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Influence of Aerobic and Nitrogen Flush Packaging Methods and Frozen Storage on Quality Characteristics of Prune Puree Incorporated Ready-to-Eat Mutton *Kheema*

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The present investigation was carried out to evaluate the influence of aerobic packaging and nitrogen flush packaging methods on quality characteristics (physico-chemical, microbial and sensory quality) of 15 % prune puree extended mutton kheema at 0, 30, 60 and 90 days of frozen storage (-18 ±1 °C). The results revealed that there was a significant (P<0.05) decrease in pH, thiobarbituric acid reactive substance (TBARS) values, tyrosine value and per cent free fatty acid (FFA) values with incorporation of prune puree. Furthermore, there was a significant (P<0.05) increase in the pH, TBARS values, tyrosine and FFA content as the storage progressed from 0-90 days in during frozen storage. Irrespective of storage days and treatments, nitrogen flush packaged mutton kheema recorded significantly (P<0.05) lower pH, TBARS, Tyrosine value and FFA content compared to aerobic packaging method. Prune puree added mutton kheema recorded significantly (P<0.05) lower standard plate counts (SPC) and yeast and mould counts, and these counts are increased as the storage progressed from 0 to 90 days during frozen temperature. Nitrogen flush packaging of mutton kheema also helped in limiting the microbial growth during entire period of storage. Organoleptic evaluation scores of all the products were rated as excellent to very good, except for the appearance, which was rated as good. However, the scores decreased significantly with increase in storage time during frozen temperature. Based on the results, it is concluded that prune puree could be beneficially incorporated at levels of 15 % improving the physico-chemical, microbial quality with more health benefits. Nitrogen flush pouches for packaging mutton kheema help in preserving the sensory scores of fresh product during frozen storage.

Keywords: Mutton kheema, prune puree, nitrogen flush packaging, frozen storage, quality characteristics.

Keema, Kheema, or Qeema is a traditional South Asian meat dish which originally meant "minced meat" (Platts, 1884). In South Asia, both lamb (mutton) and goat meat (chevon) are also minced to produce kheema, though the process of mincing is manual. In addition it is an indigenous, delicious meat product prepared by cooking comminuted meat from low grade and cheaper cuts with spices and seasonings. It is consumed fresh because of its high perishability with chances of microbial spoilage (Karthikeyan *et al*. 2000).

Extension of meat and meat products with vegetables and fruits could improve the nutritional qualities of the products. However, the incorporation of fruits and vegetables in

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processing of meat products relates to their functional properties such as water binding, fat emulsification, yield and their sensory properties. In this context, prunes are considered as healthy food because of lower fat content and contain considerable amount of important nutrients like carbohydrates, vitamins and minerals. Consumption of fruits, like plums and prunes, is useful in blood circulation problems, measles, digestive problems, in prevention of cancer, diabetes and obesity (Li, 2008). Plum derived food ingredients have been reported to function as antioxidants, antimicrobials, fat replacers and flavourings (Nunez et al. 2008). Dried plum puree contains chemical compounds that serve specific functions in foods, pectin aids in moisture retention, while malic acid enhances flavour and sorbitol acts as a natural humectant (Nunez et al. 2009).

Prunes are highly reputed in folk medical practices treatment of hypertension, diabetes, jaundice and fever. The recent studies showed that it has antioxidant, anticancer, antihyperglycemic, anti-hyperlipidemic, antihypertensive, anti-osteoporosis, laxative and hepatoprotective activities. Prunes contain dietary fibers, carbohydrates, amino acids, vitamins, minerals and antioxidant polyphenolic phytochemicals (Jabeen and Aslam, 2011).

Modern meat packaging techniques are intended to maintain the nutrient, microbial and sensory quality of the product. Changes in the packaging atmosphere (aerobic, vacuum or modified atmosphere) are used in the meat packaging to extend products shelf-life. Modified atmosphere packaging using a high carbon dioxide (CO_2) environment is an effective means of prolonging microbial shelf-life of meat during extended storage (Silliker et al. 1999). In modified atmosphere packaging (MAP), the atmosphere inside the package is modified in such a way to extend the shelf life of meat while retaining its colour and flavor. The air in package is suitably replaced by gases usually nitrogen, oxygen or carbon dioxide alone or in combination. Modified atmosphere combined with low temperature delays the deleterious effect and maintains the quality of chilled stored meat for extended periods. Carbon dioxide and nitrogen atmospheres lowers the psychrophilic counts (Christopher et al. 1980) and vacuum packaging also significantly influenced phsico-chemical quality attributes and reduced the microflora and improves the sensory attributes of grape seed incorporated restructured mutton slices (Reddy et al. 2013). Many studies have provided detailed insight into the microbiology and spoilage of red meat and poultry during storage under vacuum packaging and modified atmosphere packaging (Mc Millin, 2008).

Keeping in view the beneficial effects of prunes on human health and nutrition and taking into congruence the benefit of modification of atmosphere in the packaging system, nitrogen flushing is considered, to see its effect on shelf life of kheema prepared by incorporation of prune puree during frozen storage (-18±1^{o}C).

MATERIALS AND METHODS

Source of mutton kheema and other raw materials

Mutton kheema was procured from the retail outlet (Royal mutton shop, Hyderabad) and due care was taken during its processing as per scientific method and was immediately transported to the Department of Livestock Products Technology, College of Veterinary Science, Rajendranagar in chilled condition (Ice box) for further processing. Dried plums, common salt, vegetable oil, red chilly powder, ingredients for spice mix, onion, ginger and garlic were procured from the local market of Hyderabad. Dried plums were soaked in water (ratio of 1:2 of plum to water) for 12h at 4^{o}C and mashed in a mixer grinder (REMI, Auto-Mix-Blender) to obtain prune puree. The spice ingredients were

cleaned and dried in the hot air oven at 80ºC for 3 hours. The ingredients were ground separately in a home mixer (REMI, SUPER MIXER GRINDER) and sieved through a fine mesh. The powders were mixed in suitable proportions to obtain the spice mix and were stored at room temperature in air tight container until use. Onion, ginger and garlic were peeled of their external covering and washed thoroughly in potable water. They were cut into small pieces, weighed in required proportions in the ratio of 3:1:1, mixed and ground in a mixer-grinder (Panasonic MX-AC 3005, super mixer grinder) to obtain a fine paste. The onion, ginger and garlic paste was freshly prepared for every trail just before used.

In pre standardized trails, prune puree was added to mutton kheema at different levels (10 %, 15 % and 20 %). Among the three levels of prune puree, 15% prune puree added mutton kheema is identified as the best acceptable level. Mutton kheema incorporated with 15% level of prune puree (Treatment) and the mutton kheema without prune puree (Control) was packaged in metalized LDPE pouches (8 X 12 inches) by aerobic and nitrogen flush packaging methods is designated as Control Aerobic (CA), Control Nitrogen (CN), Treatment Aerobic (TA) and Treatment Nitrogen (TN). All packages were done manually maintaining appropriate head space and sealed. The packaged kheema was stored at frozen temperature (-18±1ÚC) to evaluate its keeping quality. The physico-chemical, microbiological, and organoleptic quality of the product was evaluated at 0, 30, 60 and 90 days intervals during frozen storage.

Evaluation of Quality Attributes

Physico-Chemical Characteristics

pH of the mutton kheema was estimated by following the method of Trout et al. (1992) using digital pH meter (Oakton Instruments, USA). The distillation method outlined by Tarladgis et al. (1960) was followed for the determination of TBARS values and expressed as mg of malonaldehyde per kg of sample. Tyrosine value was estimated adopting the procedure of Strange et al. (1977). Free fatty acids were calculated based on the method outlined by Koniecko, (1979).

Microbial Quality

The microbial quality of the kheema was evaluated by estimating the Standard plate count, psychrophilic count and yeast & mould counts following pour plating technique as per the standard procedure of APHA (1984).

Organoleptic Evaluation

The standardized mutton kheema prepared was evaluated organoleptically for appearance, flavor, juiciness, texture, mouth coating and overall acceptability using 9- point hedonic scale (where, 9 is very excellent and 0 is extremely poor) as described by Keeton (1983) by semi trained panelists consisting of teaching faculty and post graduate students of the department. The panelists were explained about the nature of experiment and were requested to record their preference. Mutton kheema was heated in microwave oven (BPL-SANYO) to desirable temperature to serve hot. Sensory evaluation was conducted between 3-4 pm every time. Warm water and bland biscuits were used as neutralizers for evaluating between samples.

Statistical Analysis

Each experiment was conducted three times and the data was analyzed using SPSS version 20.0 of windows, SPSS Chicago. The data on all parameters are analyzed using two way ANOVA analysis.

RESULTS AND DISCUSSION

Physico-Chemical Characteristics

pH

The results of influence of packaging methods and frozen storage on pH values of mutton kheema is presented in Table 1. As frozen storage period progressed from 0 to 90 days, the mean pH values were significantly ($P<0.05$) increased irrespective of treatment and packaging. Treatment groups viz. TA and TN recorded significantly ($P<0.05$) lower pH values compared to control group (CA and CN). The pH values of mutton kheema packed in aerobic condition were significantly ($P<0.05$) higher compared to nitrogen flush package. The incorporation of prune puree at 15 % significantly decreased the pH of mutton kheema initially compared to control. It may be due to the acidic nature of prune puree, due to malic acid (predominant acid), citric, tartaric, benzoic and boric acid, which might have decreased the pH of mutton kheema. Similar findings of decrease in pH were also reported in beef patties incorporated with plum puree at different levels by Yýldýz-Turp and Serdaroglu (2010).

However, on storage there was a significant increment in the pH values as the storage period progressed from 0 to 90 days. However, the increase was relatively lower which might be due to lower microbial activity during frozen storage, which reflected in lower Standard plate counts. A similar observation of increase in pH during storage was also noted by Karthikeyan et al. (2000) in hurdle treated chevon kheema stored at ambient temperature and Reddy and Rao (2000) also observed increase in pH with increase in chicken loaves during storage period.

Thiobarbituric acid reactive substances (TBARS) value

The results of TBARS value (mg malonaldehyde/kg) observed at different storage intervals during frozen storage were presented in Table 1. Treatment and nitrogen flush packaging significantly ($P<0.05$) affected the TBARS values (mg malonaldehyde/kg) of mutton kheema. TBARS values of aerobically packed mutton kheema (CA and TA) were significantly ($P<0.05$) higher compared to nitrogen flush packed mutton kheema (CN and TN). Throughout the storage study, TN samples showed significantly ($P<0.05$) lower TBARS value than other products. The significant increase in TBARS values as the storage period progressed from 0 to 90 days in both control as well as prune puree incorporated products is evident during frozen storage. This might be due to the intensity of lipid oxidation enhanced and production of more secondary products of lipid oxidation formed from the decomposition of oxidized lipid molecules which yield more TBARS values in the mutton kheema. Similar findings were also reported by Kandeepan et al. (2010) in buffalo meat kheema stored at different temperatures and Karthikeyan et al. (2000) in hurdle treated chevon kheema stored at ambient temperature.

However the incorporation of prune puree at 15% level significantly reduced the lipid oxidation (rancidity) as evident by the significantly lower TBARS values recorded in mutton kheema. The lower values recorded for mutton kheema incorporated with prune puree might be due to potential anti-oxidative property of prune puree. The antioxidant property of prune puree mainly due to polyphenolic phytochemicals such as chlorogenic acid, neochlorogenic acid, caffeic acid, coumaric acid, rutin (Donovan et al. 1998) and proanthocyanidin (Kimura *et al*., 2008). Furthermore, proanthocyanidins are direct scavengers of reactive oxygen species and have the ability to chelate metal ions such as iron. These findings are in congruent with Ýýldýz-Turp and Serdaroglu (2010) in beef patties incorporated with plum puree at different levels; Nunez et al. (2008) injected dried plum in roast beef and Lee and Ahn (2005) in irradiated turkey breast rolls formulated with plum extract.

Packaging also showed a significant effect on the lipid oxidation as evident by the lower TBARS values recorded for nitrogen flush packaging as against aerobic packaging. This may be attributed to the very inert nature of the nitrogen, which prevents oxidation, polymerization and isomerization of fatty acids present in the fat. Similar to our findings, Zanardi et al. (2002) also reported a significant lower TBARS value in nitrogen packaged (100% N_2) atmosphere in Milano-type fermented sausage and also by Scetar et al. (2013) in nitrogen (100% N_2) and vacuum packaged samples of sliced dry fermented sausage.

Tyrosine value

Tyrosine value in the meat samples indicates the level of protein breakdown during storage. Tyrosine values obtained at different storage intervals in frozen temperature under aerobic and nitrogen flush package of mutton kheema were presented in Table 1. There was a significant ($P<0.05$) increase in tyrosine values in all the groups viz., CA, CN, TA and TN as the storage period progressed from 0 to 90 days under frozen storage. The major cause for this increase might be due to proteolysis produced by either microbial growth or chemical reaction (Leistner, 1994). Tyrosine values for nitrogen flush packed samples were found to be significantly ($P<0.05$) lower, when compared to the corresponding values of aerobic packaged samples for frozen storage. This may be attributed to low microbial growth and reduced proteolysis in nitrogen packed samples in comparison to aerobically packed samples. Although tyrosine values for aerobically packaged mutton kheema were found to be high, the samples were found to have greater acceptance among the sensory panel. Further, all the aerobically packed and nitrogen flush packed samples, treated with and without prune puree did not reveal spoilage at the end 90 days of frozen storage. These results are in agreement with the findings of Morrissey et al. (1980) who reported increase in tyrosine value of buffalo meat samples stored under refrigeration. Similar results were also reported by Agnihotri (1988) in beef samples stored under refrigeration. Incorporation of prune puree at 15% level significantly lowered the tyrosine values in mutton kheema compared to control (without prune puree) which might be due to the antimicrobial activity of prune puree as suggested by Nunez et al. (2008), which coincide with the lower microbial counts recorded in the present study.

Per cent Free Fatty Acid (FFA)

Treatment (nitrogen flush packaging) and storage period were significantly ($P<0.05$) affected the percent FFA of mutton kheema (Table 1). The percent FFA was significantly ($P<0.05$) lower in nitrogen flush packaged mutton kheema (CN and TN) compared to aerobic packaged mutton kheema (CA and TA) under frozen storage. This may be due to efficient control of the lipid oxidation by nitrogen flush. These results are in agreement with the findings of Zanardi et al. (2002) in Milano-type fermented sausages and Scetar et al. (2013) in dry fermented sausage, stored at 22 and 37 °C in both vacuum and 100% N_2 atmosphere.

There was a significant ($P<0.05$) increase in percent FFA, as storage period progressed from 0 to 90 days of frozen storage irrespective of treatment and packaging. The increased FFA values during storage might be due to microbial lipolytic activity and oxidative degradation of polyenolic fatty acids. These observations are in congruence with the findings of Gopal Reddy et al. (1978) in ground rabbit meat stored under refrigeration for 10 days; Kumudavally et al. (2008) in fresh mutton treated with ethanolic extract of Green tea and Scetar et al. (2013) in dry fermented sausage stored at 22 and 37 °C in both vacuum and 100% N_2 atmosphere.

Microbial Quality

The behavior of microorganisms in food is governed by the constraints through a variety of environmental and ecological factors. These include water activity, pH, chemical composition, presence of natural or added antimicrobial agents and storage temperature as well as the processing factors such as heat treatment and physical manipulation (Hobbs, 1986).

Standard Plate Count (SPC)

Nitrogen flush packaging significantly influenced the standard plate counts of mutton kheema during 90 days of frozen storage (Table 2). The Standard plate counts recorded were lower for prune puree incorporated and nitrogen flush packed mutton kheema samples than aerobically packed control mutton kheema. This might be due to inert atmosphere (N_2 gas flush) which limits the growth of the aerobic microorganisms and plum consists of high in phenolic compounds may inhibit growth of microorganisms at a concentration of 2.6 to 5.6 mg/ml (Cevallos- casals et al. 2005). Mutton kheema incorporated with prune puree packed under nitrogen flush recorded significantly lower standard plate counts compared to all other samples of mutton kheema and during the entire storage studies. However, the frozen stored mutton kheema samples recorded lower standard plate counts. Similar findings were observed by Karthikeyan et al. (2000) in chevon kheema and by Das (2002) in chevon chunks.

As the storage period progressed from 0 to 90 days, there was a significant increase in standard plate counts irrespective of treatment and packaging. Significantly lower count than other groups, were observed at the end of 90 days of frozen storage in prune puree incorporated mutton kheema under nitrogen flush. These results are in agreement with Biswas et al. (2004) in enrobed precooked patties.

Yeast and Mould Counts

Yeast and mould counts were significantly ($P<0.05$) influenced by incorporation of prune puree and nitrogen flush packaged mutton kheema (Table 2). In general, the nitrogen flush packed mutton kheema (CN and TN) recorded a significantly ($P<0.05$) lower yeast and mould counts compared to aerobically packed mutton kheema (CA and TA). This decrease of yeast and mould counts of nitrogen flush packed samples might be due to protective atmosphere (N_2 flush) which limits the growth of yeast and mould, phenolic compounds and sorbic acid present in prune puree which may inhibit the growth of microorganisms. A Significant increase in yeast and mould counts was noticed only in CA packed mutton kheema during the entire period of frozen storage. However, yeast and mould counts were not detected in prune puree incorporated mutton kheema packed in nitrogen flush throughout the frozen storage. On the other hand, mutton kheema without prune puree packaged in nitrogen flush showed some retarding effect on the yeast and mould indicates the inertness of nitrogen and the absence of oxygen required for their growth and multiplication. These results are in accordance with Kandeepan et al. (2010) in buffalo meat kheema and Reddy et al. (2013) in aerobic packaged restructured mutton slices (RMS). Similar observations were made by Lee et al. (1983) in vacumm or nitrogen packed veal chucks and by Simard *et al.* (1983) in nitrogen packed frankfurters.

Table 1. Effect of incorporation of prune puree and packaging on the physic-chemical characteristics of Mutton Kheema under frozen storage (-18±1oC) (Mean±SE).

Days of storage	0	30	60	90	Mean
			pH		
CA	6.06±0.06 ^{bA}	6.11±0.06^{cB}	6.19±0.00^{cC}	6.31±0.01^{Bd}	6.17±0.03^{b}
CN	6.06±0.06^{bA}	6.09±0.07^{cB}	6.16±0.00^{bC}	6.28±0.01^{bD}	6.15±0.01^{b}
TA	5.57±0.06^{aA}	5.69±0.04^{bB}	5.80±0.01^{aC}	5.97±0.00^{aD}	5.76±0.05^{a}
TN	5.57±0.06^{aA}	5.66±0.10^{aB}	5.82±0.00^{aC}	5.94±0.01^{aD}	5.75±0.04^{a}
Mean	5.82±0.07^{A}	5.89±0.03^{B}	5.99±0.06^{C}	6.13±0.04^{D}	
			2-TBARS value (mg malonaldehyde/kg)		
CA	0.64±0.01^{bA}	0.75±0.01^{cB}	1.03±0.00^{cC}	1.39±0.01^{cD}	0.95±0.04^{d}
CN	0.64±0.01^{bB}	0.50±0.04^{aA}	0.66±0.01^{aB}	1.07±0.00^{aC}	0.72±0.03^{b}
TA	0.44±0.01^{aA}	0.67±0.01^{bB}	0.92±0.00^{bC}	1.36±0.00^{bD}	0.85±0.04^{c}
TN	0.44±0.01^{aA}	0.43±0.00^{aA}	0.63±0.01^{aB}	0.98±0.00^{aC}	0.62±0.07^{a}
Mean	0.54±0.02^{A}	0.59±0.07^{B}	0.81±0.03^{C}	1.20±0.05^{D}	
			Tyrosine value (mg/ 100 gm)		
CA	8.25±0.77^{bA}	9.59±0.13^{dB}	12.48±0.14^{dC}	15.41±0.10^{dD}	11.43±0.05^{d}
CN	8.25±0.77^{bA}	8.62±0.05^{bB}	10.28±0.13^{bC}	12.44±0.10^{bD}	9.90±0.02^{b}
TA	7.33±0.13^{aA}	9.26±0.08^{cB}	10.82±0.04^{cC}	13.25±0.05^{cD}	10.17±0.07^{c}
TN	7.33±0.13^{aA}	8.24±0.07^{aB}	9.24±0.05^{aC}	11.18±0.05^{aD}	9.00±0.03^{a}
Mean	7.79±0.05^{A}	8.93±0.10^{B}	10.71±0.02^{C}	13.07±0.05^{D}	
			Free fatty acid (%) value		
CA	0.1565±0.12^{bA}	0.1603±0.01^{dB}	0.2217±0.03^{dC}	0.2272±0.04^{dD}	0.1915±0.03^{d}
CN	0.1565±0.09^{bA}	0.1483±0.00^{bB}	0.1760±0.002^{bC}	0.1943±0.01^{bD}	0.1689±0.05^{b}
TA	0.1542±0.08^{aA}	0.1538±0.03^{cB}	0.2180±0.00^{cC}	02258±0.03^{cD}	0.1879±0.04^{c}
TN	0.1542±0.006^{aA}	0.1350±0.01^{aB}	0.1558±0.01^{aC}	0.1760±0.02^{aD}	0.1553±0.07^{a}
Mean	0.1554±0.07^{B}	0.1494±0.05^{A}	0.1929±0.09^{C}	0.2058±0.06^{D}	

Means with different superscripts in a row (upper case letters) and in a column (lower case letters) differ significantly (P< 0.05).

Table 2. Effect of incorporation of prune puree and packaging on the microbial counts of Mutton Kheema under frozen storage (-18±1oC) (Mean±SE).

Days of storage	0	30	60	90	Mean
			Standard plate count (log cfu/gm)		
CA	3.35±0.02^{bA}	3.67±0.03^{dB}	3.74±0.00^{dC}	3.84±0.01^{dD}	3.65±0.07^{d}
CN	3.35±0.02^{bA}	3.26±0.01^{cB}	3.31±0.02^{cB}	3.38±0.02^{bC}	3.36±0.04^{c}
TA	3.00±0.01^{aA}	3.16±0.00^{bA}	3.25±0.01^{bB}	3.34±0.01^{bC}	3.19±0.01^{b}
TN	3.00±0.01^{aA}	3.03±0.01^{aA}	3.13±0.01^{aB}	3.25±0.00^{aC}	3.10±0.10^{a}
Mean	3.18±0.07^{A}	3.28±0.07^{B}	3.36±0.04^{C}	3.45±0.03^{D}	
			Yeast and mould count (log cfu/gm)		
CA	ND	1.65±0.02^{A}	2.12±0.00^{cB}	2.34±0.00^{cC}	1.53±0.01^{c}
CN	ND	ND	1.83±0.00^{b}	1.94±0.00^{b}	0.94±0.01^{b}
TA	ND	ND	1.68±0.02^{a}	1.74±0.01^{a}	0.86±0.03^{a}
TN	ND	ND	ND	ND	0
Mean	0	0.41±0.01^{A}	1.41±0.07^{B}	1.51±0.04^{C}	

Means with different superscripts in a row (upper case letters) and in a column (lower case letters) differ significantly (P< 0.05).
CA-Control Aerobic; CN-Control Nitrogen; TA-Treatment Aerobic; TN-Treatment Nitrogen

Table 3. Effect of incorporation of prune puree and packaging on the organoleptic attributes of Mutton Kheema under frozen storage (-18±1oC) (Mean±SE).

Days of storage	0	30	60	90	Mean
			Appearance		
CA	8.11±0.11^{aC}	7.80±0.15^{aBC}	7.50±0.17^{aAB}	7.31±0.13^{aA}	7.68±0.09^{a}
CN	8.11±0.11^{aC}	7.97±0.11^{aBC}	7.69±0.12^{aB}	7.33±0.14^{aA}	7.78±0.07^{b}
TA	8.36±0.09^{aC}	7.77±0.11^{aB}	7.58±0.10^{aB}	7.38±0.14^{aA}	7.77±0.06^{b}
TN	8.36±0.09^{aD}	7.91±0.10^{aC}	7.55±0.09^{aB}	7.41±0.09^{aA}	7.81±0.04^{c}
Mean	8.24±0.04^{D}	7.86±0.05^{C}	7.58±0.03^{B}	7.36±0.08^{A}	
			Flavor		
CA	8.33±0.11^{aC}	7.72±0.12 ^{aB}	7.50±0.09 ^{aB}	6.55±0.15 ^{aA}	7.53±0.04^{a}
CN	8.33±0.11^{aB}	8.09±0.10^{bAB}	8.02±0.09^{bA}	7.94±0.09^{bA}	8.10±0.07^{c}
TA	8.36±0.10^{aC}	7.88±0.09^{abBC}	7.77±0.10^{abB}	6.61±0.10^{aA}	7.66±0.01^{b}
TN	8.36±0.10^{aB}	8.08±012^{bA}	7.94±0.11^{bA}	7.88±0.12^{bA}	8.07±0.04^{c}
Mean	8.35±0.04^{D}	7.94±0.02^{C}	7.81±0.08^{B}	7.25±0.04^{A}	
			Juiciness		
CA	8.02±0.10^{C}	7.61±0.10^{B}	7.44±0.10^{AB}	7.27±0.08^{aA}	7.59±0.04^{a}
CN	8.02±0.10^{B}	7.91±0.10^{AB}	7.80±0.09^{AB}	7.66±0.10^{abA}	7.85±0.05^{c}
TA	8.05±0.11^{B}	7.75±0.12^{AB}	7.61±0.14^{A}	7.50±0.12^{abA}	7.73±0.02^{b}
TN	8.05±0.11^{B}	7.88±0.10^{AB}	7.75±0.12^{AB}	7.61±0.13^{bA}	7.82±0.09^{c}
Mean	8.04±0.03^{D}	7.79±0.05^{C}	7.65±0.10^{B}	7.51±0.09^{A}	
			Texture		
CA	8.05±0.09^{C}	7.36±0.11^{aB}	7.16±0.13^{aAB}	6.83±0.15^{aA}	7.35±0.04^{a}
CN	8.05±0.09^{B}	7.77±0.08^{bAB}	7.66±0.09^{bA}	7.52±0.11^{bA}	7.75±0.07^{c}
TA	8.25±0.09^{B}	7.41±0.14^{aA}	7.25±0.12^{aA}	7.16±0.12^{abA}	7.52±0.03^{b}
TN	8.25±0.09^{C}	7.61±0.07^{abB}	7.57±0.08^{abAB}	7.42±0.10^{bA}	7.82±0.05^{d}
Mean	8.15±0.07^{D}	7.54±0.06^{C}	7.41±0.02^{B}	7.23±0.04^{A}	
			Mouth coating		
CA	7.72±0.12^{C}	7.25±0.09^{aB}	6.97±0.11^{AB}	6.69±0.14^{aA}	7.16±0.03^{a}
CN	7.72±0.12^{B}	7.55±0.12^{abB}	7.22±0.10^{A}	7.08±0.12^{bA}	7.39±0.01^{b}
TA	7.86±0.13^{C}	7.47±0.09^{abB}	7.16±0.09^{AB}	6.94±0.10^{abA}	7.36±0.04^{b}
TN	7.86±0.13^{C}	7.58±0.10^{bBC}	7.27±0.10^{AB}	7.11±0.07^{bA}	7.46±0.02^{c}
Mean	7.79±0.02^{D}	7.46±0.05^{C}	7.16±0.07^{B}	6.96±0.03^{A}	
			Overall acceptability		
CA	8.11±0.10^{D}	7.58±0.10^{C}	7.02±0.11^{aB}	6.55±0.08^{aA}	7.32±0.02^{a}
CN	8.11±0.10^{C}	7.86±0.10^{BC}	7.63±0.09^{bB}	7.25±0.16^{bA}	7.71±0.08^{c}
TA	8.27±0.08^{D}	7.77±0.14^{C}	7.41±0.12^{bB}	6.91±0.12^{bA}	7.59±0.05^{b}
TN	8.27±0.08^{C}	7.88±0.10^{B}	7.61±0.09^{bB}	7.18±0.09^{bA}	7.74±0.02^{c}
Mean	8.19±0.08^{D}	7.77±0.05^{C}	7.42±0.04^{B}	6.97±0.07^{A}	

Means with different superscripts in a row (upper case letters) and in a column (lower case letters) differ significantly ($P < 0.05$).
CA-Control Aerobic; CN-Control Nitrogen; TA-Treatment Aerobic; TN-Treatment Nitrogen

Psychrophilic Counts

No psychrophilic counts were detected in all groups of mutton kheema at the end of storage period of 90 days under frozen storage (Not shown in Table). This might be due to the thermal processing, packaging and storage conditions to which the mutton kheema is subjected to frozen storage. These results are in accordance with the study of Christopher et al. (1980) in the microbial flora of pork packed in carbon dioxide and nitrogen atmosphere.

Organoleptic Evaluation

The influence of packaging methods and frozen storage on organoleptic evaluation of mutton kheema extended with pruned puree is presented in Table 3. In general, all the products were scored between excellent to very good except for the appearance which was rated as good. It is observed that the scores decreased significantly with increase in days of storage in frozen temperature. These results are in congruent with Karthikeyan et al. (2000) in hurdle treated chevon keema and Kandeepan et al. (2010) in buffalo meat kheema stored at different temperatures. Mutton kheema incorporated with prune puree and packed under nitrogen flush recorded significantly higher scores for all the sensory attributes viz., appearance, flavour, juiciness, mouth coating, texture and overall acceptability during entire period of frozen storage. Similar findings were reported by Lee and Ahn (2005) in plum puree added ready-to-eat turkey breast rolls and by Zanardi et al. (2002) in Milano-type sausages. Mutton kheema stored under frozen condition had better acceptability, which may be attributed to the low temperature and lower a_w which retards enzymatic activity and microbial growth responsible for deterioration in sensory quality. Similarly nitrogen flush packaged mutton kheema, both control and treatment samples scored higher organoleptic scores than aerobically packaged mutton kheema samples which preserved the flavor and the aroma is maintained. These observations are in agreement with the findings of Yýldýz-Turp and Serdaroglu (2010) who reported a significant increase in flavour scores with incorporation of plum puree at 10% level. It is observed that the mutton kheema was not spoiled in terms of any off odour/flavour during the entire period of storage of 90 days under frozen storage.

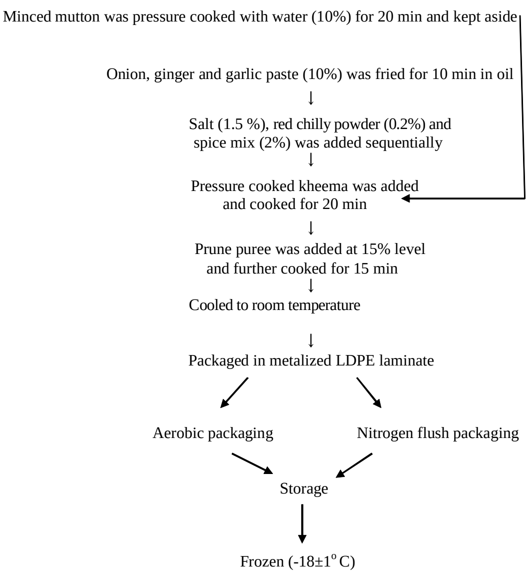

Fig1. Flow chart for the preparation of ready-to-eat kheema incorporating prune puree

CONCLUSION

It may be concluded that mutton kheema can be prepared with incorporation of prune puree at 15% level with the beneficial effect in terms physico-chemical, microbial and organoleptic quality and extending shelf life. Further, nitrogen flush packaging in metalized LDPE results in better quality by preserving during frozen temperature.

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