

**ENRICHMENT OF ENROBING MATERIAL WITH
NATURAL NATIOXIDANT AND ITS EFFECT ON THE
QUALITY OF CHEVON BALLS**

T H E S I S

**Submitted
in partial fulfillment of the requirements for the Degree
of**

M A S T E R O F V E T E R I N A R Y S C I E N C E

I N

L I V E S T O C K P R O D U C T S T E C H N O L O G Y

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DECLARATION OF STUDENT

I hereby declare that the experimental Research work and interpretation of the thesis entitled “**ENRICHMENT OF ENROBING MATERIAL WITH NATURAL ANTIOXIDANT AND ITS EFFECT ON THE QUALITY OF CHEVON BALLS**” or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis/publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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Ku. ANJANA MANJHI has satisfactorily prosecuted her course of research for a period of not less than one semester and that the thesis entitled, **“ENRICHMENT OF ENROBING MATERIAL WITH NATURAL ANTIOXIDANT AND ITS EFFECT ON THE QUALITY OF CHEVON BALLS”** submitted by her is the result of research work is sufficient to warrant its presentation to the examination in the subject of **Livestock Products Technology** for the award of M.V.Sc degree by the Maharashtra Animal and Fishery Sciences University, Nagpur.

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This is to certify that the thesis entitled **“ENRICHMENT OF ENROBING MATERIAL WITH NATURAL ANTIOXIDANT AND ITS EFFECT ON THE QUALITY OF CHEVON BALLS”** submitted by Ku. ANJANA MANJHI to the Maharashtra Animal and Fishery Sciences University in partial fulfillment of the requirement for the degree of M.V.Sc has been approved by the Student's Advisory Committee after examination in collaboration with the External Examiner.

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I AM DEDICATING THIS RESEARCH WORK TO MY DEAREST 'PAPA AND MAA'

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LIST OF ABBREVIATIONS

%	:	Per-cent
@	:	At The Rate of
°C	:	Degree Centigrade
<	:	Less than
>	:	Greater than
µg	:	Microgram
µl	:	Microlitre
A	:	Absorbance
AOAC	:	Association of Official Analytical Chemists
APHA	:	American Public Health Association
a _w	:	Water Activity
BHA	:	ButylatedHydroxyanisole
BHT	:	ButylatedHydroxytoluene
CD	:	Critical Difference
cfu/g	:	Colony Forming Unit Per Gram
cm	:	Centimeter
DHBP	:	Dried Holy Basil Powder
DSP	:	Disodium Phosphate
EC	:	Epicatechin
eg.	:	For Example
Eo	:	Essential Oils
Eq.	:	Equation
FAO	:	Food and Agriculture Organization
FFA	:	Free Fatty Acid
FRAP	:	Ferric Reducing Antioxidant Power
G	:	Gram
GAE	:	Gallic Acid Equivalent
GSE	:	Grape Seed Extract
h	:	Hours
i.e.	:	That is
LDPE	:	Low Density Polyethylene
m	:	Molar
MAP	:	Modified Atmosphere Packaging
MbO ₂	:	Oxy-myoglobin
meq/kg	:	Milliequivalent Per Kilogram
mg/kg	:	Milligram per kilogram
MIC	:	Minimum Inhibitory Concentration
Min	:	Minutes
ml	:	Milliliter
N	:	Normality
NaCl	:	Sodium Chloride
No.	:	Number

NS	:	Non-Significant
NSS	:	Normal Saline Solution
O ₂	:	Oxygen
POV	:	Peroxide Value
ppm	:	Parts Per Million
PUFA	:	Polyunsaturated Fatty Acids
Pvt. Ltd	:	Private limited
Q'	:	Quencher
RH	:	Relative Humidity
ROO	:	Peroxy Radicals
ROS	:	Reactive Oxygen Species
STPP	:	Sodium Tripolyphosphate
TBA	:	Thiobarbituric acid
TBARS	:	Thiobarbituric Acid Reactive Substances
TBHQ	:	Tert-Butylhydroquinone
TCA	:	Trichloroacetic Acid
TP	:	Tea polyphenol
TE	:	Trolox Equivalents
TPC	:	Total Plate Count
TSP	:	Textured Soya Protein
TSPP	:	Tetra Sodium Pyrophosphate
V	:	Volume
W	:	Weight
WHO	:	World Health Organization
α	:	Alpha
B	:	Beta
NaOH	:	Sodium Hydroxide
S. E.	:	Standard Error
PC	:	Psychrophilic Count
PG	:	Propyl gallate
SHMP	:	Sodium hexametaphosphate
DSPP	:	Disodium dihydrogendiphosphate
MHz	:	Megahertz
SPC	:	Standard plate count
CIRG	:	Central Institute for Research on Goats

INTRODUCTION

The livestock population of India is around 535 millions which comprises of 140.5 million goats and contribute meat production to the tune of 0.53 million tonnes (Reddy and Muthukumar, 2013. Prasad *et al.*, 2013). India rank first in goat population. Goat is a good source of meat (chevon), milk and other by-products such as hide and skin. In India, goat keeping constitutes an important business of small and marginal farmers and the landless residing in rural areas. Meat production is the primary purpose of goats rearing. The goat sector had contributed substantial revenue to the agricultural economy of the country through meat (6851 crores), milk (4588 crores), skin (648 crores), etc. which has accounted for around 8 per cent of the gross domestic product (GDP) from livestock sector (CIRG,2011).

Chevon is a healthier alternative as compared to other red meats. It has low saturated fatty acids and cholesterol specially polyunsaturated fatty acids (68.5% to 72.3%) predominate in goat meat (Devendra., 1988).A diet rich in non-saturated fatty acids is correlated with a reduced risk of stroke and coronary diseases. The nutritive value of chevon as well as other food items is becoming increasingly important in the health management of people. Addrizo (2000) stated that heart diseases through diets could be reduced in 80% of the patients who ate chevon.

Today's goat meat products are prepared in many ways following diverse recipes with several added ingredients. However, the authentic cooking practices are either baked or barbequed (asado) or stewed (guisado) with traditional cumin, garlic and chili pepper spices.

Battering and frying are the traditional methods used for preparing foods throughout the world. Empiricism has dominated its application for decades. Coatings play an important role in increasing consumer acceptance of breaded products. They provide an attractive appearance (Suderman., 1983), as well as a contrasting texture between the crisp coating and the relatively soft inner product (Scott., 1987). Enrobing/coating of meat products with edible materials improves their cooking yield and provides better protection against oxidative and microbiological deterioration, enhances their sensory qualities and could be an effective method of value addition with better consumer acceptability. Further, enrobing of meat products provides advantages such as preserving the nutritive

value, preventing moisture and weight loss, improving juiciness and tenderness. These improvements are brought about by the coating ingredients which act as sealants and also prevent high oil uptake during frying of the product (Cunningham., 1989). Breading on the fried meat enhances texture, flavour and appearance of the product (Rao and Delaney, 1995). Attempts have been made in the past to enrobe the meat products by using coating materials such as bengal gram flour, alginate, egg (Biswas *et al.* 2004; Chidanandaiah and Keshri 2006; Ahamed *et al.*, 2007). It has also helped in reduction of warmed-over flavour (WOF) in meat products (Handley *et al.*, 1996; Hergens-Madsen *et al.*, 1995).

Frying contributes for increased oxidative rancidity in enrobed meat products. Lipid hydroperoxides formed during the propagation phase of the peroxidation process are unstable and produce various chemicals which adversely affect quality of the products which in turn jeopardize the safety of the consumers by encouraging coronary heart disease, cancer and stroke like ailments (Senate Select Committee, 1977). In order to overcome the problems related to oxidative rancidity, off-flavour and colour stability in fresh as well as processed meats, the researchers have concentrated their efforts in searching the suitable antioxidant for meat during its processing. For over 50 years, synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tert-butyl hydroquinone (TBHQ) have been used as antioxidants in meat products (Formanek *et al.*, 2001). The use of these additives, however, has fallen under scrutiny due to their potential toxicological effects (Jayathilakan *et al.*, 2007; Nunez de Gonzalez *et al.*, 2008; Naveena *et al.*, 2008a). Nowadays, the meat industry is in search of economical as well as effective natural antioxidant that can replace the synthetic ones without having negative impact on quality and consumer perceptions of their finished products. Some researchers (Bozkurt, 2006; Shewalkar, 2011; Carpenter, *et al.*, 2007; Brannan, 2008; Naveena, *et al.*, 2008 and Narkhede, 2012) have screened certain natural antioxidants such as pomegranate ellagic acid, tea catechins, grape seed extract, holy basil powder etc. so far.

Green tea polyphenols, mainly rich in flavonoids (flavones, flavonones, flavonols, flavanols and anthocyanins) have demonstrated potential antioxidant properties due to their redox potential, that enabled them to act in various forms such as hydrogen donors, reducing agents, nascent oxygen quenchers and chelating metal ions in numerous food applications (Gramza and Korczak 2005).

Literature has evidenced antioxidant properties of Grape Seed Extract (GSE) both in vivo and in vitro (Yilmaz and Toledo, 2004). These properties of GSE are primarily due to flavonoids that can perform scavenging action on free radicals (superoxide, hydroxyl, and 1,1-diphenyl-2-picrylhydrazyl (DPPH), metal chelating properties, reduction of hydroperoxide formation and their effects on cell signaling pathways and gene expression (Soobrattee *et al.*, 2005; Jacob *et al.*, 2008).

Nevertheless, pertinent literature available on the studies involving Green tea and Grape Seed Extract incorporation in enrobed chevon products is limited. Therefore, the present work has been proposed so as to evaluate their efficacy on certain quality attributes of the enrobed chevon ball with the following objectives.

Objectives:

- 1) To standardize the process for the preparation of enrobed chevon meat balls using different levels of potato as an extender.
- 2) To study the effect of Green tea and Grape Seed Extract separately on physico-chemical and sensory attributes of enrobed chevon balls.
- 3) To assess the shelf life of enrobed chevon balls with selected levels of Green tea and Grape Seed Extract at refrigerated storage ($4\pm 1^{\circ}\text{C}$).

REVIEW OF LITERATURE

Goats are an important nutrient source, particularly for people in the technologically developing regions, situated mainly in the tropics. These regions account for more than 90% of the estimated world goat population of 1.57 millions and meat production to the tune of 596600 tonnes (FAO., 2011).

Meat production is the primary purpose of goat keeping. There are virtually no religious or cultural taboos on chevon consumption. Moreover, it is readily available to societies in which eating beef, pork or other meat types is prohibited. In many parts of the world, chevon is preferred over mutton and commands a better price.

Enrobing

Enrobing is a process in which the foods are traditionally coated with edible materials in the form of batter which preserves and enhances the food quality. The consumer market for deep-fried coated foods has expanded rapidly in recent years. This is due to combinations of the distinctive flavour, aroma, and crunchy texture along with the flavour and the juices that are retained in the core and in the crispy crust of products. Battering and breading are traditional methods used in preparation of value added food products and they control the texture, flavour, weight, volume, moisture loss, and fat absorption during frying. It minimizes monotony of certain food products and makes them more appealing in appearance (Elston., 1975) and taste. Batter and breading act as barriers against moisture loss by protecting the natural juices of the foods from the effects of freezing or reheating, thereby ensuring a final product with a tender and juicy core coated with a crispy crust. Enrobing also contributes to nutritional value of food product (Kroger and Igoe, 1971, Elston., 1975) by adding ingredients and protecting the product from direct contact with the cooking medium and moisture loss.

Batter can be defined as liquid dough, considered to be a thick but pourable mixture, basically consisting of flour or starch blended with water into which a product is dipped before it is breaded or fried. It sometimes incorporates a leavening agent, leading to expansion when it is fried. In practice, however, batters can also contain other ingredients, such as salt, seasonings, gums and egg. Thus, batters become highly sophisticated, complex systems in which the nature of the

ingredients is very wide-ranging and their interaction determines the final performance of the product.

Breading is a flour-based breadcrumb or cracker meal that is applied to a food in a dry form, primarily to create a desired coating texture. It is a dry food coating made from flour starch, seasonings, etc. that is coarse in nature and is applied over moistened or battered food products. The coating can be fine to coarse in particle size (Suderman and Cunningham, 1983).

Lipid Oxidation in meat and meat products

The oxidation of lipids in meat products is a key problem that reduces their shelf life. In precooked meats, lipid oxidation leads to detrimental changes in the flavour of the reheated, precooked products after refrigerated storage, leading to “warmed-over flavor”. Here, both lipids and proteins may be oxidized in a series of radical reactions that involve initiation, propagation, and termination steps with simultaneous formation of free radicals (Ladikos and Lougovois, 1990). These oxidation reactions can lead to browning, rancidity and the development of unpleasant flavour.

Lipid hydro-peroxides formed during the propagation phase of the peroxidation process are unstable and produce various chemicals which adversely affect quality and safety of the consumers by encouraging coronary heart disease, cancer and stroke like ailments (Senate Select Committee, 1977).

Membrane lipids present in subcellular organelles are highly susceptible to free radical damage. Lipids when reacted with free radicals can undergo the highly damaging chain reaction of lipid peroxidation (LP) leading to both direct and indirect effects. During LP a large number of toxic byproducts are also formed that can have effects at a site away from the area of generation, behaving as ‘second messengers’. The damage caused by LP is highly detrimental to the functioning of the cell (Devasagayam *et al.*, 2003). Lipid peroxidation is a free radical mediated process. Initiation of a peroxidative sequence is due to the attack by any species, which can abstract a hydrogen atom from a methylene group (CH₂), leaving behind an unpaired electron on the carbon atom (•CH). The resultant carbon radical is stabilized by molecular rearrangement to produce a conjugated diene, which then can react with an oxygen molecule to give a lipid peroxy radical (LOO•).

Antioxidants

Antioxidants are those compounds or substances that prevent oxidation. As oxidative stress in the body increases, the level of the pro-oxidants against antioxidants increases and the aging process accelerates. Reactive oxygen species and free radicals are the major causes of aging processes. Antioxidants can reduce the level of reactive oxygen species and free radicals slow down the aging process and increase the life span.

Antioxidants are defined as the substance that when present in low concentrations compared to those of an oxidizable substrate significantly delays or prevents oxidation of that substance (Halliwell and Gutteridge, 1989). Khlebnikov *et al.*, (2007) have defined the term antioxidant “as any substance that directly scavenges reactive oxygen species (ROS) or indirectly acts to up-regulate antioxidant defenses or inhibit ROS production.”

Antioxidants are organic lipid- or water soluble substances that can scavenge the active forms of oxygen involved in the initiation steps of the oxidation, or break the oxidative chain reaction. Antioxidants may react with the fatty acid peroxy radicals to form stable antioxidant radicals, which are either insufficiently reactive for further reactions or form non-radical products (Valenzuela and Nieto, 1996). The most widely used synthetic antioxidants in human foods are 2,6-di-tertiarybutyl-4-methylphenol (BHT), tertiary butyl-4-hydroxyanisole (BHA), tertiary butyl hydroquinone (TBHQ), and the n-propyl ester of 3,4,5 trihydroxybenzoic acid (propyl gallate, PG) These synthetic antioxidants have been used for a long time, although recently concerns have arisen due to the possible potential toxicity in some of them (Lachance *et al.*, 2001). Synthetic anti-oxidants are also having carcinogenic effect. Therefore, natural antioxidants, which are present in variable amounts in vegetables (such as fruits, leaves, flowers, roots, grains, and seeds), have gained prominence as an alternative to synthetic antioxidants (Aruoma, 1997).

Natural antioxidants are secondary constituents or metabolites found naturally in the body and in plants such as fruits and vegetables. An antioxidant can be defined in simple terms as anything that inhibits or prevents oxidation of a susceptible substrate. Plants produce a very impressive array of antioxidant compounds that includes carotenoids, flavonoids, cinnamic acids, benzoic acids, folic acid, ascorbic acid, tocopherols and tocotrienols to prevent oxidation of the

susceptible substrate (Hollman, 2001). These plant-based dietary antioxidants are believed to have an important role in the maintenance of human health because our endogenous antioxidants provide insufficient protection against the constant and unavoidable challenge of ROS (Fridovich, 1998).

Generation of free radicals or ROS during metabolism and other activities beyond the antioxidant capacity of a biological system gives rise to oxidative stress (Mikulikova and Popve, 2001). Oxidative stress plays a role in heart diseases, malaria, neurodegenerative diseases, cancer and in the aging process (Sian., 2003). This concept is supported by increasing evidence that oxidative damage plays a role in the development of chronic, age-related degenerative diseases, and that dietary antioxidants oppose this and lower risk of disease (Atoui *et al.*, 2005; Alasalvar *et al.*, 2005) and thus there arises a necessity to extract these antioxidants from the plant matrices.

There are two basic categories of anti-oxidants, namely synthetic and natural. Both synthetic and natural antioxidants are used in food products to retard lipid oxidation. Synthetic antioxidants are mainly phenolics, for example, BHA, BHT, TBHQ, and the gallates. In general, synthetic antioxidants are compounds with phenolic structures of various degrees of alkyl substitution, whereas natural antioxidants can be phenolic compounds (tocopherols, flavonoids, phenolic acids etc.), nitrogen compounds (alkaloids, chlorophyll derivatives, amino acids, and amines), or carotenoids as well as ascorbic acid. Synthetic anti-oxidants such as BHT and BHA have been used as anti-oxidants since the beginning of this century. The meat industry is in need of economical and effective natural antioxidants that can replace these synthetic antioxidants without negatively impacting their finished product quality and consumer perceptions.

Several researchers have investigated the anti-oxidative activity of flavonoid compounds and have attempted to define their structural characteristics contributing to their activity. The o-Dihydroxy groups in the B-ring, the presence of a 2-3 double bond in conjunction with 4-oxo in the C-ring, and 3- and 5-Hydroxy groups and the 4-oxo function in the A and C rings are associated with anti-oxidant activity. Phenolic acids, such as caffeic acid, chlorogenic acid, ferulic acid, sinapic acid and P-coumaric acid, appear to be more active anti-oxidants than the hydroxy derivatives of benzoic acids such as P-hydroxy benzoic, vanillic, and syringic acids.

Carotenoids also have a protective function against oxidative damage, and singlet oxygen is very powerfully quenched by β -carotene.

Butylated hydroxyl anisole (BHA):

Biswas *et al.*, (2004) reported that, the addition of antioxidants (50%BHA+50%BHT) in enrobed pork patties showed significant difference in TBA, TPC, sensory parameters under chilled and frozen storage conditions.

Sallam *et al.*, (2004) found that BHA (0.1g/kg) has significantly delayed the lipid oxidation, but had no significant effect on aerobic plate count when compared with control in chicken sausages.

Trindade *et al.*, (2010) worked on the effect of natural (rosemary and oregano extracts) and synthetic antioxidants (BHA or BHT) and their combination on irradiated beef burgers against lipid oxidation, and found that rosemary extract (100mg/kg) alone and in combination with either BHA or BHT (200mg/kg) were more effective in maintaining low oxidation level.

Shewalkar (2011) observed optimum appearance, juiciness, texture and overall palatability scores in chicken nuggets made with incorporation of 100 mg/kg BHA without non-significant effect on flavour.

Narkhede (2012) recorded significantly ($P < 0.05$) lower 2-thiobarbituric acid, peroxide value and free fatty acid values in chicken nuggets incorporated with 100 mg/kg BHA as compared to other levels and control in chicken nuggets.

Green tea

Green tea (*Camellia sinensis*) is one of the most popular beverages consumed worldwide and has been shown to exhibit anti-inflammatory and anti-carcinogenic properties, mostly due to the presence of the polyphenols known as catechins. The antioxidative ingredient in the green tea extract is green tea catechins (GTC), which comprise of four major epicatechin derivatives namely, epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG). Other components include three kinds of flavonoids, known as kaempferol, quercetin, and myricetin. A remarkably higher content of myricetin is detected in tea and its extracts.

Tang *et al.*, (2001) found that pro-oxidant effect of NaCl in red meat, poultry and fish patties could be significantly ($P < 0.01$) inhibited by addition of tea catechin @ 300 mg/kg in minced muscle and controlled lipid oxidation except in mackerel patties.

Jo *et al.*, (2003) conducted study on raw and cooked pork patties added with freeze dried green tea leaf powder (0.1%) and revealed that the TBARS values were significantly decreased in both treated patties as compared to control.

Gramza and Korczak (2005) reviewed tea constituents (*Camellia sinensis* L.) as antioxidants in lipid systems and concluded that Tea (*Camellia sinensis* L.) was an important source of dietary polyphenols.

Bozkurt *et al.*, (2006) reported that the natural antioxidants decreased TBARS formation more than BHT. Antioxidants reduced ($P < 0.05$) putrescine formation in the following order: green tea extract > thymbraspicata oil > BHT. The lowest tyramine concentration was in the recipe with green tea extract. The pH, L, b, and overall sensory quality were not significantly ($P > 0.05$) different with the addition of green tea extract, Thymbraspicata oil @ 150 and 300 ppm, green tea extract @ 150 and 300 ppm. These results indicated that the most effective antioxidant was found to be green tea extract in Turkish dry fermented sausages.

Banon *et al.*, (2007) conducted study on shelf life study of sulphite beef patties added with ascorbate, green tea and grape seed extract. They reported that the ascorbate, green tea and grape seed extracts increased the shelf life of low sulphite beef patties, delayed the microbial spoilage, redness loss, the onset of rancid flavours and lipid oxidation by 3 days. They observed no significant change in pH. Green tea extract (300mg/kg) treated patties showed inhibitory effect on *E. coli*, *Staphylococcus aureus*, *S. epidermidis*, *Streptococcus mutans*. Control patties revealed >2.3 MDA/kg TBARS values.

Kang *et al.*, (2007) observed that pork patties coated with pectin-based materials containing 0.5% green tea powder showed significant decrease in lipid oxidation ($p \leq 0.05$) and increase in radical scavenging ($P \leq 0.05$) activity.

Liu *et al.*, (2010) conducted an experiment on incorporation mixture of tea catechin (3-19%), carnosine (78-94%) and α -tocopherol (0-12%) @ 0.03mg/kg in beef patties and observed significantly lower TBARS values in tea catechin and α -

tocopherol treated patties than carnosine treated patties. Redness (a^* values) was slightly higher in tea catechin and α -tocopherol treated patties while the highest yellowness (b^* values) was observed in tea catechin treated patties.

Kenawi *et al.*, (2011) observed that addition of dried rosemary and green tea decreased the pH values and increased the acidity values for the treated and untreated samples. The reduction of pH and the increment of acidity were higher in the untreated samples compared by the treated ones. TBA values increased over time for all samples. The increment was rapid for the untreated sample. The demonstrated data showed flavour value for sample treated by the green tea was the lowest value compared with the other samples.

Shewalkar (2011) reported that chicken nuggets treated with different level of tea catechins (200, 300, 400mg/kg) observed significant ($P < 0.01$) reduction in free fatty acid (FFA)%, peroxide value, and TBARS values.

Grape Seed Extract (GSE):

The phenolic compounds in grapes (seed, skin, and pulp) can be divided into two groups, phenolic acids and flavonoids. Certain phenolic acids found in grapes include coumaric, caffeic, ferulic, chlorogenic, neochlorogenic, p-hydroxybenzoic, vanillic, and gallic acids and epicatechin-3-O-gallate whereas flavonoids include catechin, epicatechin, procyanidins and their polymers and ester forms, quercetin, red and blue anthocyanins (Jayaprakasha *et al.*, 2001; Shi j *et al.*, 2003 and Hatzidimitrioua *et al.*, 2007). The most abundant phenolics isolated from grape seeds are catechins (catechin, epicatechin, and procyanidins) and their polymers (Silva *et al.*, 1991; Prieur *et al.*, 1994).

Jayaprakasha *et al.*, (2003) documented antimicrobial properties of GSE against Gram positive (*Bacillus* and *Staphylococcus*) and Gram negative bacteria (*P. aeruginosa* and *E. coli*) whereas Ahn *et al.* (2007) reported the antimicrobial activity against certain pathogenic bacteria (*E. coli* O 157:H7 and *S. typhimurium*). However, contradictory reports indicating no antimicrobial effect of GSE as a nutraceutical was observed under the experimental conditions employed in the study.

Carpenter *et al.*, (2007) reported that GSE was found to exhibit potent lipid antioxidant activity in raw and cooked pork.

Brannan (2008) reported that GSE was an effective antioxidant in ground chicken thigh meat and did not effect moisture content and pH during storage. However GSE @0.1% level inhibited TBARS formation, helped to mitigate the prooxidative effects of NaCl and might alter the effect of NaCl on protein solubility in salted chicken patties.

Yerlikaya *et al.*, (2010) added commercial extracts of garlic, tomato and grape seed separately into batter coating formulation. Samples with added extracts had higher pH values than the control. Higher total volatile basic nitrogen value was found in the sample with tomato extract compared with extract containing garlic and grape seed extracts. They also observed that the grape seed extract was most effective in retarding oxidation and garlic extract had protective effect against spoilage. The lowest scores for sensory appearance, odour and taste were found in samples with grape seed extract.

Selani *et al.*, (2011) reported that the grape residue extracts (GSE and grape peel extract) were as effective as BHT and sodium erythorbate for preventing lipid oxidation in raw and cooked chicken meat. The grape extracts did not alter the pH values of raw and cooked samples or the colour of raw samples but they promoted alterations in the colour of the cooked product as evident from the results of the sensory and instrumental measures.

Narkhede (2012) observed that GSE treated chicken nuggets had the lowest peroxide value and free fatty acid content. He also documented the highest moisture content and the lowest total plate count as well as psychrophilic plate count in the GSE treated chicken nuggets.

Enrobed chevon balls

Enrobed chevon balls are chevon product prepared from emulsified meat, breaded or battered, then deep-fried or baked.

Enrobing food in fat, a practice called “Larding” was used in 16th century in England. Preservation of meat and other food stuff by coating them with gelatin films was proposed by Havard and Harmony (1869).

Ingredients used:

2.1 Chevron:

Chevon is consumed in all the segments of the Indian society; hence it serves as main source of red meat in the country. Clinical trials have demonstrated that inclusion of dietary saturated fats increased LDL cholesterol levels, while monounsaturated and polyunsaturated fats helped to decrease LDL cholesterol and increased HDL cholesterol levels in the blood. Based on these findings, a health claim has been made that chevon has helped to lower blood cholesterol and reduced the risk for atherosclerosis and coronary heart disease. Therefore, chevon can be recommended as a heart-healthy diet.

Chevon has been established as a lean meat with favorable nutritional qualities, and it is an ideal choice for the health-conscious consumers. It is low in calories, total fat, saturated fat and cholesterol as compared to other traditional meats. Additionally, goat meat has higher levels of iron (3.2 mg) when compared to a similar serving size of beef (2.9 mg), pork (2.7 mg), lamb (1.4 mg), and chicken (1.5 mg). Comparatively, goat meat also contains higher potassium content with lower sodium levels. Regarding essential amino acid composition, chevon closely resembles to beef and lamb (USDA, 2001). Chevron offers more nutritional value, greater health benefits, and is an ideal choice to be considered as “the other red meat.”

Gadiyaram and Kannan (2004) compared texture attributes of low-fat chevon sausages to those of beef and pork sausages and found that springiness was higher in chevon sausages whereas, cohesiveness was lower in chevon sausages. The results suggested that textural attributes of chevon sausages were comparable with the other sausages. Incorporation of chevon in sausages resulted in a low-fat product with superior water-holding and textural properties.

Wattanachant *et al.*, (2008) observed significant ($P < 0.05$) differences in fat, ash and total collagen content among groups of goat meat. The meat from younger goat was lighter in color and more tender. Storage time had a significant effect on texture of canned goat meat. Twenty days after storage, a dramatic reduction ($P < 0.05$) of hardness and chewiness was observed. The influence of different ages groups of goat meat on TBARS value was significantly increased ($P < 0.05$) when processed in water and brine.

Bhat *et al.*, (2011) reported that pH, protein%, fat%, ash% significantly ($P < 0.05$) increased whereas the moisture% of chevon *harrisa* decreased significantly ($P < 0.05$) when packed in LDPE pouches and stored for 1 week at refrigeration temperature ($4 \pm 1^\circ\text{C}$); free fatty acid and TBA also increased significantly ($P < 0.05$) with storage period. The mean sensory scores indicated that chevon *harrisa* was highly acceptable although all the sensory parameters showed a significant ($p < 0.05$) decline with storage.

2.2 Salt:

Salt (NaCl) has multiple functions in meat products. It tenderizes meat by increasing ionic strength, enhances flavour and increases water-holding capacity. At high concentrations, it also inhibits microbial growth functioning as a preservative. However, some undesirable side effects of NaCl has been observed such as promotion of lipid oxidation in raw and cooked meat and acceleration in metmyoglobin formation and discolouration even at concentrations normally used in meat products. (Rhee, 1999).

Detienne and Wicker (1999) used 1.5% NaCl and/or 0.45% sodium tripolyphosphate (STPP) in pork loins and recorded significantly improved weight gain, purge, final product yield and moisture content. Warner–Bratzler shear force was reduced to approximately 50%. A salt-phosphate interaction was observed for weight gain, purge, cook loss and expressible moisture.

Laura and Zalka (2003) observed that 3% NaCl with 15h cooling completely arrested growth of *Clostridium perfringens* spores in ham and beef.

Faithong *et al.*, (2006) found that the addition of 1-3% sodium chloride increased the weight gain in all raw samples immersed in different phosphate solutions. STPP showed a synergistic effect with salt on reducing the cooking loss. The combined effect of 2% salt and all types of phosphates yielded a good quality cooked shrimp with high acceptability.

2.3 Nitrite:

The nitrite in meat curing are added with the intention to stabilize the colour of lean tissues, provide cured meat flavour and colour to meat products, retard development of rancidity and extend the shelf life of meat products. Nitrite also acts as an antimicrobial agent (Pearson and Gillet, 1997).

Sanz *et al.*, (1998) investigated that nitrite discouraged the growth of psychrotrophs in fermented sausages. Nitrate-made sausages showed higher aroma and taste intensity.

Pearson and Gillett (2003) demonstrated that nitrite was effective in preventing the growth of the *Clostridium botulinum*, other spoilage bacteria and food poisoning organisms.

2.4 Polyphosphates:

Polyphosphates are chemical compounds that perform multiple functions in meat. Food grade polyphosphates are commonly incorporated in processed meat products to improve their quality in terms of water holding capacity, yield and meat particles binding (Anjaneyulu *et al.*, 1989).

Faithong *et al.*, (2006) observed that addition of 2% tetra sodium pyrophosphate (TSPP) and 2% sodium tripolyphosphate (STPP) for 8h were more effective in weight gain of raw shrimp, while the immersion in 3% sodium hexametaphosphate (SHMP) for 10h was less effective.

Barbut and Somboonpanyakul (2007) used mixtures of cured malva nut gum (CMG) (0, 0.2 and 0.6%) and STPP (0 and 0.5%) in emulsified chicken meat batter. The results indicated that the batters with CMG or STPP or their mixtures had decreased cook and fat losses compared with the control. Hardness values of batter using the mixture of CMG and STPP provided were higher than those of the control batter; and hardness values of batter using CMG or STPP were lower than those of the control. The batter with 0.5% STPP and one processing a mixture of CMG and STPP had higher springiness compared with batters with CMG alone or control. Increasing the CMG level to 0.6% reduced the lightness and redness of the cooked products.

Erdogdu and Ekiz (2007) studied the effects of processing conditions (cooking time, STPP concentration and dipping time) on cook losses and textural properties of red meats. For this study, meat pieces ($2 \times 2 \times 2 \text{ cm}^3$ in size) were dipped in different concentrations of STPP solutions (2 to 6%) for 10 to 30 min and were cooked in boiling water for 5 to 15 min. The results indicated that an increase in STPP concentration increased cohesiveness; an increase in cooking time resulted in higher hardness, gumminess, chewiness and cook losses, while an increase in dipping times decreased the cook losses and hardness. These results indicated that

STPP concentration, STPP dipping and cooking times had significant effect on the changes of textural properties and cook losses of red meat.

Peng *et al.*, (2009) used pre-rigor pork, ageing pork and frozen pork, which were pre-blended with five levels (0, 0.1, 0.2, 0.3, 0.4, and 0.5%) of phosphate with 3% NaCl and made into emulsion-type sausage. Higher yield and relatively stable hardness were found in emulsion-type sausage made by pre-rigor meat. It indicated that increasing of phosphate level caused alleviatable effects in increasing of hardness when emulsion-type sausage made by pre-rigor meat, but opposite effects were observed in aged meat or frozen meat. The distribution of purge loss (PL) of emulsion-type sausage was found to be affected by phosphate addition. Significant decrease of purge loss could not be obtained by increasing phosphate level during storage. Pre-rigor meat improved WHC and texture of emulsion-type sausage. Problem of WHC and texture of emulsion type sausage during storage could not be resolved by single use of phosphate at relatively higher level (3%) of NaCl.

Shu-Qin *et al.*, (2009) studied the influence of marinating with polyphosphate on Simmental beef shear value and ultrastructure. Polyphosphates were used to marinate beef at 5% disodium dihydrogendiphosphate (DSPP), 3% tetrasodium pyrophosphate (TSPP), 3% sodium hexametaphosphate (SHMP) and 3% (STPP) for one to three days. By increasing the concentration and marinating time, the tenderizing effect of polyphosphates on meat samples changed as follows: TSPP \approx SHMP > STPP > DSPP > control. The addition of polyphosphates decreased shear force significantly in comparison with control. After marinating for three days, DSPP significantly increased the soluble collagen content compared with the other polyphosphates. TSPP and SHMP both disrupted the myofibrillar structure completely and myofibril bundles collapsed together. STPP disrupted the myofibrillar structure as well. TSPP dissolved the perimysium into collagen fibers and collagen fibrils which arranged loosely and looked like dispersed silk. The perimysium was separated into collagen fibers and collagen fibrils by STPP and SHMP, but the collagen fibrils were in close contact with each other. These results showed that polyphosphates can make the soluble protein in meat to increase binding of water and improve tenderness of meat.

2.5 Spices

In general, the leaves of a plant used in cooking are denominated as culinary herbs, while any other part of the plant is known as a spice. Spices can be leaf (e.g. bay leaf), buds (clove), bark (cinnamon), root (ginger), berries (grains of pepper), seeds (cumin), or even the stigma of the flower (saffron).

Perez-Alvarez *et al.*, (2002) studied that spices are important part of human nutrition and have a place in all the cultures of the world. They observed different spices had important role in flavour and reduce the need for salt and fatty condiments, improve digestion and provide the organism with extra antioxidants that prevent the appearance of physiological and metabolic alterations.

Antioxidant activity of spices is one of the most important functional properties. Total antioxidant capacity of various commonly used spices as estimated by oxygen radical absorbance capacity (ORAC) assay has been given below (Prior *et al.*, 2003 and www.oracvalues.com):

	Spice ingredients	ORAC Value μMoles Trolox Equivalent (TE) /100 gram of sample
1.	Cloves, ground	290,283
2.	Oregano, dried	175,295
3.	Rosemary, dried	165,280
4.	Cinnamon, ground	131,420
5.	Turmeric, ground	127,028
6.	Sage, ground	119,929
7.	Cardamom	2,764
8.	Chili powder	23,636
9.	Cumin seeds	50,372
10.	Garlic powder	6,665
11.	Garlic, raw	5,708
12.	Ginger, ground	39,041
13.	Nutmeg, ground	69,640
14.	Onion powder	4,289
15.	Black pepper	34,053
16.	Onion, red, raw	1,521
17.	Onion, raw	913

Rajeshwari *et al.*, (2011) observed that both aniseeds and coriander seeds decreased serum lipids, lipoproteins and improved HDL as a result of the hypolipidemic activity and confirmed that aniseeds and coriander seeds expressed antioxidant activity as evident from controlled lipid peroxidation.

Viuda-Martos *et al.*, (2011) documented that spices were good functional foods in terms of their ability to impart antimicrobial, antiviral, anti-mutagenic, anti-inflammatory, inhibition of platelets aggregation, anti-carcinogenic, anti-ulcerous, anti-diabetic properties etc. to the foods.

2.6 Condiments

Condiments impart flavour and reduce the cost of meat products. Garlic contains allium which contributes flavour and has antibiotic activity (Pearson and Gillet, 1997).

Sallam *et al.*, (2004) investigated the antioxidant and antimicrobial effects of equivalent concentrations of fresh garlic (FG), garlic powder (GP) and garlic oil (GO) against lipid oxidation and microbial growth in raw chicken sausage during storage at 3°C. They observed the antioxidant activities following the order FG>GP>BHA>GO whereas addition of FG (30 g/kg) or GP (9 g/kg) significantly reduced the aerobic plate count and the shelf-life of the product was extended to 21 days.

Garget and Mendiratta (2006) conducted a study to develop technology for tenderization and production of enrobed pork chunks in a microwave oven. The pork cuts were cured and enrobed with cream based batter and cooked in a microwave oven at 900 MHz. Ginger (9%) and papain (0.5%) treatments caused significant ($P<0.01$) increase in the moisture content and pH of the cooked products compared to the control and cucumis treated (7.5%) samples. Overall acceptability scores were significantly ($P<0.01$) higher in all treated samples compared to the control.

2.7 Potato

Fernandez-martin *et al.*, (2000) prepared pork meat (low-fat) batters without and with the addition of three non-meat ingredients: (blood) plasma proteins, (dietary) apple and potato starch.

Malav *et al.*, (2013) evaluated the shelf life of restructured chicken meat blocks extended with sorghum flour and potato at refrigerated storage ($4\pm 1^{\circ}\text{C}$). They used sorghum flour (1:1 hydration, w/w) at 9% level and potato (boiled and mashed) at 6% level by replacing the lean meat in pre-standardized formulation. The sensory scores of treated samples and control for appearance, flavour, binding, texture,

juiciness and overall acceptability showed a progressive decline with increase in storage period but the scores were rated above good.

Ali *et al.*, (2011) observed that replacement of different levels (25, 50, 75 and 100%) of fat with hydrated potato flakes in beef patties had significantly ($p < 0.05$) higher sensory ratings for juiciness than control. No significant ($p < 0.05$) effects in flavour control as well as treated beef patties except 100%. Overall acceptability of beef patties formulated with potato flakes were higher ($p < 0.05$) than the control samples. Beef patties formulated with 75% potato flakes as fat replacer had significantly ($P < 0.05$) the highest score of overall acceptability.

2.8 Maida

Maida has been used as a binder in meat products, which improved firmness of the product and reduced cooking loss.

Padda *et al.*, (1989) reported that maida added @ 5% enhanced cooking yield significantly without significant reduction in overall palatability in the cooked goat meat balls.

Sharma *et al.*, (1989) observed that addition of 10% wheat flour increased the firmness and reduced juiciness in goat meat tikka, Moreover it has contributed for cereal flavour to the product.

Claus and Hunt (1991) observed that wheat starch at a level of 3.5% improved hardness of bologna sausage compared to low fat control and reduced fracturability compared to high fat control. Cohesiveness was very similar to that of low fat and high fat control.

2.9 Enrobing or batter ingredients

Commonly used batter ingredients are flour, seasonings, whole egg liquid, high protein egg albumen etc. (Smith, 1999). The composition of enrobing mix also plays an important role in the colour development mainly due to maillard reaction, so sugar and protein are essential in the mix (Landes and Backshear, 1971).

2.9.1 Bengal gram flour

Mukprasirt *et al.*, (2001) developed rice flour-based batter (RFBB) formulations for chicken drumstick coating as an alternative for traditional wheat

flour-based batter (WFBB). They observed the TBA values of RFBB and WFBB increased ($P < 0.05$) with increased frozen storage time at -40°C for 90 days. The RFBB with methyl cellulose (MC) exhibited the lowest TBA values, whereas WFBB had the highest values. The total plate counts of chicken drumstick were less than 1 log cfu/g sample. The RFBB with 5% oxidized corn starch and MC could be replaced WFBB on fried drumsticks. Additionally, RFBB has resulted in a healthier product due to lower fat absorption.

Biswas *et al.*, (2003) studied the effect of enrobing using bengal gram flour as a base material of enrobed pork patties. Enrobed patties had significantly higher yield, lower shrinkage, lower moisture content, higher protein content, and higher ether extract content than control patties. Although they had higher total microbial plate counts than control patties, levels were within acceptable limits. Control patties had higher (non-significant) shear values than enrobed patties. Enrobing appeared to improve the quality of pork patties.

Modi *et al.*, (2004) studied the effect of addition of different decorticated legume flours, viz., soya bean, bengal gram, green gram and black gram on the quality of buffalo meat burger. They reported that Inclusion of roasted black gram flour registered the highest yield of 95.7%, lowest shrinkage of 5% and lowest fat absorption of 26.6% on frying. Protein content of 18–20% was highest in the soya flour formulation. Free fatty acid (FFA) values increased from 14.3 to 17.3 in freshly prepared samples to 16.0–19.4 in 4 month frozen ($-16 \pm 2^{\circ}\text{C}$) stored samples and fried samples had about 25% lower FFA values. Formulations with roasted flours registered lower thiobarbituric acid (TBA) values. The burgers prepared with any of these binders (8%) were organoleptically acceptable even after storage at $-16 \pm 2^{\circ}\text{C}$ for 4 months. However, the burger with black gram flour had better sensory quality attributes compared to other legumes.

Chidanandaiah and Keshri (2007) prepared five batter mixes using bengal gram flour (BGF), finger millet (ragi) flour (FMF), and corn flour (CF). Incorporation of FMF alone or in combination with BGF decreased the coating pick up, cooking yield, moisture, pH and protein content and increased the ether extract content and shear press values compared to only BGF enrobed buffalo meat patties. Crispness of the product increased significantly ($P < 0.05$) by mixing CF with BGF.

Rajnish *et al.*, (2008) conducted an investigation to assess the effect of enrobing with bengal gram flour, corn flour, carboxy methyl cellulose (CMC) and sodium alginate (SA) with or without preservatives (nisin, tocopherol) on spent hen meat patties. Storage resulted in a significant decrease in moisture content in all the treatments but relative moisture loss was maximum in control. There was a significant increase in pH and TBA value in all the treatments during storage but the increase in TBA values was less in coated patties during storage. Addition of tocopherol reduced the oxidative rancidity in both treated GF(gram flour)and CF(corn flour) patties. Coatings maintained the sensory attributes of patties during storage and products were very much acceptable up to the end of 15thday. Nisin present in treated patties reduced microbial growth slightly during storage. Enrobed patties were microbiologically and organoleptically acceptable up to 15th day of storage at 4±1°C.

Raut *et al.*, (2011) studied chicken patties enrobed with different ratio of bengal gram flour and water (1:1.0, 1:1.1, 1:1.2, 1:1.3 and 1:1.4) and observed that the pH of enrobed chicken patties decreased with the increase in the level of water. The cooking yield and moisture content of enrobed chicken patties was reduced significantly ($P<0.05$) in 1:1.4 ratio of bengal gram flour and water. The protein and fat content were increased significantly ($P<0.05$) with increased level of water in enrobed patties All the sensory attributes viz., appearance, flavour, juiciness, texture, and overall acceptability of the enrobed patties made with 1:1.3 ratio of Bengal gram and water were improved significantly as compared to all other groups. The results of the present study suggest that the good quality enrobed chicken patties could be made with 1:1.3 ratios of bengal gram flour and water.

2.9.2 Whole egg liquid

Baker *et al.*, (1988) observed that egg protein help in structure forming and also act as a thickener. Batter consisting of egg albumen combined with corn flour produced coating with acceptable exterior and interior.

Pikul and wojciechowska (1994) documented that breading of chicken meat with bread crumbs and fresh whole egg had reduced the weight loss after deep fat frying and the TBA value was only half of the unbreaded sample during the refrigeration storage. Breaded sample had higher overall acceptability than control chicken wings.

Mukprasirt *et al.*, (2000) studied the use of albumen as the preduct in chicken drumsticks. These workers recorded enhanced batter adhesion of absorbing water on the source as well as formation of three dimensional gel networks and enhanced water binding capacity.

2.10 Effect of enrobing on different physicochemical parameters

2.10.1 pH

Biswas *et al.*, (2003) recorded that no significant difference ($P > 0.05$) in pH of enrobed or coated pork patties containing a (50:50) mixture of butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) with control.

Ahamed *et al.*, (2007) observed non-significant ($P > 0.05$) increase in pH of the enrobed cutlets during storage ($-18 \pm 1^\circ\text{C}$).

Garg and Mendiratta (2006) found that ginger (9%) and papain (0.5%) treatments caused significant ($P < 0.01$) increase in the moisture content and pH of the cooked products compared to the control and cucumis (7.5%) treated samples of enrobed pork chunks.

Chidanandaiah and Keshri (2007) observed incorporation of finger millet flour alone or in combination with bengal gram flour decreased the pH of buffalo meat patties.

Yadav and Sharma (2008) found significant increase in pH of control as well as enrobed patties during storage up to 28 days. The pH of enrobed patties with nisin was lower than that of control patties.

Yerlikaya *et al.*, (2010) found that, during the storage, pH values significantly ($P < 0.01$) increased in all treatments of batter coated shrimp.

Mahmoudzadeh *et al.*, (2010) observed that pH value in the fish burgers of both coated and uncoated significant ($P < 0.05$) increased at the end of storage periods.

Karim *et al.*, (2012) found that honey treated (@5% and 10%) chicken patties had significantly ($P \leq 0.05$) lower pH than non-treated chicken patties.

Kenawi *et al.*, (2011) observed that the reduction of pH and the increment of acidity in dried rosemary and green tea low fat beef.

2.10.2 Thiobarbituric acid (TBA)

Biswas *et al.*, (2003) found no significant difference ($P > 0.05$) in pH, 2-thiobarbituric acid (TBA) and Warner–Bratzler shear force (WBSF) values between uncoated and treated samples. Similarly, enrobed patties showed no significant ($P < 0.05$) decrease in TBA values compared to control patties, but had lower relative moisture loss at the 45th day of frozen storage.

Ahamed *et al.*, (2007) observed significant ($P > 0.05$) decline in thiobarbituric acid reactive substance number in storage condition of enrobing buffalo cutlets.

Garg and Mendiratta (2006) found that TBARS values and microbial counts increased significantly ($P < 0.01$) in enrobed pork chunks.

Kang *et al.*, (2007) reported that, the patties coated with material containing green tea leaf extract @ 0.5% showed lower TBARS value than the other treatments.

Yadav and sharma (2008) investigated that significant increase in pH and TBA value in all the treatments during storage but the increase in TBA values was less in enrobed chicken patties during storage. Addition of tocopherol resulted in significantly lower TBA values in patties containing preservatives than the control at the end of storage.

Yerlikaya *et al.*, (2010) found no-significant differences in TBA values of samples with garlic and grape seed extracts throughout storage and found that the grape seed extract was most effective to retard oxidation in batter coated shrimp.

Mahmoudzadeh *et al.*, (2010) reported that the TBA value significantly ($P < 0.05$) decreased with coating and significantly ($P < 0.05$) increased without coating in fish burgers.

Bhat *et al.*, (2011) observed TBARS value, total plate count and psychrophilic count increased significantly ($P < 0.05$) in skin meat balls.

Kenawi *et al.*, (2011) observed that green tea treated sample showed less TBA value compared with rosemary treated low fat beef product with edible packaging.

Karim *et al.*, (2012) found that TBARS, pH and fat content significantly ($P \leq 0.05$) increased during storage of enrobed chicken patties containing honey (@5% and 10%) as an antioxidant.

2.10.3 Free fatty acid (FFA)

Sarah *et al.*, (2010) noticed that the free fatty acid contents indicated much more reduction in Persian sturgeon fillets treated with 2.5% tea extracts, 5% tea extracts and 5% onion juice as compared to control.

Das *et al.*, (2011) found that the curry leaf powder treated sample had significantly lower free fatty acids content (0.31%-0.71%) as compared to control sample (0.37%-0.93%) in ground and cooked goat meat, respectively.

Sharma *et al.*, (2011) observed decrease in FFA value with addition of carrageenan as a fat replacer (1.39 %) when compared with control (2.46%). Percent decrease in FFA values was found to be 43.49 %.

Shewalkar (2011) recorded inconsistent variations in FFA content of control as well as TP treated nuggets throughout the period of storage at ($4 \pm 1^\circ\text{C}$). Although the low FFA content was recorded in the tea polyphenol treated chicken nuggets, the variations in FFA contents of all treated products did not differ significantly as compared to control.

Narkhede (2012) documented that FFA content (% oleic acid) was found to be significantly ($P < 0.05$) different in all the treatments; GSE treated chicken nuggets had the lowest FFA content followed by DHBP treated nuggets, BHA treated nuggets and control product respectively.

2.10.4 Moisture

Mukprasirt *et al.*, (2001) observed significantly higher moisture content than other treatments in case of rice flour-based battered chicken drumsticks.

Biswas *et al.*, (2003) observed lower relative moisture loss at the 45th day of frozen storage (-18±1°C) in enrobed pork patties containing antioxidant (50%BHA +50%BHT).

Ahamed *et al.*, (2007) reported that, enrobing of cutlets with edible coating had significantly (P<0.01) lower shrinkage, moisture and fat contents than uncoated cutlets.

Garg and Mendiratta (2006) observed that ginger and papain caused significant (P<0.01) increase in the moisture content and pH of the cooked products compared to the control and cucumis treated enrobed pork chunks.

Chidanandaiah and Keshri (2007) incorporated finger millet (ragi) flour alone or in combination with bengal gram flour in buffalo meat patties. These additions have resulted in decreased moisture content.

Kang *et al.*, (2007) found that the addition of 0.5% green tea powder with pectin-based materials had resulted in significantly higher moisture content than the uncoated pork patty.

Yadav and Sharma (2008) observed significant decrease ($p \leq 0.05$) in moisture content of control and enrobed patties during storage. However, relative moisture loss (RML) was more than 4% in control samples and around 3% in enrobed chicken patties.

Karim *et al.*, (2012) reported the addition of honey @ 5% and 10% in chicken patties significantly ($P \leq 0.05$) decreased the moisture content. The treatment of chicken patties with 10% honey had minimum moisture loss than control.

2.10.5 Fat

Mukprasirt *et al.*, (2001) observed significantly lower fat content but a higher moisture content than other treatments in case of rice flour-based battered chicken drumsticks.

Barbut *et al.*, (2005) reported that addition of caseinate, whey and milk powders significantly ($p \leq 0.05$) lowered the fat content in emulsified chicken meat batters as compared to the control.

Das *et al.*, (2011) observed total fat content showed a significant difference between pressure and conventional frying in battered and fried chicken. Pressure breast meat (PBM) and pressure fried leg meat (PLM) had a significantly ($p \leq 0.05$) lower fat content as compared to conventional frying leg meat (CLM) and breast meat (CBM).

Karim *et al.*, (2012) reported that fat content significantly ($p \leq 0.05$) increased during storage in chicken patties containing honey. Frozen chicken patties incorporated with 10% honey and fried in palm olein oil recorded only 10.16 % fat on the day of preparation. The fat content of frozen chicken patties incorporated with 5% honey was also significantly lower ($p \leq 0.05$) than control.

2.10.6 Microbiological quality

Biswas *et al.*, (2003) observed that enrobed samples significantly ($p < 0.05$) increased the total plate count (TPC) during chilled (21 days at $4 \pm 1^\circ\text{C}$) and frozen (45 days at $-18 \pm 1^\circ\text{C}$) storage. Control patties had increased ($p < 0.05$) TPC at the 28th day in chilled and 45th day in frozen samples. TPC in enrobed and control patties were around 3.48 and 3.05 \log_{10} cfu/g, respectively, whereas in frozen stored samples these numbers were 2.77 and 2.69 \log_{10} cfu/g at the end of storage.

Ahamed *et al.*, (2007) reported that the enrobed cutlets had slightly lower ($P > 0.05$) mesophilic bacterial counts than the control. The microorganisms such as psychrotrophic bacteria as well as yeast and mold were detected occasionally in both products but only in insignificant levels in case of enrobed buffalo cutlets.

Garg and Mendiratta (2006) observed microbial counts increased significantly ($P < 0.01$), although all enrobed pork chunks were acceptable up to 15 days of storage.

Kang *et al.*, (2007) observed that total plate count of control was the highest followed by coated with pectin-based materials (CP) and pectin-based materials containing 0.5% green tea powder (GCP).

Yadav and Sharma (2008) found significantly increased standard plate count (SPC), psychrotrophic count and yeast and mould count during storage in all the treatments. But SPC and PC increased at a higher rate in control and at the end of storage SPC count crossed the acceptability limit in control patties.

Bhat *et al.*, (2011) observed total plate count and psychrophilic count increased significantly ($P < 0.05$) from day 0 to 14 in treatments as well as control chicken meat balls. However coliforms were not detected throughout the period of storage in meat balls.

Kenawi *et al.*, (2011) observed the reduction in the total bacterial count for all treatments as compared to control all over the time of storage. The reduction was higher in the natural antioxidants treated samples than the untreated one.

2.10.8 Sensory quality

Biswas *et al.*, (2003) observed that sensory scores viz appearance and color, flavour, juiciness, texture, and overall acceptability were higher in antioxidant containing enrobed pork patty than controls during the entire storage period.

Ahamed *et al.*, (2007) reported that panelists rated significantly ($P > 0.05$) higher for various sensory attributes of enrobed cutlets throughout the storage period, but a significant ($P < 0.05$) decline in the flavour, appearance, texture and overall palatability was observed at the end of the storage period.

Garg and Mendiratta (2006) undertaken a study to develop technology for tenderization and production of enrobed pork chunks in a microwave oven. They observed that enrobed pork chunks had higher sensory attributes than the control, cucumis (7.5%) and papain (0.50%) treated samples. The storage changes were less and acceptability ranking was higher for the ginger (9%) treated samples as compared to other treatments. The results indicated that microwaves could be used for the preparation of enrobed pork chunks. The overall acceptability and shelf life of microwave cooked enrobed pork chunk could be further improved using ginger extract in the curing solution.

Kang *et al.*, (2007) observed no significant variations in sensory properties of the product subjected to various packaging methods and none of the sensorial parameter was significantly affected by gamma irradiation ($p > 0.05$). The only difference was in the odor of the vacuum packaged sample, which was higher in coated with pectin-based materials containing 0.5% green tea powder (CGP) than in the control.

Yadav and Sharma (2008) recorded that enrobed patties had higher organoleptic scores than control patties at each interval of storage. Sensory attributes for rice flour patties were higher in comparison to refined wheat flour patties.

Mahmoudzadeh *et al.*, (2010) documented that coated fish burgers had higher sensory quality than uncoated one at the beginning of storage period. However, sensory attributes of uncoated burgers were better at the end of the storage period.

Bhat *et al.*, (2011) reported the scores for various sensory attributes decreased significantly ($P < 0.05$) during storage and suggested that meat balls utilizing chicken skin were stored for a period of 14 days at refrigerated temperature ($4 \pm 1^\circ\text{C}$).

Kenawi *et al.*, (2011) found that values for colour, flavour, juiciness and overall acceptability for all samples were decreased with the duration of storage time. The reduction rate of colour for the untreated sample was higher than the treated ones followed by the green tea treated sample. Regarding the flavour, sample treated by the green tea had the lowest value compared with the other samples in low fat beef.

Karim *et al.*, (2012) found that all sensory attributes significantly ($p \leq 0.05$) declined as storage time increased. They also observed negative correlation ($p \leq 0.05$) of TBARS value with flavour and overall acceptability of chicken patties. The overall acceptability (sensory attributes) of frozen chicken patties treated with 5% honey and fried in palm olein oil was highest.

MATERIALS AND METHODS

3.1 Source of raw materials

3.1.1 Goat meat

Chevon was procured from the retail shop in Nagpur after slaughter. The fat and connective tissue were removed from the deboned meat, packaged in LDPE pouches and kept at refrigeration temperature ($4\pm 1^{\circ}\text{C}$) for 20-22 hours.

3.1.2 Spice mix

Different spice ingredients viz. aniseed, black pepper, capsicum, cinnamon, coriander, cumin seeds, nutmeg, turmeric, small cardamom, caraway seed, cardamom and cloves etc. were brought and cleaned to remove the extraneous matter followed by drying in hot air oven at 50°C for 2 hrs. The ingredients were ground in a grinder using suitable blade. All the ground spices were sieved through a fine mesh. Spice mix was prepared using the proportion of each ingredient as mentioned in Table 3.1 (Shewalkar, 2011 and Narkedde, 2012) and subsequently used in the formulation of chevon balls.

Table 3.1: Composition of spice mix

Sr.No.	Ingredients	Quantity (% by weight)
1.	Aniseed (<i>Soanf</i>)	12
2.	Black pepper (<i>Kali mirch</i>)	8
3.	Capsicum (<i>Mirch</i>)	11
4.	Caraway seed (<i>Ajowan</i>)	8
5.	Cardamom (<i>Badielaichi</i>)	5
6.	Cinnamon (<i>Dalchini</i>)	5
7.	Cloves (<i>Laung</i>)	2
8.	Coriander (<i>Dhania</i>)	20
9.	Cumin seeds (<i>Zeera</i>)	20
10.	Nutmeg (<i>Jaiphal</i>)	3
11.	Turmeric (<i>Haldi</i>)	5
12.	Small cardamom (<i>Sabzelaichi</i>)	1
Total		100

3.1.3 Condiments

Condiment paste was prepared from onion, ginger and garlic. The uppermost layer of onion, ginger and garlic was peeled off and cut into small pieces and fine condiment paste was made by blending onion, ginger and garlic in a ratio of 3:1:1 in a grinder with a suitable blade.

3.1.4 Chemicals and Media

All chemicals (Sodium chloride, Tri-chloro acetic acid, 2 -Thiobarbituric acid, Alcohol, Benzene, Ether, NaCl, Sulphuric acid, etc.) of analytical grade were procured from standard firms viz., Himedia Laboratories Pvt. Limited, Mumbai; Loba Chemie, Mumbai; Fisher Scientific, Pune; S.D. Fine, Chem. Limited, Mumbai and Microbiological media (Plate count agar, Eosinophil methylene blue agar) were procured from Himedia Laboratories Pvt. Limited, Mumbai were utilized throughout the experiment.

Sodium nitrite and Sodium tri polyphosphate (STPP) were procured from Fisher scientific, Navi Mumbai and MCC Laboratories respectively.

3.1.5 Common salt and Rice bran oil

Food grade common salt (Tata chemicals, Mumbai) and refined vegetable rice bran oil (Fortune Adani Wilmar Lt. Andhra Pradesh) required for formulation of chevon balls were purchased from local market.

3.1.6 Natural antioxidants

Grape Seed Extract (GSE) and Tea polyphenols(TP) were procured from Ambe Phytoextracts Pvt. Ltd., Delhi and Natural Remedies Pvt. Ltd., Bangaluru respectively.

3.1.7 Eggs

Fresh table eggs procured from local market were utilized according to the experimental need.

3.2 Details of Experiment

3.2.1 Experiment No. 1: Development of process for the preparation of enrobed chevon balls

Formation and preparation of chevon balls were standardized in the laboratory on the basis of sensory evaluation by a panel consisting of 6 semi-trained

members during preliminary trials. The methodology for the preparation of chevon balls has been described below –

3.2.1.1 Formulation of enrobed balls

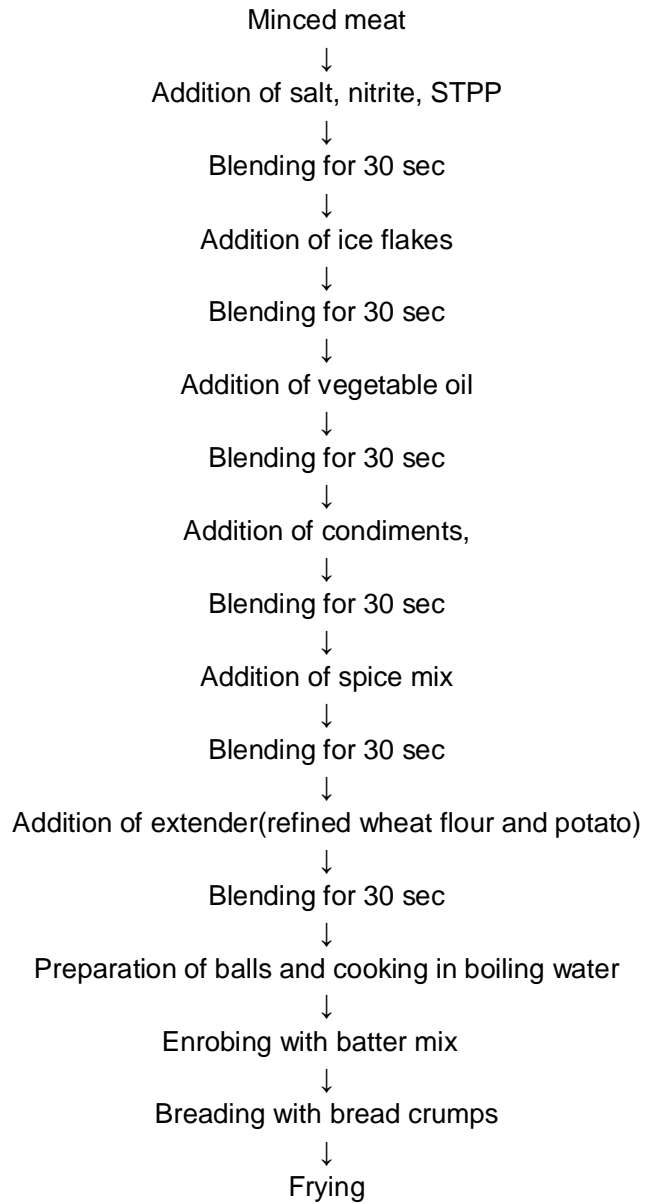
A recipe (Table 3.2) comprising of lean meat along with salt, spices, condiments and preservatives was used for the preparation of Chevon balls.

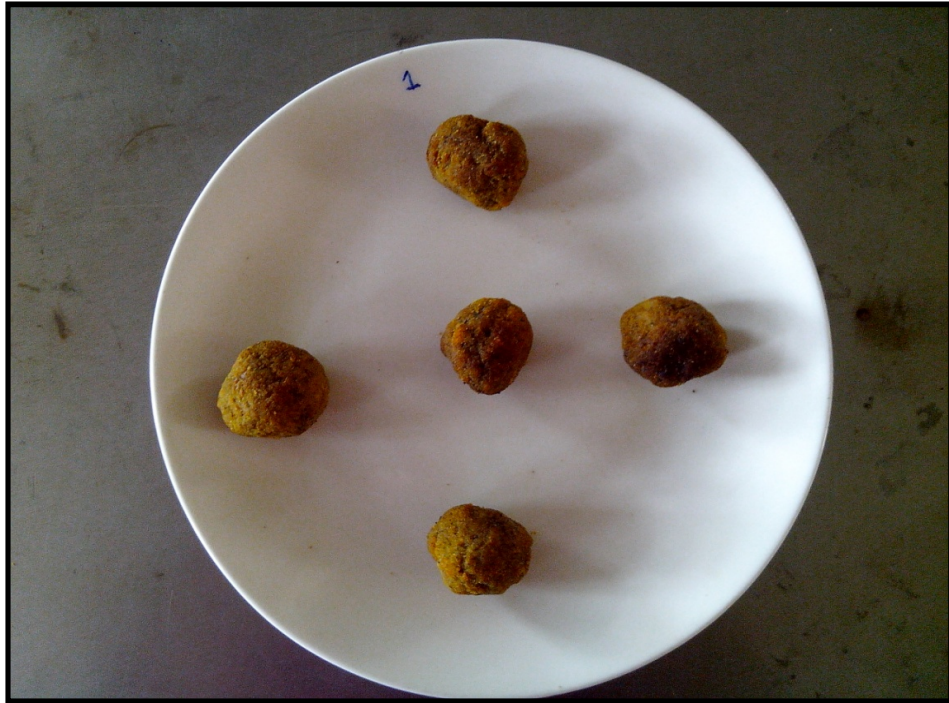
Table 2: Recipe for the preparation of enrobed chevon balls

Sr.No.	Ingredients	Quantity (% by weight)
1.	Lean meat	60
2.	Mashed potato	15
3.	Vegetable oil	6
4.	Ice flakes	5
5.	Salt	1.5
6.	Refined wheat flour	5
7.	Spice mix	2
8.	Condiments	5
9.	Sodium nitrite	0.015
10.	STPP	0.50
Total		100

3.2.1.2 Preparation of enrobed chevon balls

Flow chart





**FIG. 1 ENROBED CHEVON BALLS WITHOUT ANTIOXIDANT IN
BATTER MIX**



FIG.2 ENROBED CHEVON BALLS WITH BHA IN BATTER MIX

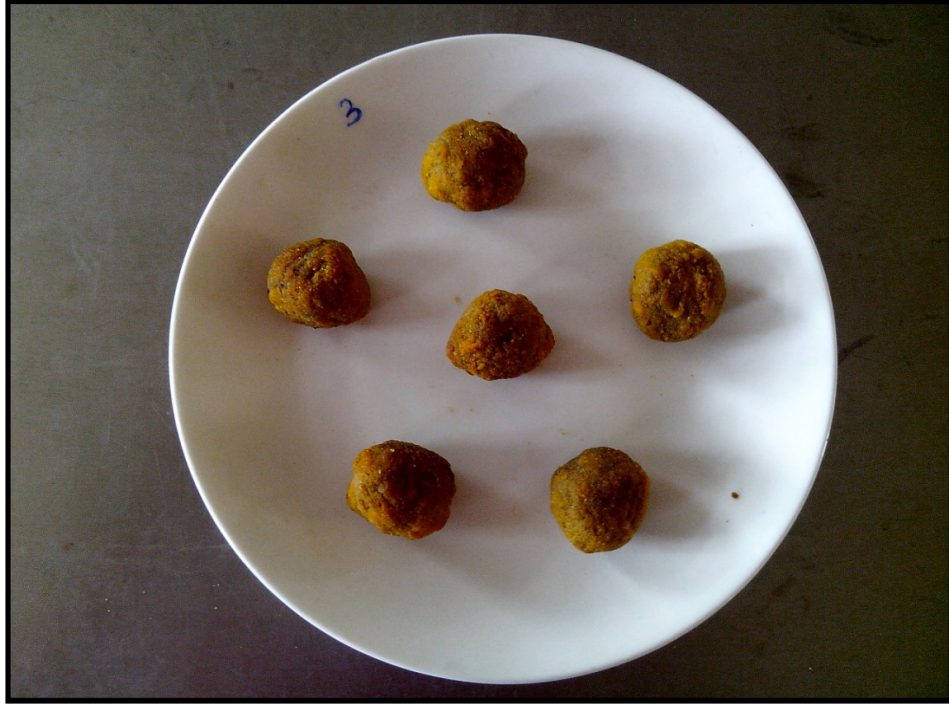


FIG. 3 ENROBED CHEVON BALLS WITH TP IN BATTER MIX

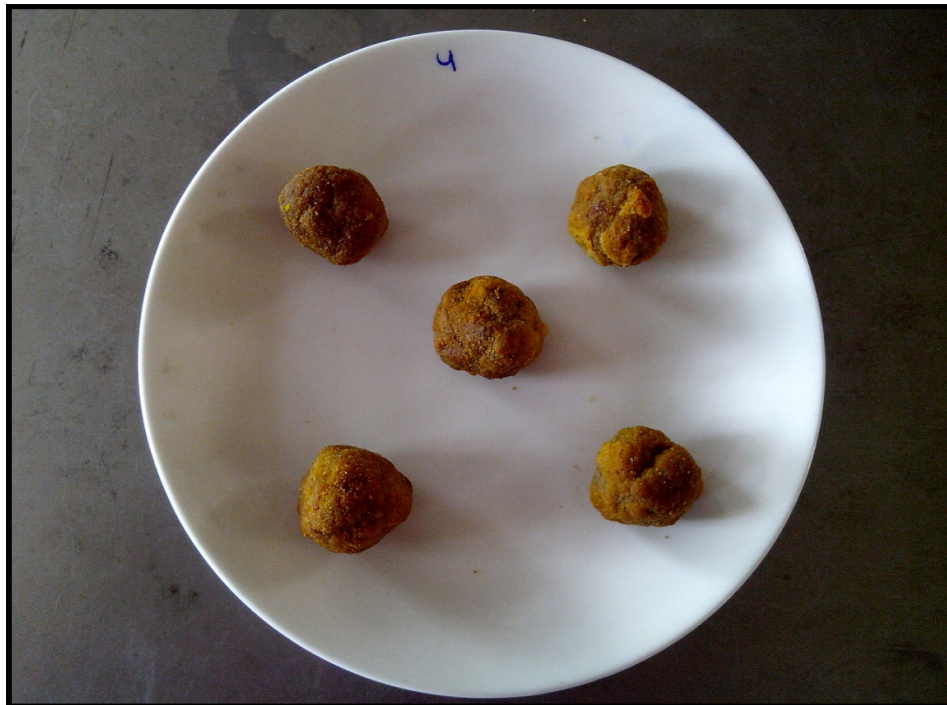


FIG. 4 ENROBED CHEVON BALLS WITH GSE IN BATTER MIX

3.2.1.2.1 Batter mix

The formulation of batter mix (Table 3.3) suggested by Biswas, 2003 was used with certain modifications.

Table 3.3: Composition of Batter mix

Sr.No.	Ingredients	Quantity (% by weight)
1.	Bengal gram flour	31
2.	Table salt	1.5
3.	Sugar	0.5
4.	Turmeric	1.5
5.	Capsicum	1.5
6.	Spice mix	1.5
7.	Whole egg	25
8.	Oil	1
9	Water	36.5
	Total	100

The batter mix was prepared by the following procedure:-

Bengal gram flour, table salt, sugar, spice mix, turmeric and capsicum powder were mixed well in a clean dry glass tray.



Whole egg liquid containing test antioxidants was then added, and mixed well.



Water was added slowly with intermittent mixing



The batter was covered properly and chilled until used

3.2.1.2.2 Cooking of meat balls

The balls were cooked in boiling water. Each ball was prepared from 7-10 g of emulsion and put in boiling water for 15-20 min till the internal temperature of balls reach $80\pm 1^{\circ}\text{C}$. Cooked balls were cooled at room temperature followed by enrobing with batter mix and then battered balls were rolled over the bread crumbs

until a uniform coating of breading material was visualized on the surface. The breaded chevon balls were deep fried using refined rice bran oil until they develop a golden brown colour. The fried balls were subsequently packaged in polyethylene pouches for further studies.

3.2.1.3 Sensory Evaluation

The enrobed chevon balls were then arranged on a white porcelain dish and immediately subjected to sensory evaluation by a panel comprising of 6 semi-trained members.

3.2.2 EXPERIMENT NO. 2: Effect of natural antioxidants on the quality of cooked enrobed chevon meat balls

3.2.2.1 Selection of level of GSE

Chevon balls were prepared by incorporating three different levels of GSE viz. 0.25%, 0.50% and 0.75% of batter mix along with control.

The level of GSE was selected on the basis of the sensory evaluation by a panel of six semi-trained members, physico-chemical evaluations, TBA number and free fatty acid content.

3.2.2.2 Selection of level of TP

Chevon balls were prepared by incorporating three different levels of TP viz. 0.25%, 0.50% and 0.75% of batter mix along with a control.

The level of TP was selected on the basis of the sensory evaluation by a panel of six semi-trained members, physico-chemical evaluations, TBA number and free fatty acid content.

For further studies, the selected levels of GSE and TP were incorporated in the batter prepared for enrobing of chevon ball.

3.2.3 EXPERIMENT NO. 3: Shelf life of chevon balls at refrigerated storage

Chevon balls were prepared as per standardization in the experiment no. 1 by incorporating BHA, GSE and TP in the chevon balls with the levels selected from earlier experiment along with negative control.

3.2.3.1 Shelf life of chevon balls during refrigeration storage

Chevon balls were packaged in LDPE pouches aseptically and stored at refrigerated temperature ($4\pm 1^{\circ}\text{C}$). The packets were labelled suitably and one

representative packet from each treatment was taken out at an interval of 5 days for periodic assessment i.e. 0th, 5th, 10th day ... until visible microbial spoilage was detected. The product was evaluated on the basis of the physico-chemical properties, TBA number, microbiological analysis (total plate count and psychrophilic plate count) as well as sensory scores during the study period.

3.3 Analysis of Chevron ball and Natural Antioxidants

3.3.1 Physico-chemical properties

The chevon ball were analyzed for the following physicochemical parameters.

3.3.1.1 Proximate analysis

Moisture (%) and fat (%) of chevon balls were determined as per the method of AOAC (1995).

3.3.1.2 pH

The pH of chevon balls were measured using digital pH meter (Systronics Digital pH meter 802) as suggested by AOAC, (1995) for which homogenized suspension was made by blending 10 g of sample with addition of 50 ml distilled water.

3.3.2 Lipid Profile Analysis of Enrobed Chevron ball

Lipid profile of enrobed chevon balls was done on the basis of TBA and FFA.

3.3.2.1 Thiobarbituric Acid (TBA) number

Thiobarbituric acid number of sample was determined as per slight modification strange *et al.*, (1970) with slight modifications. 20 g of minced chevon ball was blended with 50 ml of precooled 20% trichloroacetic acid (TCA) for 2 min. The blended content was transferred to a beaker by rinsing with 5 ml of cold distilled water and mixed together. The mixture was filtered through Whatman filter paper No. 42. The filtrate was named as TCA extract. Five ml of freshly prepared 0.01 M 2-TBA solution (stored not more than 10 days at 4^oC in amber coloured bottle) were mixed with 5 ml of TCA extract in clean oven dried test tubes in boiling water bath for 30 min. The absorbance (A) at 532 nm was recorded as TBA number.

3.3.4.3 Free fatty acid

The free fatty acid (FFA) of the product during storage study was determined using method of AOAC (1995).

20 ml benzene and neutralized alcohol mixture (1:1) was added to a flask containing fat and warmed for 30 seconds. Then 1-2 drops of phenolphthalein was added and titrated against 0.1 N NaOH solution to pale pink colour. The percent FFA was calculated in terms of percent oleic acid by using formula,

$$\text{FFA (\% Oleic acid)} = \frac{\text{TV} \times \text{N} \times 28.2}{\text{W}}$$

Where,

TV = Volume in ml of standard NaOH solution used

N = Normality of standard NaOH solution used

W = Weight in g of the fat taken

3.3.5 Sensory evaluation

A sensory panel comprising of six semi-trained members from academic staff and students of the department were involved to evaluate the quality of chevon ball for various sensory attributes viz., appearance, flavour, juiciness, texture and overall acceptability using 8 point descriptive scale (Keeton, 1983) as shown in Annexure-I, where '8' denotes 'extremely desirable' and '1' denotes 'extremely poor'.

3.3.6 Microbiological examination

The microbiological quality of chevon balls was assessed on the basis of total plate count (TPC) and psychrophilic count (PC) as per the procedure of APHA (1984).

3.3.6.1 Total plate count

3.3.6.1.1 Preparation of serial dilutions

10 g of aseptically packaged sample was triturated with addition of 90 ml of sterile 0.1% peptone water in a sterile mortar for 2 min for uniform dispersion to get 10 fold dilutions. Further serial dilutions were made in pre-sterilized test tubes containing 9 ml of 0.1% peptone water under aseptic conditions.

3.3.6.1.2 Procedure

Plate count agar (23.5 g) was suspended in one liter of distilled water and pH was adjusted to 7.00±0.02. It was boiled to dissolve completely and sterilized by

autoclaving at 15 lbs pressure for 15 min. Pour plate technique was followed for plating using 1 ml of inoculums in duplicate from appropriate dilution. The plates were incubated at $37 \pm 1^{\circ}\text{C}$ for 48 hrs. The plates showing 30-300 colonies were selected. The colonies were counted which were then multiplied by reciprocal of the respective dilutions and expressed as $\log_{10}\text{cfu/g}$ of sample.

3.3.6.2 Psychrophilic plate count

3.3.6.2.1 Preparation of serial dilutions

10 g of aseptically packaged sample was triturated with addition of 90 ml of sterile 0.1% peptone water in a sterile mortar for 2 min for uniform dispersion to get 10 fold dilutions. Further serial dilutions were made in pre-sterilized test tubes containing 9 ml of 0.1% peptone water under aseptic conditions.

3.3.6.2.2 Procedure

Plate count agar (23.5 g) was suspended in one liter of distilled water and pH was adjusted to 7.00 ± 0.02 . It was boiled to dissolve completely and sterilized by autoclaving at 15 lbs pressure for 15 min. Pour plate technique was followed for plating using 1 ml of inoculums in duplicate from appropriate dilution. The plates were incubated at $4 \pm 1^{\circ}\text{C}$ for 10 days in a refrigerator. The plates showing 30-300 colonies were selected. The colonies were counted which were then multiplied by reciprocal of the respective dilutions and expressed as $\log_{10}\text{cfu/g}$ of sample.

3.3.6.3 *E. coli* count

MacConkey agar and Eosin Methylene Blue agar were used for isolation of *E. coli*. Isolation of the organisms was made using general, selective and enrichment media and the isolates were identified on the basis of morphological, cultural and biochemical characteristics (Edward and Ewing, 1972).

3.3.7 Statistical analysis

The data obtained during the experiment were analyzed by Analysis of Variance following the procedure described by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

4.1 Process standardization for the preparation of enrobed chevon balls using different levels of potato as an extender.

Preliminary trials were conducted to decide probable level of incorporation of mashed potato in the recipe of chevon balls to standardize the formulation and procedures explained in 3.2.1.

The average values of sensory scores of chevon balls incorporated with different levels of potato (10%, 15% and 20%) have been presented in Table 4.1.

Table 4.1. Effect of different levels of potato on sensory attributes of enrobed chevon balls

Levels of potato	Appearance	Flavour	Juiciness	Texture	Overall palatability
10%	6.54±0.030	6.51±0.059 ^a	6.47±0.011 ^a	6.49±0.023	6.35±0.034 ^a
15%	6.55±0.076	6.64±0.04 ^a	6.63±0.029 ^b	6.64±0.030	6.66±0.021 ^b
20%	6.41±0.008	6.32±0.028 ^b	6.51±0.040 ^b	6.53±0.055	6.48±0.017 ^c
CD	NS	0.175	0.118	NS	0.101

NS – non significant

It was evident from the table 4.1 that appearance as well as texture of the product was not affected by the increased level of addition of potato from 10 to 20%. However flavour of the balls was significantly ($P<0.05$) reduced upon addition of 20% mashed potato in the product. It was also observed that addition of potato to the extent of 15% did not reveal significant variations in the flavour scores. The juiciness of the product was lowest in chevon balls that had 10% of mashed potato. There was significant ($P<0.05$) increase in juiciness score upon addition of 15% potato. However further increase of potato to the product did not have any effect on juiciness.

The overall palatability of the product was significantly ($P<0.05$) increased with the gradual increase in the addition of potato from 10 to 20% and the overall palatability was optimum for the product having 15% of mashed potato. However, Ali *et al.*, (2011)

reported higher overall acceptability scores for beef patties formulated with 75% potato flakes than the control samples. Based on above results, 15% addition of mashed potato during the preparation chevon balls was selected and used for subsequent studies

4.2 Effect of Grape seed extract and Green tea separately on Physico-chemical and sensory characteristics of enrobed chevon balls

4.2.1 Standardization of Grape seed extract (GSE) levels for the preparation of chevon balls.

The results of different quality characteristics viz., physico-chemical properties, oxidative stability and proximate analysis etc. of cooked chevon balls which were subsequently enrobed with different levels (0.25%, 0.50% and 0.75%) of GSE were presented in Table 4.2.

Table 4.2. Effect of different levels of Grape seed extract (GSE) in batter mix on certain quality characteristics of enrobed chevon balls

Sr. No.	Parameter	GSE				CD	
		0	0.25%	0.50%	0.75%		
1.	Physico-chemical properties	pH	6.32±0.021 ^a	6.38±0.006 ^{ac}	6.35±0.074 ^b	6.37±0.005 ^c	0.044
2.	Oxidative Stability	TBA	0.615±0.061 ^a	0.435±0.010 ^b	0.361±0.007 ^d	0.418±0.003 ^c	0.039
		RS	0.11±0.004 ^a	0.054±0.002 ^b	0.041±0.004 ^c	0.036±0.004 ^d	0.01
3.	Proximate Composition	Moisture	63.06±0.28 ^a	63.23±0.165 ^a	62.83±0.176 ^a	64.3±0.115 ^b	0.817
		Fat	24.43±0.871 ^{ak}	26.1±1.05 ^a	24.87±0.240 ^{ab}	23.1±0.288 ^b	2.2

It was observed that the incorporation of GSE as an antioxidant in batter mix showed significant ($P \leq 0.05$) increase in pH of enrobed chevon balls. These results were in agreement with that of Garg and Mendiratta (2006), who found that ginger (9%) and papain (0.5%) treatments caused significant ($P < 0.01$) increase in the moisture and pH

of the cooked products compared to the control and cucumis (7.5%) treated samples of enrobed pork chunks.

Addition of GSE at different levels (0.25%, 0.50% and 0.75%) showed significant ($P<0.05$) reduction in TBA values with increasing concentration of GSE. These observations of the present study were in agreement to the results of Narkhede (2012), who evidenced significantly lower ($P<0.05$) TBA values in all treated samples when compared with control in case of chicken nuggets.

The present study had also evidenced significant reduction ($P<0.05$) in FFA value of products irrespective of concentration of GSE and control. Similarly Das *et al.*, also (2011) found that the curry leaf powder treated sample had significantly lower free fatty acids content (0.31%-0.71%) as compared to control sample (0.37%-0.93%) in ground and cooked goat meat, respectively.

It was evident that the addition of different levels of GSE in enrobed chevon balls showed significant ($P>0.05$) increase in moisture%. This might be due to enrobing, which function as efficient barrier to moisture and/or gases in several foods (Park and Chinnan, 1990).

Addition of different levels of GSE significantly ($P<0.05$) decreased fat% as compared to control. This condition might be due to the coating ingredients, which act as sealants and also prevent high oil uptake during frying of the product (Cunningham, 1989). Similarly Mukprasirt *et al.*, (2001) also observed significantly lower fat content than other treatments in case of rice flour-based battered chicken drumsticks under frozen storage at -40°C for 90 days. Similar results were documented by Barbut *et al.*, (2006) upon addition of caseinate, whey and milk powders which significantly ($P\leq 0.05$) lowered the fat content in emulsified chicken meat batters as compared to the control.

Table 4.3. Effect of different levels of Grape seed extract (GSE) in batter mix on sensory attributes of enrobed chevon balls

Levels of GSE	Sensory attributes				
	Appearance	Flavour	Juiciness	Texture	Overall palatability
0	6.46±0.095	6.26±0.144 ^{ab}	6.33±0.127	6.43±0.096	6.18±0.105 ^a
0.25%	6.42±0.114	6.22±0.121 ^a	6.296±0.025	6.20±0.187	6.37±0.106 ^{ab}
0.50%	6.76±0.114	6.601±0.145 ^{ab}	6.722±0.248	6.60±0.122	6.80±0.167 ^b
0.75%	6.72±0.11	6.712±0.125 ^b	6.75±0.187	6.61±0.175	6.79±0.151 ^b

CD	NS	0.511	NS	NS	0.51
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Addition of different levels of GSE showed no significant ($P < 0.05$) effect on appearance, juiciness and texture but flavour and overall palatability were significantly ($P < 0.05$) affected. The enrobing and breading on the fried meat enhances flavour and overall palatability of the product (Rao and Delaney, 1995). Narkhede (2012) also recorded that addition of GSE (300, 600, 900 mg/kg) had significant ($P > 0.05$) increase flavour and overall palatability of chicken nuggets.

Table 4.4. Effect of different levels of Tea Polyphenols (TP) in batter mix on certain quality characteristics of enrobed chevon balls

Sr. No.	Parameter	TP				CD	
		0	0.25%	0.50%	0.75%		
1.	Physico-chemical properties	pH	6.32±0.021 ^a	6.30±0.005 ^{ab}	6.26±0.003 ^b	6.26±0.01 ^b	0.050
2.	Oxidative Stability	TBARS	0.615±0.061 ^a	0.427±0.002 ^{bc}	0.416±0.001 ^c	0.378±0.004 ^d	0.03
		FFA	107±0.004 ^a	0.057±0.005 ^{bc}	0.047±0.005 ^{cd}	0.037±0.002 ^d	0.01
3.	Proximate Composition	Moisture	63.06±0.28 ^a	63.38±0.03 ^a	64.33±0.08 ^{bc}	64.4±0.1 ^c	0.59
		Fat	24.43±0.28 ^a	24.56±0.23 ^a	23.66±0.28 ^{ab}	22.76±0.17 ^b	0.94

The pH of the enrobed chevon balls was increased significantly ($P < 0.05$) as compared to control but no significant difference was recorded irrespective of the levels of TP. Similar results have been reported by Karim *et al.*, (2012) were in honey treated (@5% and 10%) chicken patties had significantly ($P \leq 0.05$) lowered pH than control chicken patties.

The TBA reduced significantly ($P > 0.05$) with the addition of different levels of TP (0.25%, 0.50% and 0.75%) in enrobed chevon balls. Similarly Kang *et al.*, (2007) reported that the patties coated with material containing green tea leaf extract @ 0.5% showed lower TBARS value than the other treatments. Kenawi *et al.*, (2011) also observed that green tea treated sample showed less TBA value compared with rosemary treated low fat beef product.

The addition of different levels of TP reduced significantly ($P > 0.05$) FFA content in enrobed chevon balls as compared to control. Sarah *et al.*, (2010) noticed

that the FFA contents indicated much more reduction in Persian sturgeon fillets treated with 2.5% tea extracts, 5% tea extracts and 5% onion juice as compared to control. Shewalkar (2011) also recorded upon addition of different levels of TP in chicken nuggets significant ($P>0.05$) reduction in FFA content.

It was observed that moisture content of the enrobed chevon balls increased significantly ($P<0.05$) with the gradual increase in the level (0.25%, 0.50%, 0.75%) of TP. This might be due to enrobing materials which might have played a role of barrier to moisture and/or gases (Park and Chinnan, 1990). Similarly Mukprasirt *et al.*, (2001) observed significantly higher moisture content than other treatments in case of rice flour-based battered chicken drumsticks during frozen storage time at $-40\text{ }^{\circ}\text{C}$ for 90 days. Garg and Mendiratta (2006) also observed that ginger and papain treatments caused significant ($P<0.01$) increase in the moisture content in enrobed pork chunks.

The fat content of the enrobed product did not decrease significantly ($P<0.05$) upon addition of TP to the extent of 0.50%. However it decreased ($P>0.05$) significantly upon addition of 0.75% of TP to the product. This condition might be due to the coating ingredients, that might have acted as sealants and prevented high oil uptake during frying of the product (Cunningham, 1989). Similarly Mukprasirt *et al.*, (2001) observed significantly lower fat content than other treatments in case of rice flour-based battered chicken drumsticks. Barbut *et al.*, (2006) also reported that addition of caseinate, whey and milk powders significantly ($P\leq 0.05$) lowered the fat content in emulsified chicken meat batters as compared to the control.

Table 4.5. Effect of different levels of Tea Polyphenols (TP) in batter mix on sensory attributes of enrobed chevon balls

Levels of TP	Sensory attributes				
	Appearance	Flavour	Juiciness	Texture	Overall palatability
0	6.46±0.095	6.26±0.144	6.33±0.127	6.43±0.10	6.18±0.105 ^a
0.25%	6.52±0.089	6.48±0.101	6.65±0.101	6.37±0.046	6.55±0.073 ^{ab}
0.50%	6.57±0.127	6.67±0.100	6.72±0.211	6.59±0.111	6.83±0.107 ^b
0.75%	6.71±0.099	6.64±0.108	6.74±0.202	6.64±0.167	6.81±0.154 ^{bc}
CD	NS	NS	NS	NS	0.433

The results showed non-significant ($P>0.05$) differences in the scores of all sensory parameters with the addition of different levels of TP (0.25%, 0.50%, 0.65%) in enrobed chevon balls except overall palatability. Shewalkar (2011) reported significant ($P>0.05$) increase in overall palatability with the addition of TP at different levels (8mg/kg, 10mg/kg and 12mg/kg).

Type of Product	Storage period (Days)					Treatment (Mean±S.E.)
	0	5	10	15	20	
	pH					
Control	6.1±0.005	6.26±0.006	6.30±0.003	6.35±0.012	6.48±0.05	6.32±0.02 ^a
BHA	6.17±0.014	6.26±0.008	6.25±0.020	6.34±0.020	6.45±0.020	6.3±0.02 ^{ab}
GSE	6.14±0.023	6.26±0.011	6.32±0.037	6.35±0.014	6.47±0.012	6.31±0.03 ^a
TP	6.16±0.037	6.22±0.013	6.27±0.008	6.33±0.020	6.41±0.033	6.28±0.02 ^b
Storage Period (Mean±S.E.)	6.2±0.01 ^a	6.2±0.005 ^b	6.3±0.12 ^c	6.3±0.008 ^d	6.45±0.01 ^e	
	TBA(Thiobarbituricacid) (mg MDA/kg)					
Control	0.27±0.004	0.31±0.010	0.40±0.012	0.51±0.014	0.61±0.009	0.42±0.03 ^a
BHA	0.25±0.014	0.29±0.005	0.36±0.009	0.42±0.013	0.51±0.008	0.37±0.02 ^b
GSE	0.24±0.004	0.27±0.004	0.32±0.013	0.38±0.002	0.43±0.017	0.3±0.02 ^{cd}
TP	0.24±0.004	0.27±0.007	0.30±0.007	0.38±0.014	0.42±0.109	0.32±0.02 ^d
Storage Period (Mean±S.E.)	0.25±0.005 ^a	0.3±0.005 ^{bc}	0.4±0.012 ^{cd}	0.42±0.02 ^{de}	0.49±0.02 ^e	
	Free Fatty Acid (meq/kg fat)					
Control	0.34±0.005	0.91±0.033	1.62±0.020	2.82±0.02	4.43±0.083	2.02±0.35 ^a
BHA	0.31±0.017	0.73±0.003	1.31±0.058	2.05±0.035	3.53±0.093	1.58±0.27 ^b
GSE	0.28±0.004	0.65±0.016	1.05±0.063	1.48±0.041	2.97±0.087	1.28±0.22 ^c
TP	0.28±0.005	0.6±0.020	0.99±0.002	1.24±0.034	2.53±0.122	1.13±0.18 ^d
Storage Period (Mean±S.E.)	0.30±0.008 ^a	0.7±0.035 ^b	1.24±0.077 ^c	1.90±0.184 ^d	3.36±0.21 ^e	

Table 4.6. Effect of natural antioxidants on certain physico-chemical quality characteristics of enrobed chevon balls during refrigeration storage ($4\pm 1^{\circ}\text{C}$).

The changes observed in physico-chemical properties and oxidative stability of the chevon balls, prepared with or without incorporation of selected levels of antioxidants was assessed at a regular interval of 5 days under refrigerated storage ($4 \pm 1^{\circ}\text{C}$) and was represented in Table 4.6.

The pH of the products increased significantly ($P < 0.05$) throughout the storage. The consistent increase in pH during storage could be due to liberation of protein metabolites by bacterial enzymes (Narkhede, 2012). The study evidenced that the addition of TP in enrobed chevon balls reduced the pH of product as compared to other treatments. Similar results of gradual increase in pH of fish burgers of both coated and uncoated and batter coated shrimp during storage were reported by Mahmoudzadeh *et al.*, (2010) and Yerlikaya *et al.*, (2010) respectively. Yadav and sharma (2008) also found significant ($P < 0.05$) increase in pH of control as well as enrobed patties during storage up to 28 days. The pH of enrobed patties with antioxidant (nisin) was lower than that of control patties.

The TBA values of enrobed chevon balls also increased significantly ($P < 0.05$) throughout the storage period. The TBA value was significantly ($P < 0.05$) higher in control as compared to other treatments. Similar results were observed by Garg and Mendiratta (2006), Bhat *et al.*, (2011), Yadav and Sharma (2008) and Karim *et al.*, (2012) in different enrobed products. Among the antioxidants treated products, TBA values were lower in TP treated enrobed chevon balls followed by GSE and BHA. The increase in TBA values during storage might be due to oxygen permeability of packaging material that in turn led to faster lipid oxidation (Shewalkar., 2011 and Garg and Mendiratta 2006). Kang *et al.*, (2007) reported that the patties coated with material containing green tea leaf extract @ 0.5% showed lower TBARS value than the other treatments. Kenawi *et al.*, (2011) also observed that green tea treated sample showed less TBA value compared with rosemary treated low fat beef product with edible packaging.

The FFA content of enrobed chevon balls also increased significantly ($P < 0.05$) throughout the refrigeration period of 20 days. However FFA content decreased significantly ($p < 0.05$) in all the treatment groups except control during refrigeration storage. Although the lowest FFA contents were observed in TP treated enrobed chevon balls as compared to GSE, BHA and control. This might be due to potency of the antioxidants to retard the lipolytic changes in meat products (Narkhede, 2012). Similar finding were observed by Sharma *et al.*, (2011) and Das *et al.*, (2011) in different meat products. Sarah *et al.*, (2010) also noticed that the FFA contents indicated much more reduction in Persian sturgeon fillets treated with 2.5% tea extracts, 5% tea extracts and 5% onion juice as compared to control.

However Shewalkar (2011) recorded inconsistent variations in FFA content of control as well as TP treated nuggets throughout the period of storage at refrigerated temperature ($4\pm 1^{\circ}\text{C}$). Although the low FFA content was recorded in the tea polyphenol treated chicken nuggets, the variations in FFA contents of all treated products did not differ significantly as compared to control.

The incorporation of TP showed significantly ($P<0.05$) lower pH, TBA value and FFA as compared to GSE, BHA and control. These results indicated the effectiveness of TP over other antioxidants at the time of refrigeration storage.

Table 4.7. Effect of natural antioxidants on proximate composition of enrobed chevon balls during refrigeration storage

Type of Product	Storage period (Days)					Treatment (Mean \pm S.E.)
	0	5	10	15	20	
	Moisture (%)					
Control	63.4 \pm 0.2	60.9 \pm 0.8	57.5 \pm 0.73	54.9 \pm 0.1	52.9 \pm 0.27	57.95 \pm 0.951 ^{ac}
GSE	63.9 \pm 0.3	63.0 \pm 0.21	62.6 \pm 0.08	58.7 \pm 0.4	57.83 \pm 1.5	61.24 \pm 0.655 ^b
BHA	63.6 \pm 0.1	60.3 \pm 0.39	58.1 \pm 0.61	56.7 \pm 0.5	53.26 \pm 0.6	58.42 \pm 0.861 ^b
TP	63.0 \pm 1.3	61.6 \pm 0.42	60.1 \pm 0.79	58.0 \pm 0.2	55.8 \pm 0.37	59.64 \pm 0.651 ^c
Storage Period (Mean\pmS.E.)	64.4 \pm 0.3 ^a	61.5 \pm 0.37 ^b	59.6 \pm 0.6 ^c	57.1 \pm 0.4 ^d	54.95 \pm 0.7 ^e	
	Fat (%)					
Control	24.4 \pm 0.2	24.2 \pm 0.15	23.5 \pm 0.13	22.6 \pm 0.1	21.4 \pm 0.2	23.2 \pm 0.274 ^a
GSE	24.0 \pm 0.1	23.69 \pm 0.0	23.1 \pm 0.06	22.7 \pm 0.14	21.8 \pm 0.01	23.1 \pm 0.185 ^a
BHA	24.2 \pm 0.1	23.7 \pm 0.1	23.2 \pm 0.19	22.8 \pm 0.17	21.7 \pm 0.07	23.1 \pm 0.217 ^a
TP	23.9 \pm 0.11	23.5 \pm 0.02	23.1 \pm 0.03	22.8 \pm 0.03	22.0 \pm 0.13	23.07 \pm 0.15 ^a
Storage Period (Mean\pmS.E.)	24.1 \pm 0.09 ^a	23.7 \pm 0.09 ^b	23.8 \pm 0.07 ^c	22.8 \pm 0.06 ^d	21.7 \pm 0.08 ^e	

The changes observed in proximate composition of the enrobed chevon balls prepared with or without incorporation of selected levels of antioxidants, during assessment at a regular interval of 5 days under refrigerated storage ($4 \pm 1^{\circ}\text{C}$) were presented in Table 4.7.

It was observed that moisture content of the product decreased significantly ($P<0.05$) with the refrigerated storage period of 20 days. The loss of moisture during storage might be due to evaporation of moisture from meat during

storage (Arief *et al* 1989). These results corroborated with the findings of Yadav and Sharma (2008) and Karim *et al.*, (2012), who reported significantly reduced ($P < 0.05$) moisture in enrobed chicken patties during frozen storage. The moisture loss was lower in GSE treated enrobed chevon balls as compared to other treatments. Biswas *et al.*, (2003) also observed relatively lower moisture loss at the 45th day of frozen storage ($-18 \pm 1^\circ\text{C}$) in enrobed pork patties containing antioxidants (50%BHA +50%BHT). Kang *et al.*, (2007) also found that the addition of 0.5% green tea powder with pectin-based materials had resulted in significantly higher moisture content than the uncoated pork patty.

Non-significant ($P > 0.05$) variation was observed in fat contents of enrobed chevon balls treated with different antioxidants but a significant reduction in fat content of enrobed chevon balls was noted during storage period. Similarly Mukprasirt *et al.*, (2001) observed significantly lower fat content but a higher moisture content than other treatments in case of rice flour-based battered chicken drumsticks. Shewalkar (2011) also observed significant reduction ($P < 0.05$) in the fat content of the chicken nuggets during refrigeration storage.

Table 4.8. Effect of natural antioxidants on microbiological analysis of enrobed chevon balls during refrigeration storage

Type of Product	0	5	10	15	20	Treatment (Mean±S.E.)
TPC(Total Plate Count)						
Control	1.2±0.008	2.1±0.06	2.9±0.03	3.2±0.3	3.5±0.03	2.6±0.21 ^a
BHA	1.17±0.03	1.9±0.01	2.27±0.08	3.1±0.03	3.5±0.04	2.5±0.20 ^b
GSE	1.13±0.03	1.9±0.02	2.43±0.03	2.9±0.01	3.4±0.01	2.3±0.192 ^c
TP	1.09±0.08	1.8±0.01	2.4±0.026	2.9±0.03	3.2±0.05	2.3±0.18 ^d
Storage Period (Mean±S.E.)	1.14±0.01 ^a	1.9±0.02 ^b	2.6±0.06 ^c	3.0±0.03 ^d	3.4±0.04 ^e	
PC(Psychrophilic count)						
Control	0.19±0.05	0.61±0.01	1.45±0.07	1.8±0.03	2.1±0.03	1.2±0.17 ^a
BHA	0.18±0.05	0.47±0.01	1.08±0.04	1.5±0.05	1.8±0.038	1.01±0.1 ^b
GSE	0.19±0.04	0.42±0.06	1.01±0.03	1.4±0.04	1.73±0.01	0.9±0.14 ^{cd}
TP	0.18±0.05	0.41±0.06	0.96±0.02	1.4±0.06	1.72±0.03	0.9±0.14 ^d
Storage Period (Mean±S.E.)	0.19±0.02 ^a	0.05±0.03 ^b	2.1±0.06 ^c	1.5±0.05 ^d	1.83±0.04 ^e	

The TPC was found significantly ($P < 0.05$) lower in TP (@0.75%) and GSE (@0.75%) incorporated enrobed chevon balls as compared to the control and BHA. The low TPC in TP treated enrobed chevon balls might be due to antimicrobial activity of green tea (Banon *et al.*, 2007). Moreover, the TPC of enrobed chevon balls of all groups was found to increase significantly ($P < 0.05$) with the progress of storage period. All the products showed a significant ($P < 0.05$) increase in TPC on the consecutive day of microbiological assessment. Biswas *et al.*, (2003) also observed that enrobed samples significantly ($P < 0.05$) increased the total plate count (TPC) during chilled (21 days at $4 \pm 1^\circ\text{C}$) and frozen (45 days at $-18 \pm 1^\circ\text{C}$) storage. Similarly Kang *et al.*, (2007) documented TPC of control product was the highest.

The significant ($P < 0.05$) increase in PC was observed in all products thought the storage study. Yadav and Sharma (2008) and Bhat *et al.*, (2011) found significantly increased PC during storage in all the treatments of chicken patties and meat balls. Incorporation of TP reduced PC in enrobed chevon balls as compared to other treatments.

Salmonella and *E. coli* organisms were not detected in the enrobed chevon balls either with or without antioxidants at the end of storage study. Similar observations were also recorded by Bhat *et al.*, (2011), Shewalkar (2011) and Narkhede (2012). These bacteria are indicator of fecal contamination. Absence of these microorganisms indicated no contamination during post processing handling of enrobed chevon balls.

Table 4.9. Effect of natural antioxidants on sensory attributes of enrobed chevon balls during refrigeration storage

Type of product	Storage period (days)					Treatment (mean±S.E.)
	0	5	10	15	20	
	Appearance					
Control	7±0.01	6.72±0.012	6.37±0.027	5.77±0.103	5.23±0.145	6.22±0.159 ^a
GSE	7.1±0.057	6.96±0.033	6.82±0.015	6.52±0.037	6.43±0.035	6.76±0.063 ^{bc}
TP	7±0.058	6.98±0.016	6.78±0.064	6.52±0.020	6.04±0.088	6.66±0.089 ^c
BHA	6.99±0.006	6.83±0.011	6.73±0.018	6.51±0.054	5.97±0.03	6.60±0.087 ^d
Storage (mean±S.E.)	7.02±0.023 ^a	6.87±0.032 ^b	6.67±0.055 ^c	6.33±0.100 ^d	5.91±0.135 ^e	
	Flavour					
Control	6.92±0.056	6.73±0.012	6.26±0.092	5.66±0.285	4.73±0.261	6.06±0.203 ^a
GSE	7.20±0.026	7.03±0.033	6.85±0.031	6.66±0.029	6.37±0.011	6.826±0.071 ^b
TP	7.18±0.015	7.02±0.015	6.85±0.025	6.65±0.029	6.11±0.060	6.76±0.091 ^{bc}
BHA	6.96±0.024	6.77±0.034	6.58±0.094	6.27±0.113	5.82±0.069	6.48±0.101 ^d
Storage (mean±S.E.)	7.06±0.041 ^a	6.89±0.042 ^b	6.63±0.079 ^c	6.31±0.139 ^d	5.75±0.196 ^e	
	Juiciness					
Control	7.01±0.021	6.7±0.011	6.37±0.044	5.59±0.084	4.99±0.055	6.13±0.180 ^a
GSE	7.14±0.035	7.02±0.037	6.82±0.029	6.5±0.046	6.02±0.050	6.70±0.099 ^b
TP	7.10±0.046	6.99±0.01	6.81±0.031	6.55±0.052	6.00±0.063	6.69±0.096 ^c
BHA	7±0.015	6.72±0.024	6.51±0.014	6.21±0.017	5.79±0.127	6.44±0.103 ^d
Storage (mean±S.E.)	7.06±0.022 ^a	6.86±0.046 ^b	6.63±0.059 ^c	6.21±0.117 ^d	5.70±0.130 ^e	
	Texture					
Control	6.97±0.03	6.74±0.02	6.41±0.014	5.78±0.099	5.38±0.087	6.25±0.146 ^a
GSE	7.05±0.053	6.97±0.017	6.75±0.024	6.48±0.015	6.10±0.029	6.67±0.085 ^b
TP	7.05±0.05	6.92±0.026	6.66±0.053	6.36±0.100	6.02±0.038	6.60±0.093 ^c
BHA	6.97±0.023	6.78±0.037	6.64±0.020	6.36±0.040	5.87±0.030	6.52±0.094 ^d
Storage (mean±S.E.)	7.01±0.021 ^a	6.85±0.030 ^b	6.61±0.040 ^c	6.30±0.148 ^d	5.94±0.045 ^e	
	Overall palatability					
Control	7.01±0.044	6.76±0.032	6.43±0.078	5.32±0.127	4.45±0.072	5.99±0.236 ^a
GSE	7.1±0.057	6.95±0.032	6.72±0.034	6.43±0.066	6.00±0.112	6.64±0.098 ^{bc}
TP	7.09±0.054	6.93±0.041	6.69±0.041	6.39±0.10	5.96±0.028	6.61±0.100 ^c
BHA	7.0±0.054	6.91±0.017	6.61±0.026	6.15±0.104	5.53±0.052	6.44±0.134 ^d
Storage (mean±S.E.)	7.05±0.026 ^a	6.89±0.026 ^b	6.61±0.039 ^c	6.07±0.141 ^d	5.48±0.191 ^e	

The changes observed in sensory attributes of the enrobed chevon balls, prepared with or without addition of selected levels of antioxidants and the assessment of product at a regular interval of 5 days under refrigerated storage ($4\pm 1^{\circ}\text{C}$) was presented in Table 4.9.

Appearance of the enrobed chevon balls was found significantly ($P < 0.05$) higher in natural antioxidants treated products. The appearance of the products was found to vary in the order of $\text{GSE} > \text{TP} > \text{BHA} > \text{Control}$. Also, it was observed that the appearance of the products decreased significantly ($P < 0.05$) and gradually during 20 days of refrigerated storage. It was deduced that the decrease in appearance scores during refrigerated storage period might be mostly due to non-enzymatic browning of product as the sequel of pigment and lipid oxidation (Suradker, 2008). It was evident that the flavour and the juiciness of the antioxidants containing products were significantly ($P < 0.05$) higher as compared to the control. The order of effectiveness of antioxidants incorporation in enrobed chevon balls on both flavour and juiciness were found as $\text{GSE} \geq \text{TP} > \text{BHA} \geq \text{Control}$. The flavour and juiciness were significantly ($P < 0.05$) higher in GSE treated enrobed chevon balls throughout the storage period. These findings might be reasoned to the presence of phenolic compounds and flavonoids in GSE (Kelm *et al.*, 2000; Vrinda and Uma devi, 2001; Shi *et al.*, 2003 and Jayaprakasha *et al.*, 2001).

It was observed that texture score of all samples decreased significantly ($P < 0.05$) throughout storage period. Highest score was observed in GSE treated enrobed chevon balls. However, decreased textural scores at the end of storage might be due to release of moisture (Wu *et al.*, 2000) and changes in the properties of the proteins and fat during storage. The results evidenced significant reduction ($P < 0.05$) in overall palatability of the treated as well as control products throughout storage period. GSE treated product gained highest score of overall palatability during the refrigeration storage period. These findings were in corroboration with the results reported by Biswas *et al.*, (2003) who observed that sensory scores viz appearance and color, flavour, juiciness, texture, and overall acceptability were higher in antioxidant containing enrobed pork patty than control during the entire storage period. Moreover Bhat *et al.*, (2011) reported that scores for various sensory attributes decreased significantly ($P < 0.05$) during storage ($4\pm 1^{\circ}\text{C}$). Kenawi *et al.*, (2011) and Karim *et al.*, (2012) as well found that all sensory attributes color, flavour, juiciness and overall

acceptability for all honey treated (@5% and 10%) chicken patties significantly ($P \leq 0.05$) declined as storage time increased.

SUMMARY AND CONCLUSION

5.1 Summary

There are over 880 million goats around the world, out of which India has over 140.5 million goats (14.31%). The goat sector contributes 14,453 crores to the agricultural economy of the country through meat (6851 crores), milk (4588 crores), skin (648 crores), etc. which accounts for around 8 per cent of the gross domestic product (GDP) from livestock sector. There are no social and religious taboo associated with the consumption of chevon in India and is consumed all over the world.

Enrobing is a process in which foods are coated with edible coatings in the form of batter, which preserves and enhances their quality. Enrobing has been widely practiced in world to improve the appearance, colour, crispness, flavour, juiciness, nutritive value and microbiological profile of the product. Enrobing, thus, has enabled processors with added value at low cost.

PUFAs content is high in chevon so it is prone to oxidative deterioration. Moreover, frying also play an important role in decomposition of lipid content in meat. Lipid oxidation, which leads to rapid formation of rancid or stale flavour, denoted as warmed-over flavour (WOF), during refrigerated storage.

In order to delay this oxidative process, synthetic antioxidants (upto 200 ppm) have been successfully utilized by many food processors. However, consumer are concerned about using these additives in meat due to their possible carcinogenic effect on human and health therefore preferring either meat or any food products with reduced additives or use of natural antioxidants.

Natural antioxidants are mainly plant phenolics occurring in all parts of plants such as fruits, nuts, seeds, leaves etc. Plant phenolics are multifunctional and can act as reducing agents, free radical terminators, metal chelators and signet oxygen quenchers in addition to providing antimicrobial activity.

Keeping in mind, the wide scope of natural antioxidants in processed meat industry, present study was undertaken to assess the antioxidative and antimicrobial potential of TP and GSE in the enrobed chevon balls during its preparation and storage life.

Boneless chevon was procured from local meat market and kept at refrigeration ($4\pm 1^{\circ}\text{C}$) for ageing for overnight. After trimming of fat and tendons, mincing of meat was carried out. Emulsion was made by blending of minced and chopped meat with addition of salt, sodium nitrite, STPP, potato and other ingredients and then cooked in boiled water for 15-20 min till the internal temperature of balls has reached to $80\pm 1^{\circ}\text{C}$. After cooling at room temperature, chevon balls were enrobed with batter mix (containing natural [GSE, TP] and synthetic [BHA] antioxidants) then breaded (with bread crumbs) and fried. The enrobed chevon balls were cooled at room temperature and packaged in LDPE pouches and subsequently analyzed as per the experimental design. Acceptability of the product was judged on the basis of physico-chemical and sensory qualities as well as microbiological characteristics.

5.1.1 Effect of different levels of potato on sensory attributes of enrobed chevon balls

Incorporation of 15% mashed potato with 60% lean meat was found to be more effective as compared to other combinations on the basis of sensory assessment of the product. Hence this combination was selected and subsequently used in further study.

5.1.2 Effect of natural antioxidants on the quality of cooked enrobed chevon balls.

5.1.2.1 Physico-chemical characteristics of enrobed chevon balls.

The pH, TBA, FFA, Moisture, fat% were found to be significantly ($P < 0.05$) affected by incorporation of different levels of antioxidants in treated products.

5.1.2.2 Sensory evaluation of enrobed chevon balls.

Enrobed chevon balls incorporated with different levels of GSE and TP recorded significantly ($P < 0.05$) increased scores of overall palatability as compared to control.

5.1.3 Shelf life of enrobed chevon balls at refrigerated temperature

Enrobed chevon balls were prepared by addition of TP and GSE @ 0.75% in batter mix after selection of best performing levels from earlier experiments.

5.1.3.1 Physico-chemical properties and oxidative stability of enrobed chevon balls.

The pH of the treatment products were found to increase significantly ($P<0.05$) during the refrigerated storage period whereas significant increase ($P<0.05$) variations were observed among treatment groups when compared to control.

TBA and FFA content of the treated products revealed significant ($P<0.05$) increase during refrigerated storage period of 20 days.

It was observed that moisture and fat content of the product decreased significantly ($P<0.05$) with the refrigerated storage period of 20 days.

5.1.3.2 Microbial analysis of enrobed chevon balls.

TPC and PC increased significantly ($P<0.05$) with storage period. TP showed potent antimicrobial action as compared to other treatments.

5.1.3.3 Sensory attributes of enrobed chevon balls.

There was significant ($P<0.05$) decrease in sensory attributes of the enrobed chevon balls during storage period. In the present study GSE treated products had higher sensory scores as compare to other treatments.

5.2 Conclusions

- ❖ The values of sensory scores, physico-chemical characteristics, oxidative stability and microbiological evaluations were considerably highest in enrobed chevon balls prepared incorporation of GSE @ 0.75% and TP @ 0.75% in batter mix.
- ❖ Both of the products with natural antioxidants at these levels prevailed over the enrobed chevon balls prepared by addition of BHA @ 100 mg/kg.
- ❖ GSE and TP can be opted by the meat processing industry in near future over synthetic established antioxidants (BHA).

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THESIS ABSTRACT

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ABSTRACT

In this era of globalization and liberalization, product development and value addition are imperative for competing the domestic as well as the world market. Now-a-days consumer preferences turned towards the variety of convenient products with better acceptability and lower price tag.

Battered and fried products are very popular in India as well as in world market. Enrobing of the meat is a method of value addition which enhances texture, flavour and appearance of the product and also increases consumer acceptance. Subsequent frying of such make them products prone to oxidative changes during refrigeration storage. To overcome this problem, synthetic antioxidants are being used worldwide. Nowadays, concerns regarding food safety and toxicity of these synthetic antioxidants prompted research on natural antioxidants derived from plant sources.

The present study was aimed to assess antioxidative properties of natural antioxidants viz. tea polyphenol and grapes seed extract in enrobed chevon balls.

The enrobed chevon balls with 60% lean meat and 15% mashed potato were highly accepted by sensory panelists.

The pH, TBARS, FFA, moisture and fat content were found to be affected by addition of different levels of natural antioxidants. Incorporation of GSE @0.75% in batter mix improved flavour and overall palatability whereas incorporation of TP @0.75% increased overall palatability.

The physico-chemical properties and oxidative stability of the chevon balls were decreased significantly ($P < 0.05$) with the progress of refrigerated storage ($4 \pm 1^{\circ}\text{C}$) period. Moisture and fat decreased significantly ($P < 0.05$) with the storage period. In all the products TPC and PC increased significantly ($P < 0.05$). Scores for various sensory attributes viz., appearance, flavour, juiciness, texture and overall palatability were decreased significantly ($P < 0.05$) during the entire storage period.

The results indicated that physico-chemical, microbiological and fat% were lower in TP containing enrobed chevon balls as compared to control and other treatments. However the sensory quality and moisture percent were optimum in GSE incorporated enrobed chevon balls.

Ilcák I ljlák

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