. 2007). The use of these antioxidants has been questionable since they have been discovered to possess toxic, pathogenic and carcinogenic effects to humans and animals (Hayes et al., 2010). In addition, consumers have shifted their interest to natural antioxidants since they are considered safer than synthetic antioxidants (Jung et al., 2010). It has also been reported that these natural antioxidants, especially of plant source, have greater application potential for consumer's acceptability, palatability, stability and shelf-life of meat products one such plant with a potential to be used as an antioxidant is turmeric powder. There was not more research so far conducted before my experiment on beef meatballs with turmeric powder in Bangladesh. When meat products are enriched with natural antioxidant we can recommend this as natural antioxidant. The aim of preservation is not only to retard the food spoilage but also to control undesirable changes of wholesomeness, nutritive value and growth of microorganisms. No investigation on different levels of turmeric powder has been carried out yet. Hence, objectives of the study was to examine the addition of turmeric powder on sensory, proximate, physicochemical, biochemical, microbiological analysis and recommend value added beef meatball enriched with turmeric powder and compare its effectiveness as natural antioxidant and with a synthetic antioxidant (BHA) in delaying lipid oxidation in beef meatballs during refrigeration.

MATERIALS AND METHODS

Materials collection

Slaughtered boneless beef of 2.5 kg was collected from "Sheep, Goat & Horse Farm", Bangladesh Agricultural University; Mymensingh. The meat sample was immediately transferred to the "Animal Science Laboratory".

Sample preparation

About 2.5 kg of fresh beef sample was taken for the preparation of beef meatball. First beef was properly cleaned with fresh water and the fat was trimmed with sharp knife. Then beef was grinded properly and spices, salt, Ice flakes, refined vegetable oil, refined wheat flower, sauce was mixed with grinded beef properly as per experimental design. Five treatment groups were as control group (T_1), BHA (T_2- 0.1%), 0.1%, 0.2% and 0.3% turmeric powder treated as (T_3), (T_4), and (T_5). Then beef meatball of proper shape was prepared separately. It was then boiled in hot water for 2-3 minute. Then the water was removed from meatball properly and was fried in hot oil until reddish brown color was obtained.

Sensory evaluation

Different sensory attributes were examined. Each meatball sample was evaluated by a trained 8-member panel. The sensory questionnaires measured intensity on a 5-point balanced semantic scale for the attributes color, smell, tenderness, juiciness, and overall acceptability. Eight training sessions were held to familiarize the judges with the attributes to be evaluated and the scale to be used (Rubio et al., 2007). Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, smell, juiciness, tenderness, overall acceptability) of beef meatball using intensity scale. All samples were served in the Petri dishes. Sensory evaluation was accomplished at 0 day and repeated at 15, 30 and 60 day.

Proximate components

Proximate composition on Dry Matter, Ether Extract, Crude Protein and Ash were carried out according to methods (AOAC, 2016).

Raw and cooked p^H measurement

pH value of raw, cooked and cooking loss meatball was measured using pH meter from raw meatball homogenate. It was prepared by blending 5 g of meat with 10 ml distilled water.

Biochemical analysis

There were three types of biochemical analysis viz. FFA, Peroxide Value, Thiobarbituric Acid value. FFA value was determined according to Rukunudin et al. (1998). Peroxide value was determined according to Sallam et al. (2004). Lipid oxidation was assessed in triplicate using the 2-thiobarbituric acid method described by Schmedes and Holmer (1989).

Microbial assessment

From Table 5 for microbial assessment total viable, coli form and yeast-mould count was undertaken. Quantity of 10 g beef meatball sample was aseptically excised from stored stock sample. Each stored beef meatball samples was thoroughly and uniformly macerated in a mechanical blender using sterile diluents (0.1% peptone water) as per recommendation of International Organization for Standardization (ISO, 1995). A quantity of ten gram of minced meat meatball sample was taken aseptically transferred into a sterile container containing 90 ml of 0.1% peptone water. A homogenized suspension was made in a sterile blender. Thus 1:10 dilution of the samples was obtained. Later on using whirly mixture machine different serial dilutions ranging from 10^{-2} to 10^{-6} were prepared. Microbiological analyses were determined by Ikhlas et al. (2011).

Statistical analysis

Data were analyzed using SAS Statistical Discovery software, NC, USA. DMRT test was used to determine the significance of differences among treatments means.

RESULTS AND DISCUSSION

Sensory Evaluation

It was found that the sensory quality after fortification with bottle gourd leaf extracts was deteriorated with increased storage period (Table 1). The range of overall observed color score at different treatment was 3.58 to 4.50, flavor score was 3.55 to 4.41, tenderness score was 3.83 to 4.75, juiciness score was 3.92 to 4.75 and overall acceptability score was 3.58 - 4.33.. The range of different day's intervals of overall observation of overall acceptability score was 2.86 to 4.66. Among five treatments most preferable color, flavor, tenderness and juiciness was observed from o.3% turmeric powder group. The present findings is in agreement with Gonzalez et al. (2008) where he stated that dried plum ingredients in raw and precooked pork sausage negatively affect sensory attributes viz. color, texture, odor, and flavor as well as the nutritional quality of the product.

Proximate analysis

The DM content was increased with increased storage period because moisture loss was decreased with storage period (Table 2). The range of overall observed DM content at different treatments was 54.15 to 57.82%. The range of overall observation of different days interval DM content was 53.58 to 57.86%. Among five treatments most preferable DM content was observed at 0.3% turmeric powder group. The highest amount of DM content indicates this product is less preferable. The DM content was increased with increased storage period because moisture loss was decreased with storage period. The most preferable DM content was observed from 0 day and less preferable DM content from 60^{th} day. Similar results were reported for Indonesian traditional meatballs with a moisture content ranged from 69.52 to 71.17% (Purnomo and Rahardiyan 2008). Devatkal et al., (2010) reported that incorporation pomegranate rind and seed powder extracts did not affect the DM content of goat meat patties. The range of overall observed moisture at different treatments was 43.61 to 49.18%. The CP content was decreased with increased storage period. The range of overall observed CP content at different treatments was 22.03 to 22.99%. Among three treatments most preferable CP content was observed from 0.3% turmeric powder group. The range of overall observed of different days intervals of CP content was 22.20 to 23.11%. The range of overall observed EE content at different treatments was 11.87 to 12.02%. The range of overall observed of different days intervals of EE content was 11.87 to 12.02% (Table 2).

Table 1
Effect of turmeric powder and BHA on sensory parameters in beef meatballs.

Parameters	DI	Treatments					Mean	Level of significance		
		T_1	T_2	T_3	T_4	T_5		Treat.	DI	T*DI
Color	0	4.33±0.33	4.66±0.33	4.66±0.33	5.00±0.00	4.66±0.33	4.66^{a}±0.26	0.0102	<.0001	0.998
	15	4.33±0.33	4.66±0.33	4.66±0.33	5.00±0.00	4.66±0.33	4.66^{a}±0.26			
	30	3.33±0.33	3.66±0.33	4.00±0.57	4.33±0.33	4.00±0.57	3.86^{b}±0.43			
	60	2.33±0.33	3.0±0.0	3.33±0.33	3.66±0.33	3.33±0.33	3.13^{c}±0.26			
	Mean	3.58^{b}±0.33	4.00^{ab}±0.24	4.17^{a}±0.39	4.50^{a}±0.16	4.17^{a}±0.39				
Flavor	0	4.33±0.33	4.66±0.33	4.66±0.33	5.00±0.00	4.66±0.33	4.66^{a}±0.26	0.0032	<.0001	0.884
	15	4.33±0.33	4.66±0.33	4.66±0.33	5.00±0.00	4.66±0.33	4.66^{a}±0.26			
	30	3.33±0.33	3.66±0.33	4.00±0.57	4.33±0.33	4.66±0.33	4.00^{b}±0.38			
	60	2.33±0.33	2.66±0.33	3.00±0.00	3.33±0.33	3.66±0.33	3.00^{c}±0.26			
	Mean	3.58^{b}±0.33	3.91^{ab}±0.33	4.08^{a}±0.39	4.41^{a}±0.16	4.41^{a}±0.33				
Tenderness	0	4.66±0.33	4.66±0.33	4.66±0.33	5.00±0.00	5.00±0.00	4.80^{a}±0.20	0.0008	<.0001	0.644
	15	4.66±0.33	4.66±0.33	4.66±0.33	5.00±0.00	5.00±0.00	4.80^{a}±0.20			
	30	3.33±0.33	4.0±0.0	4.33±0.33	4.66±0.33	4.66±0.33	4.20^{b}±0.26			
	60	2.66±0.33	3.33±0.33	3.66±0.33	4.00±0.57	4.33±0.33	3.60^{c}±0.38			
	Mean	3.83^{c}±0.33	4.16^{bc}±0.24	4.33^{ab}±0.33	4.66^{a}±0.22	4.75^{a}±0.16				
Juiciness	0	4.66±0.33	4.66±0.33	4.66±0.33	5.00±0.00	5.00±0.00	4.80^{a}±0.20	0.0112	<.0001	0.906
	15	4.66±0.33	4.66±0.33	4.66±0.33	5.00±0.00	5.00±0.00	4.80^{a}±0.20			
	30	3.66±0.66	3.66±0.33	4.00±0.57	4.66±0.33	4.66±0.33	4.06^{b}±0.44			
	60	2.66±0.33	3.33±0.33	3.66±0.33	4.00±0.57	4.33±0.33	3.60^{c}±0.37			
	Mean	3.92^{c}±0.41	4.08^{bc}±0.33	4.25^{abc}±0.39	4.58^{ab}±0.22	4.75^{a}±0.16				
Overall acceptability	0	4.33±0.33	4.66±0.33	4.66±0.33	4.66±0.33	4.66±0.33	4.60^{a}±0.33	0.0466	<.0001	0.995
	15	4.33±0.33	4.66±0.33	4.66±0.33	5.00±0.00	4.66±0.33	4.66^{a}±0.26			
	30	3.33±0.33	3.66±0.33	4.00±0.57	4.33±0.33	4.33±0.33	3.93^{b}±0.37			
	60	2.33±0.33	2.66±0.33	3.00±0.00	3.33±0.33	3.00±0.57	2.86^{c}±0.31			
	Mean	3.58^{b}±0.33	3.91^{ab}±0.33	4.08^{ab}±0.30	4.33^{a}±0.24	4.16^{a}±0.39				

Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair, and 1 for poor. Mean in each row having different superscript varies significantly at values *P < 0.05. Again, mean values having same superscript in each row did not differ significantly at P > 0.05. T_1=Controlled group, T_2= Beta Hydroxyl Anisole (BHA) group, 0.1%, 0.2% and 0.3% turmeric powder as T_3, T_4 and T_5, DI=Days of Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals

The EE content was no changed with increased storage period. The most preferable EE content was observed at 0 day and less preferable EE content at 60th day. The data show that the highest amount of EE content was increased to 11.88% in all treatments after 60 days of storage. Turmeric powder group contains higher amount of EE than control group. The Malaysian Food Regulation of 1985 stated that manufactured meat should not contain more than 30% fat. Malaysian beef meatballs can be classified as low-fat meatballs since the fat content ranges from 1.69 to 11.09. The range of overall observed ash content at different treatments was 3.43 to 3.73%. The range of overall observed of different days intervals of ash content was 3.51 to 3.71%. Among these three treatments most preferable ash content was observed at 0.1% turmeric powder group. The lowest amount of ash content indicates this product is most preferable for consumers' health. The most preferable Ash content was observed at 0 day and less preferable ash content at 60th day. The ash content was significantly changed with increased storage period. The same trend was also observed by Konieczny et al. (2007) and they reported that ash content increased during frozen storage which is related to our findings.

Table 2
Composition of beef meatball using turmeric powder and BHA.

Parameters	DI	Treatments					Mean	Level of Significance		
		T_1	T_2	T_3	T_4	T_5		Treat.	DI	T*DI
DM (%)	0	54.96±0.02	54.91±0.01	53.81±0.01	52.23±0.01	52.01±0.01	53.58^{d}±0.01			
	15	57.21±0.01	56.63±0.07	53.87±0.05	54.14±0.02	53.65±0.02	55.10^{c}±0.03			
	30	58.06±0.03	57.06±0.04	56.92±0.03	55.73±0.09	54.91±0.01	56.53^{b}±0.04	<.0001	<.0001	<.0001
	60	61.06±0.02	58.08±0.04	57.85±0.05	56.29±0.02	56.01±0.01	57.86^{a}±0.02			
	Mean	57.82^{a}±0.02	56.67^{b}±0.04	55.61^{c}±0.03	54.60^{d}±0.03	54.15^{e}±0.01				
CP (%)	0	22.24±0.01	23.02±0.03	23.29±0.03	23.49±0.01	23.50±0.01	23.11^{a}±0.02			
	15	22.14±0.02	22.92±0.02	23.09±0.03	23.06±0.03	23.10±0.008	22.86^{b}±0.02			
	30	22.02±0.02	22.87±0.02	22.92±0.008	22.94±0.02	22.96±0.01	22.74^{c}±0.01	<.0001	<.0001	<.0001
	60	21.72±0.02	22.29±0.008	22.26±0.01	22.35±0.01	22.39±0.008	22.20^{d}±0.01			
	Mean	22.03^{d}±0.01	22.77^{c}±0.02	22.89^{b}±0.02	22.96^{a}±0.01	22.99^{a}±0.009				
EE (%)	0	12.22±0.05	11.65±0.03	11.82±0.02	11.81±0.02	11.77±0.02	11.85^{a}±0.02			
	15	12.02±0.01	11.45±0.01	11.87±0.02	11.93±0.005	11.85±0.02	11.82^{a}±0.01			
	30	11.90±0.01	11.42±0.01	12.00±0.008	11.96±0.02	11.92±0.02	11.84^{a}±0.01	<.0001	0.4107	<.0001
	60	11.35±0.21	11.26±0.02	12.39±0.01	12.30±0.008	12.10±0.01	11.88^{a}±0.05			
	Mean	11.87^{b}±0.07	11.44^{c}±0.01	12.02^{a}±0.01	12.001^{a}±0.01	11.91^{b}±0.02				
Ash (%)	0	3.46±0.03	3.50±0.03	3.48±0.01	3.53±0.008	3.61±0.03	3.51^{c}±0.02			
	15	3.68±0.04	3.37±0.02	3.54±0.01	3.63±0.01	3.64±0.01	3.57^{b}±0.02			
	30	3.51±0.10	3.39±0.04	3.48±0.01	3.74±0.01	3.77±0.008	3.58^{b}±0.03	<.0001	<.0001	0.0002
	60	3.74±0.10	3.47±0.02	3.62±0.01	3.81±0.003	3.92±0.01	3.71^{c}±0.03			
	Mean	3.60^{c}±0.06	3.43^{e}±0.02	3.53^{d}±0.01	3.68^{b}±0.008	3.73^{a}±0.01				

Mean in each row having different superscript varies significantly at values $P < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $P > 0.05$.T_1=Controlled group, T_2= Beta Hydroxyl Anisole (BHA) group, 0.1%, 0.2% and 0.3% turmeric powder as T_3, $T_{4\ and}$ T_5,Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals.

Physicochemical properties

The range of overall observed raw pH at different treatments was 5.63 to 6.05%. Among five treatments most preferable raw pH was observed from 0.3% turmeric powder group (Table 3). The highest amount of raw pH indicates this product is most preferable for consumers' health. The raw pH among these treatments was decreased with the increased storage period. Choi et al. (2009) reported that meat batter containing dietary fiber from rice bran have higher pH values. The decrease in raw pH values was lower in untreated samples than treated ones due to the effect of natural antioxidants which were retarded the formation of free fatty acids. It is also obvious that the values of raw pH for the product were higher than that of raw pH values of meat and this could be due to interaction effect of other ingredients which were added during processing of meat products. Among five treatments most preferable raw pH was observed from 0.2% turmeric powder group. The highest amount of raw pH indicates this product is most preferable for consumers' health than other treatment groups. The range of overall observed of different days of intervals of raw pH was 5.99 to 5.76%. The most preferable raw pH was observed at 0 day and less preferable raw pH was observed at 60th day observation. The raw pH was decreased with the increased storage period. The data showed a slight decrease in the raw pH values and an increase in the acidity values for all samples along with storage time during the 60 days of storage as a result of the increase of free fatty acids due to rancidity. Similar results have also been found in the study of antioxidant treatments during storage time using a mixture of BHA and BHT in precooked pork patties (Biswas et al. 2004). (Aksu and Kaya 2005) reported a study related to Kavurma, a cooked Turkey meat product that is usually sliced and consumed. They found that the pH of Kavurma slightly increased after 30 days of storage time.

Table 3
Physicochemical parameters of beef meatballs using turmeric powder and BHA.

Parameters	DI	Treatments					Mean	Level of significance		
		T_1	T_2	T_3	T_4	T_5		Treat.	DI	T*DI
Raw p^H	0	5.75±0.03	5.82±0.01	6.07±0.02	6.14±0.01	6.18±0.01	5.99 ^{a}±0.01	<.0001	<.0001	0.1131
	15	5.65±0.02	5.82±0.006	6.26±0.33	6.07±0.01	6.12±0.01	5.98 ^{a}±0.07			
	30	5.54±0.02	5.65±0.01	5.93±0.01	6.10±0.008	6.06±0.01	5.86 ^{b}±0.01			
	60	5.6±0.006	5.66±0.005	5.72±0.005	5.74±0.02	5.83±0.008	5.71 ^{c}±0.008			
	Mean	5.63^{b} ±0.01	5.74^{b} ±0.007	5.99 ^{a} ±0.09	6.01^{a} ±0.01	6.05^{a} ±0.009				
Cooked p^H	0	6.06±0.01	6.21±0.14	6.14±0.008	6.21±0.01	6.23±0.005	6.17 ^{a}±0.03	<.0001	<.0001	0.0343
	15	5.99±0.01	6.03±0.01	6.10±0.008	6.12±0.01	6.16±0.005	6.08 ^{b}±0.008			
	30	5.77±0.008	6.01±0.003	6.08±0.005	6.11±0.008	6.14±0.005	6.02 ^{c}±0.005			
	60	5.72±0.01	5.84±0.01	5.89±0.01	5.93±0.008	6.02±0.008	5.88 ^{d}±0.009			
	Mean	5.89 ^{d}±0.009	6.02 ^{c}±0.04	6.05^{bc}±0.02	6.09^{ab}±0.01	6.13 ^{a}±0.005				
Cooking loss (%)	0	27.41±0.08	±0.0005	0.33±0.001	0.32±0.0008	0.32±0.001	0.34 ^{d}±0.007	<.0001	<.0001	<.0001
	15	25.92±0.07	24.92±0.07	25.91±0.01	25.85±0.01	25.89±0.01	25.63^{b}±0.10			
	30	23.98±0.07	22.59±0.21	22.05±0.01	22.02±0.01	22.31±0.33	22.56^{c}±0.19			
	60	20.67±0.21	22.08±0.04	22.03±0.01	21.95±0.01	21.83±0.01	21.78^{d}±0.13			
	Mean	24.49 ^{a}±0.10	23.92^{b}±0.10	24.00^{ab}±0.01	23.94^{b}±0.01	23.96^{b}±0.10				

Mean in each row having different superscript varies significantly at values $P < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $P > 0.05$. T_1=Controlled group, T_2= Beta Hydroxy Anisole (BHA) group, 0.1%, 0.2% and0.3% turmeric powder as T_3, T_4 and T_5, DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals

Table 4
Effect of turmeric powder and BHA on bio-chemical parameters in beef meatballs.

Parameters	DI	Treatments					Mean	Level of Significance		
		T_1	T_2	T_3	T_4	T_5		Treat.	DI	T*DI
FFA (%)	0	0.41±0.002	0.40±0.001	0.39±0.001	0.38±0.003	0.38±0.001	0.39^{d}±0.001	<.0001	<.0001	<.0001
	15	0.48±0.0008	0.44±0.001	0.40±0.0006	0.40±0.0008	0.39±0.0008	0.42^{c}±0.008			
	30	0.55±0.001	0.50±0.001	0.49±0.002	0.49±0.0005	0.48±0.001	0.50^{b}±0.001			
	60	0.82±0.001	0.62±0.0008	0.59±0.002	0.58±0.001	0.58±0.001	0.64^{a}±0.001			
	Mean	0.56^{a}±0.003	0.49^{b}±0.009	0.47^{c}±0.003	0.46^{d}±0.003	0.46^{e}±0.009				
POV (meq/kg)	0	4.10±0.04	3.96±0.008	3.95±0.001	3.91±0.0005	3.90±0.001	3.96^{d}±0.01	<.0001	<.0001	<.0001
	15	4.32±0.02	4.03±0.01	4.06±0.001	4.04±0.001	4.00±0.0008	4.09^{c}±0.006			
	30	4.73±0.02	4.53±0.01	4.41±0.0008	4.36±0.0008	4.33±0.002	4.47^{b}±0.006			
	60	4.84±0.01	4.64±0.008	4.51±0.01	4.49±0.00	4.44±0.001	4.58^{a}±0.005			
	Mean	4.50^{a}±0.02	4.29^{b}±0.009	4.23^{c}±0.003	4.20^{d}±0.005	4.17^{e}±0.001				
TBARS (mg-MA /kg)	0	0.41±0.004	0.40±0.001	0.40±0.01	0.39±0.001	0.38±0.001	0.39^{d}±0.003	<.0001	<.0001	<.0001
	15	0.48±0.002	0.44±0.003	0.41±0.001	0.40±0.001	0.40±0.001	0.43^{c}±0.002			
	30	0.55±0.001	0.50±0.001	0.50±0.002	0.49±0.001	0.49±0.001	0.51^{b}±0.001			
	60	0.82±0.003	0.62±0.001	0.60±0.001	0.59±0.001	0.58±0.001	0.64^{a}±0.002			
	Mean	0.58^{a}±0.002	0.49^{b}±0.002	0.47^{c}±0.001	0.47^{d}±0.001	0.46^{e}±0.001				

Mean in each row having different superscript varies significantly at values $P < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $P > 0.05$. T_1=Controlled group, T_2= Beta Hydroxy Anisole (BHA) group, 0.1%, 0.2% and0.3% turmeric powder as T_3, T_4 and T_5, DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals FFA=Free Fatty Acid, POV=Per Oxide Value, TBARS=Thiobarbituric Acid Reactive Substances

The data showed a slight increase in the cooked pH values and a decrease in the acidity values for all samples along with natural antioxidants (Table 3). The range of overall observed cooked pH at different treatments was 5.89 to 6.13.The highest amount of cooked pH indicates this product is most preferable for consumers' health. The lowest amount of cooking loss indicates this product is most preferable for consumers' choices. The range of overall observed of different days of intervals of cooking loss was 6.17 to 5.88. The cooking loss was decreased with increased storage period. The range of overall observed cooking loss at different treatments was 24.21 to 23.96%. The different superscript was observed at controlled group than other four treatment groups indicates there were significant ($p<0.05$) differences of cooking loss of control group than other four treatment groups.

The increased loss of such nutrients deteriorates the meat nutritional quality and lowers its purchase (Jama et al., 2008) evenly similar trend with this experiment. Turhan et al. (2005) reported that addition of hazelnut pellicle fiber was found to be effective in improving cooking yield, dimensional changes and thickness of beef burgers.

Cooking yield was an important data that could be used by the meat industry to predict the behavior of their products during processing (Ulu, 2006). The values of cooking yield were similar to the results in high-fat Kung-wan meatballs reported by Huang et al. (2005) or in low-fat Kung-wan meatballs reported by Hsu and Sun (2006). The cooking yield of the Kung-Wan significantly decreased with higher natural antioxidant extract levels which is nearly with this experiment.

Biochemical properties

The range of overall observed peroxide value at different treatments was 4.54 to 4.17. The range of overall observed FFA value at different treatments was 0.58 to 0.82. The range of overall observed of different days of intervals of FFA was 0.39 to 0.64. The FFA value was increased with storage period. The most preferable FFA value was observed at 0 day and less preferable FFA was observed at 60th day of observation. The range of overall observed of different days of intervals of peroxide value was 3.96 to 4.58%. The higher ant oxidative effect on POV came in 0.3%, 0.2%, and 0.1% turmeric powder and BHT (Table 4). During storage, the peroxide value increased in all treatments. The lowest amount POV indicates this product is most preferable for consumer's health. Lund et al. (2007) reported on the peroxide values in sausage with three treatments (rosemary extract, collagen fiber preparation impregnated with rosemary extract and collagen hydrolyses impregnated with rosemary extract); samples with these three treatments showed lower values than the control group.

The peroxide value of plain meat loaf was 0.38, 1.33 and 2.40 at 0, 3 and 6 days, respectively, in aerobic storage at 4ºC. The range of overall observed of different days of intervals of TBARS value was 0.39 to 0.64. The control sample, without any added antioxidants, this may be the showed a higher level of TBARS than samples treated with 0.3%, 0.2%, and 0.1% turmeric powder or BHA. The TBARS level of samples treated with 0.3%, 0.2%, 0.1% turmeric powder was also lower than those treated with BHA; this difference was especially significant ($P < 0.05$) after 60 days of storage time. The TBA value increased until storage day 60 (Table 4). The TBARS value on day 60 was 0.58 for the control samples, 0.49, 0.47, 0.47, 0.46 for those treated with BHA, 0.3%, 0.2%, 0.1% turmeric powder. Among five treatments most preferable TBARS value was observed from 0.3% turmeric powder group. The lowest amount of TBARS value indicates this product is most preferable for consumes health. The results of this study confirm that BHA, 0.3%, 0.2%, 0.1% turmeric powder can delay lipid oxidation significantly, reducing the potential risk induced by lipid oxidation. They also tend to be better than the synthetic antioxidant BHA, which has been commercially used in the food industry. Lipid oxidation developed in all five types of meatballs (control, dittany 0.05%, dittany 0.10%, rosemary 0.05% and rosemary 0.10%) as evidenced by an increasing TBARS value. They also found that dittany and rosemary at a concentration 0.10% protected the product significantly. The levels were 0.73, 3.90 and 4.44/kg meat, respectively, in samples treated with ethanolic extract (0.15%) and 0.59, 1.24 and 1.77/kg meat, respectively, in samples treated with dried powder (0.51%). The TBARS extracts in

both sausage control group (CG) and the experimental group (EG) increased over almost the entire study period. Nassu et al. (2003) examined lipid oxidation and reported that TBARS values of fermented goat meat sausage were different at beginning of storage depending on treatment.

Meat with higher lipid oxidation values also showed higher protein oxidation and greater metmyoglobin formation. The peroxide value of plain meat loaf was 0.38-1.33 and 2.40 at 0, 3 and 60 days, respectively, in aerobic storage at 4ºC (Table 4).

Natural antioxidants, in particular polyphones, are the major plant compounds which have the ability to attenuate the oxidative damage of a tissue indirectly by enhancing natural defenses of cell and/or directly by scavenging the free radical species combat pathological disorders generated by physicochemical's Reactive Oxygen Species (ROS) (Du et al., 2010).To prevent the autoxidation process antioxidants have been utilized for many years (Lahucky et al., 2010). Antioxidants have an ability to prevent the oxidative damage of tissue indirectly by enhancing natural defenses of cell and directly by scavenging the free radical species (Verma et al., 2009). It has also been reported that these natural antioxidants, especially of plant source, have greater application potential for consumer's acceptability, palatability, stability and shelf-life of meat products (Jung et al., 2010). One such plant with a potential to be used as an antioxidant is turmeric powder. It has various functions, including pharmacological activities and antioxidant properties.

Table 5
Effect of turmeric powder and BHA on different microbial population in beef meatballs.

Parameters	DI	Treatments					Mean	Level of significance		
		T_1	T_2	T_3	T_4	T_5		Treat.	DI	T*DI
TVC(*log* CFU/g)	0	4.64±0.02	4.57±0.03	4.42±0.005	4.37±0.02	4.29±0.01	4.46^{c}±0.02	<.0001	<.0001	<.0001
	30	4.95±0.01	4.76±0.01	4.53±0.01	4.42±0.007	4.34±0.01	4.60^{b}±0.009			
	60	5.45±0.04	5.16±0.02	4.68±0.006	4.54±0.02	4.43±0.01	4.85^{a}±0.01			
	Mean	5.01^{a}±0.02	4.83^{b}±0.02	4.55^{c}±0.007	4.44^{d}±0.01	4.35^{e}±0.01				
TCC(*log* CFU/g)	0	1.18±0.03	1.14±0.02	1.10±0.002	1.08±0.006	1.06±0.002	1.11^{a}±0.01	<.0001	<.0001	0.0002
	30	1.10±0.006	1.03±0.01	1.02±0.009	1.00±0.001	0.95±0.0.01	1.02^{b}±0.005			
	60	1.02±0.009	0.95±0.03	0.84±0.02	0.78±0.008	0.71±0.005	0.86^{c}±0.01			
	Mean	1.10^{a}±0.01	1.04^{b}±0.02	0.99^{c}±0.01	0.95^{d}±0.005	0.91^{e}±0.01				
TYMC(*log* CFU/g)	0	1.96±0.01	1.85±0.01	1.79±0.008	1.72±0.006	1.66±0.01	1.80^{a}±0.008	<.0001	<.0001	0.4121
	30	1.54±0.02	1.37±0.01	1.34±0.01	1.27±0.003	1.18±0.03	1.34^{b}±0.01			
	60	1.14±0.01	1.07±0.007	1.05±0.007	1.01±0.004	0.88±0.09	1.03^{c}±0.02			
	Mean	1.55^{a}±0.01	1.43^{b}±0.009	1.39^{b}±0.008	1.33^{c}±0.004	1.24^{d}±0.04				

Mean in each row having different superscript varies significantly at values $P < 0.05$. Again, mean values having same superscript in each row did not differ significantly at $P > 0.05$. T_1=Controlled group, T_2= Beta Hydroxy Anisole (BHA) group, T3=, 0.1%, 0.2% and0.3% turmeric powder as T_3, T_4 and T_5, DI=Day Intervals, Treat= Treatment, T*DI=Interaction of Treatment and Day Intervals, TVC=Total Viable Count, TCC=Total Coliform Count, TYMC=Total Yeast-Mold Count.

Microbiological assessment

The range of overall observed aerobic plate count from the beef meatballs was 5.01-4.35 (logs CFU/g) at different treatments. Among five treatments, the plate count in the control sample (5.01 logs CFU/g) was significantly higher than in the samples treated with BHA, 0.1%, 0.2%, and 0.3% of turmeric powder. The less amount of TVC value indicates this product is most preferable for consumers' health. The initial value of TVC for fresh beef (beef not frozen and thawed) was 5.12 logs CFU/g beefs, indicating good quality beef. The less amount of TVC value indicates this product is most preferable for consumers' health. The range of overall observed of different days of intervals of TVC value was 4.46 to 4.85. During storage TVC value was increased. The initial TCC

of fresh beef was 1.25 logs CFU/g beef. The range of overall observed total coli form count from beef meatballs was 1.10–0.91 (logs CFU/g), at different treatments. During storage TCC value and TYMC value was decreased. The range of overall observed total yeast-mold count from the beef meatballs was 1.55 to 1.24 (logs CFU/g) at different treatment. The range of overall observed of different days of intervals of TYMC values was 1.40to 1.79 (Table 5). Fernández-López et al. (2003) reported on the results of a research study related to antimicrobials in beef meatballs. Some bacteria may be present in the product, but their growth is controlled under storage conditions (Fernandez Lopez et al., 2005). The initial value of TVC for fresh beef was 5.12 logs CFU/g beefs, indicating good quality beef.

CONCLUSIONS

Beef meatballs can be preserved for 60 days using with different level of turmeric powder. Highly significant differences were observed in 0.3% turmeric powder group compared to control. Hence, sensory evaluation, physicochemical properties, biochemical analysis and microbial assessment indicates 0.3% turmeric powder group was more acceptable and nutrient quality was higher in terms of biochemical and microbial studies. So we can recommend 0.3% turmeric powder as value added beef meatball enriched with natural antioxidant.

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