Utilization of gum tragacanth as bind enhancing agent in extended restructured mutton chops

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Abstract Use of extenders in meat products is not only health promoting but can also increase the economic worth of the products. Extension of the meat product is generally associated with poor binding and texture. Thus, the present study was envisaged to solve this problem by the incorporation of gum tragacanth (GT) as bind enhancing agent, used at three different levels viz., 0.1, 0.15 and 0.2 % in a pre standardized formulation of extended restructured mutton chops (ERMC), by replacing the lean meat. The products were subjected to analysis for physico-chemical, sensory and textural properties. There was no significant difference ($P>0.05$) in any of the physicochemical property parameters of product incorporated with different levels of GT except fat percent and shear force value. Mean scores for binding, texture and overall acceptability of ERMC incorporated with 0.1 % GT recorded significantly higher value ($P<0.05$) than control and other treatment products. On the basis of sensory scores and physico-chemical properties, the optimum incorporation level of GT was adjudged as 0.1 %. Hardness and adhesiveness values were significantly higher ($P<0.05$) in product with 0.1 % GT level. The product with optimum level of GT was also assessed for water activity (a_w) and microbiological characteristics. It was found that treatment as well as control products were quite acceptable up to 15th day of storage period without any marked differences in sensory quality.

Keywords Gum tragacanth · Extended restructured mutton chops · Physico-chemical properties · Sensory attributes · Texture profile analysis and microbiological studies

Introduction

Sheep is a hardy animal which have been studied to a wide range of conditions. It is a good source of meat particularly

lamb, cherished world over as no religious inhibitions is there and is consumed by all the religions and races. India is having 6.1 % of world's sheep population which contributes 2.8 % of world's mutton production (FAO 2009). The major destinations for export of Indian sheep meat are Saudi Arabia, U.A.E, Qatar, Oman and Kuwait. The higher market price, high nutritious profile and an appreciable consumer preference is behind its gradually increasing demand and therefore promotes a wide scope for research.

Incorporation of different extenders in processed mutton is in common practice by commercial meat processors. Binding is one of the problems associated with reduced consumers acceptability of the restructured mutton products, therefore various commercially available edible gums, which is hydrocolloid in nature are widely used in meat products to enhance the acceptability and functional properties of meat products. The most important properties of edible gum, in terms of gelling and shear-thinning, are water binding and viscosity which improve the products quality. Thus, hydrocolloids due to high binding and gelling property can be extensively used as binder in meat products.

Gum tragacanth (GT), a highly acid-resistant hydrocolloid, has been accepted since 1961 as GRAS at the level of 0.2–1.3 % (Anderson and Bridgeman 1985) and it has anti-tumour properties and can stimulate the immune response too. It is pourable and has a creamy mouth feel and good flavor-release properties (Weiping and Branwell 2000) and very long shelf life (Levy and Schwarz 1958). Because of its high acid stability, the gum is well suited for use in the low pH products (Verbeken et al. 2003). It consists of two main fractions: a water-insoluble component called bassorin, which has the capacity to swell and form a gel, and a water-soluble component called tragacanthin (Balaghi et al. 2010). Although the physicochemical properties and steady-state rheological evaluation of gum tragacanth have been recently established, only a few studies have dealt with the viscoelastic behavior of gum tragacanth (Mohammadifar et al. 2006). According to FDA Code of Federal Regulations, title 21 (2003), maximum usage

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levels of gum tragacanth permitted is 0.2 % in meat products as formulation aid and stabilizer/thickener. The gum is used in fruit tablets, gum drops, and pastilles as a binding agent during compression.

Due to the changing consumer demand and increasing global competition, new processing technologies and new ingredient systems are embraced by meat product manufacturing sector and this is remarkable if one considers the historically traditional and long term approach to product and process development in the meat industry. One such approach is the innovative restructuring technology, wherein low value pieces of lean meat are assembled into new shapes and forms that create a premium product at a significantly lower price point. There are some problems associated with the quality of restructured products such as oxidation, discoloration, binding strength, presence of excessive connective tissue, development of rancidity or warmed over flavour during its storage condition. A number of researchers have been working on development and incorporation of restructured meat products development and observed binding as a major problem. This problem is further compounded with extension of restructured products. Mutton has not been much explored in this regard. Therefore utilization of this edible gum into processed meat products especially in restructured meat, where binding is one of the challenge, can be effectively removed and the product quality and its acceptability can also be improved.

Materials and methods

Procurement of mutton and ribs

Sheep of age group 6–12 months were slaughtered and dressed in Experimental Abattoir of LPT Division, IVRI, Izatnagar. Mutton, thus obtained was packed in clean polyethylene bags and brought to the laboratory. It was deboned manually. Ribs were also collected at the same time from the abattoir and cleaned off the meat with knife. Deboned mutton and ribs were finally packed in clean polyethylene bags and frozen at -20°C until use.

Gum tragacanth, spices and other ingredients

GT was purchased from S.D. Fine Chemicals. Spice ingredients were purchased from the local market of Bareilly and freed from extraneous matter. These were dried in hot air oven at 50°C for 4 h and grounded and sieved through a fine mesh. The different spice ingredients used for preparation of spice mix were mixed in suitable proportion as : Coriander powder (Dhaniya)-17 %, Cumin seed (Jeera)-10 %, Aniseed (Soanf)-10 %, Black pepper (Kalimirch)-10 %, Caraway seed (Ajowan)-10 %, Turmeric (Haldi)-10 %, Dried ginger-10 %, Capsicum (Mirch powder)-8 %, Cardamom (Bada elaichi)-5 %, Cinnamon (Dal chini)-5 %, Cloves (Laung)-3 %, Nutmeg (jaibhal)-1 % and Lace (Jaipatri)-1 %. For the preparation of condiments, onion was peeled off, cut into small pieces and homogenized in a mixer to obtain a fine paste. Garlic paste was purchased from the local market of Bareilly. Refined salt (Tata Chemicals Ltd., Mumbai), refined wheat flour (Maida), Pea hull flour and potato were procured from local market of Bareilly.

Packaging materials

Low density polyethylene (LDPE) films (200 gauge) were purchased from M/s Hitkari Industries Ltd., New Delhi and used for aerobic packaging of the product during refrigerated storage and also for storage studies.

Preparation of mutton chops

Mutton was cut into small (1 cm) chunks and massaged in paddle mixer (Hobart Co. N50G) along with salt, sodium nitrite and Sodium Tripolyphosphate dissolved in chilled water. Refined wheat flour, spice mix and condiments were added one by one and massaged along with addition of pea hull flour and potato as extenders. The mix, so obtained, was bound to the ribs and given the shape of chops. Chops were wrapped in aluminium foil and kept for cooking (broiling). The pre-standardized formulation (w/w) of extended restructured mutton chops included lean Meat (66 %), ice/chilled water (12 %), refined wheat flour (3 %), salt (1.75 %), spice mix (1.75 %), condiments (5 %), sodium nitrite (150 ppm), sodium polyphosphate (0.5 %), boiled and mashed potato (5 %), pea hull flour (5 %).

In the present study, GT was used at three different levels viz., 0.1, 0.15 and 0.2 % in ERM by replacing lean meat in pre-standardized restructured mutton chops formulation. The product was analyzed for various physico-chemical properties, texture profile, colour values and sensory attributes and the optimum level of incorporation was selected for further estimation of water activity and microbiological studies.

Physico-chemical analysis

Moisture, crude fat, protein and ash of restructured mutton slices were determined by standard procedures of Association of Official Analytical Chemists (AOAC 1995) by using hot air oven, Soxhlet apparatus, Kjeldhal apparatus and Muffle furnace respectively. Shear force value was determined as per Berry and Stiffler (1981), as force required for shearing 1 cm square block measured in kg on Warner-Bratzler Shear Press (GR Elec. MFG. Co.). The different color parameters such as redness and yellowness were evaluated on a Chroma Meter CR-400 (Konica Minolta Business Technologies, Inc., Tokyo,

Japan). From these values, hue and chroma values were also determined. Ten determinations were performed from each sample. Water activity of extended restructured mutton chops were measured by a P_{a_w} kit water activity meter (Decagon Devices, Pullman, Washington, USA). The texture profile was measured with the help of instrumental texture profile analyzer (TA HD plus Texture Analyzer) at GBPAU&T, Pantnagar. The procedure used for instrumental texture profile analysis was similar to those described by Bourne (1978). Ten determinations were performed from each sample.

Sensory analysis

Sensory evaluation method using 8 point hedonic scale (Keeton 1983) was followed, where 8 = extremely liked; 1 = extremely disliked. The sensory panel consisted of minimum seven trained scientists and post graduate students of the division. Three digit coded samples were served to the panelists in random order. They were explained about the nature of experiment without disclosing the identity of the samples. Taste panel were organized around 3:30–4:00 pm every time. The sensory panelists were asked to rate their preference on 8 point descriptive scale on the sensory evaluation proforma for general appearance, flavour, juiciness, texture, binding and overall palatability. Plain water was provided to rinse the mouth in between the samples.

Microbiological analysis

Extended restructured mutton chops were prepared by incorporating the optimum level of bind enhancing agent; GT (0.1 %). The products were packed in LDPE bags and stored at refrigeration temperature (4 ± 1 °C). The products were evaluated for 15 days at an interval of 5 days for the sensory attributes, physico-chemical parameters (pH and TBARS) and microbiological parameters (TPC, PC and Coliform count).

pH

pH of extended restructured mutton chops was determined by the method described by Trout et al. (1992). Ten grams of sample was blended with 50 ml of distilled water using tissue homogenizer. The pH of suspension was recorded by immersing combined glass electrode of digital pH meter (LI 127).

Thiobarbituric Acid Value (TBA value)

The TBA Value of mutton chops was determined by using the distillation method described by Tarladgis et al. (1960). The optical density (O.D) was recorded using spectrophotometer (Model: Beckman DU 40) at 538 nm. The O.D. was multiplied by the factor 7.8 and TBA value was expressed as mg malonaldehyde/kg of sample.

Total plate count, psychrophillic count and coliform count

TPC, PC and coliform count in the samples were determined following the methods as described by APHA (1984). Ready-made media (Hi-Media, India) were used for all the microbiological examination.

Statistical analysis

The data generated from various trials under experiment were pooled, processed and analyzed by statistical method of one way-ANOVA and Mean $\pm$ S.E using SPSS software package developed as per the procedure of Snedecor and Cochran (1995) and means were compared by using Duncan's multiple range test (Duncan 1955).

Results and discussion

Physico-chemical analysis

The physico-chemical properties of extended restructured mutton chops incorporated with varying levels of GT are presented in Table 1. Cooking yields of control and all treatment products did not differ significantly ($P > 0.05$). However, there was marginal increase in cooking yield percentage with increase in the incorporation levels of GT. The enhanced cooking yield of products with increasing levels of bind enhancing agent might be due to its ability to keep solids in suspension, thus, leading to increased yield (Varela and Fisman 2011). Product pH showed non-significant difference ($P > 0.05$) on control and all other treatments, which could be attributed to neutral pH of gum. Moisture percentage showed no significant difference ($P > 0.05$) between control and treatment products, although there was slight increase in moisture content of ERM with increasing levels of GT, which might be due to a water insoluble fraction of GT called bassorin. Balaghi et al. (2010) had reported that bassorin had the capacity to swell and form a gel. There was no significant difference ($P > 0.05$) in protein percentage between control and treatment products. Among the treatments, gradual decline in protein percent was noticed with increasing levels of GT. Fat percentage recorded gradual decrease in product with increasing level of GT which could be due to the replacement of lean meat with GT, an anionic polysaccharide of high molecular weight (Weiping and Branwell 2000).

There was no significant difference ($P > 0.05$) in percent ash between control and other treatments. However, marginal increase was noticed with increasing levels of GT level. Moisture to protein ratio of all treatments did not differ significantly ($P > 0.05$) with control. Shear force value of product containing 0.1 % GT was significantly higher ($P < 0.05$) than control and product with 0.2 % GT but comparable with

Table 1 Quality characteristics of extended restructured mutton chops incorporated with different levels of gum tragacanth (mean $\pm$ S.E)

Parameters	Control	Treatment (level of gum tragacanth)		
		0.1 %	0.15 %	0.2 %
Cooking yield (%) ($n=6$)	86.2 $\pm$ 0.46	86.8 $\pm$ 0.38	87.1 $\pm$ 0.91	87.3 $\pm$ 0.91
Physico-chemical ($n_1=6, n_2=30$)*				
pH	6.3 $\pm$ 0.01	6.3 $\pm$ 0.06	6.3 $\pm$ 0.01	6.3 $\pm$ 0.01
Moisture (%)	67.3 $\pm$ 1.37	67.9 $\pm$ 0.97	68.2 $\pm$ 0.31	68.8 $\pm$ 0.18
Protein (%)	20.8 $\pm$ 1.38	20.3 $\pm$ 0.75	19.9 $\pm$ 0.56	19.3 $\pm$ 0.58
Fat (%)	4.3 $\pm$ 0.20 ^a	3.9 $\pm$ 0.27 ^{ab}	3.7 $\pm$ 0.20 ^b	3.5 $\pm$ 0.14 ^b
Ash (%)	2.6 $\pm$ 0.05	2.6 $\pm$ 0.05	2.6 $\pm$ 0.04	2.7 $\pm$ 0.05
Moisture:protein ratio	3.3 $\pm$ 0.27	3.3 $\pm$ 0.13	3.4 $\pm$ 0.09	3.6 $\pm$ 0.11
Shear force value (kg/cm ²)*	0.64 $\pm$ 0.04 ^b	0.77 $\pm$ 0.02 ^a	0.71 $\pm$ 0.03 ^{ab}	0.62 $\pm$ 0.02 ^b
Instrumental texture ($n=6$)				
Hardness (N/cm ²)	53.6 $\pm$ 0.44 ^b	56.9 $\pm$ 0.39 ^a	55.1 $\pm$ 0.90 ^b	50.1 $\pm$ 0.53 ^c
Adhesiveness (Ns/g)	-0.10 $\pm$ 0.006 ^b	-0.08 $\pm$ 0.005 ^a	-0.08 $\pm$ 0.003 ^a	-0.07 $\pm$ 0.003 ^a
Springiness (cm/mm)	0.22 $\pm$ 0.02 ^a	0.21 $\pm$ 0.01 ^a	0.20 $\pm$ 0.005 ^{ab}	0.18 $\pm$ 0.01 ^b
Cohesiveness	0.49 $\pm$ 0.01 ^b	0.52 $\pm$ 0.01 ^a	0.53 $\pm$ 0.01 ^a	0.56 $\pm$ 0.01 ^a
Gumminess (N/cm)	34.2 $\pm$ 1.15 ^c	36.2 $\pm$ 0.87 ^{bc}	37.4 $\pm$ 0.70 ^{ab}	39.6 $\pm$ 0.74 ^a
Chewiness (N/cm ²)	6.7 $\pm$ 0.16 ^a	6.1 $\pm$ 0.32 ^b	5.9 $\pm$ 0.05 ^b	5.8 $\pm$ 0.01 ^b
Instrumental color ($n=6$)				
Redness	2.4 $\pm$ 0.14	2.4 $\pm$ 0.12	2.3 $\pm$ 0.06	2.3 $\pm$ 0.07
Yellowness	13.3 $\pm$ 0.07	13.3 $\pm$ 0.07	13.2 $\pm$ 0.05	13.1 $\pm$ 0.10
Hue	79.4 $\pm$ 0.56	79.5 $\pm$ 0.52	79.9 $\pm$ 0.25	79.9 $\pm$ 0.37
Chrome	13.5 $\pm$ 0.08	13.5 $\pm$ 0.07	13.4 $\pm$ 0.06	13.3 $\pm$ 0.08
Sensory quality ($n=21$ panelists)				
General appearance	7.0 $\pm$ 0.04	7.1 $\pm$ 0.05	7.0 $\pm$ 0.05	7.06 $\pm$ 0.06
Flavour	7.0 $\pm$ 0.05	7.0 $\pm$ 0.04	6.9 $\pm$ 0.04	6.9 $\pm$ 0.05
Binding	6.8 $\pm$ 0.05 ^b	7.1 $\pm$ 0.04 ^a	6.8 $\pm$ 0.10 ^b	6.7 $\pm$ 0.09 ^b
Texture	6.9 $\pm$ 0.05 ^b	7.2 $\pm$ 0.05 ^a	6.8 $\pm$ 0.07 ^b	6.8 $\pm$ 0.09 ^b
Juiciness	7.0 $\pm$ 0.06	7.0 $\pm$ 0.03	7.1 $\pm$ 0.04	7.0 $\pm$ 0.05
Overall acceptability	6.9 $\pm$ 0.04 ^b	7.2 $\pm$ 0.05 ^a	6.8 $\pm$ 0.05 ^b	6.9 $\pm$ 0.07 ^b

*Mean $\pm$ S.E. with different superscripts in row differ significantly ($P<0.05$)

0.15 % GT level. There was non-significant difference between the shear force value of control and product incorporated with 0.2 % GT. Increase in shear force value of product might be due to the viscoelastic behavior of gum tragacanth (Mohammadifar et al. 2006). However, increasing the level of GT beyond 0.1 % led to decrease in shear force value which was expected due to undesired interaction between NaCl and GT as increased gum concentrations in the presence of electrolytes such as NaCl, KCl etc results in decrease in viscosity of the gum (Sudhakar et al. 1996).

Sensory scores

Mean sensory scores of the product incorporated with different levels of GT viz., 0.1 %, 0.15 % and 0.2 % are presented in Table 1. Among sensory attributes, general appearance, flavor and juiciness did not show any significant difference ($P>0.05$) between control and treatment products. Azarikia and Abbasi (2010) also obtained non-significant difference

between appearance and flavour of control and samples stabilized with gum tragacanth. However, scores for general appearance and flavor showed gradual decrease in trend on addition of GT which might be due to dilution of meaty colour and flavor respectively. In contrast, Weiping and Branwell (2000) had reported some flavor release properties of gum tragacanth. Mean scores for binding, texture and overall acceptability of product showed the same trend, the value for product containing 0.1 % GT level being significantly higher ($P<0.05$) than control and other treatment products. The mean scores of binding and texture of product were in accordance with shear force value of product. The same trend in overall acceptability was expected due to combined influence of binding, texture and juiciness of product.

Texture profile analysis

The results of instrumental texture profile analysis for extended restructured mutton chops incorporated with different

levels of GT as well as control are presented in Table 1. The product with 0.1 % GT level had significantly higher ($P < 0.05$) hardness than control and all other treatments. The increased hardness of this product might be expected due to change in the viscosity of product in presence of hydrocolloid (Foroghnia et al. 2007), however it was decreased beyond 0.1 % level which could be well correlated with shear force value of treatment products and Sudhakar et al. (1996) had reported about decrease in viscosity of gum in the presence of electrolytes. Mean values for adhesiveness and cohesiveness of product recorded the same trend, the value for control product being significantly lower ($P < 0.05$). The increased adhesiveness and cohesiveness in product with increasing levels of GT could be attributed to the formation of gel by bind enhancing agent. Mean value for chewiness among treatment products were comparable, although there was marginal decrease in chewiness with increasing levels of GT which could be due to melting characteristics of hydrocolloid gel.

Colour values

The results for color values have been presented in Table 1. There was no significant difference ($P > 0.05$) in any of the color parameter between control and all other treatments. However, redness, yellowness and chroma value recorded marginal decrease with increasing levels of GT level in product. Mean values of hue for ERM incorporated with different levels of GT showed gradual decrease on addition of GT in product.

On the basis of physico-chemical and sensory attributes, ERM incorporated with 0.1 % GT were adjudged as most acceptable among treatment products and thus, selected as the optimum level for further water activity estimation and microbiological studies.

Water activity

The extended restructured mutton chops incorporated only with the optimum level of GT (0.1 %) as bind enhancer were further assessed for the water activity. The values were compared with control. The gum incorporated ERM (0.96 ± 0.001) showed a significantly lower ($P < 0.05$) values than control (0.97 ± 0.002). However, moisture content of treatment product was slightly higher than control. Since, the increase was significant thus, it can be said that the lower water activity (a_w) of the treatment product indicated higher storage stability of the product.

Storage study

Mean values for physico-chemical and microbiological characteristics of control and extended restructured mutton chops

(ERM) incorporated with 0.1 % gum tragacanth are presented in Table 2.

pH

The values of control as well as treatment product showed gradual increase in values with increasing storage period and increased significantly ($P < 0.05$) on 10th and 15th day in product incorporated with optimum level of gum tragacanth. The increase in pH might be attributed to degradation of carbohydrates present in bind enhancing agent. There was not any significant change ($P > 0.05$) in pH values between control and ERM which might be due to neutral pH of gum and the results of the present study were similar with the results reported by Mandal et al. (2002) in restructured cured chicken during refrigeration storage.

Thiobarbituric Acid Value (TBA value)

Mean score values for TBA showed significant difference ($P < 0.05$) in both control as well as treatment product with increase in storage period. TBA values increased with increasing storage period which might be due to increased lipid oxidation and production of volatile metabolites in the presence of oxygen during aerobic storage (Modi et al. 2003). Although, TBA values increased gradually with increasing storage period, the values were within the acceptable limit of 1 mg malonaldehyde/kg meat (Watts 1962). Tarladgis et al. (1960) also reported that the minimum threshold value of TBARS number of cooked meat products during storage was 0.50–1.0 mg, as detected by a trained panel. A range of 0.6–2 mg was considered to be the detectable minimum level for off-flavour by inexperienced panelists (Greene and Cumuze 1982). TBA values of ERM incorporated with gum always remained below when compared to that control which might be due to low fat content of treatment product.

Psychrophilic count

Psychrophilic microbes were not detected on 0 day of storage either in control or treatment product which could be due to destruction of psychrophiles during cooking. These counts were detected on 5th day of storage and thereafter, it increased significantly ($P < 0.05$) on 10th and 15th day of storage. This could be due to the recovery of injured organisms and then multiplication during subsequent period of storage. Psychrophilic counts did not show any significant difference ($P > 0.05$) between control and treatment product throughout the storage period. However, a comparatively faster growth of psychrophiles in the treatment product might be attributed to the presence of easy source of carbohydrates. Psychrophilic counts always remained within the permissible limits of

Table 2 Effect of refrigerated storage on pH, thiobarbituric acid (TBA) content and microbial quality characteristics of aerobically packaged extended restructured mutton chops incorporated with optimized quantity (0.1 %) of gum tragacanth (GT) ($n=6$) (mean $\pm$ S.E)

Mean $\pm$ S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly ($P<0.05$)

#Coliforms were not detected in all samples; cfu colony forming units

Treatments	Refrigerated storage period (days) [#]			
	0 day	5 day	10 day	15 day
pH				
Control	6.33 $\pm$ 0.007 ^b	6.34 $\pm$ 0.005 ^{b1}	6.34 $\pm$ 0.005 ^b	6.36 $\pm$ 0.002 ^{a1}
GT (0.1 %)	6.31 $\pm$ 0.08 ^b	6.32 $\pm$ 0.005 ^{b2}	6.33 $\pm$ 0.07 ^a	6.33 $\pm$ 0.002 ^{a2}
TBA values (mg malonaldehyde/kg)				
Control	0.18 $\pm$ 0.01 ^d	0.27 $\pm$ 0.01 ^c	0.32 $\pm$ 0.01 ^{b1}	0.39 $\pm$ 0.02 ^a
GT (0.1 %)	0.16 $\pm$ 0.01 ^c	0.24 $\pm$ 0.02 ^b	0.26 $\pm$ 0.01 ^{b2}	0.34 $\pm$ 0.04 ^a
Psychrophilic count (log ₁₀ cfu/g)				
Control	Not detected	0.72 $\pm$ 0.23 ^b	1.66 $\pm$ 0.09 ^{ab}	2.74 $\pm$ 0.03 ^a
GT (0.1 %)	Not detected	0.77 $\pm$ 0.25 ^b	1.75 $\pm$ 0.07 ^a	2.75 $\pm$ 0.02 ^a
Total plate count (log ₁₀ cfu/g)				
Control	1.50 $\pm$ 0.05 ^d	2.28 $\pm$ 0.06 ^c	2.59 $\pm$ 0.02 ^b	2.91 $\pm$ 0.03 ^{a1}
GT (0.1 %)	1.60 $\pm$ 0.09 ^d	2.30 $\pm$ 0.06 ^c	2.59 $\pm$ 0.03 ^b	2.86 $\pm$ 0.05 ^{a12}

log₁₀4.6 cfu/g as reported by Cremer and Chipley (1977) in cooked meat products. The limit of psychrotrophic counts have been reported as log₁₀4 cfu/g (Jay 1996) that could cause microbiological spoilage of stored meat product.

Total plate count

Total plate count followed a gradual and significant increasing trend ($P<0.05$) from 0 to 15th day of refrigerated storage in treatment product as well as control; however these counts were well below the permissible limit i.e. log₁₀7 cfu/g for cooked meat products (Jay 1996). However, there was no significant difference ($P>0.05$) noticed in TPC between control and ERM incorporated with gum except on 15th day of storage period where TPC of treatment product is comparatively lower than that of control. TPC of control and treatment product always remained below log₁₀5.33 cfu/g during the storage period which is indicative of unacceptability of cooked meat products (Cremer and Chipley 1977).

Coliform count

Coliforms were not detected during the entire storage period in control as well as product with optimum level of gum tragacanth due to cooking of product to an internal temperature of 72 °C, which might have been lethal to the coliforms and reflecting good hygienic practices during and after preparation of products. Similar findings were observed by Sachdev and Gopal (2000) in cooked chicken rolls.

Sensory scores during storage study

The sensory scores revealed gradual decrease for all the attributes with the advancement of storage period (Table 3). The

decline in appearance of the products might be attributed to some surface dehydration in aerobic packaging. Vedamurthy (1998) (Unpublished; Thesis, IVRI, Izatnagar) also observed decrease in appearance scores in low fat chevon sausages during storage period. Mean sensory scores for general appearance

Table 3 Effect of refrigerated storage on sensory quality of aerobically packaged extended restructured mutton chops incorporated with optimized quantity (0.1 %) of gum tragacanth (GT) ($n=21$) (mean $\pm$ S.E)

Treatments	Refrigerated storage period (days)			
	0 day	5 day	10 day	15 day
General appearance				
Control	7.0 $\pm$ 0.06 ^a	6.9 $\pm$ 0.06 ^{ab}	6.8 $\pm$ 0.08 ^{bc}	6.6 $\pm$ 0.08 ^{d1,2}
GT (0.1 %)	7.0 $\pm$ 0.07 ^a	6.8 $\pm$ 0.07 ^b	6.8 $\pm$ 0.05 ^b	6.5 $\pm$ 0.06 ^{c2}
Flavour				
Control	7.06 $\pm$ 0.06 ^a	6.9 $\pm$ 0.05 ^{ab}	6.8 $\pm$ 0.06 ^{bc}	6.7 $\pm$ 0.05 ^c
GT (0.1 %)	7.00 $\pm$ 0.06 ^a	6.9 $\pm$ 0.06 ^{ab}	6.8 $\pm$ 0.05 ^{bc}	6.7 $\pm$ 0.04 ^c
Binding				
Control	6.92 $\pm$ 0.05 ^{a2}	6.8 $\pm$ 0.07 ^{ab2}	6.8 $\pm$ 0.07 ^{ab2}	6.7 $\pm$ 0.08 ^b
GT (0.1 %)	7.32 $\pm$ 0.06 ^{a1}	7.2 $\pm$ 0.04 ^{a1}	6.9 $\pm$ 0.04 ^{b1,2}	6.6 $\pm$ 0.04 ^c
Texture				
Control	6.92 $\pm$ 0.05 ^{a2}	6.8 $\pm$ 0.06 ^{ab2}	6.7 $\pm$ 0.07 ^{bc2}	6.5 $\pm$ 0.07 ^{c2}
GT (0.1 %)	7.32 $\pm$ 0.04 ^{a1}	7.1 $\pm$ 0.06 ^{b1}	6.9 $\pm$ 0.07 ^{c1}	6.6 $\pm$ 0.05 ^{d1,2}
Juiciness				
Control	7.1 $\pm$ 0.06 ^a	6.8 $\pm$ 0.06 ^b	6.6 $\pm$ 0.08 ^{bc}	6.5 $\pm$ 0.09 ^c
GT (0.1 %)	7.0 $\pm$ 0.06 ^a	6.8 $\pm$ 0.06 ^{ab}	6.6 $\pm$ 0.09 ^{bc}	6.5 $\pm$ 0.09 ^c
Overall acceptability				
Control	6.9 $\pm$ 0.06 ^{a1}	6.9 $\pm$ 0.06 ^a	6.7 $\pm$ 0.07 ^{b2}	6.4 $\pm$ 0.07 ^{c2}
GT (0.1 %)	7.2 $\pm$ 0.04 ^{a1,2}	6.9 $\pm$ 0.06 ^b	6.9 $\pm$ 0.04 ^{b1,2}	6.6 $\pm$ 0.05 ^{c1,2}

Mean $\pm$ S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly ($P<0.05$)

recorded no significant difference ($P>0.05$) between control and treatment products during storage period. The progressive decrease in flavour scores noticed with control as well as treatment product could be correlated to an increase in TBA value and free fatty acids in meat products (Tarladgis et al. 1960) under aerobic conditions. Decline in flavour scores of meat products during refrigerated storage period was reported by Nath et al. (1995) in chicken patties, Sahoo and Anjaneyulu (1997) and Thomas et al. (2006) in buffalo meat nuggets. Binding and texture of control and treatment product also followed the same decreasing trend with increase in storage period which was according to the shear force value of the products. There was significant decrease ($P<0.05$) in overall acceptability of control and treatment product on 15th day of storage which was expected due to increase in lipid oxidation, pigment oxidation and degradation of proteins and fats in ERM C with advancement in storage period. However, ERM C incorporated with optimum level of bind enhancing agent remained quite acceptable up to 15th day of storage with sensory ratings between good to very good (6.50 to 6.75).

Conclusion

Gum tragacanth has been well accepted and approved as food additives by various international authorities like WHO. Incorporation of gum tragacanth in extended restructured mutton chops resulted in marginal increase in moisture content and thereby higher cooking yield of products. Moisture to protein ratio and shear force value also increased with increase in the level of incorporation of gum tragacanth. Among the sensory attributes, binding, texture and overall acceptability showed increased values with increase in the level of incorporation of bind enhancing agent. Cohesiveness and gumminess of the products increased effectively with the addition of gum tragacanth and directed to the improved overall acceptability while there was significant increase in hardness of the product up to 0.1 % level and beyond this level, hardness showed decreasing trend. On the basis of physico-chemical characteristics and sensory scores of the products, 0.1 % level of incorporation was selected as optimum level for the preparation of ERM C and could be successfully added as bind enhancing agent in extended restructured mutton chops. Products incorporated with optimum level of gum tragacanth (0.1 %) were assessed for microbiological quality and it was found that they could be safely stored under refrigeration ($4\pm 1^\circ\text{C}$) in LDPE pouches for 15 days without marked deterioration in sensory and microbiological quality. Therefore incorporation of gum tragacanth into restructured meat formulation will improve the binding and texture as well as acceptability of the product, which in turn will make the product processing economically viable.

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