QUALITY ANALYSIS OF DRIED BEEF AND STANDARDIZATION TO SUIT THE LOCAL MARKET

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DECLARATION

I hereby declare that this thesis entitled **"QUALITY ANALYSIS OF DRIED BEEF AND STANDARDIZATION TO SUIT THE LOCAL MARKET"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Certified that this thesis, entitled "**QUALITY ANALYSIS OF DRIED BEEF AND STANDARDIZATION TO SUIT THE LOCAL MARKET**" is a record of research work done independently by **RANI CHACKO,** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Introduction

INTRODUCTION

Smoking and drying is the oldest method used to preserve meat in different parts of world. It is well accepted in many developed countries primarily, based on the sensory characteristics it imparts to the product. Furthermore, smoking increases the shelf life of meat as a result of the combined effect of drying, antimicrobial and antioxidant activities of several smoke constituents mainly formaldehyde, carboxylic acids and phenols. An additional preservative effect is also brought about by the addition of salt before the smoking process. There are a number of traditional dried meat products prepared in different parts of the world that rely on the interaction of preservation techniques involving restriction of water activity by drying, use of salt and sugar to further control water activity, microbial growth and enzymatic action and use of spices to further limit microbial growth and to impart characteristic flavour. There are many methods used to prepare these ethnic meat products. These include exposure of strips of lean meat to the sun, as in the manufacture of *pemmican* by North America Indians, or a combination of salting followed by air drying, as in the preparation of *charque* in South America and *Biltong* in South Africa (Lawrie, 1979). Dried beef product *kilishi* in Africa is prepared by partial drying of beef in sun followed by addition of ingredients before the second period of sun drying and partial roasting.

In India the people living in hilly areas produce and consume dried and smoked meat products. *Idiyirachi* is the name given to dried beef consumed by the people in hilly areas of Kerala. *Satchu* and *suka ko masu* are dried beef products prepared and consumed by people living in Sikkim, Arunachal Pradesh, Darjeeling hills and Ladakh in India. Some of these ethnic meat products are sold in local market and it contributes to local economy (Rai *et al*., 2008).

High ambient temperatures and lack of refrigeration at the commercial and domestic level have necessitated the production of meat products having an extended shelf-life under room temperature. The traditional meat product because

of unhygienic processing practices and lack of proper packaging system leads to quick spoilage. The two important factors that limit the shelf life of the dried meat products are fungal growth and oxidative rancidity. In order to extend the shelf life of dried meat and to market the same, the processing techniques needs to be standardized with incorporation of proper packaging technology.

The de-acetylated form of chitin known as chitosan is a polysaccharide found in the shells of crab and shrimps. Chitosan (poly (β (1-4) N acetyl-D-glucosamine) has been reported to possess antimicrobial and antioxidative properties that can be exploited to develop eco-friendly coating for shelf stable foods. As chitosan exhibits antimicrobial activity in the laboratory against a range of foodborne fungi, yeast and bacteria, it has attracted attention as a potential food preservative of natural origin.

The purpose of packaging is to protect the meat product from microbial contamination, light, physical damage or chemical changes. Vacuum packaging has been more beneficial for long term storage of meat products as it minimises oxidative changes of meat products.

In recent decades, food irradiation has become one of the most discussed technology for the food safety and extension of shelf life. The Prevention of Food Adulteration Act, 1954 made amendments in 1998 by extraordinary gazette and permitted irradiation of meat and meat products including chicken employing gamma irradiation at a dose of 2.5 to 4.0 kGy for extending shelf life and to destroy pathogens.

The smoked and dried beef is an important traditional meat product of rural people in hilly areas. In order to get sufficient information on the production process of smoked dried beef, to produce the same and to assess the quality changes, the present study was undertaken

1. To assess the method of preparation and qualities of the locally available dried beef.
2. To standardize and prepare a shelf stable dried beef using hurdle technology *viz.,* chitosan application, smoking, packaging and irradiation.
3. To study the quality changes of the product on storage and to assess the shelf life under ambient temperature.

Review of Literature

2. REVIEW OF LITERATURE

Smoking of meat is one of the oldest methods of preservation in which the thermal combustion of wood produces smoke, which in turn penetrates into the meat and covers the surface area of meat. The various components of the smoke contain basically antimicrobials and germicidal as well as antioxidants which in turn brought about preservation. However smoking is not an absolute method of preservation, the quality of the final product depends upon the quality of the raw material as well as quality of smoke. Smoking is a method of value addition of meat with its own advantages and disadvantages. The major quality parameters *viz*., physicochemical, chemical, microbiological and sensory attributes of the final product can be improved by incorporating various hurdle technologies like irradiation, application of chitosan and packaging.

2.1. SMOKING OF MEAT

The concept of drying meat with the application of smoke and heat has been practiced for centuries. The ancient Egyptians were one of the first civilizations credited with applying this concept for further preservation (FSIS, 2006).

Okonkwo *et al.* (1991) reported that when meat is processed to intermediate moisture level, the incorporation of smoke components could further stabilize the product during storage.

Technically, smoking is the process through which volatiles from thermal combustion of wood penetrate meat or fish flesh (Simko, 1991).

The effect of curing by smoking with respect to quality and shelf life of the product depends on the preparation of the raw material, the type of smoking, relative humidity, velocity, temperature, density and composition of the smoke and the time of smoking (Doe *et al.,* 1998).

Smoking increased the shelf life of fish as a result of the combined effect of dehydration, antimicrobial and antioxidant activities of several smoke constituents mainly formaldehyde, carboxylic acids and phenols (Doe, 1998).

Kalilou *et al.* (1998) reported that the traditional techniques used in Africa, Latin America and Asia often combine drying with salting, smoking, frying, or fermentation which yielded a wide range of products such as biltong in South Africa, charque in Brazil and kilishi in Sahelian countries.

Gonulalan *et al.* (2003) reported that there were no large differences between the traditional and liquid smoked tongues in terms of chemical, microbiological and sensory properties. The traditional smoke application gives slightly better results than liquid smoke application.

2.2. CHITOSAN

The production of chitosan from crustacean shell waste consists of a number of processing steps like removal of protein from shell by treatment with 1-2 per cent Sodium Hydroxide followed by removal of calcium by 10 per cent Hydrochloric acid, deacetylation of chitin by treatment with 40-50 per cent Sodium Hydroxide, rinsing, pH adjustment and drying (Knorr, 1984).

The experimental evidence had shown that chitosan is safe (Hirano, 1992).

Chitosan solubility and charge density which allows the appearance of the antimicrobial effect is directly affected by the degree of deacetylation (Kubota *et al*, 2000; Zheng and Zhu, 2003).

Devlieghere *et al.* (2004) reported that various methods of preparation of chitosan results in difference in the deacetylation degree, distribution of acetyl groups, chain length and conformational structure and will have an influence on solubility, antimicrobial activity and other properties.

Rao *et al.* (2005) showed that there is an increase in reducing power of chitosan upon irradiation and indicated enhanced antioxidant activity that can be exploited for radiation processed food industry in reducing radiation induced lipid peroxidation.

Irradiation lead to 65 per cent and 41.3 per cent increase in antioxidant activity of chitosan over untreated and autoclaved chitosan respectively (Rao *et al.,* 2005b).

Rinaudo (2006) reported that solubility of chitosan is related to decetylation, ionic concentration and pH, nature of the acid used for protonation, distribution of acetyl groups along the chain and conditions of isolation and drying. Chitosan is usually soluble in acidic solutions and is tested in acetic acid by dissolving it in 1 per cent or 0.1 M acetic acid.

2.2.1. Food Applications of Chitosan

Furda (1980) patented chitosan use as lipid binding food additive.

Knorr (1982, 1983) reported its emulsification properties, dye absorption capacity and other properties of chitosan, such as water binding capacity, bioactivity and toughness, making it a quality material for incorporation in food industry.

Gennedios and Hanna (1997) reviewed the application of edible coatings of chitosan on meat, poultry and sea foods and opined that it could improve the quality of fresh, frozen and processed meat, poultry, and sea food products by retarding moisture loss, reducing lipid oxidation and discolouration.

Develieghere *et al.* (2004) reported that chitosan can be applied as a coating on fruits and vegetables and observed that *Bacillus cereus* was very sensitive to chitosan while *Listeria monocytogenes* and different lactic acid bacteriae were less susceptible.

Chitosan and its derivatives have got application in food industry as a protective, fungistatic and antibacterial agent. It can be used as a dietary fibre and to reduce cholesterol as it can bind to lipids (Rinaudo, 2006).

Shijin (2008) reported that the chitosan coating increased the shelf life of vacuum packed ready to eat chicken fry up to 7 days at room temperature and 32 days at chiller storage, whereas, the control samples spoiled at 5 days in room temperature and 28 days in chiller storage.

Recently, a chitosan starch film has been prepared using microwave treatment which may find potential application in the food packaging technology (Dutta *et al.*, 2009).

2.3. PACKAGING

Vacuum packaging lowers total plate count and favours lactobacilli, whereas pseudomonas usually dominates the spoilage microflora of PVC-wrapped meats (Pierson *et al.,* 1970; Roth and Clark, 1972; Gill, 1983).

Faster bacterial growth is favoured in PVC-wrapped meats compared to vacuum packaged meats (Seideman and Durland, 1983).

Smith *et al.* (1983) reported that vacuum packaging was superior to modified atmosphere packaging for maintaining desirable appearance of wholesale loins; however neither appearance nor palatability of cooked lamb chops was dependent on packaging method during wholesale storage of loin at 0 to 28 days.

Thayer (1993) showed that shelflife of poultry and beef can be significantly extended by ionizing radiation in combination with vacuum packaging or modified atmosphere packaging.

Monk *et al.* (1995) studied the use of vacuum packaging and irradiation of fresh ground beef at 1.5 and 2.5 kGy showing that vacuum packaging extend

shelf life for more than 15 and 21 days, respectively compared to shelf life of non irradiated which is only 4 days.

Vacuum packaging was better than aerobic packaging for irradiation and subsequent storage of meat, as it minimized oxidative changes in turkey patties and produced minimal amounts of volatile compounds that might be responsible for irradiation off-odour during storage (Ahn and Jo, 2000).

In food manufacturing, packaging is a post-production process, where a product is enclosed in a container (or wrapping) for many purposes, including protection, transportation, distribution, storage, retailing and end-use (Robertson, 2006).

Salke Dinkar Babanrao (2007) reported that vacuum packaging along with irradiation has significantly increased the shelf life of beef cutlet to three fold at chiller temperature compared to the control.

2.4. IRRADIATION OF FOOD

The meeting of the Joint Expert Committee (JEC), convened in 1976, recommended the unconditional acceptance of irradiated food items, including chicken. This paved the way for the development of Draft International General Standards on Irradiated Foods and a Draft International Code of Practice for the operation of irradiation facilities used for the treatment of foods through the Codex Alimentarius Commission (WHO, 1977).

The FAO / IAEA / WHO / Joint Committee on Irradiated foods at its meeting in Geneva in 1980 came to a conclusion that foods irradiated in the range up to 10 kGy are toxicologically as well as microbiologically safe and nutritionally adequate and that no health hazard results from consuming such irradiated foods (WHO, 1981).

In 1990, Food and Drug Administration and in 1992, United States Department of Agriculture approved irradiation at the dose range of 1.5 to 3.0

kGy for destroying pathogenic bacterial organisms. The USDA approved the dose up to 4.5 kGy (WHO, 1999).

The Food and Drug Administration in USA, amended the food additive regulations by establishing a new maximum permitted energy level of X-rays for treating food of 7.5 MeV provided that the X-rays are generated from machine sources that use tantalum or gold as the target material (FDA, 2004).

The irradiation technique offers the possibility of processing packaged meat products in great quantities although it requires a high investment and maintenance cost (Borsa, 2006).

In India, the Ministry of Health and Family Welfare amended the Prevention of Food Adulteration Act, 1954 through a special Gazette in 1998 and meat and meat products including chicken were permitted for irradiation at dose of 2.5 to 4.0 kGy to extend shelf life and to control pathogens (PFA, 1998)..

Kuttinarayanan *et al.* (2006a) stated that the treatment of meat with ionizing radiation is an effective method to reduce or eliminate several food borne pathogens and larvae of parasites.

According to Thayer (2007), radioactivity cannot be induced in foods by treatment with gamma rays from ^{137}Cs or ^{60}Co. Irradiation can inactivate protozoan or helminth parasites and significantly decrease the probability of viable foodborne bacterial pathogens in fish, poultry, and red meats.

2.5. SHELF LIFE

Bhagirathi and Sharma (1983) observed rapid proliferation of bacteria and onset of spoilage changes of mutton carcass by 6 to 8 h by exposing to natural atmospheric temperature.

Narsimharao and Shreenivasmurthy (1986) recorded the total plate count of meat stored at 30^{o}C on 0, 6, 12, 18, and 20 h of storage as 3.6, 4.2, 4.9, 6.2

and 7.2 log cfu per g respectively. Unacceptable odour was noticed at about 20 h of storage.

Aworh *et al*. (1999) reported that low dose irradiation, up to 6 kGy, inhibited microbial growth and extended the shelf life of traditional Nigerian meat and fish products. Irradiated 'kilishi' and smoked-dried catfish were found acceptable in sensory qualities by a consumer panel up to 4 to 6 months of storage at 21–31°C.

The effect of irradiation (2.0 kGy) on the growth and toxin production of S*taphylococcus aureus* and *Bacillus cereus* in roast beef and gravy during storage at temperature (15 and 22^{o}C) was assessed by Grant and Patterson (1992) and noted a 3.4 log reduction in number of these organisms.

Irradiated spices, packaging material (10.0 kGy) and luncheon meat (2.0 kGy) kept in refrigerator (1-4^{o}C) for 12 months showed that gamma irradiation decreased the microbial count of spices, packaging material and packed products and increased the shelf life. However, taste, odour, appearance and texture scores of irradiated product were significantly lower than non irradiated samples (Al-Bachir, 2005).

Jenifer (2006) reported that irradiation process preserved the minced beef for 8 to 10 days, 22 to 25 days and 32 to 33 days at 1.0, 2.0 and 3.0 kGy, respectively.

Ahire Girish Sureshrao (2009) reported that irradiation process increased the shelf life of chiken tikka up to 60 days where as the non irradiated samples spoiled around 25 days in aerobic packaging under chiller storage.

2.6. PHYSICAL QUALITIES (COLOUR AND ODOUR)

Modified atmosphere packaging such as flushing of nitrogen and carbon dioxide at different proportions or vacuum packaging suppressed the normal

poilage flora and thereby extend retail shelf life (Eyles and Warth, 1981; Stier *et al*., 1981; Fey and Regenstein, 1982).

According to Narsimharao and Sreenivasmurthy (1986) unacceptable odour in fresh meat was developed by 6 days at refrigerated storage (4 ± 1°C) when the shelf life of meat was assessed by considering sensory parameter such as discolouration and odour.

Paul *et al.* (1990) observed freshly ground mutton irradiated at 2.5 kGy had a better colour, odour and microbiological acceptability than nonirradiated or irradiated mutton at 1.0 kGy. The meat chunks irradiated at 1.0 and 2.5 kGy remained in acceptable condition for 3 and 5 weeks, respectively whereas the shelf life of irradiated mince was 2 and 4 weeks respectively. In contrast, non irradiated meat chunks and mince spoiled within one week of storage.

Grant and Patterson (1991) observed that microbiological population of irradiated pork was mainly composed of lactic acid bacteria, which were responsible for 'sour' or 'dairy' odours.

Vacuum packaging was better than aerobic packaging for irradiation and subsequent storage of meat because it minimized oxidative changes in turkey patties and produced minimal amount of volatile compounds that might be responsible for off odour during storage (Ahn *et al.,* 2000).

Badr (2004) reported that panelist preferred both irradiated and nonirradiated rabbit meat samples, as the samples were having high acceptance as judged by appearance and odour until rejection. Non irradiated samples were rejected due to appearance of mould growth, slime formation and off odours by day 6 while irradiated sample showed off odour and mould growth by 12 to 21 days of storage.

Kuttinarayanan *et al.* (2006b) studied the keeping quality of irradiated beef fry and reported an enhanced shelf life of 28 to 32 days in irradiated

samples, whereas control samples spoiled organoleptically by 7 to 9 days of storage in the chiller.

2.7. PHYSICOCHEMICAL QUALITIES

2.7.1. Proximate Composition

According to Sakala *et al.* (1987), carbohydrates, lipids, proteins and amino acids were affected to a minimal degree as a result of low to medium dose of irradiation.

Heath *et al.* (1990) showed that there was no difference in moisture content of non-irradiated (65.0 per cent) and irradiated (64.0 per cent) chicken meat at 100, 200, and 300 k rads.

In a study conducted by Katta *et al.* (1991) found that chicken carcass irradiated at various dose levels ranging from zero to 3.0 kGy using gamma radiation and stored in refrigerator conditions did not show any variation in their fatty acid profile.

Wheeler *et al.* (1999) conducted study on the proximate composition of ground beef patties and found that fat and moisture percentage were not affected by irradiation. They did not observe significant difference in the values of proximate composition between irradiated and non-irradiated patties up to 5 weeks in chiller storage.

Wu *et al.* (2000) studied the moisture loss and lipid oxidation of pre-cooked beef patties stored in edible coatings and observed 66 per cent reduction in relative moisture loss in chitosan coated beef patties after three days of storage.

Du *et al.* (2001) studied the cooked chicken patties packed in oxygen permeable or impermeable bags, irradiated at 0 or 3 kGy which on analysis revealed that average moisture, fat and pH were unaffected by irradiation.

Trace components of food such as essential amino acid, essential fatty acids, minerals and elements were unaffected under practical irradiation conditions although some vitamins such as vitamin C and vitamin B1 have partially lost (Lee, 2004).

Smith and Pillai (2004) reported that macronutrient (protein, lipid and carbohydrate) and mineral content were unaffected by irradiation.

Rana Raj (2006) observed irradiation at different doses did not significantly affect proximate composition like moisture, ether extract, protein, crude fibre, ash, nitrogen free extract, gross energy, calcium and phosphorus content of intermediary moisture pet food.

Salke Dinkar Babanrao (2007) in beef cutlet, Shijin (2008) in chicken fry and Sonika (2009) in rabbit meat did not observe any significant change in proximate composition due to either irradiation or packaging.

2.7.2. Sodium Chloride

Greenberg *et al.* (1959) studied the inhibitory effect of sodium chloride on growth and toxin production in *C. botulinum* types A and B in cured meat. With less than 6.25% sodium chloride there was no inhibition of toxin production as well as putrefactive changes. Between 6.25 and 9.0% there was no inhibition of toxin production, but the putrefactive changes did not occur, and above 9.0% the growth was inhibited.

Sodium chloride is one of the most frequently used ingredients in meat processing. Sodium chloride affects flavour, texture and shelf life of meat products. Besides the perceived saltiness, the sodium chloride brings out the characteristic taste of the meat product enhancing the flavour (Gillette, 1985).

Salt controlled microbial growth, enhanced the texture, ripening and shelf life of cheese. It lowered water activity, strengthened gel structure and enhanced color in processed meats (Ravishankar and Juneja, 2000).

The amount of sodium chloride that needs to be added in foods required to prevent microbial growth was about 16.54% salt solution to bring the water activity to 0.9. In certain instances, sodium chloride was added mainly as a flavoring and functional ingredient and hence in these cases the effect could be indirect. The antimicrobial effect of sodium chloride might be called indirect is which reduced the water activity in many foods and thereby indirectly prevents microbial growth (Ravishankar and Juneja, 2000).

A concentration of 8.0% or more of sodium chloride completely inhibited growth of enteropathogenic *E. coli* at different temperatures and pH levels while a concentration of 4.0% in combination with pH 5.6 and 200 ppm of nitrite did not inhibited growth of enteropathogenic *E. coli* (Ravishankar and Juneja, 2000).

2.7.3. Rehydration ratio

Although drying is one of the oldest and most widely used methods of food preservation, however, its success largely depends on the rehydration (reconstitution) of dried products. The dried products will be acceptable for food uses only if a good color, texture, flavor and nutritive value are resumed when these are reconstituted or rehydrated in water. Many factors affect the quality of the dried vegetables during reconstitution which includes the drying methods adopted, pre-treatment, period of soaking, temperature of soaking water, ratio of water to dried product, rate of heating and length of cooking. (Sarker and Setty, 1976).

The rehydration characteristics of dried product were used as a quality index and they indicate the physical and chemical changes during drying as influenced by processing conditions, sample pre treatment and composition (Feng and Tang, 1998)

2.7.4. pH

Niemand *et al.* (1981) reported that a dose of 2.0 kGy had little effect on the lactobacilli and the metabolites produced from these bacteria lowered the pH.

Irradiation did not influence the pH of fillet americain, but pH values of samples stored at 3ºC increased slightly by 0.2 to 0.4 pH units (Tarkowski *et al.*, 1984).

Increase in pH value during storage of cooked pork patties containing rosemary, ginseng and BHA/BHT as added antioxidant was reported. (McCarthy *et al*., 2001).

Irradiation did not show any significant effect on the pH of vacuum packaged turkey breast meat samples at 1.5 kGy on day 0, but increased slightly after 10 days of storage at 4ºC (Nam and Ahn, 2002).

The pH of the salmon trim (control) was 6.16 on day one of the experiment and all of the chitosan treated salmon trim samples had higher pH values, which increased with chitosan percentage (Todd Andrew Nicholas, 2003).

According to Biswas *et al.* (2006), there was no significant difference found among samples treated with different combinations of spice mix and curry leaf powder but the pH value of chicken patties increased significantly on day 7 and onwards.

Salke Dinkar Babanrao (2007) conducted a study on preservation of meat cutlet employing gamma radiation under different packaging systems and observed that pH values of the beef cutlet were non significantly increased from 0 to 10^{th} day of storage and thereafter it was gradually decreased.

Chukwu and Imodiboh (2009) reported an increase in pH upon storage in dried beef Kilishi.

2.7.5. Tyrosine value

The irradiation of meat at 1 to 10 kGy could be useful in retaining quality since proteolysis by endogenous enzymes would be diminished (Lawrie, 1998).

Karthikeyan *et al.* (2000) reported higher protein degradation in keema when stored at ambient temperature. The unusual higher tyrosine values noted in treated keema was due to proteolysis of added soy protein isolates and skim milk powder when compared to that of untreated keema.

Dushyanthan *et al.* (2001) observed that mutton packed in multilayered films under vacuum revealed lower mean tyrosine values of 20.54 mg and 21.35 mg per 100g of meat, respectively. Anaerobic environment and barrier property of multilayered film for oxygen led to lower proteolysis and hence the lowest tyrosine values.

Naveena *et al.* (2001) observed an increase in tyrosine value in smoked spent hen meat treated with ginger extract when stored at room temperature due to proteolysis.

There was no significant difference in tyrosine value among aerobic (8.89 mg/100g), vacuum (9.25 mg/100g) and modified atmospheric (8.59 mg/100g) packaging methods when the samples were stored at 4 ± 1^{o}C (Jayanthi, 2003).

Kuttinarayanan (2005) reported that proteolytic changes as estimated by tyrosine value had not shown any significant change between control and irradiated turkey breast samples initially. As the period enhanced from 0 to 25th day a non significant increase in tyrosine value was noticed, which is an expected biochemical change in refrigerated meats.

Jenifer (2006) reported that irradiation treatment of minced beef had no significant effect on tyrosine values compared to control samples at day zero. As storage days increased, tyrosine value increased with significant change among the treatments.

Rajeshkumar *et al*.(2007) reported that the mean values of tyrosine value of the pork nuggets increases during the shelf life study at chiller temperature (+4ºC) which is statistically deemed to be highly significant ($p<0.01$).

Tyrosine value of buffalo meat stored at chiller temperature (4ºC) increased significantly with increase in storage time (Kandeepan and Biswas, 2007).

Shijin (2008) observed that tyrosine value, indicating the proteolytic changes in meat showed a comparatively higher value in control non-irradiated samples (6.96 mg/100g) compared to the treatment groups with the lowest in chitosan treated irradiated (6.05 mg/100g) followed by irradiated samples (6.14 mg/100g) of chicken fry.

2.7.6. Thiobarbituric Acid Reactive Substances (TBARS)

Dempster (1985) reported that doses of 1.03 and 1.54 kGy irradiation of vacuum packaged beef burger gave significantly higher peroxide value than for raw control.

Narain *et al*. (1988) reported that the TBA values of reconstituted, salted and dried tilapia fillets decreased until 30 days of storage. Minimal variation in TBA values was observed with further increase in storage period up to 90 days.

Darmadji and Izumimoto (1994) showed that there is decrease in TBA values of minced meat during storage at 30ºC and the decrease depended upon concentration of chitosan. The chitosan concentration of 0.2, 0.5 and 1.0% decreased the TBA value by 10, 25 and 40% respectively. After 10 days of storage the TBA value of meat containing chitosan was the same as that of day 0, where as the TBA value of the control samples increased sharply.

According to Murano *et al.* (1998) ground beef patties irradiated (2.0 kGy) and stored under air and those irradiated under vacuum and stored under air, showed a higher degree of lipid oxidation (TBA value) compared with samples irradiated and stored under vacuum or non-irradiated.

Shahidi *et al.* (1999) reviewed about the antioxidant properties of chitosan in muscle foods for reducing the TBA values and warmed-over-flavor in cooked poultry and uncured meat.

Du *et al.* (2001) reported that at day 0, the TBARS of aerobically packaged turkey and pork patties were significantly higher than those of vacuum packaged, but not for beef. Aerobic packaging significantly increased TBARS in cooked turkey, pork and beef patties after seven days of storage, but vacuum packaging was very effective in preventing lipid oxidation irradiation and had only a minor effect.

The TBA values of smoked cat fish gradually declined during storage. TBARS decreased at week 2 and somewhat increased at week 4 then decreased again at week 6. This characteristic time course of TBARS could be due to aerobic packaging and room temperature storage (Silva, 2002).

In a study conducted by Kamil *et al.* (2002) on the antioxidant activity of chitosans of different viscosity in cooked comminuted flesh of herring (*Clupea harengus*) observed lower peroxide values, TBARS and total volatile aldehydes than the control samples. Low viscosity chitosan (14cP) exhibited the strongest antioxidative effect.

Aerobic packaging and irradiation both increased the lipid oxidation of turkey breast patties, but presence of oxygen was a more critical factor than irradiation on lipid oxidation during storage. The TBARS of meat was the highest with aerobic packaging, the lowest with vacuum packaging and in the middle with double packaging (Nam and Ahn, 2003).

Irradiation (2 kGy) and storage of turkey breast rolls (vacuum packaged shortly after cooking) increases the TBARS value from 0.104 to 0.175 mg mal/kg, while in non-irradiated it increased from 0.029 to 0.183 mg mal/kg at 0 to 28 days respectively because of presence of residual oxygen or oxygen permitting packaging material during storage. However, due to vacuum packaging TBARS did not change significantly at 0 or 14 days of refrigerated storage (Zhu *et al.,* 2004).

Rao et al. (2005) found out that TBARS values increased by 49 per cent due to irradiation (4.0kGy) in uncoated mutton kababs and chitosan coating (1 per cent) resulted in 24 per cent decrease in TBARS value in irradiated mutton kababs. Chitosan coated irradiated kababs during storage at ambient temperature had 28 per cent lower TBARS values than control samples.

Rao et al. (2005) reported that in case of intermediate moisture bacon the TBARS values increased by 56 per cent on irradiation. Chitosan coating lowered the values by 30 per cent. The TBARS values increased on storage of uncoated irradiated samples, but chitosan coating appears to prevent lipid peroxidation during storage since no significant difference was observed in irradiated samples on storage up to 28 days.

Kuttinarayanan and Ramanathan (2010) reported significant effect on TBARS value due to irradiation and storage in beef *Longissimus dorsi.*

2.7.7. Microbiological Analysis

2.7.7.1. Aerobic Plate Count (APC)

Niemand *et al.* (1981) reported that aerobic bacteria were reduced by 99.99 per cent in irradiated vacuum packaged beef cuts at dose of 2 kGy. However, at 4^{o}C storage there was a rapid increase in bacterial numbers in control and radurized samples for 5 weeks thereafter control samples maintain

level of approximate log 8 bacteria/ g whilst the number in radurized samples slowly increased until it reach unacceptable by 11 weeks.

Irradiation dose required for inactivating 90 per cent of the colony forming units (cfu) of common foodborne pathogens associated with meat and meat products were in the range of 1.0 to 4.0 kGy (Thayer, 1993).

Darmadji and Izumimoto (1994) studied the effect of chitosan in meat preservation and observed that 0.5-1.0 per cent chitosan inhibited the growth of spoilage bacteria in meat during incubation at 30°C for 48 hours or at 4°C for 10 days.

Zhao *et al.* (1996) studied packaging atmosphere had no apparent effect on total aerobic count in irradiated pork chops at 7 days, however air packed samples had a higher count than other treatment (vacuum or presence of carbon dioxide) at 14 days. Irradiation at dose of 1 kGy did not eliminate aerobic organism but reduced their numbers and subsequent growth during storage.

Shahidi *et al.* (1999) described the antimicrobial activity of chitin, chitosan and their derivative against different bacteria and the concentration of chitosan required for bacterial inhibition depends on the degree of acetylation of chitosan.

Giroux *et al*. (2001) showed that gamma irradiation below 5 kGy with antioxidants reduced bacterial populations with improved physicochemical qualities

Quattara *et al.* (2002) observed significant results ($P<0.05$) by combining γ-radiation and edible coating on APC of shelf stable foods like pre-cooked shrimps.

In a study conducted by Sunil *et al.* (2007) on the antimicrobial activity of chitosan on minced buffalo meat, a significant ($P< 0.05$) reduction in APC in meat mince with 0.5 per cent and 1.0 per cent chitosan was observed on day

eight of storage. Addition of chitosan resulted in one log reduction in *Staphylococcus aureus* counts on day six of chiller storage.

A significant reduction in Aerobic Plate Count was observed by low dose irradiation by Jenifer (2006) in minced beef, Kuttinarayanan (2007) in buffalo beef, Salke Dinkar Babanrao (2007) in beef cutlet, Shijin (2008) in chicken fry and Sonika (2009) in rabbit meat.

Kuttinarayanan *et al.* (2006a) reported that the treatment of meat with ionizing radiation is an effective method to reduce or eliminate several food borne pathogens and larvae of parasites.

Al-Bachir and Zeinou (2009) reported that all doses of gamma irradiation reduced the total mesophilic aerobic plate counts of minced camel meat. They also stated that the microbial shelf life of camel meat was significantly extended from less than 2 weeks (control) to more than six weeks (samples irradiated with 2, 4 or 6 kGy) in refrigerator.

2.7.7.2. Yeast and Mould Count (Y&M)

Niemand *et al.* (1983) reported that vacuum packaging contributes to shelf life extension of ground beef and simultaneously it suppressed the fungal growth so vacuum packaging can be combined with irradiation to extend the shelf life of ground beef.

Abu-Tarboush *et al.* (1997) showed that yeasts of genera *Candida*, *Saccharomyces* and *Alternaria* started to grow on day 12 in chicken treated with less than 5.0 kGy, but not in samples treated with more than 5 kGy and stored at 4^{o}C for 21 days of storage.

Narvaiz *et al.* (1998) compared the effects of radiation on *Aspergillus parasiticus* and showed that heated or irradiated samples had a decreased level of aflatoxin as compared to untreated samples, and the combined treatment reduced the aflatoxin level below the detection limit of less than 30 ppb.

Nieto-Sandoval *et al.* (2000) observed moulds, yeasts and sulfite reducing *Clostridia* were the most resistant species, although irradiation at 10.0 kGy led to optimum sanitization of red paprika.

Kannat *et al.* (2004) reported that gamma irradiation at doses below 10 kGy used to control fungal growth.

Some of the known yeasts that cause spoilage of meat products are *Debaromyces*, *Candida*, *Rhodotorula* and *Trichosporon*. *Debaromyces* and *Candida* are found to cause spoilage in cured meat. On the other hand, *Trichosporon* caused rancidity on refrigerated beef, poultry and lamb due to degradation of lipids by lipase (Jay *et al.* 2005).

Sebti *et al.* (2005) found that 0.1 per cent chitosan inhibited the total growth of *Aspergillus niger* for 10 days.

Balamatsia *et al.* (2006) studied the effect of low dose radiation on the microbiological characters of chicken meat stored aerobically at 4^{o}C and they found that *Pseudomonas* sp*., Enterobacteriaceae*, yeast and moulds were highly sensitive to gamma radiation and were completely eliminated at 2 kGy.

Chouliara *et al.* (2006) reported that yeast were most resistant followed by lactic acid bacteria and their reduction is dose dependent. Yeast did not show any major growth due to injury caused by irradiation (2 and 4 kGy) but survival without death. Hence, irradiation did not affect the yeast population during 28 days of ripening of fermented sausage.

Kuttinarayanan *et al.* (2006c) observed a 97 per cent reduction with respect to yeast and mould count in minced beef by irradiation at 2.0 kGy.

Kuttinarayanan (2007) reported 95 to 98 per cent reduction with respect to yeast and mould count in meat and meat products by irradiation at 2.0 kGy.

2.7.8. Organoleptic Qualities

2.7.8.1. Colour

Kropf (1980) reported that colour is probably the single greatest appearance that determines whether the meat cut would be purchased.

Darmadji and Izumimoto (1994) opined that addition of chitosan to meat resulted in better sensory attributes and had good effect on the development of red colour of meat during storage. There was an increase in a* and b* values of all chitosan added meat samples during storage.

In a sensory evaluation of irradiated ground beef (1.0, 2.5 and 5.0 kGy) conducted, revealed that odour and flavour of the irradiated cooked ground beef was slightly disliked while no difference was perceived in the colour and texture. The lower the dose of irradiation, the better the taste appreciated (Lefebvre *et al.*, 1994).

Fresh meat can be spoiled at ambient temperature by psychrotrophic microorganisms. However, at temperatures above 25°C it will be spoiled by mesophilic Enterobacteriaceae and Acinetobacter (Garbutt, 1997).

Sensory evaluation was conducted by Fu *et al.* (1995) in raw beef steaks and ground beef irradiated at 2.0 kGy and reported no significant difference in colour, but detected off odours which quickly dissipated after opening vacuum pouches.

Murano *et al.* (1998) showed that irradiation did not affect colour of ground beef patties, with differences being due to packaging atmosphere. Samples stored under vacuum were darker and redder than aerobically packed samples.

The extent of colour change by irradiation in vacuum packaged cooked pork sausage was lesser than that of raw pork. Irradiation significantly increased

the redness of cooked vacuum packaged sausages regardless of storage time (Jo *et al.*, 2000).

Gonulalan *et al.* (2003) conducted sensory evaluation of smoked beef tongue prepared by traditional smoking and liquid smoking and reported that traditionally smoked tongue received higher scores for colour compared with liquid smoked ones and results were statistically significant at 10^{th}, 15^{th} and 30^{th} day of storage.

Zhu *et al.* (2003) reported that irradiation up to 2 kGy had limited effects on colour and oxidation of vacuum packaged commercial turkey ham.

Smith and Pillai (2004) reviewed that irradiation at a dose less than 3 kGy had no significant effect on flavour, texture or colour of ground beef.

Shijin (2008) reported that there was significant improvement in colour by chitosan coating, irradiation and their combination (8.35, 8.36, and 8.39 respectively) than control non-irradiated (8.31) samples of chicken fry on the day of preparation.

2.7.8.2. Flavour

Flavor of raw meat comes from juice that depends on saltiness, sweetness of blood and less importantly depends on presence of creatine and creatinine (Crocker, 1945).

Niemand *et al.* (1981) observed a higher ranking throughout storage period for both appearance and odour evaluation in radurized samples. On the day of irradiation, experienced person could detect a faint but typical irradiation odour in radurized samples although it was not found to be objectionable. Radurized samples had a low score in fourth week and higher score at eight week than control when evaluated for aroma and taste.

Ahn *et al.* (1998) suggested that irradiation produced many unidentified volatiles products that could be responsible for the off odour in irradiated raw meat.

Drying and aging is another factor that can affect the flavor of meat products (Aberle *et al.* 2001).

Zhu *et al.* (2003) reported that irradiation had a significant influence on odour and flavour of vacuum packaged turkey ham, but overall quality changes in irradiated turkey ham at 2.0 kGy were less.

Traditionally smoked tongue samples scores were increased with storage time for flavor and aroma, with values of 7.0 and 8.67 at 0 and 30 days of storage, respectively. These values were 6.33 and 7.33 for liquid smoked tongues, respectively and were significantly different (Gonulalan *et al.,* 2003).

Kanatt *et al.* (2005) reported that irradiation of Indian ethnic meat product like chilly chicken, mutton shammi kabab and pork salami either at 1, 2 or 3 kGy did not impart any detectable odour.

One of the procedures used for development of aroma and flavor is smoking. Flavors of smoking come from phenols, alcohol, organic acids and carbonyl groups of wood smoke (Jay *et al.,* 2005).

Shijin (2008) reported that, in chiller stored chicken fry samples significant reduction of flavour score was noticed with enhanced storage period.

Brewer (2009) showed that irradiating fresh meat, even at low doses, can result in off-odours and flavours which have been described as rotten egg, bloody, fishy, barbecued corn, burnt, sulfur, metallic, alcohol or acetic acid and suggested methods to decrease the detrimental effects of irradiation include oxygen exclusion (vacuum packaging), replacement with inert gases (nitrogen), addition of protective agents (antioxidants), and post-irradiation storage to allow flavour to return to near normal levels .

2. 7.8.3. Juiciness

Berry *et al.* (1981) stated that hot boned roast from *semimembranosus* and *semitendinosus* muscles had higher shear force values, higher amount of connective tissue, lower tenderness and higher juiciness score than cold deboned cooked roast when served as cubes.

Smith *et al.* (1983) reported that after 7 days of storage cooked chops from loins that had been vacuum packaged were less juicy than cooked lamb chops from loins that had been packaged in either of the modified atmospheres (20 per cent CO_2, 80 per cent N_2 or 40 per cent CO_2, 60 per cent N_2). There was no difference in juiciness, flavour desirability or overall palatability among cooked chops that were related to the method of packaging.

Luchsinger *et al.* (1996) evaluated acceptance of fresh or frozen irradiated boneless pork chops (1.5, 2.5 and 3.85 kGy) using a trained panelist and consumers. They did not observe any differences in acceptance, meatiness, freshness or juiciness of products irradiated at 2.5 kGy or below.

Abu-Tarboush *et al.* (1997) reported that irradiation doses (2.5 to 10.0 kGy) had little effect on the sensory acceptability (appearance, odor, texture and taste) of both raw and cooked chicken. Moreover, juiciness and tenderness of cooked chicken were only slightly affected by irradiation.

Johnson *et al.* (2004) showed that overall acceptance, juiciness and tenderness of non-irradiated diced chicken and frankfurters were significantly lower than irradiated (1, 2 and 3 kGy) at day 18 and day 32, respectively at 4^{o}C.***2. 7.8.4. Tenderness***

Collagen shrinks when irradiated wet (Perron and Wright, 1950) and caused softness and tenderness of texture as an immediate effect (Coleby *et al.*, 1961).

Perception of tenderness has been described in terms of following conditions of meat during mastication such as softness to tongue and cheek, persistence to tooth pressure, ease of fragmentation, meatiness, adhesion and residue after chewing (Forrest *et al.,* 1975).

If the meat is tender, consumers see it as juicy and flavorful (Shorthose and Harris, 1991).

According to Huffman *et al.* (1996), when consumers were asked if tenderness, juiciness or flavor was the most important factor determining their eating satisfaction, 51 per cent of consumers said that tenderness was the most important factor determining their eating satisfaction at home or at a restaurant.

Tenderness has strong positive correlation with overall likeness of the meat (Neely *et al.,* 1998).

Murano *et al.* (1998) investigated the changes in flavour, texture and juiciness of ground beef patties after either 2 or 7 days storage at 25^{o}C prior to cooking. It was noted that, irradiated, air or vacuum packed samples were more tender, irradiated vacuum packed samples were more moist and irradiated air packed samples had least after taste.

Ohene-Adjei *et al.* (2004) reported that irradiation (1.5 kGy) of loin chops decreases the tenderness, which might be due to weakened texture of meat system due to irradiation that caused loss of moisture through drip or purge loss.

Arthur *et al.* (2005) suggested that on low dose irradiation (1 kGy) of ground beef patties the tenderness and juiciness were not dose related and ratings decreased with increased duration of frozen storage.

Kanatt *et al.* (2006) observed that irradiation treatment did not cause any significant changes in the textural properties and sensory qualities of ready to eat shrimps.

Kuttinarayanan and Ramanathan (2010) opined that a combination of irradiation and electrical stimulation could improve tenderness and reduce aerobic plate count of meat obtained from old bulls.

2. 7.8.5. Overall acceptability

When beef was irradiated by 1.0 kGy prior to the addition of mayonnaise sauce showed no significant taste difference when compared to non irradiated samples (Tarowski *et al.*, 1984).

Darmadji and Izumimoto (1994) reported that addition of chitosan to meat resulted in an increase in overall sensory attributes. There was a decrease in rancidity and spoilage flavours of beef mince prepared with chitosan thereby causing a more acceptable taste.

The consumer acceptance of irradiated poultry cooked products based on colour, appearance, flavour, mouth feel and overall acceptability using a nine point Hedonic scale, 73 per cent participants gave the product a minimum rating of 7.0. (Hashim *et al.*, 1995).

Badr *et al.* (2004) studied that the samples of fried burgers prepared from both irradiated and non-irradiated fresh rabbit meat had similar high score for odour, taste, texture and juiciness. This indicated that irradiation of rabbit meat at 1.5 and 3.5 kGy doses did not significantly affect the sensory quality of cooked meat.

Johnson *et al.* (2004) reported that although quality of the irradiated samples decreased with increasing storage time, the overall acceptance of flavour, juiciness, tenderness and mouth feel of non-irradiated diced chicken and frankfurter were significantly lower than irradiated (1, 2 and 3 kGy) at day 18 and 32, respectively.

Consumer acceptance study of irradiated cutlet, beef and minced beef by Kuttinarayanan (2005) revealed that 20 to 22 per cent consumer responded, 72.5

per cent liked to purchase irradiated cutlet and 37 per cent were ready to pay more to irradiated product, since it can be kept at chiller conditions. Majority of them did not observe any peculiar smell or taste difference in the products due to irradiation.

Materials and Methods

3. MATERIALS AND METHODS

The study on the effect of low dose gamma radiation and chitosan on shelf-life and quality changes of Smoked dried beef under aerobic and vacuum packaging was conducted at the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy.

Six batches of Smoked dried beef was prepared, packaged, irradiated at 2.5 kGy and stored at room temperature (25-30^{o}C). Samples were analysed for physical, physicochemical, microbiological and organoleptic qualities on the day of preparation and on day 5, 10, 15, 20, 25, 30, 45, 60 and 75 of storage or until spoilage, whichever was earlier. The samples were also analysed for proximate composition on the day of preparation.

3.1. SURVEY AT ADIMALY GRAMAPANCHAYAT

A survey was conducted in hundred houses at Adimaly Grama Panchayat in Idukki District where traditionally smoked beef is a popular product and the details regarding the methodology of production of Smoked dried beef were collected using a questionnaire (Appendix I). Twenty five samples were procured and brought to Department of Livestock Products Technology and analysed for physical, physicochemical, microbiological and organoleptic qualities.

3.2. PREPARATION OF SMOKED DRIED BEEF

Cattle in the age group of 6-8 years brought from Kerala Livestock Development Board farms were given sufficient rest, slaughtered and dressed under hygienic condition in the Department of Livestock Products Technology. The *Longissimus dorsi* muscles of the slaughtered cattle were harvested. The meat was cut into steaks of size of 4”×2”×0.5” (Length, Breadth, Thickness). Half of the sample was rubbed with sodium chloride (10.0g), powdered pepper (1.0 g) and turmeric (0.5 g) per 100 g of meat. Other half of sample was rubbed

with sodium chloride (10.0 g), powdered pepper (1.0 g), turmeric (0.5 g) and chitosan (1.0 g) per 100 g of meat so that uniform distribution of ingredients on the surface was obtained. The samples were kept for one hour at room temperature. The steaks so prepared were subjected to smoking at smoke house for six hours. The temperature and humidity of the smoke house were recorded. The weight loss of the samples was recorded.

3.3. PACKAGING

3.3.1. Aerobic Packaging

Eighty grams of Smoked dried beef was aerobically packaged in oxygen permeable high-density polyethylene pouches (HDPE, 200 μ) and sealed by pulsed sealing machine (Sevana, Kochi).

3.3.2. Vacuum Packaging

Similarly, eighty grams of Smoked dried beef was vacuum packaged (740 mm of Hg) in oxygen impermeable polyamide-polyethylene pouches (PA-PE, 80 μ, OTR: < 52 cc / m^2 / 24 h, CO_2 TR: 208 cc / m^2 24 h, WTR: 5 g / cc / m^2 / 24 h at 38^oC, 90 per cent RH) using a single chamber vacuum packaging machine (Sevana, Kochi).

3.4. GAMMA IRRADIATION

Half of the packets of aerobic and vacuum packaged samples were subjected to gamma radiation at 2.5 kGy using Gamma Chamber 5000, (BRIT-DAE, Mumbai) where ^{60}Co is the source of radiation.

The samples were designated as follows and kept at room temperature.

1. ANR - High Density Polyethylene packed, Non irradiated
2. AIR - High Density Polyethylene packed, Irradiated
3. CANR - Chitosan added, High Density Polyethylene packed, Non irradiated

4. CAIR - Chitosan added, High Density Polyethylene packed, Irradiated
5. VNR - Polyamide Polyethylene packed, Non irradiated
6. VIR - Polyamide Polyethylene packed, Irradiated
7. CVNR - Chitosan added, Polyamide Polyethylene packed, Non irradiated
8. CVIR - Chitosan added, Polyamide Polyethylene packed, Irradiated

3.5. PHYSICAL QUALITIES

Smoked dried beef samples kept at room temperature were opened on 0, 5, 10, 15, 20, 25, 30, 45, 60 and 75 days of preparation and examined for signs of spoilage, *viz*., change in colour, odour, consistency, slime formation and mould growth.

3.6. PHYSICOCHEMICAL QUALITIES

3.6.1. Chemical Composition

3.6.1.1 Proximate Composition

Smoked dried beef was analysed for its proximate composition, *viz*., moisture, fat, protein, ash and acid insoluble ash content on the day of preparation. The composition was expressed as percentage of the Smoked dried beef.

3.6.1.1.1. Moisture

The moisture content of the Smoked dried beef was analysed as per (AOAC, 1990). A 30 g sample in an evaporating dish was kept in a hot air oven at 100ºC to 102ºC for 16 to 18 h. The weight of the dry samples was taken after cooling in a desiccator. The difference in the weight was recorded as the moisture content and expressed as percentage.

3.6.1.1.2. Fat

Fat was estimated as per AOAC (1990). Fat content of three grams of moisture free sample was extracted in petroleum ether (boiling range 40-60^{o}C) using Socs Plus Solvent Extraction System (Pelican Equipments, India). Ether extract obtained was dried to a constant weight at 100^{o}C, cooled and weighed. The difference in weight is the total fat content of sample and expressed as percentage of the smoked dried beef.

3.6.1.1.3. Protein

The Copper Catalyst Kjeldal method was used to determine the protein content of the samples (AOAC, 1990). The analysis was conducted in Kel Plus Nitrogen Estimation System (Pelican Equipments, India). The total nitrogen estimated was converted to percentage of protein by multiplying with the constant.

Protein % = 6.25 X % Nitrogen.

3.6.1.1.4. Ash

Ash is the total mineral content of a sample. Five grams of sample was placed in a silica crucible and kept in a muffle furnace at 600±20^{o}C for 2.5 hours. Then the sample was transferred to a desiccator, allowed to cool and weighed immediately. The resultant weight is the total mineral content of the sample and ash content was converted to wet matter basis (AOAC, 1990).

3.6.1.1.5. Acid Insoluble Ash

To the ash obtained 25 ml of dilute hydrochloric acid (1:1) is added and the mixture is boiled for 5 minutes. It is then filtered through a quantitative filter paper. The residue is thoroughly washed with hot water. The filter paper is dried and burned to obtain the amount of ash. The amount of acid-insoluble ash is obtained by subtracting the filter paper ash from the total ash (AOAC, 1990).

3.6.1.1.6. Energy Calculation

The energy content of Smoked dried beef was determined as per FAO (2002) on wet matter basis.

Energy (kcal) = (fat per cent x 9) + (protein per cent x 4) + (carbohydrate per cent x 4).

3.6.1.2. Sodium Chloride

The samples were digested in concentrated nitric acid and perchloric acid (AOAC, 1990). The wet ash obtained after digestion was used for estimating sodium content. Sodium content of the samples was estimated by flame photometer (Systronics 128, India). The sodium obtained in parts per billion was expressed as sodium chloride in gram percentage.

3.6.2. Rehydration Ratio

Smoked dried beef was dipped in water for one hour for rehydration. The product and water proportion was 1:20. The rehydration ratio was calculated by dividing the rehydrated weight by that of dehydrated sample (Narain *et al.* 1998).

3.6.3. pH

The pH was determined as per Garcia *et al*. (1995). The pH was determined in slurries made from 10g samples in 10 ml distilled water blended in a stomacher (Seward Stomacher® 400 circulator). Measurements were made with a digital pH meter (µ pH system-Systronics, India).

3.6.4. Tyrosine Value (TV)

The tyrosine values of the samples were estimated as per the method described by Pearson (1968) as follows.

Two grams of sample were weighed and 40 ml of 5 per cent trichloroacetic acid solution were added. After homogenization for 2 min the

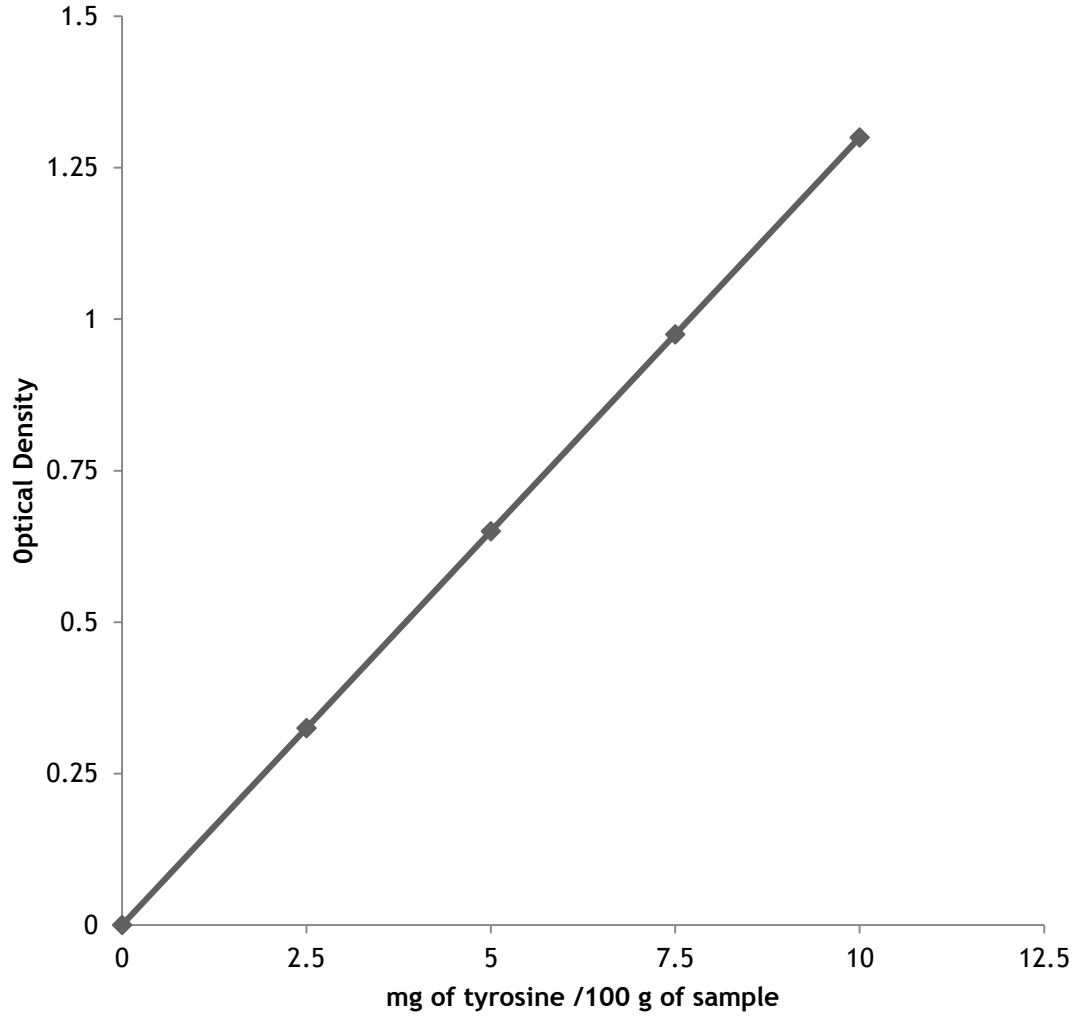

Figure 1. Standard graph for Tyrosine value

sample was filtered and the filtrate was collected. The filtrate, termed TCA extract was used in the estimation of tyrosine value. To 2.5 ml of TCA extract, equal quantity of distilled water was added in a test tube and shaken with 10 ml of 0.5 N NaOH and 3 ml of diluted Folin and Ciocalteu's phenol (FC) reagent (1 ml of concentrated FC reagent and 2 ml of distilled water). After mixing, the contents were allowed to stand for 5 min at room temperature, the optical density was measured at 660 nm in UV-Vis Spectrophotometer 119 (Systronics, India) using a blank containing 2.5 ml of 5 per cent TCA, equal quantity of distilled water was added in a test tube and shaken with 10 ml of 0.5 N NaOH and 3 ml of diluted Folin and Ciocalteu's phenol (FC) reagent (1 ml of concentrated FC reagent and 2 ml of distilled water) for comparison. By reference to the standard graph (Figure) the TV was calculated and expressed as mg/100 g of Smoked dried beef.

3.6.4.1. Standard Graph for Tyrosine Value

0.1 g tyrosine were dissolved in 5 per cent trichloroacetic acid in a 500 ml volumetric flask and then solution was made up to the mark with water. The following volumes of tyrosine solution were then added to a series of 100 ml volumetric flasks: 0, 1, 3, 5, 7, 10, 12, 15, 20 ml. Each was made up to the mark with double distilled water and mixed. 5 ml of each solution were shaken with sodium hydroxide solution and diluted Folin and Ciocalteu's reagent and then treated as described as for the determination above. The standard graph (Figure 1) was prepared by plotting optical density against mg tyrosine/100 g sample (assuming that 2 g were used).

Recoveries were checked by adding known amounts of tyrosine dissolved in trichloroacetic acid solution.

3.6.5. Thiobarbituric Acid Reacting Substances (TBARS)

The TBARS were determined as per Witte *et al.* (1970) with modifications. Accurately weighed 20 g sample was blended with 50 ml chilled

extracting solution containing 20 per cent trichloroacetic acid in 2 M ortho-phosphoric acid for 1.5 to 2 min. The resultant slurry was transferred to a 100 ml volumetric flask. Then the sample was made up to 100 ml using deionised distilled water. This solution was filtered through Whatman No.1 filter paper. Five ml filtrate was transferred to a screw capped vial followed by the equal quantity of 2-thiobarbituric acid solution (Merck, Germany) (0.005 M in distilled water). The solution was mixed by inverting the vial and kept for 15 h in darkness at room temperature. The absorbance was determined at 530 nm against blank containing 5 ml distilled water and 5 ml 2-thiobarbituric acid solution (0.005 M in distilled water) in UV Vis Spectrophotometer 119 (Systronics, India). The absorbance was converted to TBARS values and was expressed as mg of malonaldehyde per kg (mg mal / kg) of Smoked dried beef.

3.7. MICROBIOLOGICAL ANALYSIS

Sealed packets of Smoked dried beef was opened under aseptic precautions and 25 g of the sample was homogenized for 30 seconds at 230 rpm with sterile 225 ml of 0.01 per cent peptone water (diluent) in a stomacher (Seward Stomacher® 400 circulator) so as to form one in 10 dilution of the sample. Further serial 10 fold dilutions were prepared by transferring one millilitre of inoculum to nine millilitre of the diluents. Selected serial dilutions were used to estimate the count of aerobic bacteria, yeast and mould and converted and expressed as $\log_{10}$ cfu (colony forming units)/g of sample.

3.7.1. Aerobic Plate Count (APC)

Aerobic plate count (APC) of each sample was estimated by pour plate technique, as described by Mortan (2001). From the selected dilution of each sample, 1 ml of inoculum was transferred in labeled duplicate petri dishes of size 100×17 mm. To each of these inoculated plates, about 15-20 ml sterile molten Standard Plate Count Agar (HiMedia, Mumbai) maintained at 45^{o}C was poured and mixed with the inoculum by gentle clockwise, anticlockwise, forward and backward movements. The inoculated plates were allowed to solidify at room

temperature and incubated at 37°C for 24 hours in inverted position. At the end of the incubation period, the plates having colonies between 20 and 200 were selected and counts were taken with the help of a digital colony counter (Royal, India). The number of cfu per g of the sample was calculated by taking the average of duplicate plates and multiplied by the dilution factor and converted to $\log_{10}$ cfu/g of sample.

3.7.2. Yeast and Mould Count

Method described by Beuchat and Cousin (2001) was followed for estimation of yeast and mould count per gram of the sample. Potato Dextrose Agar (HiMedia, Mumbai) was used for the estimation of yeast and mould count by pour plate technique. From the selected dilutions of each sample 1 ml of inoculum was transferred on to duplicate plates. To each plate 15 to 20 ml of sterile molten media at 45°C was added, mixed well and allowed to solidify. The plates were incubated at 25-27°C for 3 days. After incubation colonies were counted with the help of a digital colony counter (Royal, India) and average count was multiplied with the dilution factor and expressed as $\log_{10}$ cfu/g.

3.8. ORGANOLEPTIC EVALUATION

The organoleptic evaluation was undertaken after desalting, rehydration, and frying of Smoked dried beef. The panelists were served with coded samples and a score card was also provided (Appendix II). They were asked to rate in the nine point Hedonic scale (Badr, 2004). The individual scores were recorded and the average was taken as the score for the particular attribute.

3.9. COST OF PRODUCTION

The cost of production of Smoked dried beef was calculated based on the prevailing cost of beef and other ingredients used for the preparation.

3.10. STATISTICAL ANALYSIS

The data obtained with respect to physiochemical, microbiological and sensory evaluation of the samples were analyzed by one way analysis of variance and Wilcoxon test using SPSS package (version 17) as per Snedecor and Cochran (1994).

Results

4. RESULTS

4.1. SURVEY AT ADIMALY GRAMAPANCHAYAT

In order to get information about the method of preparation, ingredients incorporated, keeping quality and method of preservation of locally available smoked dried beef a survey was conducted with a questionnaire, in 100 houses at Adimaly Gramapanchayat, Idukki district, Kerala. Among them 98 percent consumed either sun dried beef or smoked dried beef. The details are given in table 1.

Table 1. Percentage consumption of various dried beef

Sl. No.	**Type**	**Percentage (n:100)**
1	**Smoked dried beef**	53
2	**Sun dried beef**	18
3	**Both sundried and smoked beef**	27
4	**Not consumed**	2

More than 50 per cent of the persons surveyed consumed dried beef at least once in two to four months. About 12 per cent of the people consumed dried beef very rarely. It was observed that 82.65 percent of the consumers prepared product in their home itself (Table 2).

Table 2. Sources of dried beef

	Source	**No. of persons (98)**	**Percentage**
1	**Market**	6	6.12
2	**Home**	81	82.65
3	**Free supply**	11	11.23

Among the 82.65 per cent who prepared dried beef at home, 64 per cent preferred smoke drying as the method of preparation. The other methods include sun drying (21 per cent) or a combination of sun drying and smoking (15 per cent).

Salt was the major ingredient used for curing. Eighty persons out of 81 surveyed used salt as ingredient and 96 per cent used turmeric. Along with salt and turmeric few persons used ingredients such as pepper, chilli powder, garam masala etc. (Table 3).

Tabe 3. Common curing ingredients used

Sl. No.	Ingredients	No. of persons (81)	Percentage
1	**Salt**	80	98.76
2	**Turmeric**	78	96.30
3	**Pepper**	32	39.51
4	**Chilli powder**	4	4.94
5	**Other ingredients such as Garam masala, coriander powder, green chilli, ginger**	3	3.70

Those who had practised sun drying; the period of drying varied from 3-6 days on hot summer days. The smoking was conducted by hanging the meat above the traditional oven and the smoke was generated from fire wood. The process continued for 3 to 4 days.

The various method of packaging included polythene covers, wrapping in polythene covers, keeping in bamboo baskets or use of air tight containers. The average shelf life noticed was about 4 -5 weeks with shortest duration of 3 -4 weeks in plastic tins. Some preferred refrigerated storage (Table 4).

Table 4. Different method of packing and storage

	Method of packing	Number (81)	Percentage	Average shelf life obtained (weeks)
1	**Plastic tins (Room temperature)**	37	45.68	3-4 weeks
2	**Polythene covers- sealed (Room temperature)**	6	7.41	4-5 weeks
3	**Wrapping in polythene covers (Room temperature)**	13	16.05	4-5 weeks
4	**Kept in bamboo baskets above oven**	23	28.4	4-5 months
5	**Refrigeration**	2	2.47	4-5 months

Out of 100 persons surveyed, only four has marketed their product on small scale in different areas. Their response is shown in table 5. It was observed that there is a heavy demand and a good profit for the product. Unfortunately very few want to refine their technology and to get trained better in the field.

4.1.1. Quality Analysis of the Samples

Twenty five samples collected from different producers were divided according to the method of preparation in to three groups and were subjected to assessment of chemical composition (Table 6), physicochemical qualities and microbiological qualities (Table 7).

The moisture, fat, protein, ash, energy and sodium chloride content varied non significantly ($P>0.05$) between samples prepared by different producers in different methods, where as acid insoluble ash and carbohydrate content were significantly ($P<0.05$) different. Similarly physicochemical qualities like pH, TBARS, TV, Rehydration ratio were non significant between samples procured from different producers. Aerobic plate count and yeast and mould count were significantly different among samples prepared in different methods by producers.

Table 5. Details of marketing of dried beef

Sl. No		PALCO	MALABAR	HIGHRANGE MEATS	Home Made
1	**Marketing area**	Adimaly	Idukki, Ernakulam	Idukki	Neriamangalam
2	**Market**	Bakery	Small retail shops	Cold storage & shops	Directly from home
3	**Price fixation**	According to price of meat, ingredients and labour	According to price of meat, ingredients, labour and demand	According to price of meat, ingredients, labour and demand	Price of meat
4	**Demand**	High	High	High	High
5	**Profit**	Satisfactory	Satisfactory	Good	Marginal
6	**Constraints**	Nil	Nil	Nil	Unexpected spoilage in some seasons
7	**Satisfaction with present method/ technology**	Yes	Yes	Yes	No
8	**Requirement of improved technology**	No	No	No	Yes
9	**Contact with scientific personnel**	Not contacted	Not contacted	Not contacted	Not contacted
10	**Interest in training**	No	No	No	Yes

Table 6. Chemical composition of samples from survey

	Moisture	Fat	Protein	Ash	Acid Insoluble Ash	CHO	Energy	Sodium chloride
Sun Dried Beef	$21.41^{a}\pm1.81$	$10.88^{a}\pm0.96$	$55.03^{a}\pm2.27$	$5.51^{a}\pm0.43$	$0.05^{a}\pm0.001$	$7.18^{ab}\pm0.40$	$346.75^{a}\pm8.2$	$3.86^{a}\pm0.95$
Smoked Beef	$21.09^{a}\pm1.62$	$9.07^{a}\pm0.77$	$58.15^{a}\pm1.99$	$4.97^{a}\pm0.61$	$0.07^{b}\pm0.005$	$6.73^{b}\pm0.49$	$341.10^{a}\pm6.8$	$2.67^{a}\pm0.40$
Dried Beef (Sundried & Smoked Beef)	$23.61^{a}\pm1.16$	$8.31^{a}\pm0.42$	$57.70^{a}\pm0.88$	$4.64^{a}\pm0.56$	$0.08^{c}\pm0.004$	$5.74^{bc}\pm0.28$	$328.56^{a}\pm6.71$	$3.04^{a}\pm0.67$

Table 7. Physicochemical and Microbiological qualities of samples from survey

	pH	TBARS	TV	Rehydration Ratio	Aerobic Plate Count($\log_{10}$ cfu/g)	Yeast And Mould Count($\log_{10}$ cfu/g)
Sun Dried Beef	$5.60^{a}\pm0.07$	$0.62^{b}\pm0.07$	$1.09^{c}\pm0.05$	$1.25^{d}\pm0.02$	$3.28^{a}\pm0.14$	$3.41^{a}\pm0.15$
Smoked Beef	$5.54^{a}\pm0.06$	$0.44^{b}\pm0.04$	$1.07^{c}\pm0.05$	$1.15^{d}\pm0.01$	$2.45^{b}\pm0.07$	$2.95^{b}\pm0.06$
Dried Beef (Sundried & Smoked Beef)	$5.42^{a}\pm0.05$	$0.62^{b}\pm0.07$	$1.05^{c}\pm0.06$	$1.16^{d}\pm0.02$	$3.21^{a}\pm0.07$	$3.66^{c}\pm0.14$

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$)

4.2. PREPARATION OF SMOKED DRIED BEEF

Cattles in the age group of 6-8 years procured from Kerala Livestock Development Board farms were transported to Department of Livestock Products Technology. They were given sufficient rest to overcome the stress and slaughtered under hygienic condition. Sufficient quantities of meat from *Longissimus dorsi* were harvested. The meat was cut into steaks of size of 4"×2"×0.5" (Length, Breadth, Thickness). Half of the sample was rubbed with sodium chloride (10.0 g), powdered pepper (1.0 g) and turmeric (0.5 g) per 100 g of meat. Other half of sample was rubbed with above ingredients and chitosan (1.0 g) per 100 g of the meat to get uniform distribution of the curing ingredients throughout the sample. The samples were kept for one hour at room temperature and then subjected to smoking at smoke house for six hours. The initial weight of the sample, temperature and humidity of the smoke house was recorded. After six hours of smoking, smoked and dried beef were collected. The loss of weight was recorded and the yield was calculated. Half of the different treatment groups were packed separately at the rate of 80 g in oxygen permeable film (High Density Poly Ethylene, 200 μ) and other half in oxygen impermeable film (polyamide-polyethylene pouches, 80 μ). Half of the packets in aerobic and vacuum packaging were subjected to gamma irradiation at 2.5 kGy using Gamma Chamber 5000, (BRIT-DAE, Mumbai). The samples were kept at room temperature and were examined for the signs of spoilage *viz.,* change in colour, odour, consistency, slime formation and mould growth after opening the packets. The samples were assessed for physical qualities, physicochemical qualities, microbiological and organoleptic qualities on the day of preparation and on day 5.10,15, 20, 25, 30, 45, 60 and 75 or till its spoilage whichever was earlier.

4.2.1. Yield of the Product

The yield of the product, drip loss of the control sample and chitosan added sample are shown in table 8. Chitosan application significantly ($P<0.05$) improved the yield of the product after curing. Drip loss was significantly

(P<0.05) reduced by chitosan addition. The drip loss of chitosan added samples was 109.65 ± 5.19 ml and drip loss of control samples was 322.80 ± 14.68. A significantly (P<0.05) higher yield of smoked dried beef was obtained by chitosan addition on comparison with control samples.

Table 8. Yield of smoked dried beef

Treatment	Wt. of meat (Kg)	Wt. of meat after curing (Kg)	Drip loss (ml)	Wt of dried beef (Kg)	Yield (Percentage)
Control	5.00	5.18^{a}±0.04	322.80^{b}±14.68	2.50^{a}±0.05	50
Chitosan added	5.00	5.54^{b}±0.05	109.65^{a}±5.19	2.75^{b}±0.02	55

Means bearing same alphabets in the column do not indicate significant difference (P<0.05).

4.3. PHYSICAL QUALITIES AND SHELF-LIFE

The samples were examined for the presence of signs of spoilage by the presence of change in physical qualities like odour, colour, slime formation and mould growth. The shelf life of smoked and dried beef based on physical signs of spoilage are shown in table 9 and represented in figure 2.

Table 9. Shelf life of smoked dried beef

Treatment Groups	Non Irradiated (Days)	Irradiated (Days)
Aerobic packing(A)	27-29	61-63
Chitosan with Aerobic packing (CA)	35-37	66-68
Vacuum Packing(V)	39-43	78-80
Chitosan with Vacuum packing (CV)	48-50	79-83

The minimum storage life was noticed in non irradiated aerobically packed sample and it had a shelf life of 27- 29 days. All the treatments like chitosan

application, vacuum packaging and irradiation extended the shelf life of the product. On an average the irradiated samples had two times the keeping quality than that of non irradiated samples.The non spoiled samples were subjected to various analysis on day 5, 10, 15, 20, 25, 30, 45, 60 and 75 or till its spoilage whichever was earlier.

4.4. PHYSICOCHEMICAL QUALITIES

4.4.1. Chemical Composition

The chemical composition *viz.,* percentage of moisture, fat, protein, ash, acid insoluble ash and sodium chloride were assessed on the day of preparation.

4.4.1.1 Proximate Composition

The smoked dried beef was analysed for its proximate *viz*., moisture, protein, fat and ash on the day of preparation. The carbohydrates and other components were assessed by subtracting the sum of these from 100.00. Data is shown in table 10 and presented in figure 3.The moisture content varied from 31.63 ± 0.22 (ANR) to 36.93 ± 0.26 (CVNR) and the values were significantly different ($P<0.05$) among some of the groups. Chitosan added samples irrespective of irradiation or vacuum packaging had a significantly higher moisture percentage than that of non chitosan added samples. The fat percentage varied from 6.03 ± 0.19 (CVNR) to 8.33 ± 0.34 (ANR) and the values were significantly different ($P<0.05$). It has shown a similar trend similar to that of moisture in case of chitosan added samples. The protein and ash percentage also showed a similar trend to that of moisture and fat with higher concentration of protein in VNR samples and ash in CVNR samples. Since carbohydrates and other constituents are assessed by subtraction, the low moisture non chitosan added samples had higher yield of carbohydrate related substances than high moisture chitosan added samples. The acid insoluble ash was maximum in chitosan added samples and less in non chitosan added samples.

Table 10. Chemical Composition of smoked dried beef

Treatments		% Proximate Composition						kcal/100g	g%
		Moisture	Fat	Protein	Ash	CHO	AIA	Energy	NaCl
A	NR	$31.63^{b}\pm0.22$	$8.33^{b}\pm0.34$	$44.62^{b}\pm0.14$	$10.34^{b}\pm0.14$	$5.08^{ab}\pm0.27$	$0.19^{ab}\pm0.01$	$273.77^{b}\pm2.19$	$5.10^{b}\pm0.12$
	IR	$31.78^{b}\pm0.31$	$7.95^{b}\pm0.41$	$44.53^{b}\pm0.19$	$10.23^{b}\pm0.14$	$5.51^{b}\pm0.23$	$0.20^{abc}\pm0.01$	$271.70^{b}\pm3.25$	$5.11^{b}\pm0.07$
CA	NR	$36.27^{a}\pm0.40$	$6.37^{a}\pm0.19$	$41.58^{a}\pm0.22$	$11.51^{a}\pm0.12$	$4.28^{ab}\pm0.30$	$0.21^{c}\pm0.01$	$240.73^{a}\pm2.47$	$6.44^{a}\pm0.13$
	IR	$36.43^{a}\pm0.37$	$6.35^{a}\pm0.16$	$41.87^{a}\pm0.35$	$11.43^{a}\pm0.12$	$3.92^{a}\pm0.23$	$0.20^{bc}\pm0.00$	$240.30^{a}\pm2.42$	$6.50^{a}\pm0.15$
V	NR	$32.18^{b}\pm0.36$	$8.25^{b}\pm0.52$	$44.75^{b}\pm0.32$	$10.04^{b}\pm0.13$	$4.78^{ab}\pm0.44$	$0.18^{a}\pm0.01$	$272.35^{b}\pm3.54$	$5.19^{b}\pm0.09$
	IR	$32.20^{b}\pm0.34$	$8.20^{b}\pm0.51$	$44.48^{b}\pm0.88$	$10.11^{b}\pm0.11$	$5.01^{ab}\pm0.99$	$0.19^{ab}\pm0.01$	$271.75^{b}\pm4.07$	$5.17^{b}\pm0.1$
CV	NR	$36.93^{a}\pm0.26$	$6.03^{a}\pm0.19$	$42.35^{a}\pm0.88$	$11.58^{a}\pm0.19$	$3.94^{a}\pm0.31$	$0.22^{c}\pm0.01$	$238.12^{a}\pm1.03$	$6.43^{a}\pm0.08$
	IR	$36.75^{a}\pm0.42$	$6.10^{a}\pm0.24$	$41.77^{a}\pm0.31$	$11.54^{a}\pm0.11$	$3.85^{a}\pm0.24$	$0.22^{c}\pm0.01$	$237.34^{a}\pm2.94$	$6.42^{a}\pm0.16$

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$).**A**-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoil

AIA- Acid insoluble ash; **NaCl** – Sodium chloride; **CHO**- Carbohydrate and related substances

The energy level varied between 273.77 ± 2.19 (ANR) to 237.34 ± 2.94 (CVIR) samples and the values were significantly different (P<0.05).

4.4.1.2. Sodium Chloride

Similar to proximate composition the sodium chloride (NaCl) content of chitosan added and non chitosan added samples were significantly different. The sodium chloride level varied from 5.10 ± 0.12 (ANR) to 6.50 ± 0.15 (CANR). The irradiation and packaging had no significant action on the sodium chloride content of the treatments. The data is presented in figure 4.

4.4.2 Rehydration Ratio

The rehydration ratio of the smoked dried beef is given in table 11 and figure 5. Irradiation has not shown any significant effect (P>0.05) where as the chitosan application reduced the rehydration ratio significantly (P<0.05). Similarly the method of packing was non significant for rehydration capacity of smoked dried beef.

Table 11. Rehydration ratio of smoked dried beef

Treatments		Rehydration ratio
A	NR	1.35^{b}±0.02
	IR	1.28^{b}±0.03
CA	NR	1.21^{a}±0.07
	IR	1.20^{a}±0.02
V	NR	1.33^{b}±0.05
	IR	1.32^{b}±0.04
CV	NR	1.21^{a}±0.02
	IR	1.21^{a}±0.01

Means bearing same alphabets in the column do not indicate significant difference (P<0.05).

4.4.3. pH

The pH of the different treatment samples were assessed up to 75 days of storage or spoilage which ever was earlier. The data is shown in table 12. The trend of increase in pH in irradiated and non irradiated samples due to storage is shown in figure 6a and 6b.

On storage the pH has shown an upward trend until spoilage. The chitosan application had a significant effect ($P<0.05$) in enhancing the pH on the day of preparation. Throughout the study period the values were significantly higher than that of day 0. Up to 15^{th} day the significant difference was only due to chitosan addition whereas after 15^{th} day irradiation as well as packaging had their influence in changing the pH.

4.4.4 Tyrosine value (TV)

The data of tyrosine value of smoked dried beef in mg/100 g is shown in table 13. The trend of the change is shown in figure 7a and 7b. Initially the smoked dried beef samples had a tyrosine value of 5.69 ± 0.04 which significantly ($p<0.05$) reduced due to addition of chitosan in other treatment groups. There was no significant difference in different packaging. Throughout the study period storage had a significant effect in increasing the tyrosine value of smoked dried beef.

The irradiated sample under vacuum packaging had a higher value of 7.47 ± 0.04 (VIR) and 6.63 ± 0.07 (CVIR) which were significantly higher than initial values. Similar to irradiation, addition of chitosan had a beneficial effect in reducing tyrosine value throughout the study period.

4.4.5. Thiobarbituric Acid Reacting Substances (TBARS)

The TBARS values of the dried beef are shown in table 14 as mg of malonaldehyde/ Kg of dried beef. The effect of chitosan, vacuum packaging and irradiation on the TBARS values has shown in figure 8a and 8b. Initially chitosan

Table12. pH of smoked dried beef

Treatments		Days of Storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	NR	5.53^{a}	5.58^{a*}	5.62^{a*}	5.66^{a*}	5.70^{a*}	5.77^{a*}	S	S	S	S
	IR	5.56^{a}	5.59^{a*}	5.62^{a*}	5.65^{a*}	5.69^{a*}	5.72^{a*}	5.78^{a*}	5.84^{a*}	5.94^{ab*}	S
CA	NR	5.80^{b}	5.83^{b*} +0.02	5.86^{b*}	5.89^{b*}	5.93^{d*}	5.96^{c*}	6.01^{c*}	S	S	S
	IR	5.83^{b}	5.84^{b*}	5.87^{b*}	5.89^{b*}	5.91^{bc*}	5.93^{bc*}	5.96^{bc}	5.98^{b*}	6.02^{c*}	S
V	NR	5.54^{a}	5.56^{a*}	5.59^{a*}	5.63^{a*}	5.66^{a*}	5.71^{a*}	5.81^{a*}	S	S	S
	IR	5.57^{a}	5.61^{a*}	5.64^{a*}	5.67^{a*}	5.70^{a*}	5.74^{a*}	5.79^{a*}	5.85^{a*}	5.88^{a*}	5.93^{b*}
CV	NR	5.79^{b}	5.81^{b*}	5.83^{b*}	5.85^{b*}	5.88^{bc*}	5.90^{bc*}	5.93^{b*}	5.97^{b*}	S	S
	IR	5.82^{b}	5.83^{b*} +0.02	5.83^{b*}	5.86^{b*}	5.87^{b*}	5.89^{b*}	5.91^{b*}	5.93^{b*}	5.96^{b*}	5.99^{a*}

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$).
* represents significance difference between storage periods.
A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

Table 13. Tyrosine values of smoked dried beef (mg/100 g)

Treatments		Days of Storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	5.69^{e} ±0.04	5.79^{e*} ±0.04	5.99^{e*} ±0.03	6.19^{e*} ±0.04	6.53^{f*} ±0.08	7.59^{f*} ±0.10	S	S	S	S
	IR	5.49^{cd} ±0.04	5.60^{d*} ±0.04	5.80^{d*} ±0.04	6.03^{d*} ±0.04	6.14^{cd*} ±0.04	6.34^{cd*} ±0.05	6.59^{c*} ±0.08	6.81^{c*} ±0.08	7.26^{a*} ±0.10	S
CA	**NR**	5.30^{b} ±0.06	5.39^{b*} ±0.05	5.54^{b*} ±0.08	5.81^{bc*} ±0.09	6.05^{c*} ±0.08	6.52^{de*} ±0.08	7.30^{e*} ±0.09	S	S	S
	IR	5.19^{b} ±0.05	5.45^{bc*} ±0.01	5.67^{c*} ±0.05	5.87^{c*} ±0.05	6.05^{c*} ±0.07	6.27^{c*} ±0.09	6.40^{c*} ±0.08	6.84^{c*} ±0.05	7.41^{a*} ±0.04	S
V	**NR**	5.61^{de} ±0.03	5.71^{e*} ±0.03	5.84^{d*} ±0.04	6.05^{d*} ±0.03	6.30^{de*} ±0.07	6.64^{e*} ±0.08	7.46^{e*} ±0.13	S	S	S
	IR	5.47^{c} ±0.03	5.53^{cd*} ±0.02	5.60^{bc*} ±0.03	5.68^{b*} ±0.02	5.78^{b*} ±0.03	5.93^{b*} ±0.04	6.08^{b*} ±0.04	6.24^{b*} ±0.03	6.49^{b*} ±0.05	7.47^{a*} ±0.04
CV	**NR**	5.26^{b} ±0.04	5.46^{bc*} ±0.03	5.62^{bc*} ±0.03	6.03^{d*} ±0.04	6.39^{ef*} ±0.05	6.70^{e*} ±0.04	6.97^{d*} ±0.04	7.69^{d*} ±0.13	S	S
	IR	4.98^{a} ±0.04	5.09^{a*} ±0.03	5.25^{a*} ±0.03	5.35^{a*} ±0.03	5.45^{a*} ±0.03	5.54^{a*} ±0.04	5.69^{a*} ±0.04	5.91^{a*} ±0.05	6.11^{c*} ±0.04	6.63^{b*} ±0.07

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$).
* represents significance difference between storage periods.
A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

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added non irradiated sample (CANR) had the lowest value 0.46 ± 0.02 and was significantly different (P<0.05) from that of other treatment groups except CVNR samples indicating irradiation and non addition of chitosan had significantly influenced TBARS value. Storage had a significant effect on the values.

In smoked dried beef samples irrespective of the treatment groups TBARS values were significantly (P<0.05) lowered initially and was increased during storage. Even prior to spoilage none of the samples revealed values as that of 0 day observation. This was especially true in case of irradiated samples which indicate that smoking is having an advantage for reduction of TBARS in irradiated samples. The highest value of 0.64 ± 0.02 was observed in vacuum packed irradiated samples and the lowest value of 0.46 ± 0.02 was observed in chitosan added non irradiated samples at day 0. The TBARS value of chitosan added irradiated sample even at the day 75 was significantly (P<0.05) lower than initial reading.

4.5. MICROBIOLOGICAL ANALYSIS

4.5.1. Aerobic Plate Count (APC)

The aerobic plate count of smoked dried beef expressed in $\log_{10}$ cfu/g during the storage period is shown in table 15 and trend in the change in microbial load is shown in figure 9a and 9b.

The aerobic plate count 2.21 ± 0.03 was noticed in ANR samples and was non significant from other non irradiated samples. Irradiation had a significant effect in reducing the aerobic plate count and a synergistic effect with the addition of chitosan. Chitosan alone had non significant effect in reducing the aerobic plate count in smoked dried beef. Aerobic and vacuum packaging did not reveal any significant effect on aerobic plate count on the day of preparation. Storage of the product under ambient temperature had a significant effect (P<0.05) in enhancing the aerobic plate count, always with a significantly lower count in irradiated groups both in chitosan added and vacuum packed samples. Even at day 75, VIR

Table 15. Aerobic Plate Count of smoked dried beef. (log_{10}cfu/g)

Treatments		Days of Storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	NR	2.21^{c} ±0.03	2.89^{d*}	3.43^{e*} ±0.03	4.00^{e*} ±0.02	4.88^{e*} ±0.02	5.03^{c*} ±0.04	S	S	S	S
	IR	1.78^{b}	2.34^{b*}	2.80^{bc*} ±0.01	3.09^{b*} ±0.03	3.62^{bc*} ±0.20	4.04^{a*} ±0.17	4.62^{b*} ±0.27	5.03^{b*} ±0.04	5.85^{b*} ±0.03	S
CA	NR	2.16^{c}	2.78^{d*}	3.26^{e*} ±0.08	3.63^{cd*} ±0.06	4.16^{d*} ±0.14	4.62^{b*} ±0.11	5.11^{b*} ±0.11	S	S	S
	IR	1.46^{a}	2.16^{a*}	2.58^{a*} ±0.08	2.93^{ab*} ±0.01	3.40^{ab*} ±0.12	3.93^{a*} ±0.17	4.64^{b*} ±0.31	4.80^{b*} ±0.15	5.72^{b*} ±0.12	S
V	NR	2.20^{c}	2.63^{c*}	3.06^{d*} ±0.09	3.81^{de*} ±0.02	4.15^{d*} ±0.19	4.82^{bc*} ±0.07	5.07^{b*} ±0.09	S	S	S
	IR	1.68^{ab}	2.24^{ab*}	2.66^{ab*} ±0.03	3.12^{b*} ±0.17	3.25^{ab*} ±0.06	3.88^{a*} ±0.03	4.04^{a*} ±0.07	4.80^{b*} ±0.03	5.00^{a*} ±0.03	5.63^{a*} ± 0.06
CV	NR	2.20^{c}	2.58^{c*}	2.86^{c*}	3.51^{c*} ±0.05	3.94^{cd*} ±0.02	4.72^{bc*} ±0.05	5.01^{b*} ±0.02	5.67^{a*} ±0.05	S	S
	IR	1.52^{a}	2.11^{a*}	2.66^{ab*} ±0.07	2.82^{a*} ±0.05	3.22^{a*} ±0.13	3.72^{a*} ±0.08	3.92^{a*} ±0.06	4.49^{a*} ±0.10	4.98^{a*} ±0.10	5.13^{a*} ±0.20

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$).

***** represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

sample and CVIR sample had a count of 5.63 ± 0.06 and 5.13 ± 0.20 which were non significant (P>0.05).

4.5.2. Yeast and Mould Count

The yeast and mould count of smoked dried beef stored up to 75 days is given in table 16 and the trend of growth is shown in figure 10a and 10b.

On the day of preparation the counts were non significant among aerobic packaging, vacuum packaging and chitosan application where as irradiation has significantly reduced the count. The initial count 1.90 ± 0.03 (ANR) was significantly (P<0.05) reduced to 1.26 ± 0.09 in AIR and CVIR samples. Even though there was no significant difference due to addition of chitosan, on storage it was found that both irradiation and chitosan application significantly reduced the yeast and mould count throughout the study period, where as aerobic packing and vacuum packing was non significant (P>0.05). The storage period had a significant effect (P<0.05) in increasing the yeast and mould count and reached 4.88 ± 0.02 (VIR) and 4.69 ± 0.02 (CVIR) and the values themselves were significant indicating chitosan had a significant effect in reducing the yeast and mould count in long run.

4.6. ORGANOLEPTIC EVALUATION

The organoleptic qualities *viz*., colour, flavour, juiciness, tenderness and overall acceptability of the fried product were evaluated with the help of nine point Hedonic scale.

4.6.1. Colour

The samples on organoleptic analysis by the semi-trained panellists showed that irradiated samples had an effect in enhancing the colour score slightly on the day of preparation. The highest score of 8.36 was recorded in AIR samples compared to 8.24 in non irradiated samples. Chitosan application did not reveal any significant change in the colour score of the smoked dried beef samples.

Table 16. Yeast and mould count of smoked dried beef. (log $_{10}$ cfu/g)

Treatments		Days of Storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	NR	1.90^{c} ±0.03	2.52^{d*} ±0.04	2.82^{c*} ±0.02	3.12^{c*} ±0.01	3.76^{e*} ±0.02	4.12^{e*} ±0.01	S	S	S	S
	IR	1.26^{a} ±0.09	2.22^{bc*}± 0.03	2.66^{a*} ±0.03	2.97^{a*} ±0.02	3.00^{a*} ±0.04	3.40^{b*} ±0.03	3.80^{b*} ±0.01	4.11^{b*} ±0.03	4.84^{d*} ±0.02	S
CA	NR	1.75^{bc} ±0.02	2.65^{c*} ±0.01	2.82^{c*} ±0.01	3.07^{b*} ±0.02	3.29^{d*} ±0.08	3.88^{d*} ±0.02	4.09^{d*} ±0.02	S	S	S
	IR	1.26^{a} ±0.09	2.18^{bc*}± 0.02	2.67^{a*} ±0.02	2.97^{a*} ±0.02	3.07^{ab*} ±0.02	3.38^{ab*} ±0.05	3.80^{b*} ±0.02	4.01^{a*} ±0.02	4.71^{c*} ±0.02	S
V	NR	1.73^{bc} ±0.04	2.42^{d*} ±0.04	2.80^{c*} ±0.02	3.04^{b*} ±0.02	3.19^{dc*} ±0.02	3.79^{d*} ±0.02	4.12^{d*} ±0.04	S	S	S
	IR	1.33^{a} ±0.08	2.16^{ab*}± 0.04	2.63^{a*} ±0.02	2.91^{a*} ±0.03	3.04^{a*} ±0.02	3.28^{a*} ±0.04	3.72^{a*} ±0.03	4.00^{a*} ±0.01	4.51^{b*} ±0.03	4.88^{b*} ±0.02
CV	NR	1.90^{b} ±0.03	2.26^{c*} ±0.02	2.73^{b*} ±0.01	3.01^{b*} ±0.02	3.17^{bc*} ±0.04	3.61^{c*} ±0.02	4.01^{c*} ±0.02	4.45^{c*} ±0.03	S	S
	IR	1.26^{a} ±0.09	2.06^{a*} ±0.05	2.63^{a*} ±0.01	2.86^{a*} ±0.01	3.05^{a*} ±0.02	3.33^{ab*} ±0.05	3.74^{a*} ±0.02	3.94^{a*} ±0.05	4.38^{a*} ±0.04	4.69^{a*} ±0.02

Means bearing same alphabets in the column do not indicate significant difference ($P<0.05$).
***** represents significance difference between storage periods.
A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

The trend of reduction in the colour score is shown in table 17 and figure 11a and 11b. It was observed that in many treatments groups, the colour score was significantly reduced indicating storage had a significant effect. The lowest score of 7.53 and 7.7 was observed on day 75 in VIR and CVIR samples respectively.

4.6.2. Flavour

The flavour score of smoked dried beef is shown in table 18. Initially the samples had a excellent score of 8.17 in ANR samples and was not significantly changed due to either addition of chitosan, vacuum packaging or irradiation.

The change in the flavour score on storage is shown in figure 12a and 12b. It was observed that storage period had a significant effect in reducing the score up to 75 days of storage. Fairly good score of 7.63 (VIR) and 7.58 (CVIR) were retained in irradiated samples and were significantly different.

4.6.3. Juiciness

The juiciness score of smoked dried beef is given in table 19. Initially the control samples had a score of 8.35 which was not altered by the application of irradiation but vacuum packaging reduced the score.

Application of chitosan, vacuum packaging followed by irradiation had improved the juiciness to 8.44 from 8.35. Up to 5^{th} day juiciness score was retained except in case of ANR samples and from 15^{th} day onwards storage had a significant effect in reducing the juiciness score. The trend of reduction of juciness score is shown in figure 13a and 13b. It reached to 7.77 (VIR) and 7.67 (CVIR) by 75^{th} day of observation indicating storage had reduced the score.

4.6.4. Tenderness

The tenderness score of the smoked dried beef during storage period is shown in table 20. Almost all the treatment groups and control group obtained a

Table 17. Colour score of smoked dried beef

Treatment		Days of storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	8.24	8.10	8.00*	7.89*	7.78*	7.55*	S	S	S	S
	IR	8.36	8.27	8.20	8.00*	8.00*	7.85*	7.68*	7.55*	7.35*	S
CA	**NR**	8.24	8.09	8.08	7.96*	7.85*	7.63*	7.41*	S	S	S
	IR	8.28	8.18	8.13	8.13	8.03	7.92*	7.80*	7.63*	7.53*	S
V	**NR**	8.26	8.18	8.04	7.91*	7.77*	7.68*	7.48*	S	S	S
	IR	8.28	8.26	8.18	8.08	7.97*	7.92*	7.83*	7.76*	7.70*	7.53*
CV	**NR**	8.28	8.18	8.00	7.93*	7.91*	7.73*	7.71*	7.54*	S	S
	IR	8.32	8.21	8.16	8.05	7.95*	7.93	7.86*	7.78*	7.77*	7.70*

* represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

Table 18. Flavour score of smoked dried beef

Treatment		Days of storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	8.17	8.04	7.91*	7.88*	7.74*	7.59*	S	S	S	S
	IR	8.18	8.05	7.96	7.89*	7.83*	7.80*	7.73*	7.63*	7.57*	S
CA	**NR**	8.19	8.03	8.00	7.93*	7.91*	7.87*	7.45*	S	S	S
	IR	8.23	8.00	7.98	7.95*	7.86*	7.79*	7.78*	7.76*	7.63*	S
V	**NR**	8.18	8.13	8.13	8.04	7.91*	7.82*	7.73*	S	S	S
	IR	8.21	8.13	8.05	7.98	7.91*	7.89*	7.83*	7.79*	7.71*	7.63*
CV	**NR**	8.25	8.13	8.00	7.96*	7.83*	7.70*	7.63*	7.46*	S	S
	IR	8.31	8.22	8.16	8.09	7.98*	7.90*	7.86*	7.74*	7.74*	7.58*

*represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

Table 19. Juiciness score of smoked dried beef

Treatment		Days of storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	8.35	8.12*	8.02*	8.01*	7.98*	7.67*	S	S	S	S
	IR	8.38	8.23	8.09	8.04*	8.00*	7.96*	7.99*	7.93*	7.82*	S
CA	**NR**	8.14	7.98*	7.96*	7.94*	7.93*	7.85*	7.60*	S	S	S
	IR	8.22	8.13	8.02	7.96	7.93*	7.92*	7.83*	7.77*	7.70*	S
V	**NR**	8.21	8.18	8.04	7.93*	7.93*	7.88*	7.86*	S	S	S
	IR	8.27	8.13	8.05	8.01	7.94*	7.93*	7.89*	7.79*	7.89*	7.77*
CV	**NR**	8.24	8.13	7.95*	7.91*	7.80*	7.72*	7.68*	7.56*	S	S
	IR	8.44	8.23	8.18	8.13	7.98*	7.91*	7.88*	7.86*	7.79*	7.67*

* represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

Table 20. Tenderness score of smoked dried beef

Treatment		Days of storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	8.13	8.01	7.98*	7.96*	7.87*	7.60*	S	S	S	S
	IR	8.27	8.10	8.03	7.96*	7.88*	7.82*	7.75*	7.71*	7.63*	S
CA	**NR**	8.20	8.03	7.91*	7.83*	7.78*	7.75*	7.58*	S	S	S
	IR	8.23	8.11	8.05	7.93*	7.88*	7.81*	7.72*	7.70*	7.64*	S
V	**NR**	8.25	8.18	8.17	8.16	8.09*	7.97*	7.85*	S	S	S
	IR	8.28	8.15	8.08	8.08	8.01	8.00	7.98*	7.94*	7.90*	7.88*
CV	**NR**	8.18	7.93	7.89*	7.80*	7.70*	7.63*	7.62*	7.58*	S	S
	IR	8.22	8.15	8.11	8.02	7.98	7.94*	7.92*	7.86*	7.73*	7.65*

* represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

score of above 8.1 out of 9.0. Highest score of 8.28 was recorded in VIR samples up to 5th day of storage. The score was not significantly different from that of 0th day. The trend of reduction of the score is shown in figure 14a and 14b.

Initially either chitosan application or vacuum packaging had not shown any significant difference in tenderness 0f the product. Storage had a significant effect in reducing the tenderness, after day 5 in non irradiated samples and after day 10 in irradiated samples. Even at day 75, the samples retained a fairly good score of 7.88 (VIR) and 7.65 (CVIR) and were significantly different themselves indicating samples had retained its good tenderness.

4.6.5. Overall acceptability

Overall acceptability score of a product indicates the general acceptability of the product by the consumer and is the product of all the sensory attributes and not the sum of the individual attributes. The product was well acceptable throughout the study period as revealed by fairly a good score of more than 7.5 or above. The data is given in table 21.

A very good score of 8.3 was observed in ANR samples and was increased by process of irradiation. Irradiated samples were better throughout the study period. From 10th day onwards storage had a significant effect in reducing the overall acceptability score. Initially chitosan application or vacuum packaging was not having any significant difference in changing the overall acceptability score and later the highest overall acceptability was noticed in chitosan added vacuum packed irradiated sample followed by vacuum packed irradiated sample and had the extended shelf life of 75 days. The trend in reduction of the overall acceptability score is given figure 15a and 15b.

4.7. COST OF PRODUCTION

The cost of production of smoked dried beef was calculated for both the non chitosan and chitosan added groups and is presented in table 22. The cost of

Table 21. Over all acceptability score of smoked dried beef

Treatment		Days of storage									
		0	**5**	**10**	**15**	**20**	**25**	**30**	**45**	**60**	**75**
A	**NR**	8.30	8.17	8.08*	7.99*	7.77*	7.56*	S	S	S	S
	IR	8.40	8.27	8.17	8.08*	7.97*	7.88*	7.66*	7.48*	7.25*	S
CA	**NR**	8.32	8.18	8.13*	8.03*	7.90*	7.69*	7.43*	S	S	S
	IR	8.40	8.28	8.10*	8.10*	7.96*	7.93*	7.88*	7.74*	7.63*	S
V	**NR**	8.21	8.12	8.00*	7.88*	7.79*	7.67*	7.48*	S	S	S
	IR	8.35	8.24	8.22	8.11*	8.09*	7.89*	7.84*	7.69*	7.61*	7.54*
CV	**NR**	8.38	8.22	8.13*	8.03*	7.90*	7.69*	7.58*	7.40*	S	S
	IR	8.47	8.33	8.28	8.25*	8.06*	8.05*	7.89*	7.84*	7.73*	7.59*

* represents significance difference between storage periods.

A-Aerobic Packing; **C**-Chitosan added; **V**-Vacuum Packing; **NR**-Non Irradiated; **IR**-Irradiated; **S**-Spoiled

production was Rs. 252.35 for chitosan added groups and was Rs. 268.18 for non chitosan groups.

Table 22. Cost of production of smoked dried beef

Item	Cost (Rs)	
	Non chitosan	**Chitosan**
Meat (5Kg)	650	650
Salt (10.0%)	2.1	2.1
Turmeric (0.5%)	4.6	4.6
Pepper (1.0%)	13.75	13.75
Chitosan (1.0%)	-	23.5
Total	670.45	693.95
Yield %	50	55
Product cost/ Kg	268.18	252.35

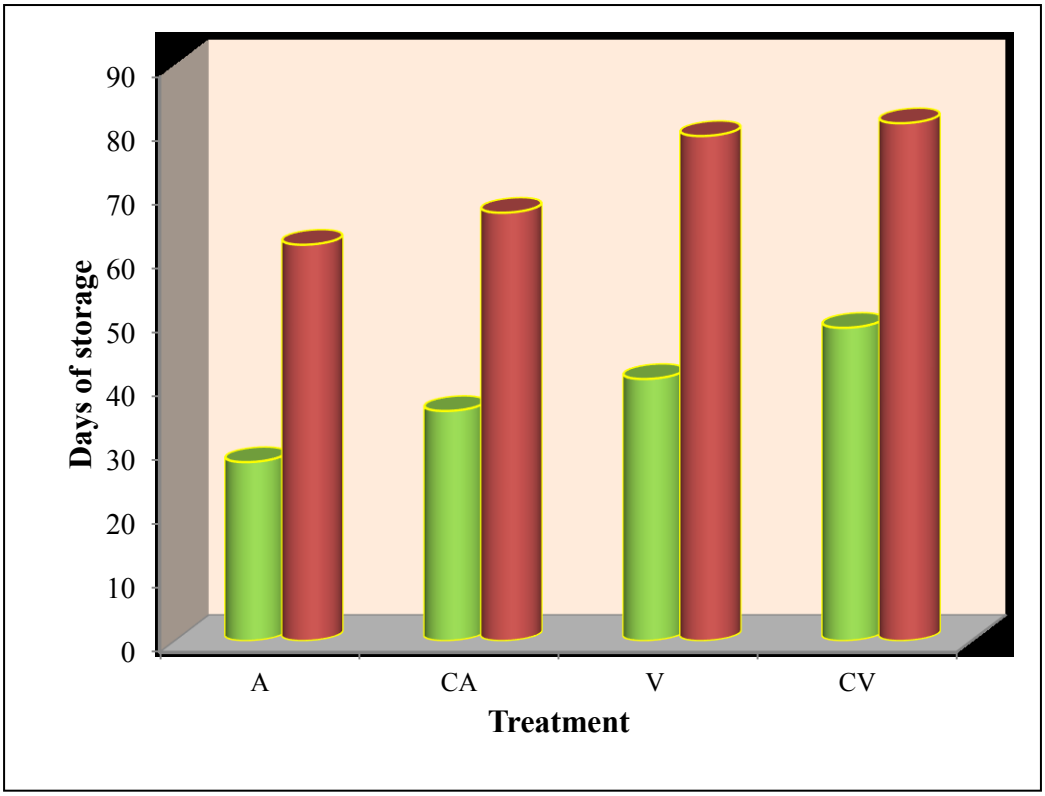

Figure 2. Shelf life of smoked dried beef in room temperature storage

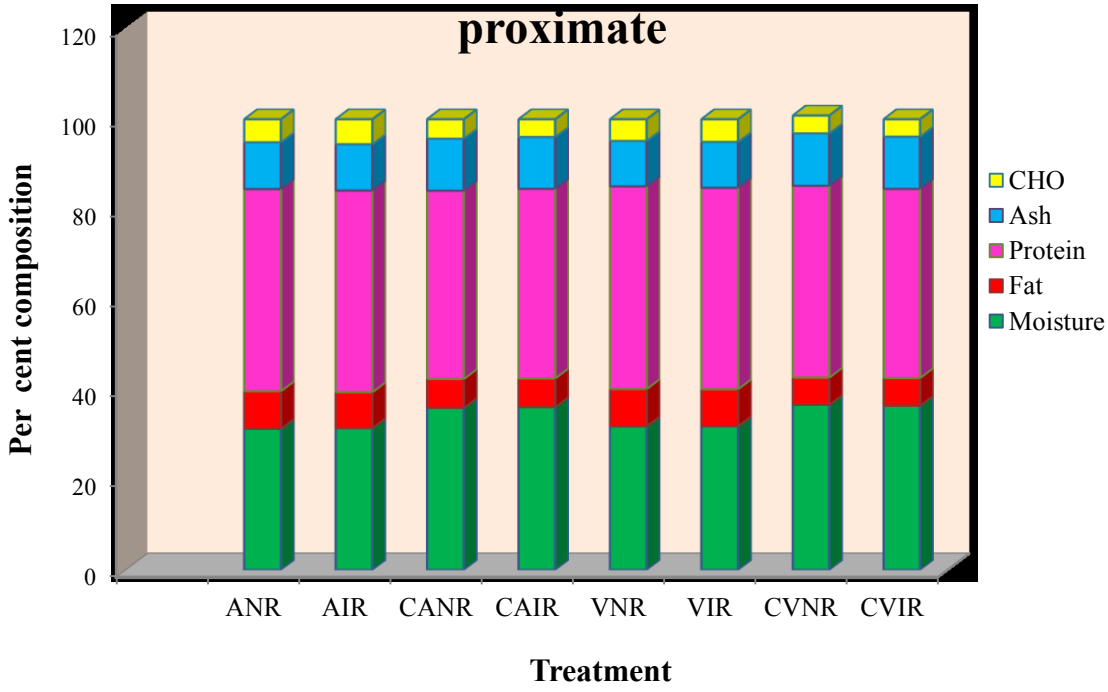

Figure 3. Proximate composition of smoked dried beef

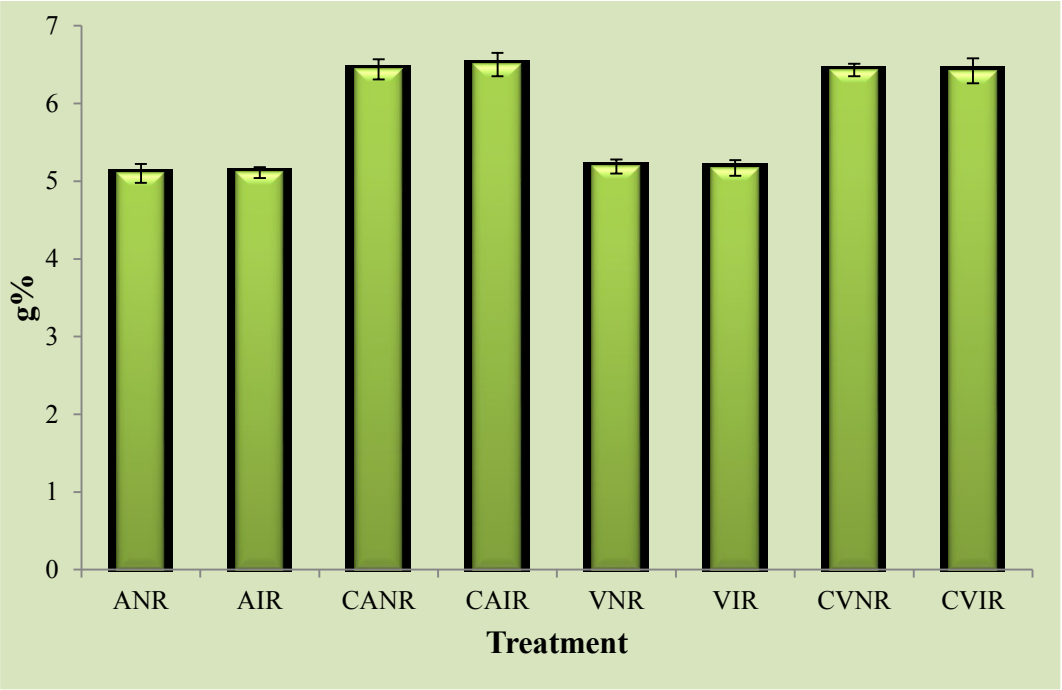

Figure 4. Sodium chloride content of smoked dried beef

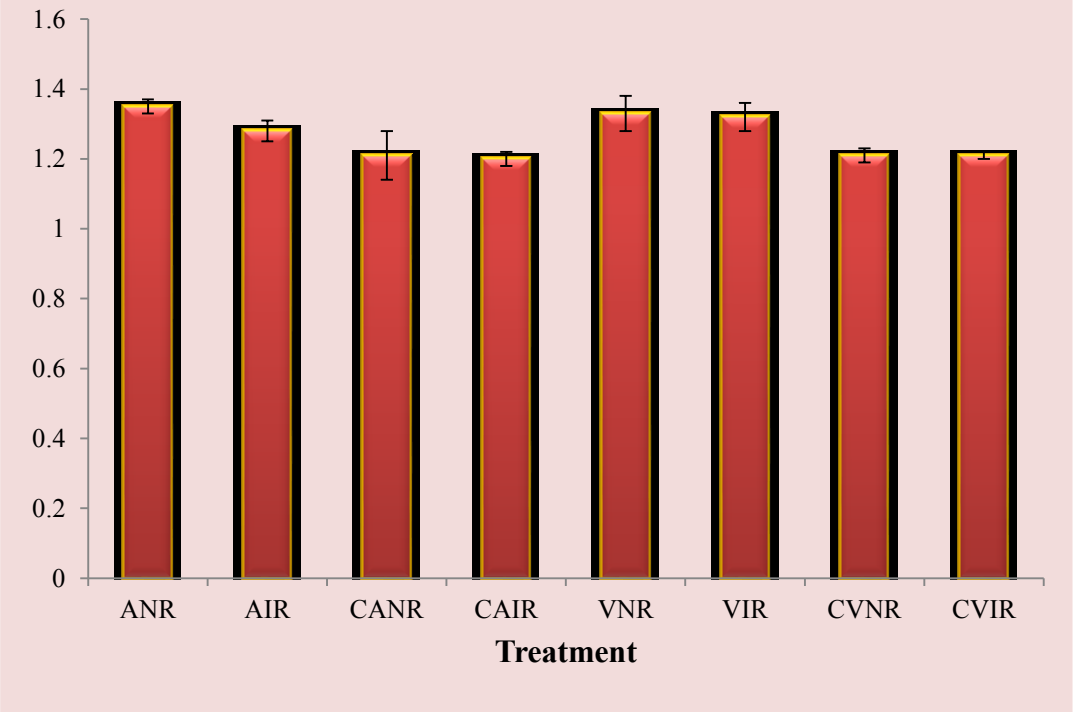

Figure 5. Rehydration ratio of smoked dried beef

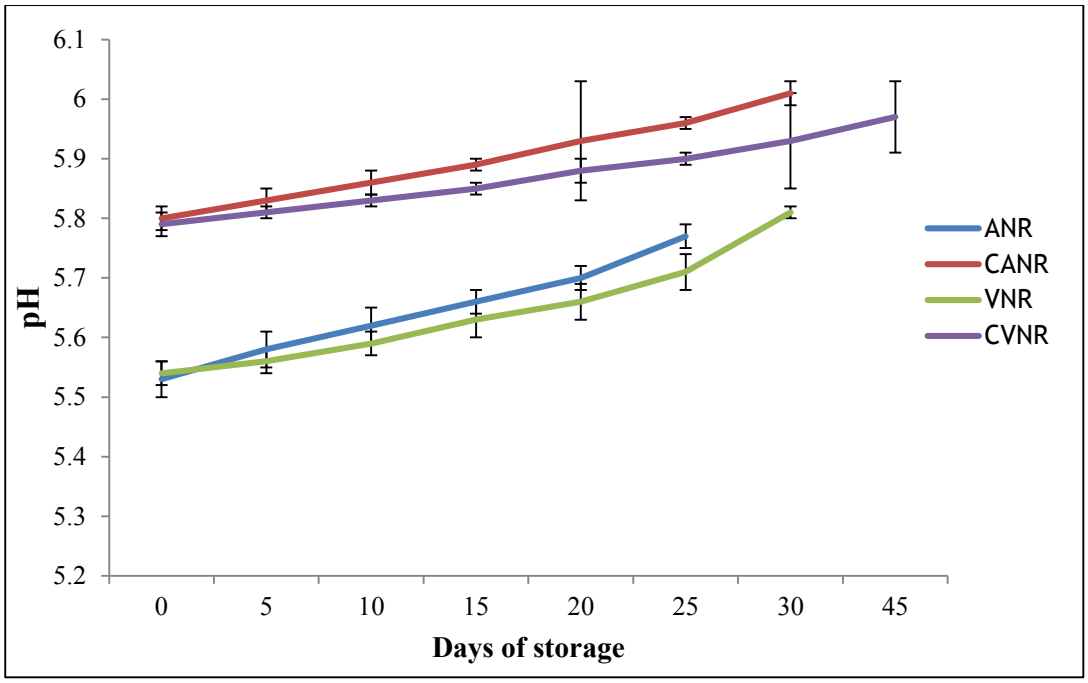

Figure 6a. pH value of non-irradiated smoked dried beef

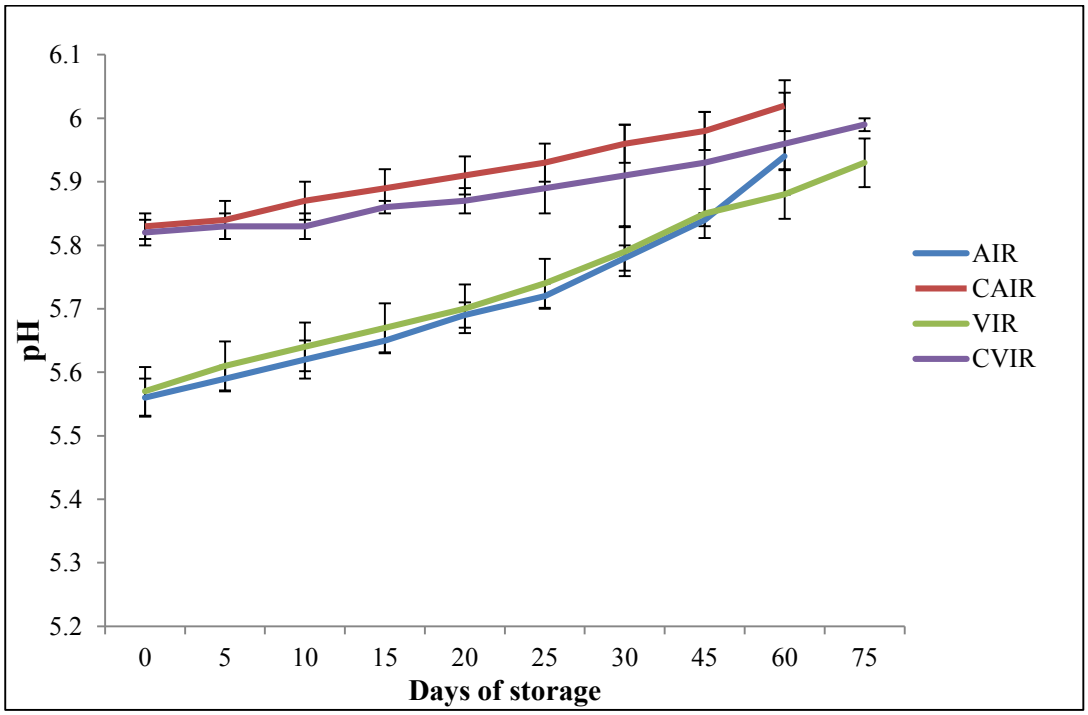

Figure 6b. pH value of irradiated smoked dried beef

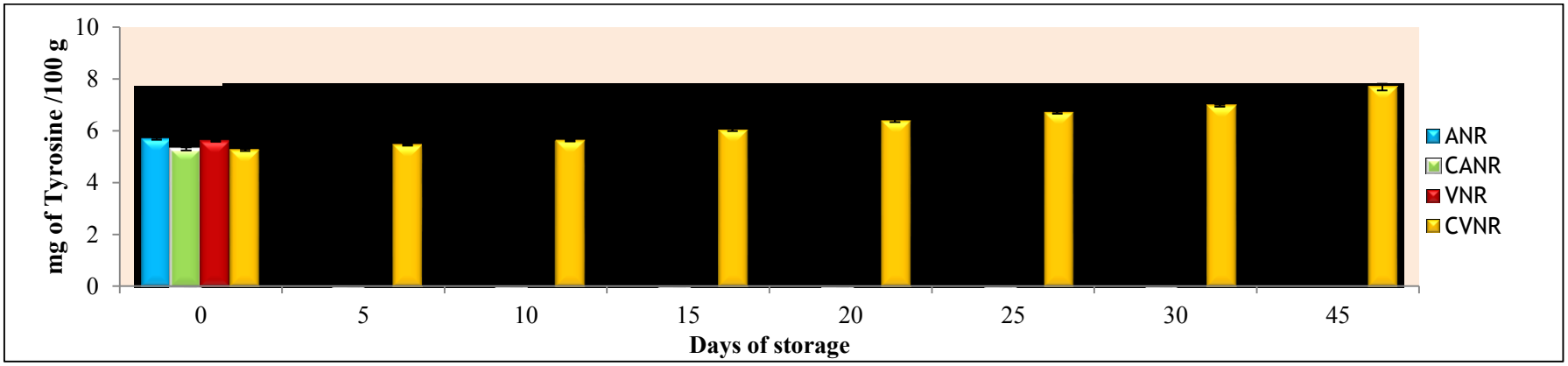

Figure 7a. Tyroine value of non irradiated smoked dried beef

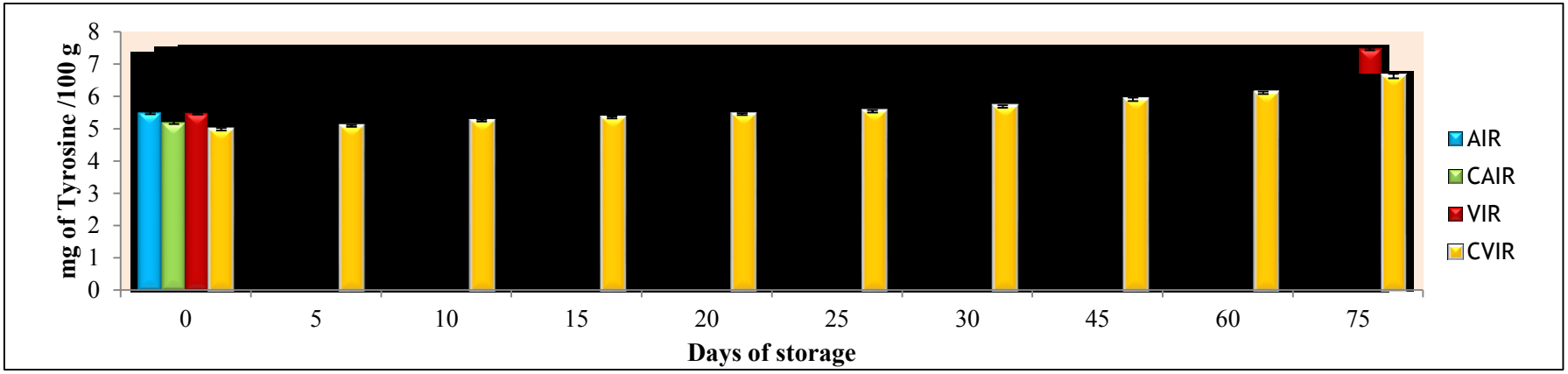

Figure 7b. Tyroine value of irradiated smoked dried beef

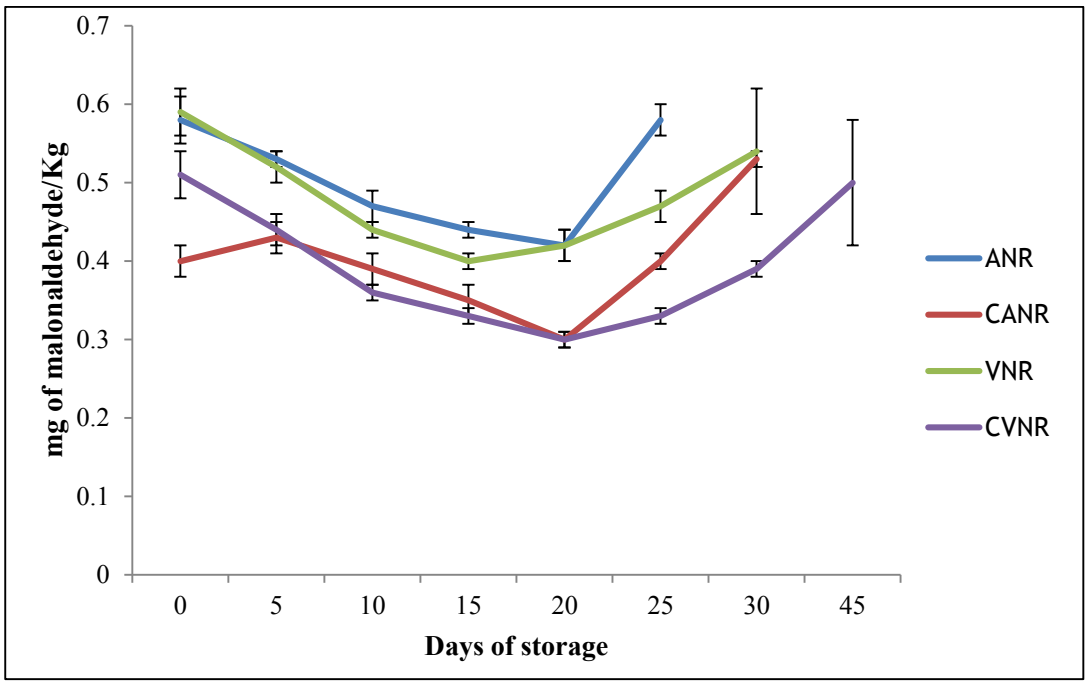

Figure 8a. TBARS value of non irradiated smoked dried beef

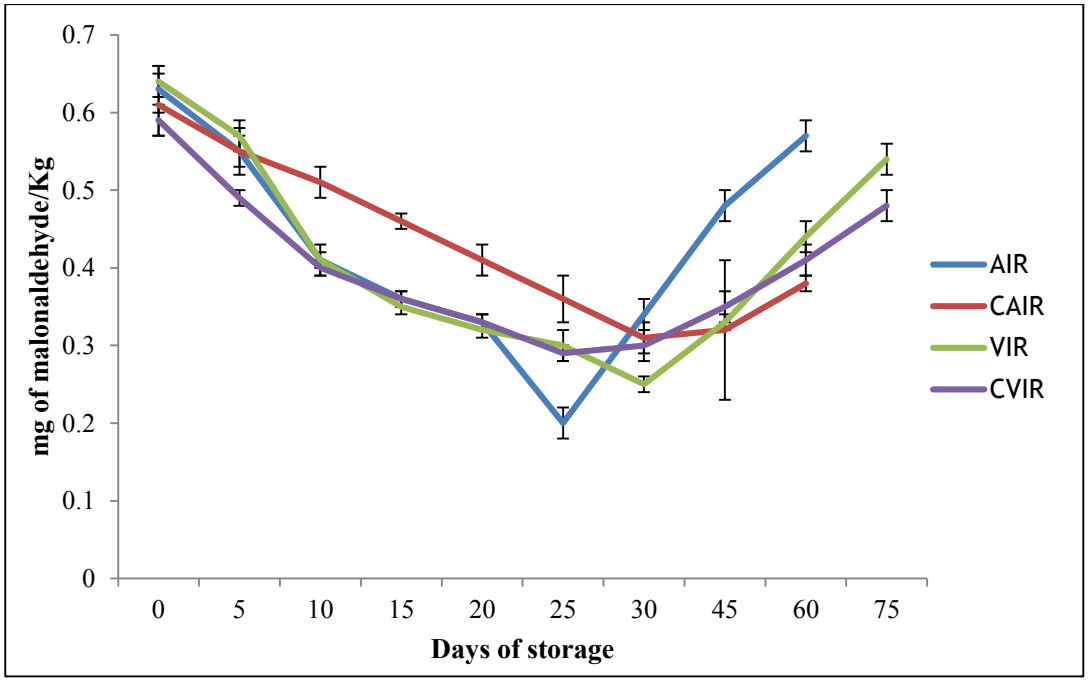

Figure 8b. TBARS value of irradiated smoked dried beef

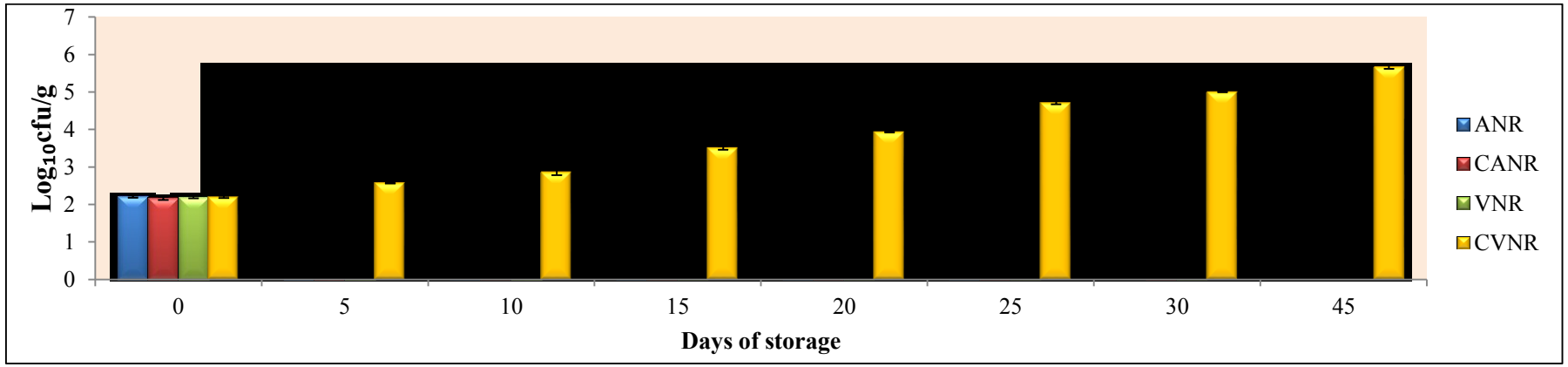

Figure 9a. Aerobic plate count of non irradiated smoked dried beef

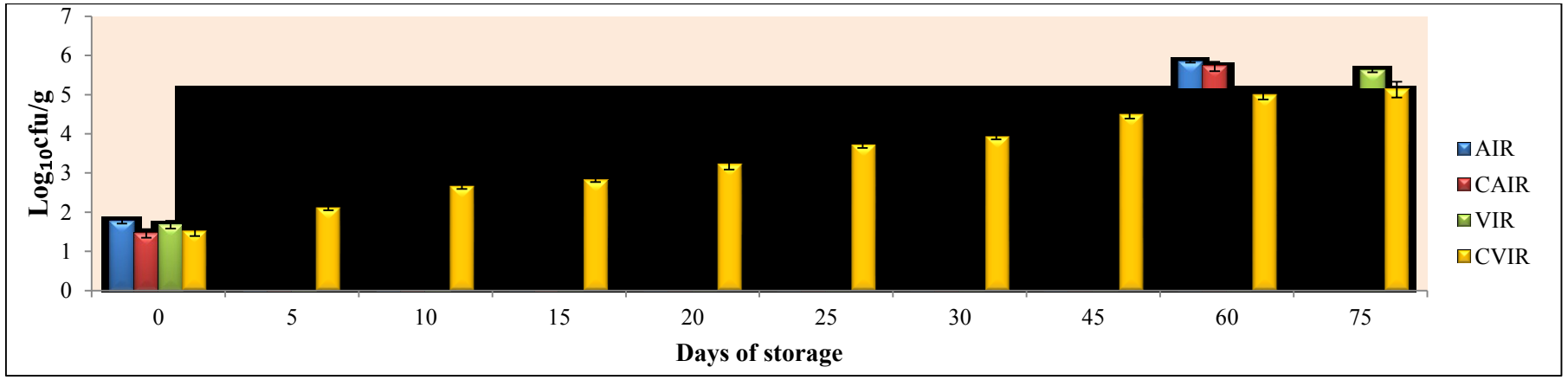

Figure 9b. Aerobic plate count of irradiated smoked dried beef

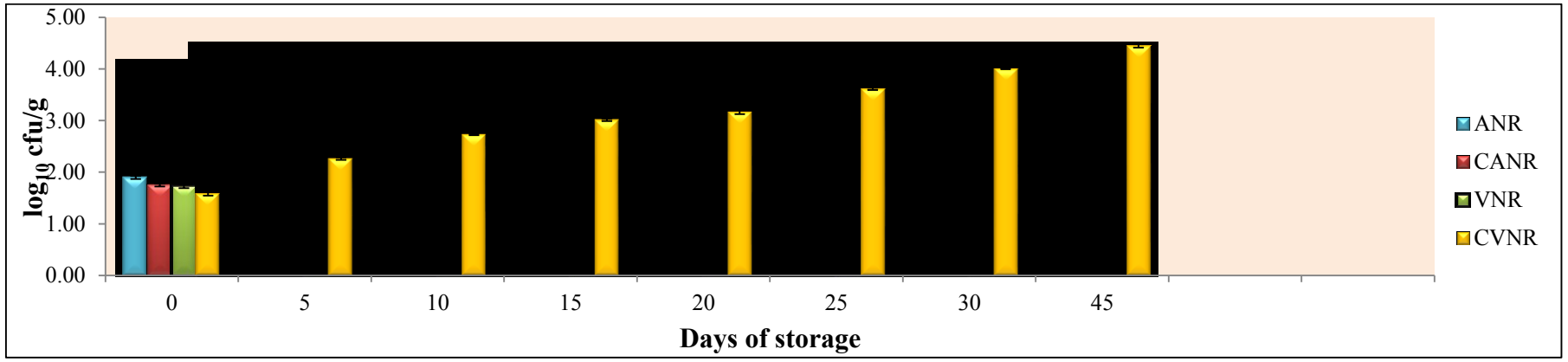

Figure 10a. Yeast and mould count of non irradiated smoked dried beef

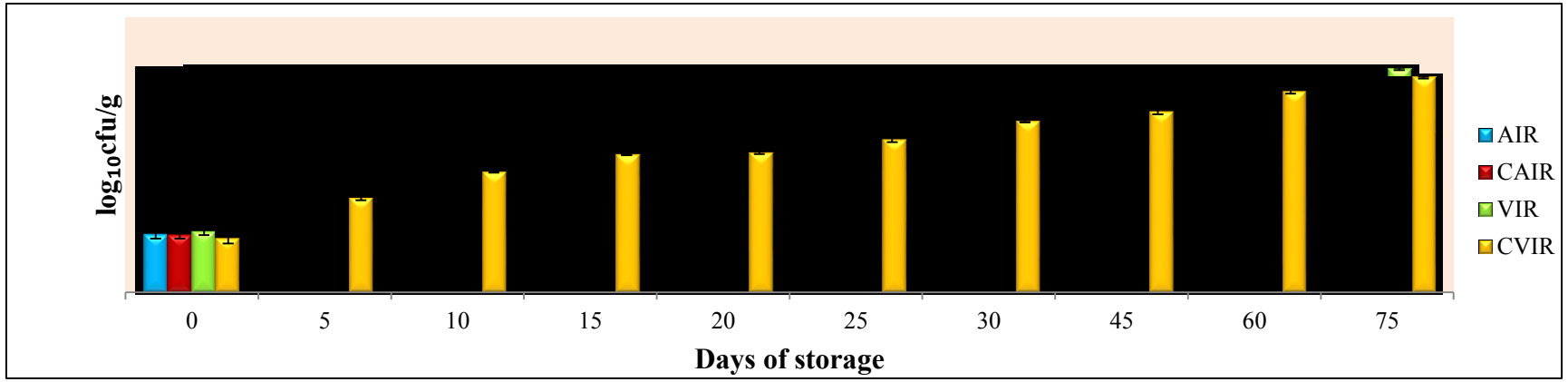

Figure 10b. Yeast and mould count of irradiated smoked dried beef

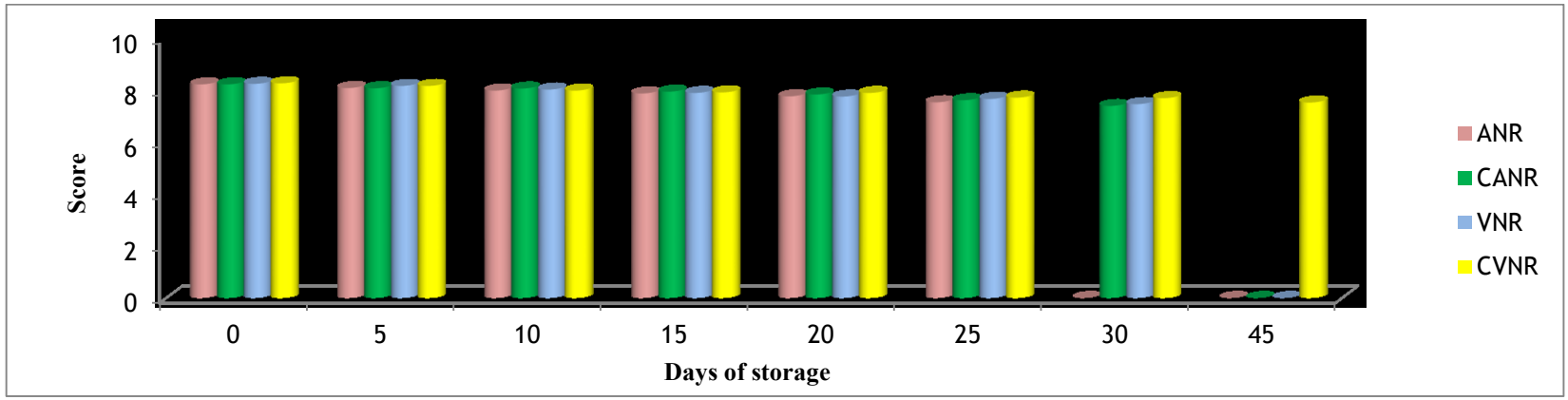

Figure 11a. Colour score of non irradiated smoked dried beef

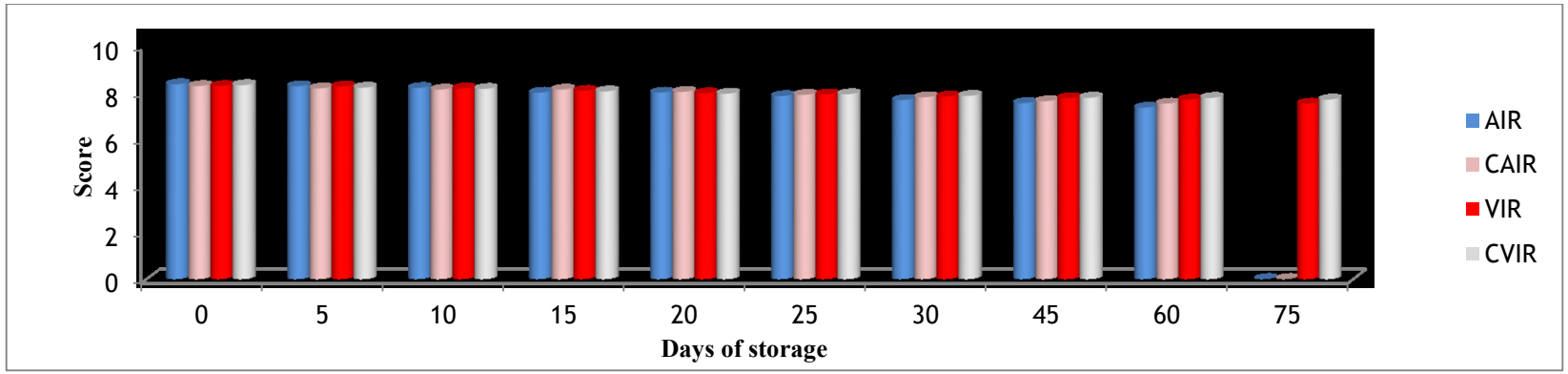

Figure 11b. Colour score of irradiated smoked dried beef

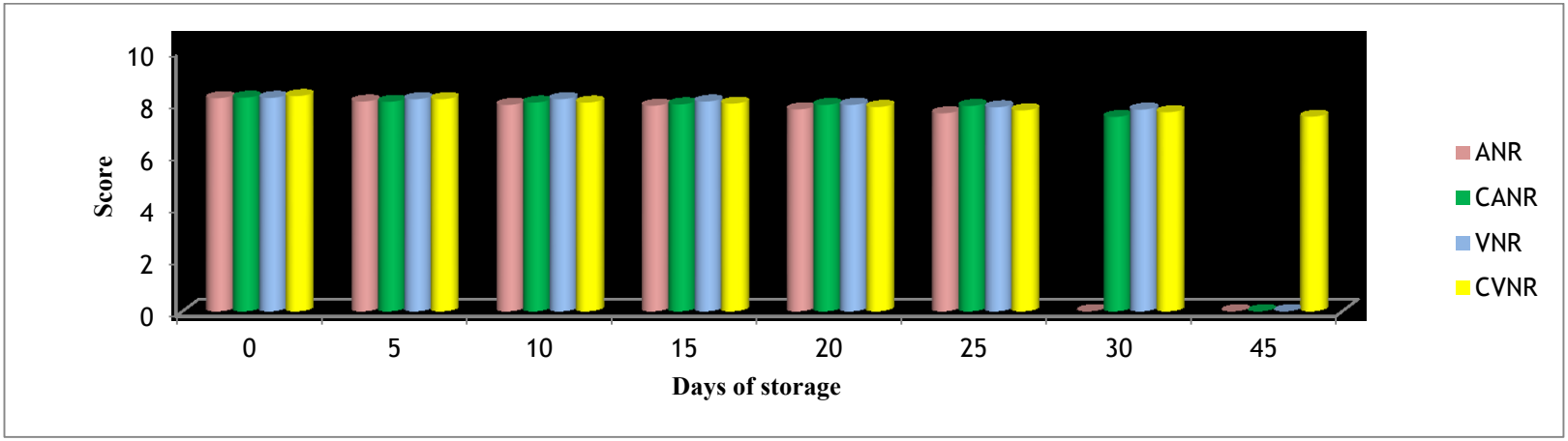

Figure 12a. Flavour score of non irradiated smoked dried beef

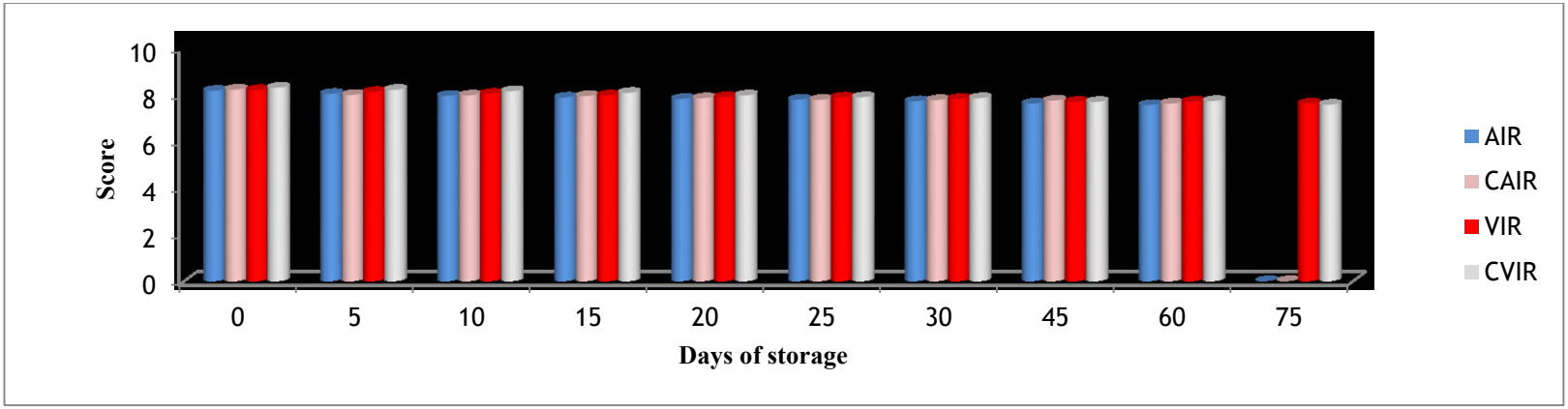

Figure 12b. Flavour score of irradiated smoked dried beef

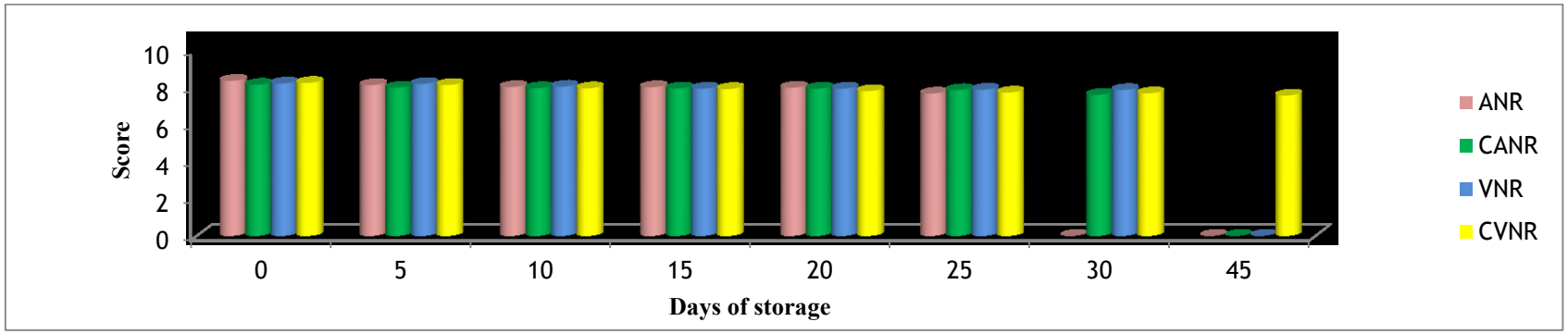

Figure 13a. Juiciness score of non irradiated dried beef

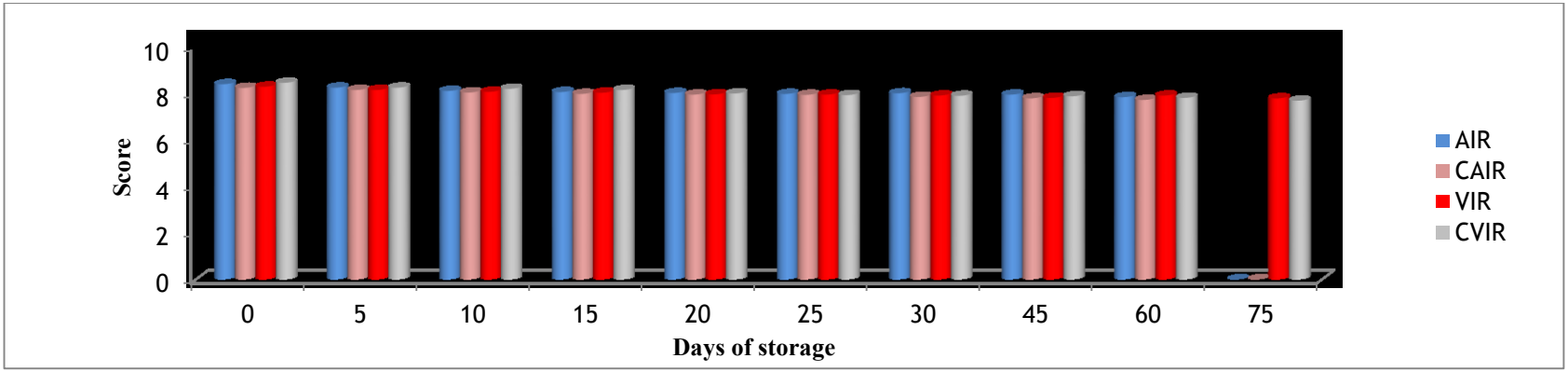

Figure 13b. Juiciness score of irradiated dried beef

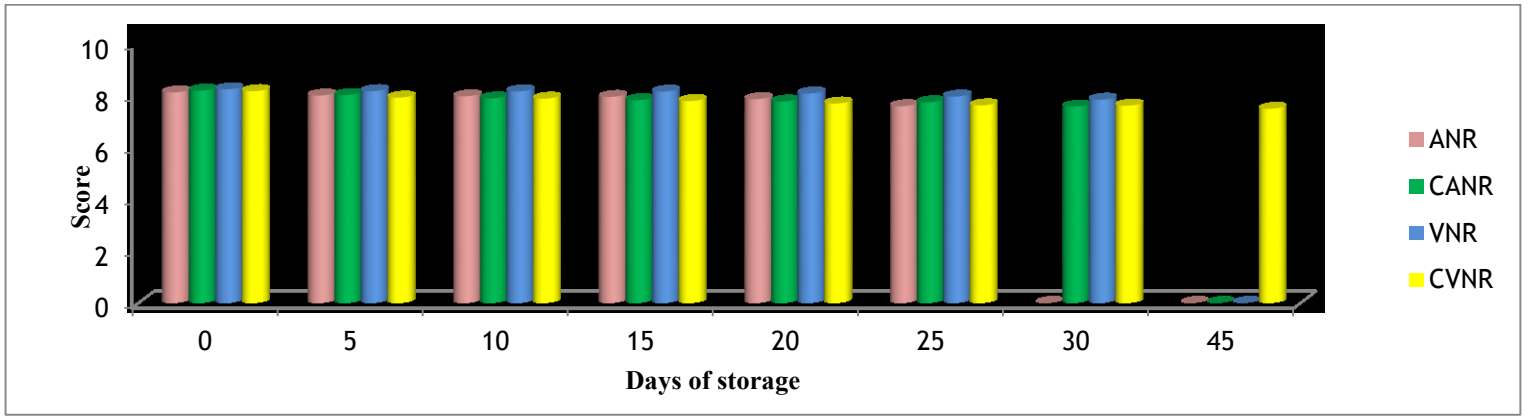

Figure 14a. Tendernes score of non irradiated dried beef

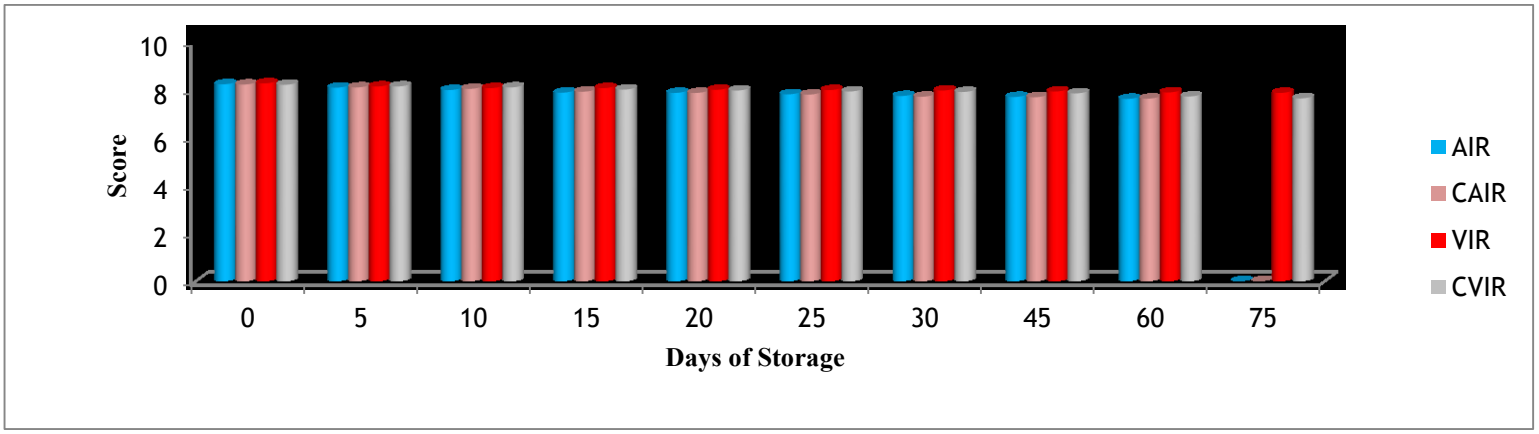

Figure 14b. Tendernes score of irradiated dried beef

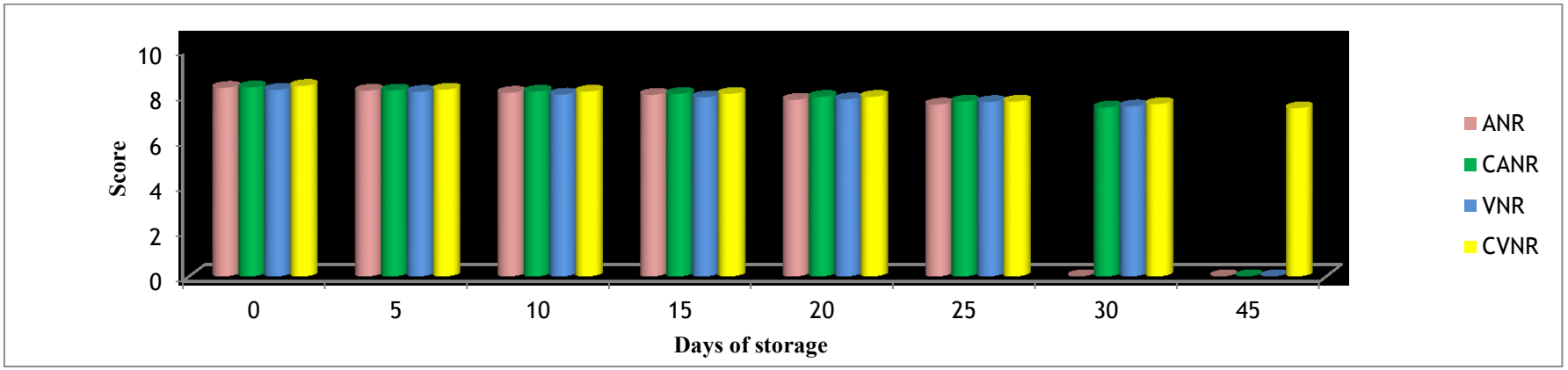

Figure 15a. Overall acceptability score of non irradiated smoked dried beef

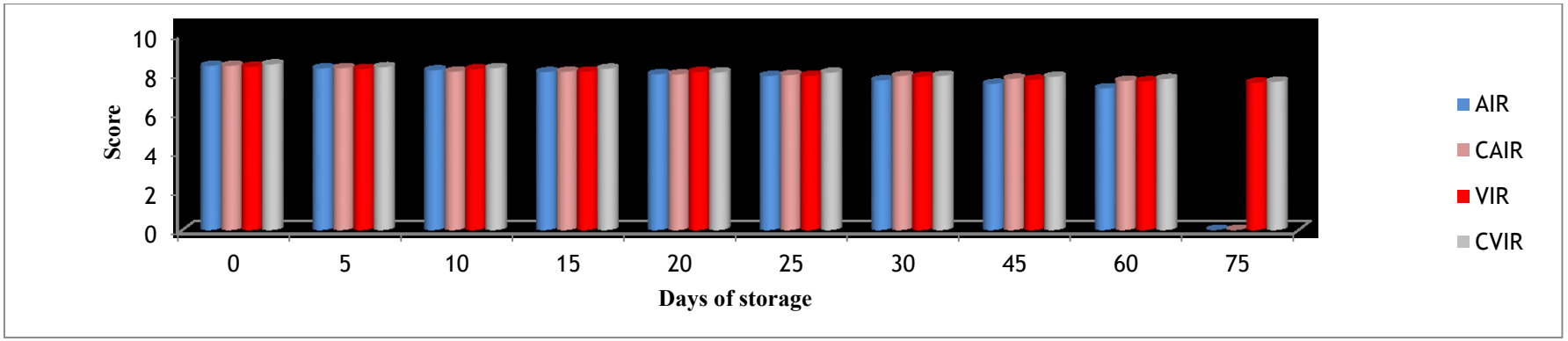

Figure 15b. Overall acceptability score of irradiated dried beef

Discussion

5. DISCUSSION

Smoked dried beef popularly known as *Idiyirachi* is a common value added preserved meat available in hilly areas of Kerala. Since many people have migrated from these areas to different parts of Kerala as well as to other places, such products are marketed extensively. But there is no uniform pattern of production or processing of the smoked dried beef. In order to get a general concept about the method of preparation hundred houses at Adimaly Grama panchayat of Idukki district of Kerala was selected and a survey was conducted with a preformed questionnaire. The survey revealed information regarding method of preparation, different ingredients used, packaging and storage of the product.

The main source of the *Idiyirachi* was in the form of traditional household preparations. Its shelf life was observed to be very short, which varied from 4-5 weeks. But in the cases where the product was kept above the oven (continuous smoking) or in refrigeration (low temperature), it had an extended shelf life of 4-5 months.

Lawrie (1998) reported 3 year or more shelf life for compressed blocks of dehydrated beef in sealed cans at moderate storage temperature with a decrease in reconstitution capacity after 12 months. In the present study the storage period was very short mainly due to the unhygienic practice of preparation, packaging and the storage at ambient temperature. The refrigerated sample had a shelf life of 4-5 months which is somewhat sufficient for marketing the product.

5.1.1. Quality analysis of the sample

The chemical composition of different products like sundried beef and smoked beef showed no significant difference except in case of acid insoluble ash. This might be due to the different surroundings in which the product was prepared. Most of the educated Keralites are concerned about the intake of sodium chloride, this may be the reason, the product samples contained comparatively

low percentage of sodium chloride and the mean content varied non significantly between different methods of preparation.

The physicochemical qualities non significantly differed between different methods of preparation whereas acid insoluble ash, aerobic plate count and yeast and mould count differed significantly. This might be due to change in the different surroundings where the products were prepared and handled.

In light of the above, it could be inferred that the method of preparation ran down in the households from generation to generation. This was the reason, the physicochemical characteristics remained comparable. But environmental factors and hygiene played a role in changing the quality of the product. From the response of the persons who marketed the product, it was observed that there was a great demand for the product. Even though they were not interested in refining their technology, the proper transfer of technology is important in improving the quality of the product.

5.2.1 Yield of the product

Addition of chitosan has improved the cured meat weight by 1.108 times and reduced the drip loss significantly. Similarly the yield of the product was 2.75 ± 0.02 in case of chitosan added samples against 2.50 ± 0.05 in control samples. By the addition of 1 per cent chitosan, there was a 5 per cent higher yield of the product while keeping quality remains unaltered. Knorr (1982, 1983) reported the chitosan as a water binding agent. This might be the reason for the increased yield of chitosan added products in comparison to control. Shijin (2008) did not observe a higher yield of the product by the addition of chitosan, whereas, in the present study about a 5 per cent higher yield was noticed. It might be due to difference in the total moisture content of the product.

5.3. PHYSICAL QUALITIES AND SHELF LIFE

The control samples had a shelf life of 27 to 29 days. Chitosan addition, vacuum packaging and irradiation extended the shelf life of the product. Rao *et al.*

(2005) in intermediate moisture mutton kabab, Sunil (2007) in minced meat, Shijin (2008) in chicken fry reported an increased shelf life due to chitosan addition. Extension in shelf life and reduction in bacterial count by the application of irradiation was reported by Grant and Patterson (1991), Kuttinarayanan (2005), Jenifer (2006), Shijin (2008) and Ahire Girish Sureshrao (2009). Similarly in the present study, irradiation of samples extended the shelf life by three to four times in different treatments and the findings are in agreement with earlier reports.

The colour and odour was not significantly different between various treatments as observed at the time of opening the packets. Ahn *et al.* (2000) reported that vacuum packaging was better than aerobic packaging for irradiation, since it minimized the oxidative changes. Similarly, Thayer (1993) also opined that extension of shelf life could be attained with irradiation in combination with vacuum packaging. In the present study vacuum packaging and chitosan application with irradiation or vacuum packaging with irradiation alone extended the shelf life to about 78-83 days and this three month period is sufficient to market the product in many parts of the state.

5.4. PHYSICOCHEMICAL QUALITIES

5.4.1 Chemical composition

Chitosan addition had a significant effect in changing the proximate composition, whereas, either vacuum packaging or irradiation did not alter the values significantly. There was a significant difference in energy level and sodium chloride content between groups and this might be due to addition of 1.0 per cent chitosan in excess of other ingredients. Non significant effect due to irradiation were reported by Sakala *et al.* (1987), Katta *et al.* (1991) Wheeler *et al.* (1999) and Wu *et al.* (2000) in different meat and meat products. The present study is in agreement with the findings of Smith and Pillai (2004), Al-Bachir (2005) and Rana Raj (2006) in different foods. The significant increase in moisture level of chitosan added sample led to increased yield of final product without altering

shelf life. It can be exploited for commercial preparation of smoked dried meat products.

5.4.2. Rehydration Ratio

The rehydration nature of a dried product was used as a quality index in many dried products. Irradiation has not significantly altered the rehydration capacity of the product whereas chitosan application reduced the same. Knorr (1982, 1983) and Gennedios and Hanna (1997) reported improved water binding capacity of chitosan in various products. In the present study, the chitosan added sample yield was 5 percent higher and the moisture percentage of treatments was significantly higher than that of non chitosan incorporated samples. This higher moisture percent retained in the smoked dried beef might be the reason for reduced rehydration capacity. This indicates that application of chitosan did not affect the final yield as well as organoleptic quality of the product.

5.4.3. pH

The initial pH of 5.53 in control sample was significantly increased by the process of chitosan addition whereas irradiation did not reveal such a change. Nicholas (1992) reported significantly higher pH value in chitosan treated salmon products and opined that it might be due to residual base left over from the processing of chitosan. Tarkowski *et al.* (1984), Nam and Ahn (2002), Al-Bachir (2005), Salke Dinkar Babanrao (2007) did not observe significant change due to irradiation in different meat and meat products and the present study is also in agreement with the previous reports. Storage had a significant effect in increasing the pH. Biswas (2006) in chicken patties and Chukwu and Imodiboh (2009) in dried beef '*Kilishi'* reported an increase in pH upon storage and the results are in agreement with the present study. The increase in pH might be due to the action of micro organisms which were present in smoked dried beef at ambient temperature since the chance of endogenous enzymatic action are remote.

5.4.4. Tyrosine Value

Tyrosine is the first released amino acid due to protein break down in meat. It is estimated as mg of tyrosine per 100 g of meat. The control sample on the day of preparation had a tyrosine value 5.69 ± 0.04. Chitosan application and irradiation changed these values. Chitosan applied samples had a lower value compared to control samples where as different packaging systems did not change the values significantly.

Storage had a significant effect on increasing the tyrosine value up to 75 days. Irradiated as well as chitosan applied samples had significantly lower values in comparison to non irradiated and non chitosan added samples. Karthikeyan *et al*. (2000) reported higher protein degradation in meat products at ambient temperature. Naveena *et al*. (2001) also obtained similar trend in smoked spent hen meat and result of the present study are in agreement with the earlier findings. Dushyanthan *et al*. (2001) reported vacuum packaging as an effective method for reducing the tyrosine value and the result of the present study also agrees with the findings. Shijin (2008) reported chitosan application, irradiation and a combination of these two in reducing the tyrosine value both under chiller condition and room temperature storage of chicken fry. The present study comprising of intermediate moisture food, chitosan application, irradiation and vacuum packaging had the maximum beneficial effect in reducing tyrosine value even though all these hurdle technologies had an effect in reducing the same. The content of tyrosine can be one of the criteria to say whether a sample is spoiled or not as evidenced by its higher value in the spoiled sample.

5.4.5. Thiobarbituric Acid Reacting Substances (TBARS)

Estimation of TBARS in meat and meat products will represent the extent of oxidative rancidity changes. The TBARS values of chitosan applied non irradiated samples both in aerobic and vacuum pack had the lowest values indicating irradiation and non addition of chitosan individually or together had significantly influenced TBARS values. There are various reports that irradiation had significantly influenced TBARS values. Murano *et al*. (1998), Du *et al.*

(2001), Nam and Ahn (2003), Kuttinarayanan and Ramanathan (2010) reported higher TBARS values in irradiated samples and results of the present study are in agreement with previous studies. There was a significant reduction in TBARS value due to application of chitosan. Darmadji and Izumimoto (1994), Kanatt *et al.* (2004) Rao *et al.*(2005), and Shijin (2008) reported the beneficial effect of chitosan in minimising lipid oxidation and reducing TBARS values in various meat products. The effect of vacuum packing in reducing the TBARS values was reported by Nam and Ahn (2003), but such a beneficial effect was not noticed in present study. From the above results it can be inferred that irradiation could increase the lipid oxidation and rancidity which can be effectively controlled by application of chitosan. But vacuum packaging alone cannot change the effect of irradiation on TBARS values.

5.5. MICROBOLOGICAL ANALYSIS

5.5.1. Aerobic Plate Count (APC)

In India irradiation of meat and meat products is permitted to destroy the pathogenic organisms and to extend the shelf life of meat and meat products including chicken. The smoked dried meat contained very less percentage of moisture; hence the recommended dose of irradiation as per PFA may not be sufficient to get the desired effect. Initially the product had an aerobic plate count of 2.21±0.03. Chitosan application or vacuum packaging did not alter the count significantly, where as irradiation alone or in combination had significantly reduced aerobic plate count. It was observed that there was a 20 per cent reduction in aerobic plate count initially due to irradiation and this low reduction might be due to low moisture level of the dried beef. There are various reports of higher percentage of reduction in fresh meat and meat products (Niemand *et al.*, 1981) in beef cuts, Jenifer (2006) in minced beef, Kuttinarayanan (2007) in buffalo meat, Salke Dinkar Babanrao (2007) in beef cutlet, Shijin (2008) in chicken fry and Sonika (2009) in rabbit meat). On storage there was a significant increase in aerobic plate count and chitosan added samples showed a lower aerobic plate especially in aerobically packed smoked dried beef. In case of vacuum packed

non irradiated samples, chitosan application alone had no significant effect in reducing the count. Initially the effect of chitosan was not similar to that reported by Sunil *et al.* (2007) whereas from 10 to 15 days of storage the results were promising and a significant difference was noticed in chitosan applied samples both under aerobic and vacuum packing. The present study was not in agreement with Kanatt *et al.* (2005) who observed that even after 28 days of storage the aerobic plate count of irradiated samples did not reach that of control non irradiated samples.

5.5.2. Yeast and Mould Count

The initial count of 1.90 ± 0.03 was significantly reduced by the process of irradiation in all the treatment groups, like that of APC chitosan application or vacuum packaging did not have any significant effect. The non significant count of yeast and mould was noticed in chitosan applied irradiated samples under both the packaging systems. Irradiation extended the shelf life of the product by more than two times and vacuum packaging followed by irradiation extended the same by another 15 days. Monk *et al. (*1995) in chicken breast and Balamatsia *et al.* (2006) in chicken reported a significant reduction in yeast and mould count by irradiation at low dose. The present study also showed a significant reduction but not to the extent of the earlier reports. It may be due to low moisture content of the smoked dried meat compared to chicken meat. Kuttinarayanan *et al.* (2006c) and Kuttinarayanan (2007) reported a reduction of above 95 per cent in yeast and mould count in various meat and meat products by irradiation. The variation in the product may be one of the reasons for not obtaining such a result in the present study. Shahidi *et al.* (1999) and Sebti *et al.* (2005) reported the beneficial effect of chitosan in reducing or inhibiting the growth of numerous yeast and mould. In the present study irradiation alone or in combination with chitosan application and vacuum packaging had significant effect in reducing the count. Compared to aerobically packed samples, vacuum packaging had a better shelf life and chitosan application further extended the storage life.

Under ambient temperature of storage a drastic increase in aerobic plate count and yeast and mould count was noticed under both systems of packaging. It can be inferred from the above results that application of chitosan, vacuum packing followed by irradiation, can extent the storage life of product to above 80 days without any signs of spoilage.

5.6. ORGANOLEPTIC QUALITIES

5.6.1. Colour

Packets were opened at various days of evaluation and observed for the signs of spoilage. Non spoiled samples were noted. Sufficient quantity of the product was rehydrated, fried in oil and taste panel studies were conducted with the help of nine point Hedonic scale. The purchaser always goes for a product by its appearance and the colour of the product plays an important role in marketing. In the present study a good score of 8.24 was obtained for the control sample and was improved by the process of irradiation, but was not changed by application of chitosan. Aerobic or vacuum packing was not effective individually whereas chitosan application, vacuum packaging and irradiation improved the score to 8.32. Lefebvre *et al.* (1994), Fu *et al.* (1995), Murano *et al.* (1998), Zhu *et al.* (2003) and Smith and Pillai (2004) reported no change in colour due to irradiation in meat and meat products where as Zhao *et al.* (1996) reported less desirable colour due to irradiation in various meats. The present study is in agreement with Jo *et al.* (2000) who reported a better colour in cooked vacuum packed irradiated sausages. Darmadji and Izumimoto (1994) reported better sensory attributes due to addition of chitosan. In the present study even though chitosan was not contributory for sensory attributes, in long run there was significant difference in colour score in chitosan added smoked dried beef. As storage period increased there was a significant reduction in colour score and results are in agreement with Shijin (2008) in chicken fry and Ahire Girish Sureshrao (2009) in chicken tikka.

5.6.2. Flavour

The combined perception received by the sense of taste and smell is recorded as flavour of a product. Initially the control sample had a very good score of 8.17 and was not changed due to chitosan application, irradiation or vacuum packaging. Zhao *et al.* (1996), Zhu *et al.* (2003) and Zhu *et al.* (2004) reported flavour changes due to irradiation in various meat products. Whereas Arthur *et al.* (2005) and Kanatt *et al.* (2005) are in agreement with results of the present study and they did not observe any detectable odour or flavour changes in irradiated meat products. Ahn *et al*. (2000b) reported beneficial effects of vacuum packaging for increasing the flavour score in irradiated products. There was no significant difference initially due to vacuum packaging, but later the score varied significantly in vacuum packaged and chitosan applied samples. As the storage period enhanced, the flavour score reduced due to various biochemical changes that took place in the product, since it was kept under ambient temperature. But even after 75 days of storage, samples retained a fairly good score of above 7.5 out of 9.

5.6.3. Juiciness

The juiciness of the product was initially 8.35 out of 9 in control samples. It was numerically improved by the process of irradiation and significantly improved by chitosan application, vacuum packaging followed by irradiation. In many occasion irradiated samples had a better score than counterpart non irradiated samples. The results of the present study are in agreement with Murano *et al.* (1998) and Johnson *et al.* (2004), who reported higher juiciness scores for irradiated products. Luchsinger *et al.* (1996) and Abu-Tarboush *et al.* (1997) observed no significant change in juiciness due to irradiation. There was a gradual reduction in juiciness and it reached a good score of above 7.5 by 75 days of storage in VIR and CVIR samples. The values were significantly reduced from the original value. Irradiation, chitosan application and vacuum packaging had a beneficial effect in retaining fairly a good score during storage period.

5.6.4. Tenderness

The dried product after frying in oil retained a good score of 8.13 in control sample and was increased by the process of irradiation in all the treatment groups. Initial value of 8.13 was increased to 8.27 by the process of irradiation. Always irradiated samples retain the higher value whether it was subjected to chitosan application or vacuum packaging prior to irradiation. Hashim *et al.* (1995), Murano *et al.* (1998) and Arthur *et al.* (2005) reported increased tenderness due to irradiation. Coleby *et al.* (1961) reported that irradiation caused shrinkage of collagen, which resulted in softness and tenderness in meat foods. This may be the reason for significantly higher tenderness score in irradiated products. Whereas Ohene-Adjei *et al.* (2004) reported a decrease in tenderness and Kanatt *et al.* (2006) observed no significant change in tenderness due to irradiation. The tenderness of the product had maintained its initial level without much change up to 10^{th} day of storage. From there onwards days of storage had a significant effect in reducing the score which might be due to the low juiciness of the product. Similar results were observed by Shijin (2008) in chicken fry and Ahire Girish Sureshrao (2009) in chicken tikka. The samples at the final stage of storage had a comparatively good score of above 7.5 in VIR and CVIR samples and were significantly different with higher value in VIR samples.

5.6.5. Overall Acceptability

The overall acceptability is the product of the individual sensory qualities. The sample initially had a score of 8.3 and was improved by the process of irradiation. Similar to other sensory attributes, chitosan application or vacuum packaging was not having benefit on improving the scores individually. Up to 5^{th} day of storage the score was not significantly affected. From there onwards storage had a significant effect. Since many of the scores improved significantly due to irradiation, the overall acceptability also improved. Johnson *et al.* (2004) and Kanatt *et al.* (2005) reported a similar trend in irradiated products. Even after 75 days of storage, the samples had a good score of above 7.5, indicating that

irradiated samples along with chitosan application and vacuum packaging can be stored beyond 80 days. Darmadji and Izumimoto (1994) reported the beneficial effects of chitosan in improving the overall sensory attributes and the observation in the present study is in agreement, where chitosan applied vacuum packed and irradiated samples had the maximum score throughout the study.

5.7. COST OF PRODUCTION

The cost of production of any ready-to-serve or ready-to-cook food items in Kerala are highly varying since many of the raw materials are brought from outside the state. The cost of production of the two groups, that is control sample and chitosan added sample are shown in table 22. The yield of the final product in case of non chitosan added sample was only 50 per cent with moisture 31-32 per cent moisture. The cost comes to Rs. 268.18 per Kg. In the sample containing chitosan at 1 per cent level, even though the cost of production was higher, the yield was also higher (55 per cent). Thus cost of production lowered to Rs. 252.35 per Kg of smoked dried beef. As far as producer is concerned, the yield is more per unit Kg of meat used; hence the production cost is low and leads to higher profit.

From the above results it can be inferred that ready to use smoked dried beef preserved by chitosan application, smoking, drying, vacuum packaging and irradiation had extended the shelf life to 83 days, as against control samples which had shelf life of 27-29 days. Incorporation of chitosan had many beneficial effects and decreased the negative effects brought about by irradiation even though it was mainly used for controlling the pathogenic and spoilage causing organisms.

As noticed in the survey conducted, aerobically packed smoked dried beef had a shelf life of only 4-5 weeks, just like in the experimental studies which can be extended nearly to 90 days by incorporating various hurdle technologies. A meat product having a shelf life of nearly 3 months at ambient temperature can be marketed through retail outlets which cover the entire state. If cold chain is maintained, the shelf life can be further extended and a wider market can be

obtained. The process of irradiation destroys many of the spoilage bacteria and fungi including pathogenic organisms and the negative effects brought by irradiation can be controlled by addition of chitosan. Hence the final product is safe and can be popularised.

Summary

6. SUMMARY

Idiyirachi is a popular meat product prepared by smoking and drying which is consumed extensively in the hilly areas of Kerala. In order to get an idea about the method of preparation, hundred houses in Adimaly Grama panchayat of Idukki district of Kerala were selected and a survey was conducted with a preformed questionnaire. The survey revealed information regarding method of preparation, ingredients incorporated, packaging and methods of storage of the product. About ninety eight percent of the people surveyed consumed dried beef. More than eighty percent of the people prepared dried beef at their home itself for house hold consumption. Majority preferred smoking and drying over sun drying. The survey revealed that shelf life of the locally prepared dried beef was very short. This was due to the unhygienic practices of preparation, packaging and the ambient storage temperature. From the response of the persons who marketed the product, it was observed that there is a great demand for the product.

Twenty five samples were collected from different producers and were divided according to the method of preparation into three groups and were assessed for chemical composition, physicochemical qualities and microbiological qualities. The moisture, fat, protein, ash, energy, sodium chloride content, pH, TBARS, TV and Rehydration ratio varied non significantly where as acid insoluble ash and carbohydrate content, aerobic plate count and yeast and mould count varied significantly between samples prepared by different methods. From the survey results, it can be inferred that the method of preparation passed on from household to household through generations. This was the reason why the physicochemical characteristics remained comparable in the various samples. But environmental factors and hygienic practices played a role in changing the quality of the product. In order to extend the shelf life of dried meat and to market the same, the processing techniques needs to be standardized with incorporation of proper packaging technology.

Radiation preservation of meat in India is permitted by PFA in 1998 and it leads to improvement in the microbial quality and thereby extends the shelf life. The disadvantages of radiation preservation can be minimized with the incorporation of different hurdles technologies like addition of chitosan, vacuum packaging etc.

The study on the effect of low dose gamma radiation and chitosan addition on shelf-life and quality changes of smoked dried beef under aerobic and vacuum packaging was conducted in the Department of Livestock Products Technology, Mannuthy. Six batches of meat were procured from the animal slaughtered at Department of Livestock Products Technology. Half of the meat steaks prepared was rubbed with salt (10.0 per cent), turmeric (0.5 per cent) and powdered pepper (1.0per cent) and the other half was rubbed with the above ingredients and 1 per cent chitosan. The samples were cured for one hour at room temperature and smoked for six hours. Half of the different treatment groups were packed in HDPE pouches and other half was vacuum packed in PAPE pouches. Half of the packets in aerobic and vacuum packaging were subjected to gamma irradiation at 2.5kGy and the samples were kept at room temperature. The irradiated and non-irradiated smoked dried beef under various treatment groups and packaging were analysed for different quality parameters, viz., physical, physiochemical, microbiological and organoleptic qualities on the day of preparation and on days 5, 10, 15, 20, 25, 30, 45, 60 and 75 or until spoilage whichever was earlier. The samples were subjected to proximate analysis on the day of preparation.

Addition of chitosan improved the weight of cured meat and reduced the drip loss significantly. The yield of the product was 2.75 ± 0.02 in case of chitosan added samples against 2.50 ± 0.05 in control samples. By the addition of one per cent chitosan, there was about five per cent higher yield of the product while the keeping quality remained unaltered. It can be exploited for commercial preparation of smoked dried meat products.

The proximate composition was analysed on the day of preparation. Addition of chitosan had a significant effect in changing the proximate

composition where as vacuum packaging or irradiation did not alter the values significantly. The moisture content varied from 31.63±0.22 (ANR) to 36.93±0.26 (CVNR) and the values were significantly different. A similar trend was observed for fat, protein, ash, carbohydrate and sodium chloride content between chitosan added and non chitosan added treatments.

Irradiation did not significantly alter the rehydration capacity of the product where as chitosan application significantly reduced the same. The pH showed an upward trend during storage until spoilage. The chitosan application had a significant effect in increase in the pH on the day of preparation. Initially the smoked dried beef samples had a tyrosine value of 5.69 ± 0.04 which significantly reduced due to addition of chitosan and irradiation in other treatment groups. Throughout the study period storage had a significant effect in increase in tyrosine value. The initial TBARS value of 0.59 ± 0.03 mg mal/ kg was changed to 0.64±0.03 mg mal/kg due to irradiation under vacuum packaging but chitosan application made it non significant. The TBARS values of chitosan applied non irradiated samples both in aerobic and vacuum packing had the lowest values indicating that irradiation and non addition of chitosan had significantly influenced TBARS values on storage.

The initial aerobic plate count of 2.21 ± 0.03 was noticed in ANR samples and was non significant from other non irradiated samples. Irradiation had a significant effect in reducing the aerobic plate count and had a synergistic effect with the addition of chitosan. Chitosan alone had non significant effect in reducing the aerobic plate count in smoked dried beef. Storage of the product under ambient temperature had a significant effect in increasing the aerobic plate count, always with a significantly lower count in irradiated groups both in chitosan added and vacuum packed samples. Irradiation had significantly reduced the count yeast and mould count. The initial count 1.90 ± 0.03 (ANR) was significantly reduced to 1.26 ± 0.09 in AIR and CVIR samples.

The organoleptic qualities of the product were assessed with the help of nine point Hedonic scale. The colour score on the day of preparation was significantly improved due to irradiation but was not changed by application of chitosan and different methods of packaging. But chitosan application, vacuum packaging and irradiation improved the score to 8.32. Initially the control sample had a very good flavor score of 8.17 and was not changed due to chitosan application, irradiation or vacuum packaging. The juiciness score of the product was initially 8.35 out of 9.0 in control samples. It was numerically improved by the process of irradiation and significantly improved by chitosan application, vacuum packaging followed by irradiation. Initial tenderness score of 8.13 was increased to 8.27 by the process of irradiation. Always irradiated samples retained a higher value whether it was subjected to chitosan application or vacuum packaging prior to irradiation. The sample initially had an overall score of 8.3 and irradiation improved the score. Storage significantly decreased the organoleptic quality score of the product. The cost of control sample was Rs. 268.18 per kg whereas in the case of chitosan incorporated samples it was Rs. 252.35 per kg. The lower cost was due to the higher yield of the product.

The minimum storage life was noticed in non irradiated aerobically packed sample and it had a shelf life of 27- 29 days. All the treatments like chitosan application, vacuum packaging and irradiation extended the shelf life of the product. The irradiated samples had three to four times the keeping quality than that of non irradiated samples. Vacuum packaging, chitosan application with irradiation or vacuum packaging with irradiation alone extended the shelf life to about 78-83 days. In the light of above results, irradiation method of preservation in combination with different hurdles like chitosan addition, vacuum packaging can be recommended to increase the shelf life of smoked dried meat under storage at room temperature.

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Appendix

Appendix 1. Survey Questionnaire

1. Date of survey:

2. Name & Address of Head of the Family:

Panchayath: Taluk:
District:

3. Details of the Family Members

Sl.No	Name	Age	Sex	Relationship With Head of Family	occupation

4. Knowledge about Non vegetarian food?

5. Have you ever consumed dried beef/ Smoked beef?

Dried Beef - Y / N

Smoked Beef- Y / N

6. Frequency of consumption:

7. What is the source:
   a. Market
   b. Home made
   c. Free supply

8. If Homemade, method of preparation:

   a. Sun drying
   b. Smoking
   c. Both
      Brief description of the method:

9. Ingredients added & Quantity:

10. Method of Packing & Storage:

11. What is the usual shelf life noticed?

    11a. Keeping quality – duration (months)

12. What are the usual spoilage conditions?

13. Seasonal variation in spoilage:

14. Do you market it? Y / N

    If yes

a. Where is it marketed?

b. How is it marketed?

c. How is the price ascertained?

d. Demand:

e. Profit:

f. Constraints in marketing:

15. Are you satisfied with present method/ technology? Y / N

16. Do you want to refine your technology? Y / N

17. Have you approached any agency for the purpose & its result?

18. Are you interested in any training?

Appendix II. Score card for taste panel evaluation

Name of the Product: **Smoked dried beef** Date: Sample No:

	Colour	Flavour	Juiciness	Tenderness	Overall acceptability	
	Extremely Appealing	Delicious	More Juicy	Very Tender	More Acceptable	9
						8
						7
	Appealing	Desirable	Juicy	Tender	Acceptable	6
						5
						4
	Less appealing	Not so desirable	Less Juicy	Tough	Less Acceptable	3
						2
						1

Guide lines for giving judgement: If you feel that the colour of the product given to you for taste panel evaluation is extremely appealing, put a tick mark in any one of the three boxes against colour. Lower box signifies that it is less appealing and a tick in the central box signifies that it is for appealing. Similarly mark for the other characters viz., flavour, juiciness, tenderness and overall acceptability.

Specify comments if any:

Name and designation: Signature:

QUALITY ANALYSIS OF DRIED BEEF AND STANDARDIZATION TO SUIT THE LOCAL MARKET

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Abstract of the thesis submitted in partial fulfilment of the Required for the degree of

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ABSTRACT

Smoked dried meat of cattle and buffalo are very popular in hilly areas and a sought after product. In order to assess the quality, method of preparation and consumption pattern, a survey was conducted at 100 households in Adimaly Gramapanchayat, Idukki district, Kerala. It was revealed that ninety eight per cent of people had consumed the product, smoking is the preferred method over sun drying and eighty per cent of the people prepared the product at their home. Twenty five samples were collected and were divided according to the method of preparation. On assessment of chemical composition, physicochemical qualities and microbiological qualities, the moisture, fat, protein, ash, energy, sodium chloride content, pH, TBARS, TV and Rehydration ratio varied non significantly and acid insoluble ash and carbohydrate content, aerobic plate count and yeast and mould count varied significantly between samples prepared by different methods. Unhygienic preparation practices shortened the shelf life of the product but nevertheless the product had a great demand.

Six batches of meat were procured from the animal slaughtered at Department of Livestock Products Technology. Half of the sample was rubbed with salt (10%), powdered pepper (1.0%) and turmeric (0.5%) and to the other half chitosan (1.0%) was incorporated in excess of above ingredients. Cured meat samples were subjected to smoking and drying in the smoke house. The temperature and relative humidity of the smoke house were recorded. Both the smoked samples were packed separately in HDPE (aerobic) and PAPE (vacuum). Half of the sample from each group were subjected to gamma irradiation at 2.5 kGy and stored at ambient temperature.

The proximate composition of the sample was analysed on day of preparation and other quality parameters were assessed on days 5, 10, 15, 20, 25, 30, 45, 60 and 75 or until spoilage which was detected by the physical signs of spoilage.

The irradiated sample had an extended shelf life of 79-83 days compared to non irradiated sample which had a storage life of 27-29 days. Maximum storage life was noticed in chitosan applied smoked dried beef, placed in vacuum and irradiated at 2.5kGy.

Chitosan addition improved yield, reduced drip loss and changed proximate composition. By the addition of one per cent chitosan, there was about five per cent higher yield without altering shelf life and content of moisture, fat, protein, ash, carbohydrate and sodium chloride content were significantly changed.

Irradiation did not alter the rehydration capacity but chitosan application decreased it. Addition of chitosan showed a higher pH on the day of preparation. Addition of chitosan and irradiation reduced tyrosine value. Irradiation and non addition of chitosan individually or in combination increased TBARS values. Aerobic plate count and yeast and mould count were significantly reduced due to irradiation alone and in combination with chitosan. The pH, TV,TBARS and microbial load increased due to storage.

The organoleptic qualities like colour, flavour, juiciness, tenderness and overall acceptability of the product were improved by irradiation initially and reduced on storage in all samples. Chitosan added and vacuum packaged product showed higher scores compared to control. The cost of control sample was Rs. 268.18 per Kg and in the case of chitosan incorporated samples it was Rs. 252.35 per Kg.

Irradiation in combination with different hurdles like addition of chitosan, vacuum packaging can be recommended for the production of shelf stable smoked dried beef and can be marketed without much quality change since the product has a great demand.