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Ascertaining the refrigerated storage life of wheat bran and grape seed extract enriched meatballs (*Goshtaba*) under aerobic conditions

Sajad S[1], Ahmad SR*[1], Wani SA[1], Sofi AH[1], Farooq J[1], Khan AA[1], Hussain SA[1], Masoodi FA[2], Irshad S[1] and Nazir T[1]

[1]FVSc & AH, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir -190006
[2]Departmenof FST, University of Kashmir, Srinagar - 190006

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- *Corresponding author.
- *E-mail address:* sh.rafeh @gmail.com (Ahmad SR)

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ABSTRACT

Three types of meatballs (*Goshtaba*) viz. control, dietary fiber (8% hydrated wheat bran) rich and anti-oxidant rich (0.1% grape seed extract) *Goshtaba* were prepared from good quality mutton, packaged in low density polyethylene pouches (LDPE-200μm gauge) and analyzed during storage (4±1°C) to ascertain their aerobic refrigerated storage life. The emulsion stability and cooking yield of the dietary fiber rich product was improved. The pH of dietary fiber rich product increased significantly (P≤0.05), while as that of antioxidant rich *Goshtaba* decreased significantly (P≤0.05) with the increase in the storage period. The water activity of all the samples showed an increasing trend over the storage period. The microbial parameters (total plate count, psychrophilic count) increased during the storage period, but the values were decreased in the product fortified with grape seed extract (GSE), depicting an anti-microbial effect of GSE. The sensory quality was decreased in all the products with increase in storage life, but the rate of decline was slowest in GSE treated meatballs. It was concluded that the product treated with GSE as anti-oxidant source retained most of the desirable properties during the aerobic refrigerated storage for at least 26 days as against 17 days in case of other products.

Key words: Aerobic, Dietary fiber, *Goshtaba*, Meatballs, Refrigerated storage

INTRODUCTION

Wazwan, a famous meat-based cuisine of Kashmir, has its roots in the amalgamation of various culinary practices brought by different settlers over time (Shah *et al.* 2017). *Goshtaba*, which is considered the "King of Wazwan", is a meatball made by emulsifying hot boned lamb meat and cooking it in curd-based gravy called *Yakhni* (Rather *et al*. 2015). The traditional method of preparing the meat emulsion involves pounding the meat on a stone with a wooden hammer, which is a laborious and time-consuming process that compromises hygiene. To overcome this, researchers at the Division of Livestock Products Technology, SKUAST-Kashmir have developed a faster machine processing method for *Goshtaba* emulsion, which ensures food safety and control over the formulation (Qureshi *et al.* 2021).

The researchers have also upgraded the conventional *Gosht*aba, which is loaded with unhealthy animal fats and salts, to a functional healthier version that is appreciated by health-conscious consumers. The growing demand for nutritionally wholesome diets and ready-to-eat fortified foods has led to an exponential expansion of the market for fortified meat products (Sajad *et al*. 2020a). Therefore, there is a tremendous scope for nutritionally fortified *Goshtaba*, prepared on modern scientific lines, to be taken up by promising meat processors within and outside the country.

To enable the commercialization of *Goshtaba*, it is necessary to determine the product's storage life under different packaging conditions. Hence, a study was designed to estimate the refrigerated storage life of aerobically packaged *Goshtaba*".

MATERIALS AND METHODS

Hind leg portions from the freshly dressed sheep carcasses (12-18 months old animal) was procured from the local market. Deboning was done immediately and the lean meat obtained (after its rigor stage) was used for the preparation of the product (immediately or later as per need). Animal fat used in the experiments was obtained from the carcass of the same kill. Low density polyethylene (LDPE) films (200 μm guage) were used for aerobic packaging of the product.

Machine processing of *Goshtaba*

The machine processing as standardized after the earlier experiments at the Division of Livestock Products Technology, FVSc and AH was adopted for processing of emulsion for *Goshtaba* (Ahmed, 2022). The raw emulsion obtained was moulded in the shape of spherical balls (70-80g) and then kept in refrigeration until cooked in boiling gravy. The formulation of the three types of *Goshtaba* developed is given in table 1. The analysis (table 2) revealed T_1 as dietary fiber rich product (dietary fiber content of 2.02% as compared to 0.24% of T_0) and T_2 as antioxidant rich product (DPPH-RSA % of 51.09 as compared to 32.53 of T_0).

The partially cooked meat balls were transferred to the boiling *Yakhni* and cooked for 25 minutes to a core temperature of 72ºC. The meat balls now called as *Goshtaba* along with the *Yakhni* so obtained was cooled to room temperature and then kept under chilled conditions in a refrigerator until subjected to analysis (Hussain *et al*. 2017). The product so developed were analyzed for parameters like dietary fiber content and antioxidant potential (DPPH scavenging activity). It was found that wheat bran increased the dietary fiber content (2.02 as against 0.24 in others) and grape seed extract enhanced the antioxidant potential (DPPH-RSA (%) of 51.09 in T_2).

All the treatments (T_0, T_1 and T_2) were packaged aerobically in LDPE and stored at refrigeration temperature (4±1°C). The samples were analyzed at regular intervals of 7 days up to 14th day of storage, thereafter, the products were analyzed at an interval of only 3 days and continued till the product was not fit for consumption.

Analytical procedures

The emulsion stability of the raw samples was determined as per the method of Baliga and Madaiah (1970) with slight modifications. For cooking yield, the weight of *Goshtaba* was recorded before and after cooking and then the values were expressed in percentage. The pH was determined by the method of Trout *et* al. (1992) by using digital pH meter (Model EE-011, Tanco Laboratory Equipments Ltd. India).

Table 1. Formulation of *Goshtaba*

Ingredients	Percentage (%)		
	T_0 (Control)	T_1 (Fiber Rich)	T_2 (Antioxidant Rich)
Lean meat	90	82	90
Animal fat	10	10	10
Wheat bran (1:1 hydrated)	-	8	-
Total	100	100	100
GSE	-	-	0.1
To the above, following ingredients shall be added (on weight basis)			
Sodium chloride	2.0	2.0	2.0
Potassium chloride	0.5	0.5	0.5
Chilled water/Ice flakes	10.0	10.0	10.0
Large cardamom seeds	0.20	0.20	0.20

(Chisti, 2022)

TBARS was estimated by the method of Witte *et al.* (1970) and DPPH activity by the method of Brand-Williams *et al.* (1995). The per cent moisture, protein, fat, dietary fiber and ash content of the product samples were evaluated as per standard procedure of Association of Official Analytical Chemists (AOAC, 2019). For sensory evaluation, samples of products from all treatments were presented to the semi-trained experienced taste panel members consisting of scientists and post-graduate students (both male and female) of Faculty of Veterinary Sciences and Animal Husbandry, Shuhama, SKUAST-K for evaluation of various sensory parameters as per 8-point descriptive scale (Keeton, 1983), where 8 is extremely desirable and 1 is extremely undesirable. The microbiological quality was assessed by following the methods as described by APHA (2015). The data generated was analyzed statistically following the method of Snedecor and Cochran (1994) using SPSS version 20 software package. Analysis of variance by one way and two way was computed with 5% level of significance.

RESULTS AND DISCUSSION

The values obtained for emulsion stability, cooking yield, dietary fiber and DPPH-RSA (calculated on day 0 only) for the control and treated *Goshtaba* are reported in table - 2. The values of emulsion stability and cooking yield of control were significantly (P≤0.05) lower than high dietary fiber (HDF) *Goshtaba* and were comparable with anti-oxidant rich *Goshtaba*. The increase in the emulsion stability and cooking yield of HDF *Goshtaba* can be attributed to improvement of hydration and binding properties of the product because of the presence of soluble dietary fibers in the wheat bran (Mir and Masoodi, 2017). The results are in agreement with Sajad *et al.* (2020b) reported an increase in the cooking yield upon the incorporation of different levels of dandelion in chicken loaves; Haq (2022) reported an increase in the emulsion stability as well as the cooking yield in fiber rich *goshtaba* using wheat bran; Badr and El-Waseif (2018) reported an increase in the cooking yield upon the production of low fat beef meat balls formulated by replacing fat with different levels of potato peel powder.

Table 2: Physico-chemical properties of high dietary fiber and anti-oxidant rich *Goshtaba* (Mean±S.E)

Parameters (%)	T_0 (Control)	T_1 (Fiber Rich)	T_2 (Antioxidant Rich)
Emulsion Stability	94.62± 0.25[a]	95.48± 0.34[b]	94.67± 0.02[a]
Cooking Yield	91.30±0.32[a]	93.12±0.49[b]	91.39±0.36[a]
Dietary fiber	0.24±0.04[a]	2.02±0.04[b]	0.24±0.02[a]
DPPH-RSA	32.53±0.34[a]	44.56±0.23[b]	51.09±0.29[c]

N=3 for cooking yield and n= 6 for other parameters

The values obtained for pH and water activity for the control and treated *Goshtaba* are reported in table - 3. The mean values of pH for control were significantly (P≤0.05) greater than high dietary fiber (T_1) and anti-oxidant rich (T_2) *Goshtaba*. There was a significant (P≤0.05) difference in the mean pH values of control, T_1 and T_2. Overall mean pH value of control was significantly (P≤0.05) greater than T_1 and T_2 *Goshtaba*. During storage, an overall increase in pH was observed in control and T_1 *Goshtaba*. However, T_2 *Goshtaba* showed an overall decrease in pH. The mean pH values of control and treated *Goshtaba* increased non-significantly (P>0.05) up to the 29th day of storage. The mean values of water activity for control, T_1 and T_2 *Goshtaba* showed a non-significant (P>0.05) difference. During storage, an overall increase in water activity (aW) was observed in control, T_1 and T_2. The mean water activity (aW) values of control and treated *Goshtaba* increased significantly (P≤0.05) up to the 29th day of storage. The increase in the pH of control and HDF *Goshtaba* may be due the formation of NPN compounds and basic ammonium ions along with the buffering action of meat proteins. However, the decrease in the pH of AOR *Goshtaba* may be due to the metabolic activities of bacteria which utilize fermentable carbohydrates (Kumar *et al.* 2015). The increasing trend of water activity (aW) in control, T_1 and T_2 might be due to the moisture absorbed from the gravy, thereby leading to an overall increase in the amount of available water for micro-organisms to proliferate (Kumar *et al.* 2015). Qureshi *et al.* (2018) also reported an increase in the pH upon the incorporation of fenugreek seed powder in functional spent hen meat patties; Haq (2022) reported the similar increasing trend in the pH as well as in the water activity of low fat fiber rich *Goshtaba* using wheat bran; Kumar *et al.* (2007) reported decrease in pH of vacuum packaged chicken patties extended with different unconventional non-meat extenders. Ahmed (2022) reported the similar findings in the pH of *Goshtabas* which were prepared with the partial replacement of animal fat with vegetable oil and fortified with grape seed extract; Bumla *et al.* (2021) was in agreement with the findings of the pH values of *Goshtaba* being in the acidic range and attributed it to the low pH of *Yakhni* (curd gravy) used in its preparation. Chisti (2022) reported similar trend in the water activity of functional *Goshtaba* developed by fat content optimization and walnut kernel incorporation. Kumar *et al.* (2017) exhibited increase in the water activity of chicken meat biscuits on storage. Overall mean TBARS values of T_0, T_1 and T_2 *Goshtaba* were 1.01±0.07, 0.97±0.07, 0.91±0.07 respectively for entire storage period. The TBARS values of T_0, T_1 and T_2 *Goshtaba* increased significantly (P≤0.05) during the storage period. The TBARS values of treated Goshtaba were significantly (P≤0.05) lower than the control on all days of storage, with T_2 Goshtaba exhibiting the lowest values, thereby confirming the antioxidant role of grape seed extract.

The values obtained for microbiological parameters for the control and treated *Goshtaba* are reported in table - 4. Total plate count of control was higher than treated *Goshtaba* with AOR *Goshtaba* having the lowest counts. During storage, an overall significant ($P\leq0.05$) increase in total plate count was observed in control and treated *Goshtaba*. The mean total plate count values of control and treated *Goshtaba* increased significantly ($P\leq0.05$) up to 29th day of storage. The AOR *Goshtaba* showed lowest total plate counts, which might be due to the anti-microbial effect of grape seed extract (Kumar *et al.* 2015). The results agree with Haq (2022) and Ahmed (2022), who found a similar trend in antioxidant rich *Goshtaba* during aerobic storage. Coliforms were not detected during the entire storage period in any of the products. It might be due to the stringent hygienic measures adopted during processing and packaging of meat products (Ahmad *et al.* 2020). Psychrophilic counts were not detected during initial period of storage up to 14th day in control as well as in treated *Goshtaba*. Psychrophilic count of treated *Goshtaba* was lower than control but the difference was non-significant ($P>0.05$); the lowest counts observed in AOR *Goshtaba*. During storage, an overall significant ($P\leq0.05$) increase in psychrophilic count was observed in control and treated *Goshtaba* from 14th to 29th day. Mean psychrophilic count of control and treated *Goshtaba* increased significantly ($P\leq0.05$) from 14th to 29th day of storage. The AOR *Goshtaba* showed lowest psychrophilic count which might be due to the anti-microbial effect of grape seed extract (Kumar *et al.* 2015). The values for all microbiological parameters were within acceptable limits for all days of storage.

Table 3: Effect of storage period on physico-chemical properties of aerobically packaged high dietary fiber and anti-oxidant rich *Goshtaba* under refrigeration (Mean±S.E)

Treat-ments	**Storage periods (days)**								**Treatments Mean ± SE**
	0	**7**	**14**	**17**	**20**	**23**	**26**	**29**	
pH									
T_0	5.37 ± 0.02^{bA}	5.38 ± 0.03^{cA}	5.42 ± 0.04^{cAB}	5.44 ± 0.03^{cAB}	5.49 ± 0.01^{cBC}	5.53 ± 0.01^{cC}	5.62 ± 0.03^{cD}	5.71 ± 0.01^{cE}	**5.50 ± 0.02^{c}**
T_1	5.08 ± 0.02^{aA}	5.17 ± 0.03^{bB}	5.33 ± 0.01^{bC}	5.35 ± 0.01^{bC}	5.37 ± 0.00^{bCD}	5.40 ± 0.00^{bD}	5.41 ± 0.00^{bD}	5.42 ± 0.01^{bD}	**5.32 ± 0.02^{b}**
T_2	5.05 ± 0.01^{aF}	5.03 ± 0.02^{aF}	5.03 ± 0.02^{aF}	4.96 ± 0.01^{aE}	4.88 ± 0.01^{aD}	4.80 ± 0.00^{aC}	4.76 ± 0.01^{aB}	4.68 ± 0.01^{aA}	**4.90 ± 0.02^{a}**
Water Activity (aW)									
T_0	0.97 ± 0.002^{A}	0.98 ± 0.003^{B}	0.99 ± 0.002^{B}	0.99 ± 0.002^{B}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	**0.99±0.001**
T_1	0.97 ± 0.002^{A}	0.98 ± 0.003^{B}	0.99 ± 0.002^{B}	0.99 ± 0.002^{B}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	**0.99±0.001**
T_2	0.97 ± 0.002^{A}	0.98 ± 0.003^{B}	0.99 ± 0.002^{B}	0.99 ± 0.002^{B}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	1.00 ± 0.00^{C}	**0.99±0.001**
TBARS (mg MDA/Kg)									
T_0	0.20 ± 0.01^{cA}	0.42 ± 0.01^{bB}	0.81 ± 0.003^{cC}	0.90 ± 0.003^{cD}	1.12 ± 0.01^{cE}	1.33 ± 0.003^{cF}	1.53 ± 0.003^{cG}	1.73 ± 0.01^{cH}	**1.01 ± 0.07^{c}**
T_1	0.20 ± 0.02^{bA}	0.41 ± 0.01^{bB}	0.79 ± 0.004^{bC}	0.88 ± 0.004^{bD}	1.00 ± 0.01^{bE}	1.31 ± 0.003^{bF}	1.49 ± 0.003^{bG}	1.68 ± 0.003^{bH}	**0.97 ± 0.07^{b}**
T_2	0.21 ± 0.01^{aA}	0.37 ± 0.01^{aB}	0.75 ± 0.003^{aC}	0.83 ± 0.003^{aD}	0.94 ± 0.01^{aE}	1.24 ± 0.003^{aF}	1.43 ± 0.01^{aG}	1.56 ± 0.003^{aH}	**0.91 ± 0.07^{a}**

Mean ± SE with different small letters column-wise and capital letters row-wise as superscripts differ significantly ($P\leq0.05$)
For pH and Water activity (aW), N=6

Table 4: Effect of storage period on microbiological parameters of aerobically packaged high dietary fiber and anti-oxidant rich Goshtaba under refrigeration (Mean±S.E)

Treatments	**Storage periods (days)**								**Treatments Mean ± SE**
	0	**7**	**14**	**17**	**20**	**23**	**26**	**29**	
Total Plate Count (log cfu/g)									
T_0	0.98 ± 0.01^{bA}	1.79 ± 0.01^{cB}	2.88 ± 0.01^{cC}	3.13 ± 0.01^{cD}	3.38 ± 0.01^{cE}	3.69 ± 0.01^{cF}	4.02 ± 0.01^{cG}	4.24 ± 0.17^{aH}	**3.01 ± 0.15^{a}**
T_1	0.97 ± 0.01^{bA}	1.76 ± 0.01^{bB}	2.84 ± 0.01^{bC}	2.99 ± 0.01^{bD}	3.08 ± 0.01^{bE}	3.43 ± 0.01^{bF}	3.98 ± 0.01^{bG}	4.35 ± 0.01^{aH}	**2.93 ± 0.15^{a}**
T_2	0.88 ± 0.01^{aA}	1.67 ± 0.01^{aB}	2.72 ± 0.01^{aC}	2.96 ± 0.01^{aD}	3.05 ± 0.01^{aE}	3.37 ± 0.01^{aF}	3.92 ± 0.01^{aG}	4.28 ± 0.01^{aH}	**2.86 ± 0.15^{a}**
Coliforms were not detected in any of the samples									
Psychrophilic Count (log cfu/g)									
T_0	-	-	1.25 ± 0.01^{cA}	1.57 ± 0.01^{cB}	1.75 ± 0.01^{cC}	1.87 ± 0.01^{cD}	2.03 ± 0.01^{cE}	2.17 ± 0.01^{cF}	**1.33 ± 0.12^{a}**
T_1	-	-	1.23 ± 0.01^{bA}	1.54 ± 0.01^{bB}	1.73 ± 0.01^{bC}	1.85 ± 0.01^{bD}	2.00 ± 0.01^{bE}	2.12 ± 0.01^{bF}	**1.31 ± 0.12^{a}**
T_2	-	-	1.14 ± 0.01^{aA}	1.46 ± 0.01^{aB}	1.64 ± 0.01^{aC}	1.76 ± 0.01^{aD}	1.85 ± 0.01^{aE}	2.01 ± 0.01^{aF}	**1.23 ± 0.11^{a}**

Mean ± SE with different small letters column-wise and capital letters row-wise as superscripts differ significantly ($P\leq0.05$)
N = 6; - (Not Detected)

Table 5: Effect of storage period on the sensory attributes of aerobically packaged high dietary fiber and anti-oxidant rich *Goshtaba* under refrigeration (Mean±S.E)

Treat-ments	Storage periods (days)								Treatments Mean ± SE
	0	7	14	17	20	23	26	29	
Appearance									
T_0	7.76±.10^{aG}	7.62±.11^{abG}	7.23±.10^{aF}	6.71±.10^{aE}	5.67±.11^{aD}	4.38±.11^{aC}	2.67±.11^{aB}	1.24±.10^{aA}	**5.41±0.18^{a}**
T_1	7.52±.11^{aE}	7.48±.15^{aE}	7.43±.20^{aE}	6.76±.10^{aD}	6.67±.11^{bD}	4.67±.17^{aC}	2.48±.11^{aB}	1.33±.11^{aA}	**5.54±0.18^{a}**
T_2	7.81±.09^{aE}	7.86±.08^{bE}	7.86±.08^{bE}	6.81±.09^{aD}	7.00±.00^{cD}	5.71±.17^{bC}	4.19±.16^{bB}	2.19±16^{bA}	**6.18±0.15^{b}**
Flavour									
T_0	7.90±.07^{bF}	7.86±.08^{bF}	7.76±.10^{bF}	6.86±.08^{aE}	4.81±.09^{bD}	3.71±.10^{bC}	1.81±.09^{aB}	1.24±.10^{aA}	**5.24±0.20^{b}**
T_1	7.00±.00^{aD}	7.00±.00^{aD}	7.00±.00^{aD}	7.00±.00^{bD}	3.90±.17^{aC}	1.62±.11^{aB}	1.71±.10^{aB}	1.19±.09^{aA}	**4.55±0.20^{a}**
T_2	8.00±.00^{bF}	8.00±.00^{cF}	8.00±.00^{cF}	7.00±.00^{bE}	5.57±.11^{cD}	4.57±.11^{cC}	1.62±.11^{aB}	2.05±.16^{bA}	**5.60±0.19^{b}**
Texture									
T_0	7.86±0.08^{F}	7.86±0.08^{F}	7.86±0.08^{F}	7.14±0.08^{E}	5.33±0.11^{aD}	3.33±0.11^{aC}	2.52±0.11^{bB}	1.33±0.11^{aA}	**5.40±0.20^{a}**
T_1	7.76±0.10^{F}	7.81±0.09^{F}	7.81±0.09^{F}	7.14±0.08^{E}	6.24±0.14^{bD}	4.24±0.10^{bC}	1.81±0.09^{aB}	1.33±0.11^{aA}	**5.52±0.20^{ab}**
T_2	7.81±0.09^{F}	7.81±0.09^{F}	7.81±0.09^{F}	7.19±0.09^{E}	6.48±0.11^{bD}	5.29±0.10^{cC}	3.57±0.11^{cB}	1.86±0.19^{bA}	**5.98±0.17^{b}**
Juiciness									
T_0	7.76±0.10^{D}	7.86±0.08^{D}	7.86±0.08^{D}	6.81±0.09^{C}	1.38±0.11^{aB}	1.14±0.08^{aAB}	1.19±0.09^{aAB}	1.05±0.05^{aA}	**4.38±0.25^{a}**
T_1	7.86±0.08^{E}	7.86±0.08^{E}	7.76±0.10^{E}	6.76±0.10^{D}	5.57±0.11^{cC}	5.19±0.09^{cB}	5.10±0.07^{cB}	4.33±0.11^{cA}	**6.30±0.11^{c}**
T_2	7.86±0.08^{F}	7.81±0.09^{F}	7.86±0.08^{F}	6.90±0.07^{E}	4.57±0.11^{bD}	3.43±0.11^{bC}	2.10±0.18^{bB}	1.48±0.11^{bA}	**5.25±0.20^{b}**
Saltiness									
T_0	7.19±0.09	7.14±0.08	7.14±0.08	7.14±0.08	7.14±0.08	7.24±0.10	7.19±0.09	7.19±0.09	**7.17±0.03^{a}**
T_1	7.14±0.08	7.14±0.08	7.14±0.08	7.19±0.09	7.19±0.09	7.19±0.09	7.14±0.08	7.19±0.09	**7.17±0.03^{a}**
T_2	7.10±0.07	7.10±0.07	7.14±0.08	7.14±0.08	7.19±0.09	7.19±0.09	7.19±0.09	7.19±0.09	**7.15±0.03^{a}**
Mouth coating									
Control	7.81±0.09	7.86±0.08	7.86±0.08	7.81±0.09	7.86±0.08	7.86±0.08	7.81±0.09	7.90±0.07	**7.85±0.03^{a}**
DLP	7.86±0.08	7.86±0.08	7.86±0.08	7.86±0.08	7.86±0.08	7.81±0.09	7.86±0.08	7.86±0.08	**7.85±0.03^{a}**
DLE	7.86±0.08	7.86±0.08	7.90±0.07	7.86±0.08	7.86±0.08	7.90±0.07	7.95±0.05	7.90±0.07	**7.89±0.02^{a}**
Overall Acceptability									
T_0	7.90±0.07^{bF}	7.81±0.09^{bF}	7.81±0.09^{bF}	7.19±0.09^{E}	5.38±0.11^{D}	3.71±0.16^{C}	2.38±0.11^{bB}	1.29±0.10^{aA}	**5.43±0.20^{a}**
T_1	7.43±0.11^{aE}	7.19±0.09^{aE}	7.19±0.09^{aE}	7.33±0.11^{E}	5.38±0.11^{D}	3.52±0.11^{C}	2.62±0.11^{bB}	1.90±0.17^{bA}	**5.32±0.17^{a}**
T_2	7.48±0.11^{aE}	7.19±0.09^{aE}	7.19±0.09^{aE}	7.38±0.11^{E}	5.38±0.11^{D}	3.57±0.11^{C}	1.57±0.11^{aB}	2.00±0.20^{bA}	**5.22±0.19^{a}**

Mean ± SE with different small letters column-wise and capital letters row-wise as superscripts differ significantly (P≤0.05)
N =21, 8-point descriptive scale (8 = extremely desirable, 1 = extremely undesirable)

The values obtained for sensory attributes for the control and treated *Goshtaba* are reported in table - 5. The mean values of sensory attributes for control, T_1 and T_2 *Goshtaba* showed significant (P≤0.05) difference for appearance, flavour, texture, juiciness scores and non-significant (P>0.05) difference for saltiness, mouth-coating and overall acceptability scores. During storage, an overall decrease in all the sensory attributes except saltiness and mouth-coating was observed in control, T_1 and T_2. The mean sensory attributes *viz.* appearance, flavour, juiciness, texture and overall acceptability of control and treated *Goshtaba* decreased significantly (P≤0.05) up to the 29th day of storage. The decrease in appearance might be due to lipid oxidation; decrease in flavor might be due to expected loss of volatile flavor components; decrease in texture might be attributed to degradation of muscle fiber proteins by bacterial action. The decrease in the overall acceptability is the reflective of the decrease in appearance, flavor and texture scores (Mir and Masoodi, 2017). The results for sensory parameters agree with Ahmad *et al.* (2020), who reported decreases sensory quality in restructured buffalo meat fillets enriched with natural sources of dietary fibers and antioxidant components. Sajad *et al.* (2020a) reported similar findings of sensory attributes in functional chicken loaves incorporated with dandelion (*Taraxacum officinale*) leaf powder. Rovida *et al.* (2020) concluded that the sensory quality of spent hen meat treated with ginger extract was desirable.

CONCLUSION

In order to improve the nutritional profile and extend the storage life of meat balls such as *Goshtaba*, the addition of natural antioxidant and dietary fiber components has been investigated. This approach has been found to be technologically feasible, with product quality being maintained under aerobic refrigerated conditions. One study looked at the incorporation of wheat bran as a dietary fiber source in *Goshtaba*, which is normally deficient in both natural antioxidants and dietary fiber. The results showed that the wheat bran-enriched *Goshtaba* was acceptable for consumption for up to 17 days of storage. Another approach was to incorporate grape seed extract as a natural antioxidant. This was found to increase the aerobic storage life of the product, with the grape seed extract-enriched *Goshtaba* remaining acceptable for consumption for up to 26 days of storage. These findings suggest that the addition of natural antioxidant and dietary fiber components to meat products such as *Goshtaba* can improve their nutritional value and extend their shelf life, while maintaining product quality. This could be of great value in the development of healthier and more sustainable meat-based foods.

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