EVALUATION OF QUALITY CHARACTERISTICS OF FUNCTIONAL CHICKEN NUGGETS INCORPORATED WITH CHICKEN GIZZARD BLEND CONTAINING SORGHUM FLOUR AND OILSEED

Thesis

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By

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Deepshikha

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Authoress

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November, 2020

CERTIFICATE

This is to certify that the thesis entitled "**EVALUATION OF QUALITY CHARACTERISTICS OF FUNCTIONAL CHICKEN NUGGETS INCORPORATED WITH CHICKEN GIZZARD BLEND CONTAINING SORGHUM FLOUR AND OILSEED**" submitted in partial fulfillment of the requirements for the degree of **Master of Veterinary Science** with major in **Livestock Products Technology** of the College of Post Graduate Studies, G.B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona fide* research carried out by **Miss. Deepshikha Singh, Id. No. 44669,** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

(P.K. Singh)
Chairman
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Pantnagar
November, 2020

CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Miss Deepshikha Singh, Id. No. 44669,** a candidate for the degree of **Master of Veterinary Science** with major in **Livestock Products Technology**, agree that the thesis entitled "**EVALUATION OF QUALITY CHARACTERISTICS OF FUNCTIONAL CHICKEN NUGGETS INCORPORATED WITH CHICKEN GIZZARD BLEND CONTAINING SORGHUM FLOUR AND OILSEED**" may be submitted in partial fulfillment of the requirements for the degree.

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ABBREVIATIONS

%	:	Percentage
@	:	at the rate of
°C	:	Degree Centigrade
ANOVA	:	Analysis of Variance
APHA	:	American Public Health Association
cfu	:	Colony forming units
df	:	degree of freedom
DPPH	:	2,2-diphenyl-1-picrylhydrazyl
FAO	:	Food and Agriculture Organisation
FFA	:	Free fatty acid
G	:	Gizzard
g	:	gram
MDA	:	Malonaldehyde
MSS	:	Mean sum of squares
NaCl	:	Sodium chlooride
PCA	:	Plate count agar
PDA	:	Potato dextrose agar
PUFA	:	Poly unsaturated fatty acid
PV	:	Peroxide value
SE	:	Standard error
TBA	:	Thiobarbituric acid
TBARS	:	Thiobarbituric acid reacting substance
TPC	:	Total plate count
USDA	:	United States Department of Agriculture

Introduction

According to the **Livestock Census of 2019** the total livestock population is 535.78 billion with an increase of 4.6% over livestock census of 2012. The total poultry population in 2012 was 729.2 billion and in 2019 it is about 851.81 million with an increase of about 16.8%. The Indian poultry market, consisting of broilers and eggs was worth INR 1,750 Billion in 2018. The market is further projected to reach INR 4,340 Billion by 2024**(Indian Poultry Market Report, 2019).**

The relationship between the consumption of broiler meat and health is multifaceted as it provides a variable but moderate energy content, highly digestible proteins (with low levels of collagen) of good nutritional quality, unsaturated lipids (mainly found in the skin and easily removed), B-group vitamins (mainly thiamin, vitamin B6, and pantothenic acid), and minerals (like iron, zinc, and copper). In todays world the consumers are becoming more and more concerned about the food that they eat as it is directly related to health. The people today demand food which have the potential of providing benefits beyond basic nutrition and may play a role in reducing or minimizing the risk of certain diseases and other health conditions i.e. functional foods.

Poultry industry produces a lot of edible by products which can be further utilized for meat production. The **CII-McKinsey Report (1997**) on "Food and Agriculture Integrated Development Action (FAIDA)" has identified poultry products as having the third highest growth potential after wheat and milk based products. Gizzard, a byproduct of poultry industry which is a muscular organ weighing about 0.07-0.10 kg /head**.** It has about 72.66% moisture, 4.2% fat, 18.2% protein. Gizzard has been successfully incorporated in various processed meat products to increase the protein content without increasing the cholesterol and fat content significantly.

Dietary fibre is an important part of human diet. One such fiber is Sorghum, an old cereal that originated in parts of Africa over 50,000 years ago. It belongs to the family called *Panicoideae.* Grain sorghum(GS) is a dietary staple for approximately 500+million people in more than 30 countries positioning this commodity as the 5th

most valuable cereal crop in the world exceeded only by rice, wheat, corn and barley. Sorghum is a source of carbohydrates (60-70%), proteins (8-12%), oil (2.8-3.6%), fiber (approximately 8%), ash (1-2%), vitamins and phytochemicals, such as phytosterols, policosanols, carotenoids and phenolic compounds, including flavonoids tannins, anthocyanins, among others, which contribute it sbiological potential **(Cardoso *et al.*, 2014; Chávez *et al.*, 2017)**.GS has shown to protect against chronic health conditions and diseases that are particularly prevalent in western societies, such as cellular oxidation, inflammation, hypercholesterolemia, cancer, and type 2 diabetes (**Awika *et al.*, 2004).** Sorghum is known to be gluten free, high in fiber and they are also known to possess Policosanol known to have cholesterol lowering potential.

Oilseeds apart from being a source of oil have a lot of importance as nutritious food items. They contain most of the food components like carbohydrates, proteins, oils, minerals, vitamins, essential fatty acids (EFA) and essential amino acids (EAA). In general oilseeds contain about 20-25% oil/fat, 20-30% each of proteins and sugar, 5-10% of minerals, vitamins, and other micro-nutrients.

Considering these above mentioned aspects, the following study will be conducted to prepare functional chicken nuggets incorporated with chicken gizzard blend containing sorghum flour and oilseeds with following objectives -

- To standardize the optimum level of chicken gizzard.
- To standardize the optimum level of dietary fiber (Sorghum flour).
- To optimize the level of selected oilseed in functional chicken nuggets.
- To study the proximate composition and physico-chemical characteristics of functional Chicken nuggets prepared by incorporating test ingredients i.e. gizzard, sorghum flour and oilseeds.
- To study textural properties of functional chicken nuggets prepared by incorporating test ingredients gizzard, sorghum flour and oilseeds.
- To study storage stability characteristics and sensory characteristics (4±1ºC) of functional chicken nuggets.

Review of Literature

2.1 CHICKEN

Chicken meat has become the highest contributor (37%) to total meat production in India **(FAO, 2008).** It is accepted by every community as there is no religious taboo. A broiler is any chicken (*Gallus gallus domesticus*) that is bred and raised specifically for meat production. Poultry meat is rich in niacin and moderately rich in thiamine, riboflavin and ascorbic acid. It is a good source of iron and phosphorus. Half of iron in meat is present as haem iron, which is well absorbed (15-20%) compared with only 1-10% of iron from plant food. White meat is abundant in poly-unsaturated and mono-unsaturated fatty acids like Omega 3 and Omega 6 fatty acids, which help to reduce the 'bad cholesterol' like the LDL and increases the 'good cholesterol' the HDL. In particular, the substitution of one daily serving of red meat with a daily serving of poultry reduced CV risk by 19%. Also white meat is preferred over red meat as it is associated with cancers. In general, increased consumption of red meat is associated with higher cancer risk, whereas white meat is considered moderately protective or neutral Notably, red meat is characterized by a higher proportion of total fat (up to 20% vs. approximately 4% in lean poultry meat), especially of saturated fats, and a reduced content of polyunsaturated fats.

2.2 GIZZARD

Gizzard is a muscular part of digestive system of bird with main purpose of grinding of food. Gizzard is a good source of protein with low fat and cholesterol level. Gizzard contains approximately 20% proteins **(Kondaiah *et al.*, 1987)** and has potential for using in cost effective, convenient ready to eat chicken products. Studies on development of fried chicken gizzard and its storage stability has been reported **(Pangas *et al.*, 1998).** It is estimated that during slaughtering of birds, about 10 to 13 % live poultry weight is wasted in the form of skin, gizzard, heart and other by-products. Effective utilization of these by-products for production of value added meat products is one way to realize maximum returns from poultry sector **(Subhashkumar, 2009)**. Also utilization of by products will reduce wastage and associated disadvantages.

Gizzard forms nearly 3% of dressed chicken **(Charonpong *et al.*, 1980)** and as such it is less preferred by the consumer due to its peculiar flavour and texture.

2.3 SORGHUM

Sorghum is an old cereal that originated in parts of Africa over 50,000 years ago. It belongs to the family called *Panicoideae.* Sorghum is known to be gluten free, high in fiber and also known to possess Policosanol, a cholesterol lowering agent.The higher amount of dietary fiber in cereals is not only desirable for their nutritional properties but also for their functional and technological characteristics **(Thebaudin *et al.*, 1997**). Phyto-chemicals present in sorghum has potential to significantly impact human health as it reduces the risk of certain types of cancer in humans compared to other cereals. It is also useful in reducing the obesity in humans **(Awika *et al.*, 2004**). In a study conducted by (**Malav *et al.*, 2013**) restructured chicken meat blocks extended with optimum level of extenders viz., 9% sorghum flour (1:1 hydration, w/w) and 6% potato (boiled and mashed) retained good to very good acceptability when stored aerobically in LDPE pouches under refrigeration at 4±1ºC for 15 days without any marked demotion of physico-chemical, microbiological and sensory quality. Sorghum is also a good source of calcium and it can fulfill the deficiency of calcium in meat. Sorghum being gluten free is good for people having gluten allergy.

2.4 OILSEEDS

India is one of the largest producer of oilseeds. Oilseed are cultivated mainly to extract oil from them.

Sesame contains lignin, sesamin, sesamolin and sesamol of which sesamolin and sesamol have antioxidant activity and is very stable against deterioration by oxidation **(Sowmya *et al.* 2009).** Moreover as sesame oil contains high levels of gamma-tocopherol it results in high plasma levels of vitamin E activity which is believed to be beneficial for the prevention of cancer and heart disease.

The Latin name of the flaxseed is *Linum usitatissimum*, which means "very useful". Flaxseeds have nutritional characteristics and are rich source of ω-3 fatty acid: α-linolenic acid (ALA), short chain polyunsaturated fatty acids (PUFA), soluble and insoluble fibers, phytoestrogenic lignans (secoisolariciresinol diglycoside-SDG), proteins and an array of antioxidants **(Ivanova *et al.*, 2011; Singh *et al.*, 2011).** Its growing popularity is due to health imparting benefits in reducing cardiovascular diseases, decreased risk of cancer, particularly of the mammary and prostate gland, anti-inflammatory activity, laxative effect, and alleviation of menopausal symptoms and osteoporosis.

The common sunflower (*Helianthus annulus* L.) is a species of the Asteraceae family grown commercially worldwide offering a variety of nutritional and medicinal benefits. The sunflower seed and sprout contain valuable antioxidant, antimicrobial, anti-inflammatory, antihypertensive, wound-healing, and cardiovascular benefits found in its phenolic compounds, flavonoids, polyunsaturated fatty acids, and vitamins **(Fowler, 2006**). Sunflower seed contains 35–42% oil and is naturally rich in linoleic acid (55–70%) and consequently poor in oleic acid (20–25%) **(Youle *et al.*, 1978).**

2.5 pH

pH is a measure of hydrogen ion concentration, a measure of the acidity or alkalinity of a solution. Ideal pH value of meat ranges from 5.8 to 6.3. The meat with higher pH has the better water retention properties. The quality factors affected by pH include: color, grading characteristics and shrink of carcasses and wholesale cuts: texture, cooking loss and tenderness of steaks and roasts; and processing and binding characteristics of comminuted and restructured meats **(Briskey, 1964; Davis *et al.*, 1974).**

2.6 Common salt

Salt is a mineral consisting primarily of sodium chloride (NaCl), a chemical compound belonging to the larger class of salts. Salt in its natural form occurs as a crystalline mineral known as rock salt or halite. There is a small amount of sodium naturally founds in fresh meat. Salt basically has three function i.e. adds flavor (pleasant up to 2-3%), restricts microbial growth, interacts with lean meat proteins to give increased water retention, yield, etc., increased meat binding, cohesion, etc., increased fat binding and texture changes.

2.7 Spices and condiments

The term spice is derived from the Latin word species meaning 'fruits of earth'. Spices are defined as aromatic or fragrant vegetable product used for flavoring, seasoning, or imparting aroma to foods. Spices possess antioxidant capacity, mainly due to the presence of phenolic compounds. They exhibit antioxidant property by scavenging free radicals, chelating transition metals, quenching of singlet oxygen, and enhancing the activities of antioxidant enzymes **(Rubió *et al.*, 2013). Stoilova *et al.* (2007)** reported that the CO_2 extract of ginger had *in vitro* activity comparable with that of BHT in inhibiting the lipid peroxidation both at 37 and 80°C.studies on the antimicrobial potential of cinnamon and cloves found that water infusion of cinnamon and clove inhibited the growth of eight species of yeast, including *Saccharomyces cerevisiae* **(Shelef 1984).**

2.8 Cooking yield

Meat loses volume and weight during the cooking process by expulsion of fluid. This change in fluid content brings about modifications in the textural qualities of meat which are in addition to the heat-induced changes in protein and fat. Amount of weight lost from meat gradually increases with cooking temperature and that muscle (sarcomere) length, pH and salt content also affect the weight loss on cooking **(Offer *et al.*, 1988; Tornberg, 2005)**. Myosin from white fibres has been reported to be less thermally stable, thus more susceptible to denaturation, than myosin from red fibres in both beef **(Egelandsdal *et al.*, 1994)** and chicken **(Liu *et al.*, 2015)**. Both muscle and connective tissue changes during the process of cooking may have an influence upon texture and cooking loss of processed poultry meat.

2.9 Water holding capacity

WHC is defined as the ability of meat and meat products to bind water **(Pearce *et al.*, 2011)** during slicing, mincing, and pressing and also during transport, storage, processing, and cooking**.** Poor WHC results in high drip and purge loss from meat and meat products, which can represent significant loss of weight from carcasses and cuts and may affect the yield and quality of processed meats **(Aaslyng, 2002; Woelfel *et al.*, 2002)**

2.11 Texture profile analysis (TPA)

Texture profile parameters will be evaluated as per **Bourne (1978).** 3 samples from the cooked product of the 3 breeds of poultry will be taken with measurements of

1×1×1 inch³. Samples will be analyzed on TA-HD Plus Analyzer (Stable Micro Systems, Godalming, UK) using P/72 probe. The instrument settings will be predetermined as follows: 1mm/s, distance: 30 mm, Targn mode- strain: 75% and time: 5 sec.

The results will be interpreted as follows:

Hardness (N/cm^2 or g/mm^2) =	The maximum force which is required to compress a given sample.
Cohesiveness (ratio) =	It is the extent to which a sample could be deformed prior to rupture i.e., A2/A1, whereA1is the total energy required for 1st compression and A2is the total energy required for 2nd compression.
Springiness (cm/mm) =	It is the ability of the sample to recover its original shape after a deforming force is removed from sample.
Chewiness (N/cm or g/mm) =	It is the work required to masticate the sample for swallowing (springiness ×gumminess).

2.12 Storage stability

TBARS

TBARS test measures malondialdehyde (MDA) present in the sample, as well as malondialdehyde generated from lipid hydroperoxides by the hydrolytic conditions of the reaction.

Heating accelerates lipid oxidation and production of volatiles in meat **(Han *et al.*, 1995; Byrne *et al.*, 2002; Beltran *et al.*, 2003)** by disrupting muscle cell structure, inactivating antioxidant enzymes and other antioxidant compounds, and releasing iron from heme pigments **(Kanner 1994; Mei *et al.*, 1994)**. This is why TBARS value increases rapidly in cooked meat.

DPPH value

2,2-Diphenyl-1-picrylhydrazyl (DPPH) is a stable free radical and has been commonly used to screen phenolic compounds containing high free radical scavenging ability **(Wettasinghe *et al*., 2000).** When a hydrogen atom or electron was transferred to the odd electron in DPPH, the absorbance at 515–517 nm decreased proportionally to the increases of non-radical forms of DPPH**.** High free radical scavenging ability is regarded as high antioxidant activity.

Peroxide Value

The peroxide value is known as a classical method for measuring 1° oxidation products **(Olsen *et al.,* 2005).** This value helps in judging the degree oxidative spoilage of fats. It is one of the most frequently used test for determining oxidative rancidity. It measures the concentration of peroxides and hyperperoxide formation in initial stages of lipid oxidation. The major process in oxidation of lipids in meat is the polyunsaturated fatty acid peroxidation from cell membranes. The major catalysts being transitional metal ions like Fe^{2+} and Cu^{2+}, hence heme-iron compounds present in meat can contribute to this process. This heme-iron helps in accelerating lipid peroxidation **(Decker *et al.,* 1990; Pikul, 1992).**

Free Fatty Acid Value (FFA)

Bhoyar *et al.* (1998) observed that the free fatty acid content significantly increases with storage time in case of vacuum packaging and LDPE packaging but the rate was slower in Vacuum Packaging. **Sallan *et al*. (2004)** reported that no significant change occurs in triglycerides of chilled broiler during storage at 0 and 6ºC. The phospholipid content decreased whereas the free fatty acid content increased during storage increased. These changes were more significant at 6ºC.

Summo *et al.* (2006) observed that in vacuum packed ripened sausages, there was significantly ($p<0.01$) higher FFA value than unpacked sample. This indicates that vacuum packed sample has a higher degradation of lipid as compared to stored unpacked sample.

Microbiological Analysis

Lawrie (1998) stated that increasing spoilage organism results in greater protein degradation in meat samples. This protein degradation results in increase in pH, which is attributed to accumulation of more metabolites **(Bell *et al.,* 1978).**

Jay (1987) and Ziauddin *et al.* (1996) reported that threshold level of microbial spoilage is log 7.5- 8.0/g. Spoilage of meat occurs as a result of organic matter decomposition mainly protein along with carbohydrate and fat due to bacterial, yeast and mould action. Cooked meat when refrigerated, is susceptible to lipid oxidation and phospholipid oxidation which in turn results in development of warmed-over flavor **(Cross *et al.*, 1987).**

Liestner *et al.* (1981) stated that the logarithmic increase in aerobic plate count and gradual increase in case of *S. aureus* count in untreated keema during the period of storage occurs mainly as a result of pH and conductive $a_{w.}$ **Cerveny *et al.* (2009)** observed that the type of storage of meat and meat products determines the type of microorganisms present in them.

Sensory Analysis

Stone *et al.* (2004) stated that sensory evaluation of any product is the scientific method of evoking, measuring, analyzing and interpreting responses to product as perceived by the senses of sight, smell, touch, taste and hearing. **Barbanti *et al.* (2005)** stated that the tenderness of meat is one of the most important factors in analyzing the acceptance of any product by consumers. It is considered as one of the most important eating quality characteristic. It is one of the most important factors that determine the quality of poultry meat and consumer acceptance **(Lee *et al.*, 2009).**

Materials and Methods

3.1 Location of experiment

The experiment was conducted in the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture & Technology, Pantnagar.

3.2 Source of raw materials

3.2.1 Chicken meat

Fresh chicken was purchased from Instructional Poultry Farm of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

3.2.1.1 Slaughtering and Dressing of birds

The birds were first weighed to determine the live weight. They were slaughtered according to standard procedures of slaughter at Department of Livestock Products Technology.

3.2.2 Spice and condiment mix

Spice mix (Chilli powder, black pepper powder, coriander and turmeric) & condiments (garlic and ginger) were purchased from local market.

3.2.3 Chemicals and media

All the chemicals and media used in the study are of analytical grade and were obtained from Hi media® Mumbai.

3.2.4 Test ingredients

Oilseeds (sesame, linseed, sunflower) and sorghum flour were purchased from local market.

3.3.1 Flowchart for preparation of chicken nuggets

Deboned chicken meat

↓

Cutting into small pieces

↓

Minced using 8mm plate followed by 4mm plate

↓

Addition of salts, spices, condiments and other additives and mixed properly

↓

Addition of test ingredients(Gizzard blend containing sorghum flour and oilseeds)

↓

Nuggets were placed in moulds and allowed to cook in steam

↓

Nuggets were taken out from mould and allowed to cool

↓

Packed in air tight polythene bags

3.3.2 Selection of ingredients levels for the nuggets

INGREDIENTS	CONTROL	T1	T2
Bonelesss meat	100 grams	92 grams	66grams
Gram dal	3%	3%	3%
Nacl	1.5%	1.5%	1.5%
Polyphosphate	0.3%	0.3%	0.3%
Ginger	1%	1%	1%
Garlic	1%	1%	1%
Onion	3%	3%	3%
Spice mix	3%	3%	3%
Refined oil	1%	1%	1%
Black pepper	0.3%	0.3%	0.3%
Chicken Gizzard	-	8%	-
Chicken gizzard blend 1- Gizzard 2- Sorghum flour 3- Oilseed			 8% 14% 12%

Control (Chicken nuggets)

T_1 (Chicken nuggets + Gizzard 8%)

T_2 (Chicken nuggets + Gizzard 8% + Linseed 12% + Sorghum flour 14%)

3.3.3 Packaging

The cooked product was packaged aerobically in LDPE bags. They were sealed with the help of packaging machine and stored at a temperature of 4±1ºC.

3.4 MATERIAL AND METHOD

The product containing gizzard blend with optimum level of sorghum flour and oilseeds were subjected to physico-chemical analysis, proximate analysis, sensory evaluation and storage stability tests at refrigeration temperature.

3.4.1 Physico-chemical Characteristics

Cooking yield

Yield of chicken nuggets was calculated on percent basis **(Kalilou *et al.*, 1998)** based on weight of raw nuggets as follows.

Cooking yield% = Weight of cooked nuggets/Weight of raw nuggets x 100

Water holding capacity

It was estimated by centrifugation method as described by **Wardlaw *et al.* (1973).** 10 g of ground meat from each sample was taken individually in polycarbonate centrifuge tube. 15 ml 0.6M sodium chloride was added in it. It was then stirred with the help of a glass rod for 2 min and then held for 15 min at 4ºC. It was then re stirred for 1 mi and centrifuged at 3000 rpm for 25 min. The supernatant volume will be measured.

The formula for calculating WHC is as follows-

$$\text{WHC\%} = \frac{\text{Volume of NaCl (ml)} - \text{Volume of supernatant (ml)}}{\text{Weight of sample}} \times 100$$

Texture profile analysis (TPA)

Texture profile parameters was evaluated as per **Bourne (1978).** 3 samples from the cooked product of the 3 breeds of poultry was taken with measurements of 1×1×1 inch^3. Samples will be analyzed on TA-HD Plus Analyzer (Stable Micro Systems, Godalming, UK) using P/72 probe. The instrument settings will be predetermined as follows: 1mm/s, distance: 30 mm, Targn mode- strain: 75% and time: 5 sec.

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Chewiness (N/cm or g/mm) =	It is the work required to masticate the sample for swallowing (springiness ×gumminess).

pH

For pH determination, each sample will be first blended with distilled water, 5 times the weight of sample to produce a uniform suspension. The pH will be then recorded using pH SINTIX 3030i meter by immersion of the pH meter electrode into aliquot of the samples, until we get a stable value.

3.4.2Proximate Analysis

Moisture

Moisture will be determined by **AOAC (1995)** method. 5g of the sample was transferred to a weighed metallic dish. It was then placed in a hot air oven at 100±2ºC. The sample was dried till a constant weight is obtained. The dish was then kept in dessicator for cooling. The loss in weight was determined to calculate moisture content (%).

$$\text{Moisture (\%)} = \frac{\text{Fresh weight(g)} - \text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

Protein

The protein content of the sample was determined by micro-Kjeldhal method as described in **AOAC (1995)**. 2g of the sample was taken in a digestion flask followed by addition of 7.5g digestion mixture (K2SO4 ; CuSO4 in 9:1 ratio) and 10 ml of concentrated sulphuric acid followed by addition of 10ml of H2O2. The contents were digested till a blue/green transparent solution is obtained. The volume of digested mixture was made up to 100ml with distilled water. A 20ml aliquot of digested mixture was distilled with excess of 40% NaOH solution containing 2 to 3 drops of mixed indicator (10ml of 0.1% bromocresol green + 7ml of 0.1% methyl red indicator in 95% alcohol in 1 liter boric acid). The ammonia which is entrapped was titrated against 0.1N HCl. A reagent blank will be similarly digested and distilled. Nitrogen content in the samples was calculated by the following formula:

Nitrogen% =

$$\frac{\text{Sample titre} - \text{Blank titre} \times \text{Normality of HCl} \times 14 \times \text{Volume made up}}{\text{Aliquot of digest taken} \times \text{Weight of sample taken}}$$

Nitrogen% will be converted to Protein % by multiplying the result with 6.25.

Fat (Ether Extract)

Soxhlet method **(AOAC, 1995)** was used for determination of fat. 1g of dried sample was transferred to a thimble. Petroleum ether (Boiling point 40-60ºCwas used as solvent. It was subsequently evaporated and the extracted fat was weighed after complete drying in an oven at 60ºC. The fat% in dried sample was calculated as follows, which was converted into wet basis by multiplying with a moisture factor.

$$\text{Fat (\%)} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

Total Ash

Total Ash was determined by taking 5g of the sample. It was weighed in a pre weighed silica dish. Then the sample was ignited on a burner till the fumes ceases and then the sample was transferred to a muffle furnace at 500±15ºC for 4 hrs. The sample was then transferred to dessicator for cooling. After cooling, the silica dish was reweighed and total ash% was calculated **(AOAC 1995)** according to the following formula:

$$\text{Ash (\%)} = \frac{\text{Weight of ash(g)}}{\text{Weight of sample (g)}} \times 100$$

Crude fiber

Moisture free and ether extracted samples were transferred from thimbles to spout less beaker of 1 litre capacity and in each beaker, 200 ml and 1.25% sulphuric acid was added. It was refluxed for 30 minutes on hot plate of crude fiber assembly having arrangement for condenser after boiling started and thereafter filtered through muslin cloth. For removing the acid from the residue, it was washed several times with hot water. The residual material on muslin cloth was again transferred to the respective spout less beakers and in each beaker 200 ml sodium hydroxide of 1.25% concentration was added. It was again refluxed for 30 minutes after the boiling started and thereafter filtered through muslin cloth and cleansed with hot water for 5-6 times until it became free from alkali. Thereafter total residue was transferred in a clean, dry silica crucible and was dried at 100 degree centigrade for 24 hours in hot air oven. It was then cooled and kept in dessicators and weighed. The residue was then burnt in Muffle furnace at 600 degree centigrade for 2 hours. After 12 hours, silica crucibles carrying ash were transferred into desiccators, cooled and weighed again. Weight loss during ignition was recorded as the weight of crude fiber.

Crude fiber (%) (dry matter basis) = b-c/a x100

a= wt. of sample on DM basis (g)

b= wt. of silica crucibles plus residue before ignition (g)

c= wt. of silica crucible plus residue after ignition (g)

3.4.3 Storage Stability

Thiobarbiturate acid reactive substances (TBARS) value

TBARS value was estimated by a procedure as stated by **Tarladgis *et al.* (1960).** 10g of the sample was taken and added to 49ml of distilled water in which 1ml of sulphanilamide reagent (1g of sulphanilamide dissolved in solution containing 40ml of concentrated HCl and 160 ml of distilled water was added. It was blended with the help of pestle and mortar. 48ml of distilled water was used for washing the mortar and 2ml of HCl solution (1:2 with distilled water will be added. The contents were then transferred to Kjeldhal flask after adding 5-6 glass beads. The contents were then heated on high heat and distillate was collected in glass beaker. 5ml of the portion was then be taken out into a test tube in which 5ml of TBA reagent (1.442g of TBA in distilled water) will be added. The tubes were then kept in hot water bath for 35 minutes. The contents were then cooled under tap water for 10 minutes. The O.D. (Optical density) was recorded at 538 nm against blank TBARS water. The TBARS value was calculated as malonaldehyde per 1000g of sample using the following formula.

TBARS value (mg of malonaldehyde/1000g of sample) = O.D. of sample × 7.8

DPPH radical scavenging activity

DPPH (2,2-diphenylpicrylhydrazyl) principle states that when the purple colored DPPH, which is a stable free radical, reacts with free radical of the sample, it is reduced to diphenylpicryl hydrazine which is yellow in colour **(Kirby *et al.*, 1997).**

DPPH assay was performed as per the method stated by **Tepe *et al.* (2005)** with slight modifications. 0.1g of the samples were taken in clean test tube and 5ml of 0.004% DPPH in methanol was added to test tube. The samples were homogenized for 30 seconds with constant stirring. Absorbance level were measured with the help of spectrophotometer at 517nm, taking methanol as blank. Measurements will be depicted as absorbance.

Peroxide value

Peroxide value of the given sample was determined as stated by **Koniecko (1979).** 25g of the sample was accurately measured and transferred to a mortar and pestle. 137ml of chloroform was added to it along with 5 g of sodium sulphate. It was properly homogenized. The filtrate was then collected in Erlenmeyer flask using Whatmann’s filter paper no. 12. 87 ml of the filtrate was collected in the Erlenmeyer flasks and divided into 3 samples having 27 ml each. One of the parts will be transferred to hot air oven at 80ºC to evaporate the chloroform and to determine the fat content in 27 ml of the sample. In the second part, 30 ml glacial acetic acid was added along with 2ml freshly prepared potassium iodide. The contents were swirled and kept undisturbed for 2 minutes. After that, 100ml distilled water was added to stop the reaction. Then 2 ml of starch solution was added to the flask and shaken. A blue color solution was obtained which was titrated against 0.01N sodium thiosulfate pentahydrate until blue colour of the solution disappears. The titration value of the blank was also be noted. Peroxide value of the sample was obtained as:

Peroxide value (mill equivalent peroxide/ kg sample) = $S \times N \times 1000/g$

Where,

S = ml sodium thiosulphate (blank corrected)

N = normality of sodium thiosulphate solution

g = weight of the sample

Free fatty acid value

This value was determined as per the method of **AOAC (1995)** with slight modifications. 15g of the sample was taken and grinded with mortar and pestle. It was dissolved in 150ml of petroleum and mixed thoroughly. The samples were filtered with the help of Whatmann filter paper no. 42. 90ml of the filtrate will be collected. The samples was then divided into 20-20 ml separately into different beakers which was pre cleaned and weighted. One of the two beakers were kept in hot air oven at 100±1ºC for drying. In the other sample, 10ml ethyl alcohol was added and mixed properly in which 2 drops of 1% phenolphthalein indicator was added. The filtrate was titrated against 0.1N NaOH and light pink colour was observed which was the end point. The free fatty acid content of the sample was calculated as follows:

$$\%\text{FFA as oleic acid} = \frac{\text{N}\times\text{mlofNaOHusedintitration}\times 0.282}{\text{Fatweight}}\times 100$$

Tyrosine Value

20 grams of meat sample was taken and blended in 50 ml of cold 20% Trichloroacetic acid foe 2 minutes. The blend sample is mixed and rinsed with 50 ml of clean and distilled water, filtrate of the solution with Whattmann filter paper no 1 and then volume of filtrate is collected in 100ml measuring cylinder. The collected filtrate is termed as trichloroacetic acid extract and now this is used in estimation of TBA no and Tyrosine value.

2.5ml of TCA extract is diluted with an equal amount of distilled water in a clean dry test tube, add 10 ml of 0.5 N NaOH and 3ml of diluted Folin ciocalteau phenol reagent after proper mixing of all keep the test tube undisturbed for 15 minutes. The absorbance value of developed blue color is measured at 660nm in a spectrophotometer, for comparison use a blank test tube of 5ml of 5% TCA.

3.4.4 Microbiological analysis

Preparation of samples

Samples were prepared as specified by **APHA (1992)** with slight modifications. Five grams of sample were accurately weighed and triturated in a clean and sterile pestle and mortar to which 45ml of sterile normal saline solution was aseptically added. Four clean and sterile test tubes were taken in duplicate and marked as test tube no 2 to 4. Nine ml of sterile normal saline solution were added to each test tube aseptically. Then, 1ml of diluted sample from pestle and mortar were transferred to test tube no.2 and pipette tip was discarded. With fresh sterile tip the test tube contents was mixed properly, to get the dilution 10^2. One ml of properly mixed suspension from test tube no 2 was aseptically transferred to test tube no. 3 and pipette is discarded. The above procedure was repeated to get serial dilutions of 10^{-3} and10^{-4}. Lastly, one ml of suspension from test tube no. 4 was discarded and disposed off properly.

Total plate count

Total plate count were determined as per **APHA (1992)** method using plate agar count. 1 ml of appropriate dilution of the sample was transferred aseptically into sterile petri plates in duplicates. The plates were then poured with 10-15ml sterilized plate count agar medium at 45ºC.

After solidification, the petri plates were incubated at 37ºC for 24-48 hours. The colonies were then counted with the help of colony counter. The average no. of colonies were multiplied with dilution factor to obtain total count as colony forming unit (CFU) per g of the sample. This count was then converted to total plate count of log CFU/g of sample.

Yeast and mould count

Sterilized potato dextrose agar was used for determining yeast and mould count. The pH of this agar was adjusted to 3.5±0.1 using 1% tartaric acid (presterilzed) as stated in **APHA (1992)**. Appropriate dilutions were taken in petri plates over which agar medium was transferred. After solidification, the petri plates were incubated at 22ºC for 2-3 days. The average number of colonies for the given dilutions were determined. The number of yeast and mould per gram of the sample were calculated as log CFU/g of the sample.

Coliform count

The coliform count was determined as per **APHA (1992).** 1ml of appropriate dilution of the sample will be aseptically transferred to sterile petri plates in duplicates. The cultured petri plates was then prepared by pouring 10-15 ml of sterilized violet red bile agar on sample. After rotating the plates clockwise and anti-clockwise to ensure proper mixing, the plates will be allowed to set. The plates were then incubated at 37ºC for 18-24 hours. The average no. of colonies were then multiplied with dilution factor to obtain total count as colony forming unit (CFU) per g of the sample. This count was then converted to Coliform count of log CFU/g of sample.

3.5 Sensory evaluation

The sensory quality of the roasted chicken samples was determined by using 8 point descriptive scale as described by **Keeton *et al*. (1984).** Point 8 denotes extremely desirable and 1 denotes extremely poor. A semi trained sensory panel of judges were drawn from Post Graduate students and staff of Veterinary College, Pantnagar. The judges were requested to examine and evaluate the product for different sensory attributes such as colour, texture, appearance, flavor, juiciness and overall acceptability.

3.6 Statistical Analysis

Statistical analysis of the results obtained in the form of data was done using ANOVA technique using completely randomized design (CRD) as per the method stated by **Snedecor and Cochran (1994).**

Results and Discussion

The present study was carried out to prepare functional chicken nuggets incorporated with chicken gizzard blend containing sorghum flour and oilseed (linseed) and to study the effects of its incorporation on quality characteristics and storage stabilities at 4±10°C up to 15 days of storage.

Preliminary trials were conducted to select the oilseed to be used in the experiment on the basis of sensory evaluation. Three oilseeds i.e. sunflower, linseed and sesame seeds were analyzed by sensory trial to select one. Preliminary trials were also conducted to optimize the level of sorghum flour, chicken gizzard and oilseed (linseed) to form a proper gizzard blend. The optimized chicken gizzard blend was incorporated in the final product and was compared with control and nuggets incorporated with gizzard. The following physicochemical properties cooking yield, water holding capacity, moisture content, protein content, fat content, texture profile analysis along with sensory evaluation were assessed. The following storage stability parameters pH, TBARS value, free fatty acid value, peroxide value, DPPH, Tyrosine value, Total plate count, coliform count and yeast and mould count were assessed during storage at 4±10 °C on 0, 5, 10 and 15 day.

The following abbreviations were used in this experiment-

C – Control containing chicken nuggets with no chicken gizzard blend

T1- Treatment containing chicken gizzard at the rate of 8%

T3- Treatment containing chicken gizzard (8%) blend incorporated with sorghum 14% and oilseed (linseed) 12%

4.1 Standardization of level of incorporation of gizzard, sorghum flour and selected oilseed.

4.1.1 Optimization of level of gizzard

8%, 14% and 20% level of gizzard were selected for final optimization in the product. Mean ± SE values of sensory scores presented in Table 4.1, Fig 4.1 and ANOVA in table 4.2.

Table 4.1: Effect of different level of gizzard on sensory score of chicken nuggets

Parameter	Appearance	Texture	Juiciness	Flavor	Overall acceptability
C	7.28±0.15a	7.28±0.17a	7.88±0.05a	7.88±0.07a	7.84±0.17a
TG8	7.25±0.12a	7.05±0.18b505	7.85±0.02a	7.85±0.18a	7.85±0.18a
TG14	6.12±0.02b	6.00±0.05c	6.22±0.04b	6.00±0.15b	6.51±0.05b
TG20	5.14±0.02c	5.64±0.09d	5.14±0.02c	5.04±0.19c	5.24±0.09c

n= 21, n=4; Mean ± SE, bearing small alphabet superscripts row wise differ significantly (P<0.05)
C: chicken nuggets, TG8: Chicken nuggets +Gizzard 8%
TG14: Chicken nuggets +Gizzard 14% TG20: Chicken nuggets+ Gizzard 20%

ANOVA revealed a significant difference (P<0.05) in appearance, flavor, texture, juiciness and overall acceptability of control and treatments. From the above data it can be concluded that TC8 had a better score in appearance, texture, juiciness, flavor and overall acceptability than TD14 and TG20. There was no significant (P>0.05) difference between TC8 and Control. It can be said from the above data that the sensory scores decreased with increasing the amount of gizzard in chicken nuggets.

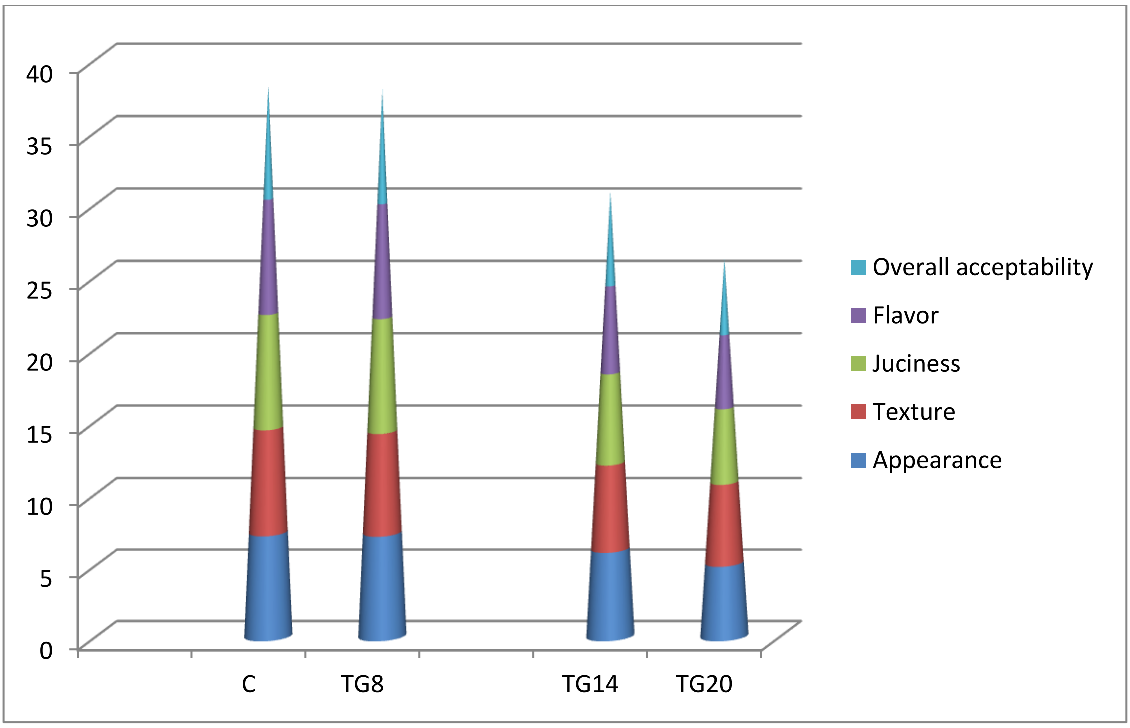

Fig. 4.1: Stacked cone chart on effect of different levels of Gizzard on sensory attributes of chicken nuggets.

Table 4.2: ANOVA of sensory scores of Gizzard on sensory attributes of chicken nuggets

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Appearance	3.0	0.14	80	0.048	3.11
Texture	3.0	0.84	80	0.044	19.28
Flavour	3.0	0.98	80	0.085	11.50
Juiciness	3.0	0.41	80	0.029	14.28
Overall acceptability	3.0	0.76	80	0.035	21.47

4.1.2 Optimization of sorghum flour

8%, 14% and 20% level of sorghum flour were selected for final optimization in the product. Mean ± SE values of sensory scores presented in Table 4.3, Fig 4.2 and ANOVA in table 4.4.

Table 4.3: Effect of different level of sorghum flour on sensory score of chicken nuggets

Parameter	Appearance	Texture	Juiciness	Flavor	Overall acceptability
Control	7.28±0.15b	7.78±0.17a	7.83±0.05a	7.28±0.07b	7.14±0.17b
TSF8	7.85±0.12a	7.05±0.18b	7.81±0.02a	7.85±0.28a	7.95±0.18a
TSF14	6.42±0.08b	6.20±0.06c	6.02±0.04b	6.70±0.15b	6.70±0.05b
TSF20	5.24±0.05c	5.34±0.09d	5.24±0.02c	5.54±0.19c	5.04±0.09c

n= 21, n=4; Mean ± SE, bearing small alphabet superscripts row wise differ significantly (P<0.05)
Control- chicken nuggets TSF8- chicken nuggets +8% sorghum flour
TSF14- chicken nuggets +14% sorghum flour TSF20- chicken nuggets +20% sorghum flour

ANOVA revealed a significant difference (P<0.05) in appearance, flavor, texture, juiciness and overall acceptability of control and treatments. From the above data it can be concluded that TSF8 had a better score in appearance texture juiciness flavor and overall acceptability than T-SF14 andT-SF20. There was no significant (P>0.05) difference between TSF8 and Control.

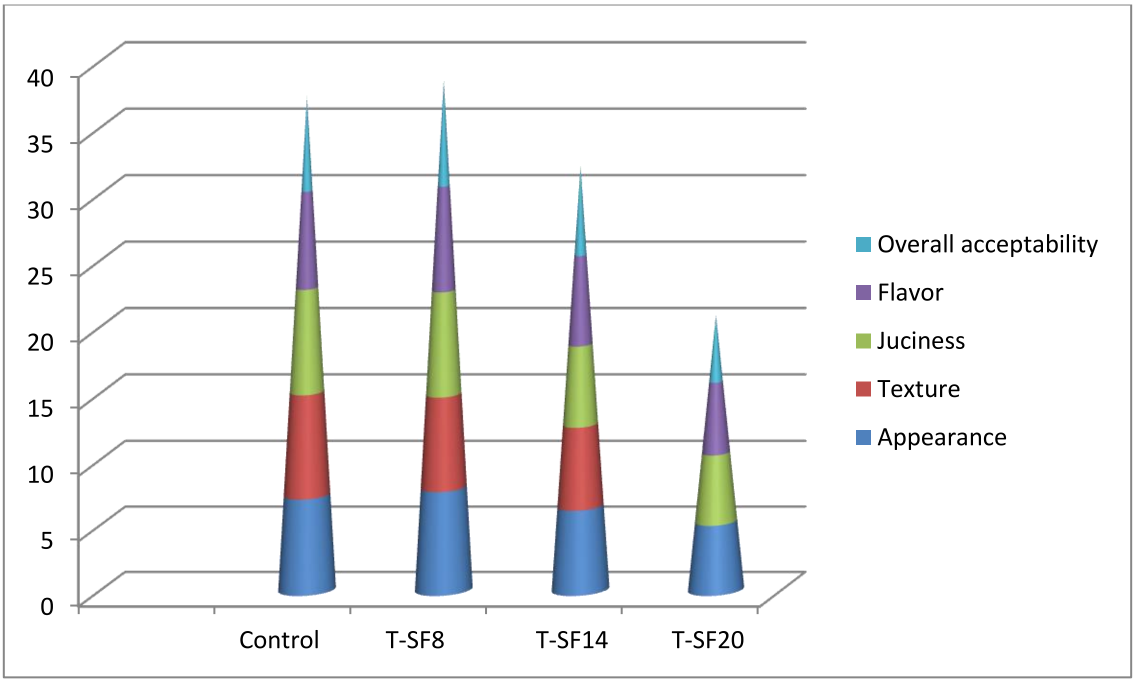

Fig. 4.2: Stacked cone chart on effect of different levels of sorghum flour on sensory attributes of chicken nuggets.

Table 4.4: ANOVA of sensory scores of sorghum flour on sensory attributes of chicken nuggets

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Appearance	3.0	2.14	80	0.88	28.11
Texture	3.0	0.44	80	0.064	6.28
Flavour	3.0	0.48	80	0.085	6.50
Juciness	3.0	0.31	80	0.039	4.28
Overall acceptability	3.0	0.56	80	0.025	17.47

4.1.3 Selection of oilseed

Three oilseed flaxseed, sesame and sunflower seeds were evaluated at 8% level for incorporation in the product. Mean ± SE values of sensory scores presented in Table 4.5, Fig 4.3 and ANOVA in table 4.6.

Table 4.5: Effect of different oilseed on sensory score of chicken nuggets

Parameter	Appearance	Texture	Juiciness	Flavor	Overall acceptability
Control	7.28±0.15b	7.78±0.17a	7.83±0.05a	7.28±0.07b	7.94±0.17a
TF	7.85±0.12a	7.05±0.18c	7.21±0.02a	7.85±0.28a	7.65±0.18b
TS	7.42±0.08c	7.20±0.06b	6.32±0.04b	6.70±0.15b	6.70±0.05c
TSf	6.24±0.05d	5.34±0.09d	5.24±0.02c	5.54±0.19c	5.04±0.09c

n= 21, n=4; Mean ± SE, bearing small alphabet superscripts row wise differ significantly (P<0.05)

Control- chicken nuggets

TF- Chicken nuggets +8% flaxseed

TS- Chicken nuggets +8% sesame seeds

TSf- Chicken nuggets +8% sunflower seeds

ANOVA revealed a significant difference (P<0.05) in appearance, flavor, texture, juiciness and overall acceptability of control and treatments. From the above data it can be concluded that TF had a better score in appearance, juiciness, flavor and overall acceptability than TS and TSf. From the above data it can be said that chicken nuggets incorporated with sunflower seeds scored least for all the sensory parameters which can be due to the roughness present in sunflower seeds.

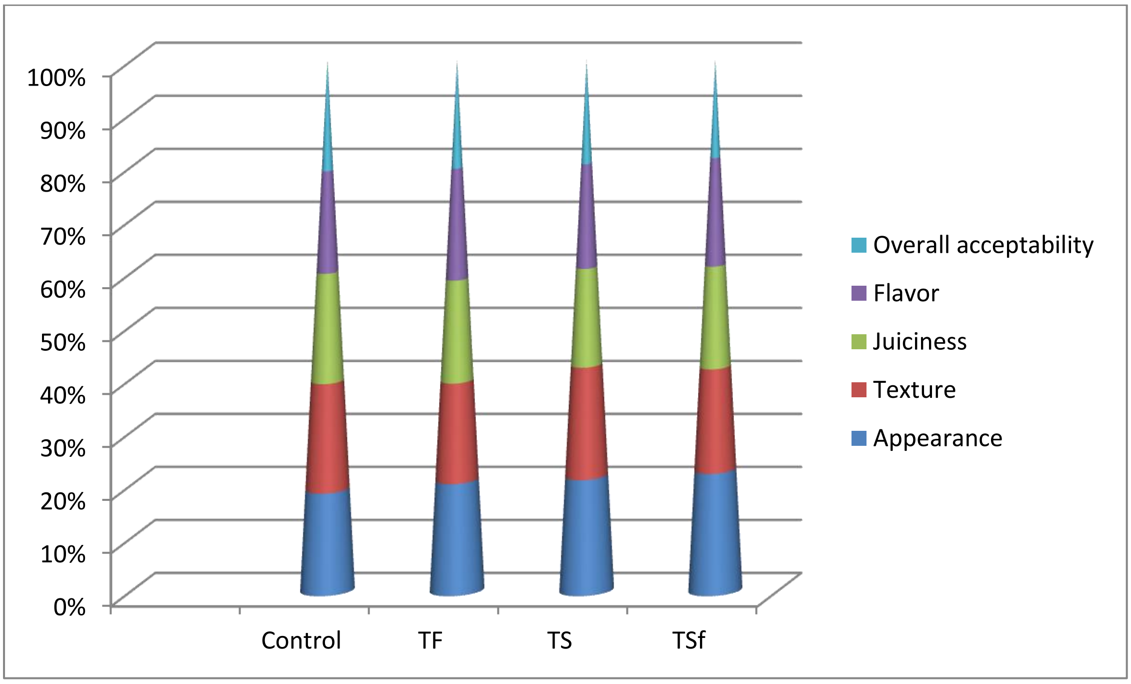

Fig. 4.3: Stacked cone chart on effect of different oilseeds on sensory attributes of chicken nuggets.

Table 4.6: ANOVA of sensory scores of oilseeds on sensory attributes of chicken nuggets

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Appearance	3.0	1.14	80	0.98	9.11
Texture	3.0	0.34	80	0.054	1.38
Flavour	3.0	0.38	80	0.035	5.50
Juciness	3.0	0.41	80	0.059	9.48
Overall acceptability	3.0	0.46	80	0.025	4.37

4.1.4 Optimization of level of selected oilseed

On the basis of various preliminary sensory trials 8%, 14% and 20% level of selected oilseed (flaxseed) were selected for final optimization in the product. Mean ± SE values of sensory scores presented in Table 4.7, Fig 4.4 and ANOVA in table 4.8.

Table 4.7: Effect of different level of flaxseed on sensory score of chicken nuggets

Parameter	Appearance	Texture	Juiciness	Flavor	Overall acceptability
Control	7.88±0.15a	7.78±0.17a	7.03±0.05a	7.88±0.07a	7.94±0.17a
TF6	7.85±0.12a	7.25±0.18b	7.21±0.02a	7.75±0.28b	7.65±0.18b
TF12	7.02±0.08b	6.20±0.06c	7.32±0.04b	7.78±0.15b	7.70±0.05b
TF20	6.24±0.05c	5.34±0.09d	7.74±0.02c	6.54±0.19c	5.04±0.09c

n= 21, n=4; Mean ± SE, bearing small alphabet superscripts row wise differ significantly (P<0.05)
Control- chicken nuggets
TF6- chicken nuggets +6% flaxseed
TF12- chicken nuggets +14% flaxseed
TF20- chicken nuggets +20% flaxseed

ANOVA revealed a significant difference (P<0.05) in appearance, flavor, texture, juiciness and overall acceptability of control and treatments. The sensory scores decreased with increase in the amount of flaxseed incorporated in chicken nuggets for appearance and texture. However the juiciness increased with increasing amount of incorporated flaxseed. From the above data it can be concluded that TF12 had a better score in juiciness, flavor and overall acceptability thanTF14andTF20.

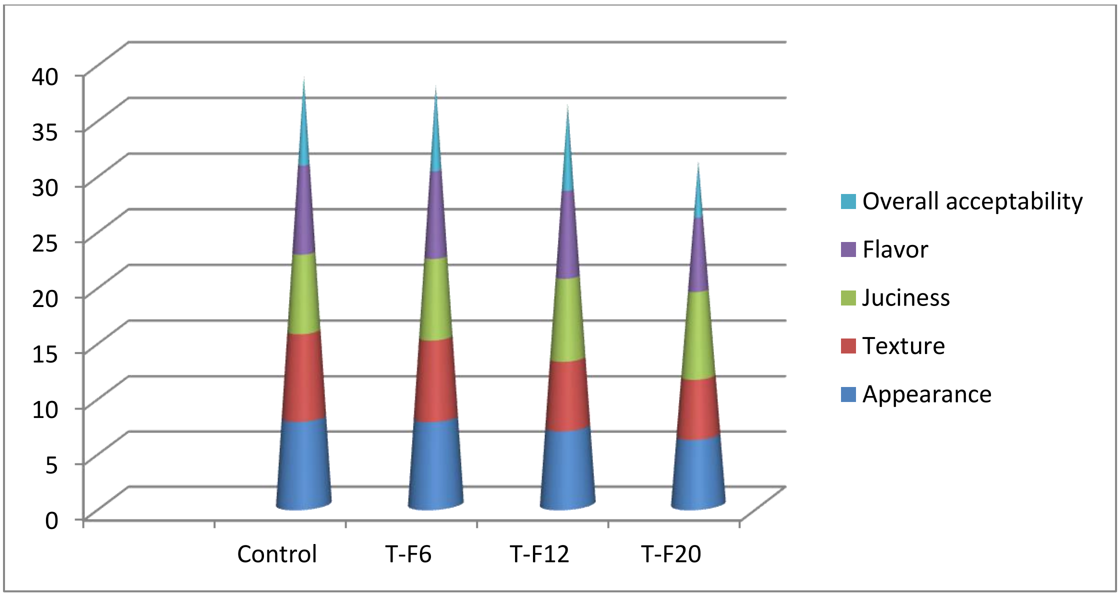

Fig. 4.4: Stacked cone chart on effect of different levels of flaxseed on sensory attributes of chicken nuggets.

Table 4.8: ANOVA of sensory scores of flaxseed on sensory attributes of chicken nuggets

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Appearance	3.0	2.12	80	1.98	8.11
Texture	3.0	0.24	80	0.074	1.37
Flavour	3.0	0.45	80	0.085	4.30
Juciness	3.0	0.42	80	0.079	9.48
Overall acceptability	3.0	0.62	80	0.015	3.37

4.2 Evaluation of proximate composition, cooking yield and water holding capacity of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed

4.2.1 Proximate analysis of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

The proximate analysis of the chicken nuggets incorporated with chicken gizzard blend containing sorghum flour and oilseed is presented in table 4.9 and fig 4.5 with analysis of variance in table 4.10.

Table 4.9: Mean ± SE for proximate analysis of chicken nuggets incorporated gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

PARAMETERS	C	T1	T2
Protein	18.22±0.145a	18.25±0.019a	17.45±0.011b
Fat	7.83±0.014b	7.80±0.019b	9.17±0.017a
Moisture	69.20±0.126a	68.96±0.124a	61.47±0.035b
Ash	2.38±0.019b	2.42±0.017b	3.51±0.019a
Crude fibre	0.29±0.002b	0.33±0.003b	1.76±0.037a

n=6, mean ± SE values bearing different superscript in each row by small alphabets (a, b, c) differ significantly ($P<0.05$)

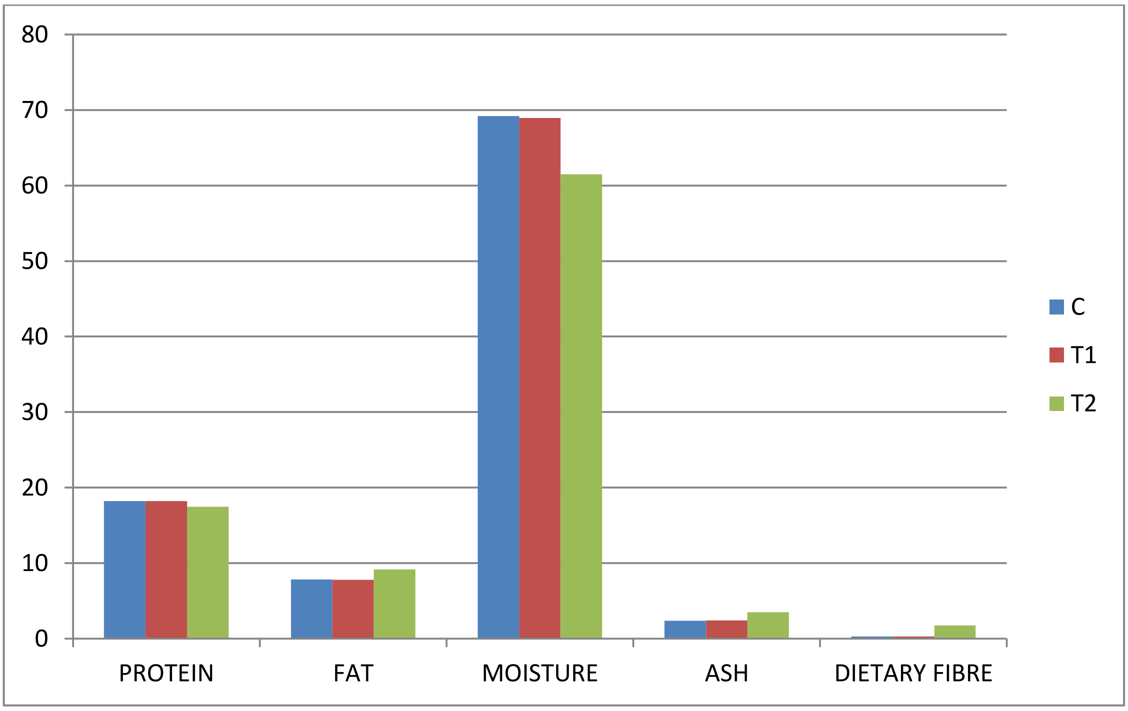

Fig. 4.5: Proximate analysis of chicken nuggets incorporated gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Table 4.10: Proximate analysis of chicken nuggets incorporated gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameters	Treatment		Error		F Value
	df	MS	df	MS	
Protein	2.0	0.9514974	15.0	0.4295790	22.14953**
Fat	2.0	3.777934	15.0	0.0016954	2228.330**
Moisture	2.0	105.6042	15.0	0.0637156	1657.43 **
Ash	2.0	2.443400	15.0	0.0021033	1161.682**
Crude Fiber	2.0	4.327874	15.0	0.0027298	1585.383**

The mean± SE of protein concentration for C, T1 and T2 were 18.22± 0.14, 18.23±0.019 and 17.45±0.011 respectively.

The mean± SE of fat content for C, T1 and T2 were 7.83±0.014, 9.17±0.017 and 7.80±0.019respectively.

The mean± SE of moisture concentration for C, T1 and T2 were 69.20±0.126, 68.96±0.124 and 61.47±0.035 respectively.

The mean± SE of ash concentration for C, T1 and T2 were respectively 2.38±0.019, 2.42±0.017 and 3.51±0.019respectively.

The mean± SE of crude fiber concentration for C, T1 and T2 were 0.29±0.002, 0.30±0.003 and 1.76±0.037 respectively.

The protein content of T2 was significantly lower than C and T1. There was no significant difference between C and T1 but numerically T1 had slightly higher protein content. **Bilek and Turhan (2009)** reported that the protein contents in raw beef patties with added flaxseed flour decreased from 19.65 % to 17.27 %. **Sharma *et al.* (2014)** reported that the percentage protein in flax seed flour added restructured mutton chops was similar to control and decreased slightly due to replacement of lean meat with a fat rich ingredient.

The fat content of T2 increased significantly ($P<0.05$) than control and T1 which might be due to higher fat content of flax seed (37 per cent). These results are in accordance with **Bilek and Turhan (2009)** in beef patties added with various levels of flax seed flour.

The moisture content of T2 was significantly lower than C and T1.This might be due to increment in dry matter in the nugget formulation. Similar results were obtained by **Turhan *et al.* (2005)** for beef burgers formulated with hazelnut pellicle. Due to the hydrophilic nature of sorghum flour more water is retained in the nuggets.

Total ash content of T2 was significantly higher (P<0.05) than C and T1. However there was a non significant (P>0.05) difference between C and T1. Numerically T2 had slightly higher ash content than C. Similar results were obtained in a experiment conducted by **(Turhan *et al.*, 2007)** in low fat beef burgers. **Sharma *et al.* (2014)** noted that addition of various levels of flax seed flour increased ash content of restructured mutton chops. The addition of sorghum flour also increases the dry matter content and thereby increasing the ash content.

The crude fiber content increased significantly (P<0.05) in T2 as compared to C and T1. This increment might be due to replacement of lean meat by flax seed flour which is excellent dietary fiber source (28 %) **(Prasad, 2000)**.Although meat is a poor source of fibre however, small amount of fiber content noticed in control was due to addition of spices and condiments during processing of nuggets. These results are congruent with **Yadav *et al.* (2017)** in chicken nuggets incorporated with wheat bran and dried apple pomace. It has been reported that SF is a rich source of complexcarbohydrates and dietary fiber **(Rooney and Awika 2005).** Flaxseed is also a good source of fiber.

4.2.2Cooking yield

Mean ± SE values of cooking yield for C, T1 and T2 are presented in Table 4.11 , Fig 6 and ANOVA in table 4.12.

Table 4.11: Comparison of cooking yield of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameter	C	T1	T2
Cooking Yield	81.31±0.3a	81.38±0.4a	90.41±0.2b

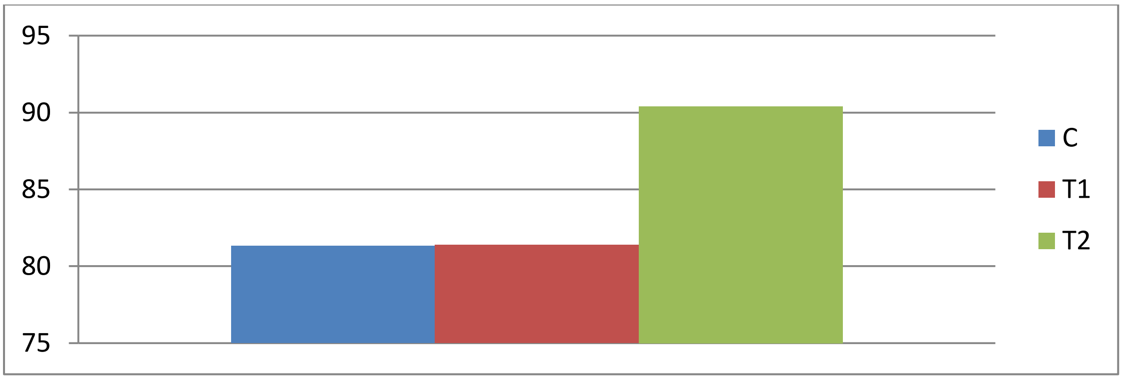

Fig. 4.6: Chart showing comparison of cooking yield of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Table 4.12: ANOVA of cooking yield for chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameters	**Between group**		**Within group**		**F Value**
	df	**MS**	**df**	**MS**	
Cooking yield (percent)	2.0	0.3602	15.0	2.80	0.152

Analysis of variance revealed a significant difference (P<0.05) between treatments. Mean ± SE values for cooking yield of C, T1 and T2 were81.31±0.3, 81.38±0.4 and 90.41±0.2brespectively. It can be concluded from the above mentioned data the T2 had significantly higher (P<0.05) cooking yield than C and T1. There was no significant (P>0.05) difference between cooking yield value of C and T1**.** In a study conducted by **(Reddy *et al.*, 2018)** it was found that the cooking yield of chicken nuggets increased with increasing the amount of flaxseed powder. This can be due to hydrophilic nature of flaxseed starch and the gelatinizing property on heating, which prevents evaporative moisture loss during cooking. Also due to the hydrophilic nature of sorghum flour more water was attracted in the product and thereby giving a better cooking yield.

4.2.3 Water holding capacity

Mean ± SE values of cooking yield for C, T1 and T2 are presented in Table 4.13, Fig 4.7 and ANOVA in table 4.14.

Table 4.13: Comparison of cooking yield of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameter	C	T1	T2
WHC%	41.16±0.21b	41.29±0.31b	49.17±0.33a

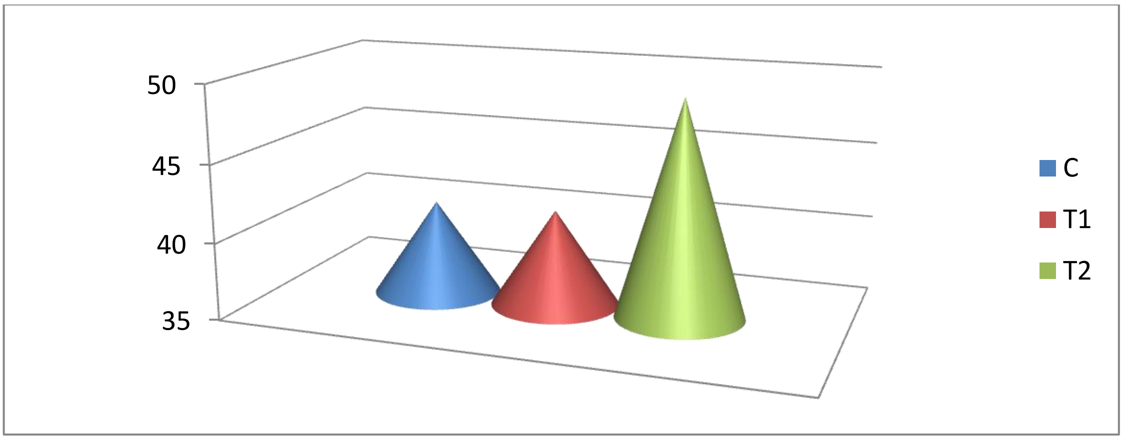

Fig. 4.7: Comparison of WHC of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Table 4.14: ANOVA of WHC for chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Cooking yield (percent)	2.0	0.8102	15.0	3.80	0.252

Analysis of variance revealed a significant difference (P<0.05) between treatments. Mean ± SE values of WHC of C, T1 and T2 were 41.16 ± 0.21, 41.29 ± 0.31 and 49.17 ± 0.33 respectively. It can be concluded from the above mentioned data the T2 had significantly (P<0.05) higher WHC than C and T1. There was non significant (P>0.05) difference between WHC of C and T1.This might be due to formation of thermo reversible gels by flax seed gum. As a result a much more stable meat protein matrix is formed which leads to a smaller release of water and fat, thus improving binding properties of final products **(Reddy *et al,* 2018)**. Poor WHC lead to high drip and purge loss, which can lead to significant loss of weight from carcasses and cuts and may affect the yield and quality of processed meats (**Aaslyng, 2002**).

4.3 Evaluation of texture profile analysis chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed

Mean ± SE values of hardness, springiness, cohesiveness and chewiness for C, T1 and T2 are presented in Table 4.15, Fig 4.8 and Fig 4.9 and ANOVA in table 4.16.

Table 4.15: Comparison of TPA of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameter	**C**	**T1**	**T2**
Hardness	3428.32±56.141b	3499.21±68.524b	5794.48±79.237a
Springiness	0.64±0.012a	0.62±0.021a	0.45±0.015b
Cohesiveness	0.44±0.009a	0.45±0.009a	0.33±0.006b
Chewiness	454.68±14.361a	452.89±10.852a	350.46±12.546b

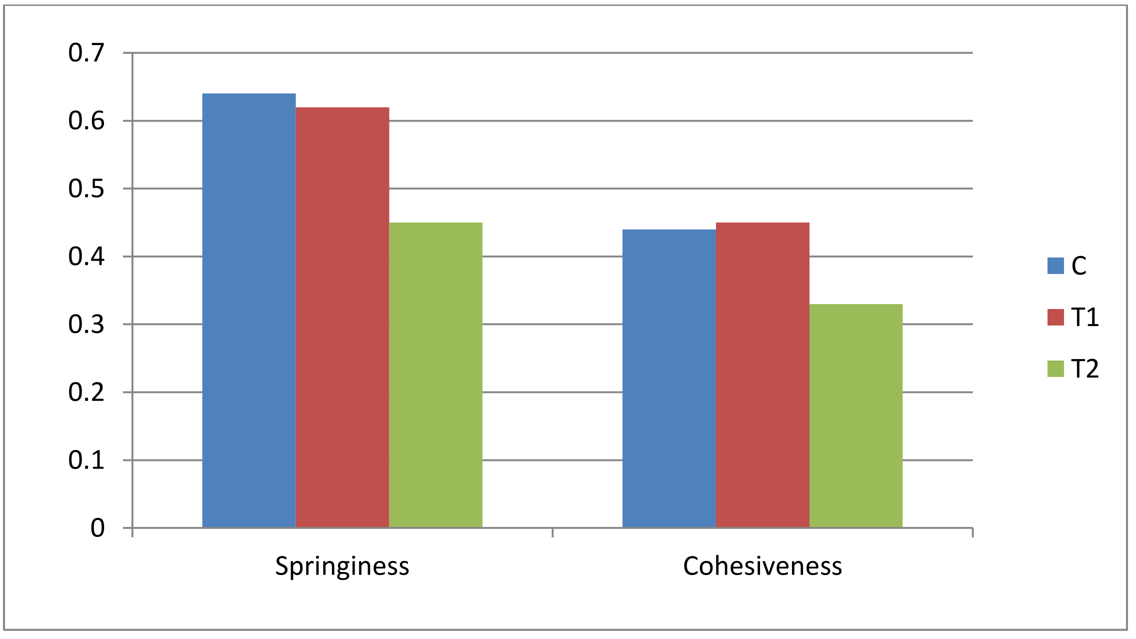

Fig. 4.8: Comparison of springiness and cohesiveness of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

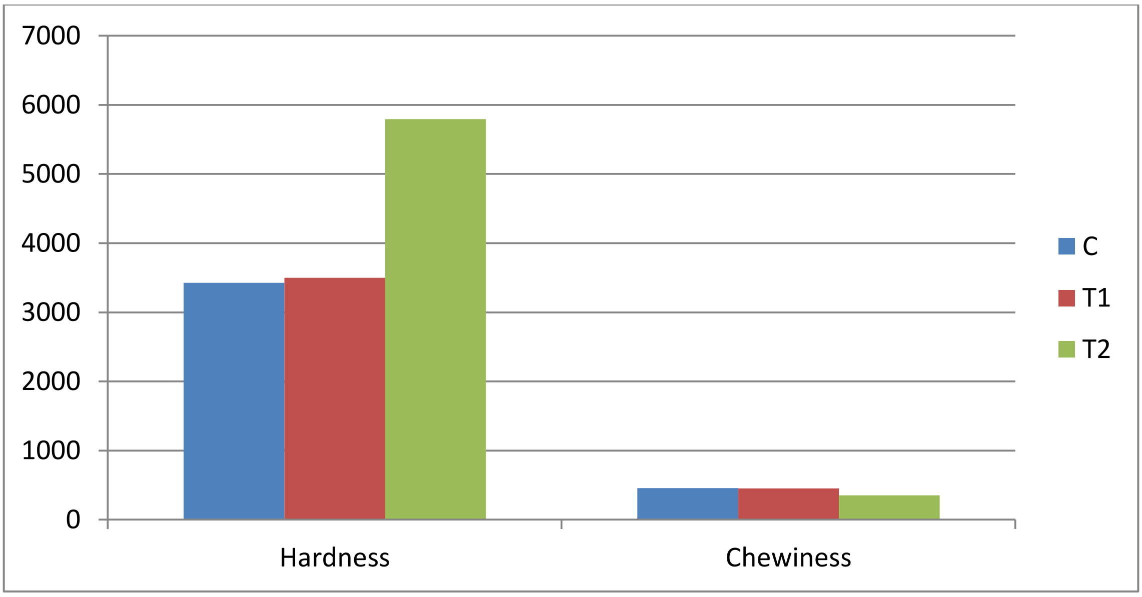

Fig. 4.9: Comparison of hardness and chewiness of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Table 4.16: ANOVA of TPA of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed (flaxseed)

Parameters	Between group		Within group		F Value
	df	MS	df	MS	
Hardness	2.0	2219486	15.0	423820	785.5289
Springiness	2.0	.06268994	15.0	0.0015	39.31894
Cohesiveness	2.0	.02640561	15.0	0.0004	65.65181
Chewiness	2.0	21354.50	15.0	962.83	22.17881

4.3.1 Hardness

The mean± SE value for hardness was 3428.32±56.141, 3499.21±68.524 and 5794.48±79.237 for C, T1 and T2 respectively.

Analysis of variance revealed a significant difference between treatments. Hardness of T2 was found to be significantly higher than T1 and C. The addition of flax seed significantly ($P<0.05$) influenced the hardness values of chicken nuggets. T2 had higher hardness values than C and T1which might be attributed to gel formation by flaxseed. **Chen *et al. (*2004)** reported that the high viscosity of flaxseed gum in aqueous solutions leads to interaction between meat proteins and flaxseed gum. The major forces responsible for this interaction are electrostatic in nature and are involved in the formation of salt soluble meat protein and flaxseed gum mixture gels. According to a study conducted by **Devatkal *et al.* (2010)** incorporation of sorghum flour at the level of 10% increased the hardness of gluten free chicken nuggets extended with sorghum flour.

4.3.2 CHEWINESS

The mean± SE value for chewiness were 454.68±14.361, 452.89±10.852 and 350.46±12.546, for C, T1 and T2, respectively.

ANOVA revealed a significant difference (P < 0.05) between the mean chewiness values if C, T1 and T2. Chewiness of T2 was significantly lower than C and T1. There was no significant difference (*P* >0.05) between chewiness values of C and T1. The results were in correlation to the study conducted by **Devatkal *et al.(* 2010)** in which incorporation of sorghum flour at the level of 10% decreased the chewiness of chicken nuggets. Sorghum flour has high water and fat absorption properties and helps meat protein to form a three-dimensional structure by gelatinization of protein and starch. Also, the addition of flaxseed at the rate of 12% may have contributed to the decrease of chewiness in chicken nuggets due to its gel forming tendency.

4.3.3 SPRINGINESS

The mean± SE value for springiness were0.64±0.012, 0.62±0.021a and 0.45±0.015b for C, T1 and T2 respectively. ANOVA revealed a significant difference (P <0.05) among different treatments.

TPA showed that springiness of T2 was significantly lower (P >0.05) than C and T1. There was no significant difference (*P* >0.05) in the chewiness value of C and T1.These results were in correlation to the study conducted by **Devatkal *et al. (*2010)** in which incorporation of sorghum flour at the level of 10% decreased the springiness of chicken nuggets.

4.3.4 COHESIVENESS

The mean± SE value for cohesivenesswere0.44±0.009, 0.45±0.009 and 0.33±0.006for C, T1 and T2 respectively. ANOVA revealed a significant difference (*P* >0.05) among different treatments. The cohesiveness value of T2 was significantly lower than that of C and T1. There was no significant difference (P <0.05) between cohesiveness value of C and T1.

Plant protein acts as diluents to reduce interaction among myosin heavy chains of animal proteins and thereby reducing firmness of the three-dimensional structure. In a study conducted by **Devatkal *et al.* (2010)** it was reported that incorporation of sorghum flour at the level of 10% decreased the cohesiveness of chicken nuggets.

4.4 Evaluation of storage stability of chicken nugget containing gizzard and chicken gizzard blend containing sorghum flour and oilseed (flaxseed) during refrigerated storage (4±10°C)

4.4.1 pH

Mean ± SE values of pH during refrigeration storage of chicken nuggets are presented in Table 4.17, Fig 4.10 and ANOVA in table 4.23. Analysis of variance revealed a highly significant (P<0.01) difference in treatment and storage. Interaction of treatment and storage was also found to be significant (P<0.01).

Table 4.17: Means ± S.E value of pH of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	**C**	**T1**	**T2**	**OVERALL MEAN**
0 DAYS	6.12±0.005bC	6.13±0.003bC	6.17±0.003aD	6.14±0.00C
5 DAYS	6.46±0.019bB	6.51±0.024aB	6.23±0.019cC	6.40±0.02B
10 DAYS	6.44±0.021bB	6.49±0.004aB	6.43±0.004bB	6.45±0.01B
15 DAYS	6.73±0.004aA	6.73±0.003aA	6.51±0.002bA	6.66±0.00A
STORAGE MEAN	6.44±0.01b	6.47±0.01a	6.34±0.01c	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet (A, B, C, D) differ significantly (P<0.05)

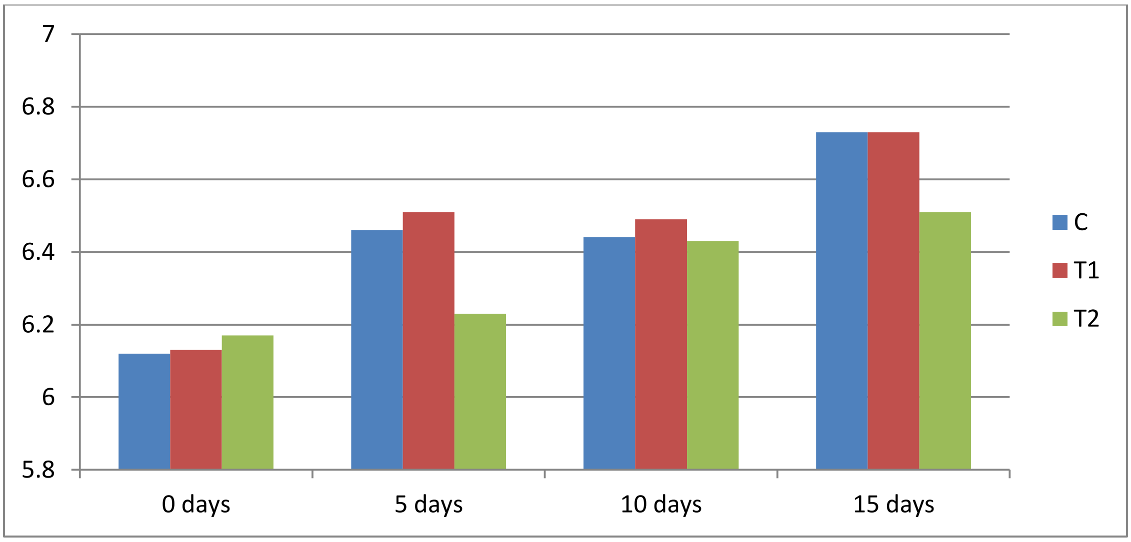

Fig. 4.10: Comparison of pH value of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

pH increased from 6.12±0.005 to 6.73±0.004, 6.13±0.003 to 6.73±0.003 and 6.17±0.003 to 6.51±0.002for C, T1 and T2 respectively. There was a significant ($P<0.05$) increase in pH of C and T1 from 0 to 5thand 10th to 15th day. There was non significant ($P>0.05$) difference in the pH values of C and T1 from 5th to 10th day. It was observed that pH value of T2 increased significantly ($P<0.05$) throughout the storage period. Although, the pH value of T2 was significantly higher than C and T1 at 0th day, it was found that T2 had significantly lower pH value than C and T1 at the end of the storage period owing to the antioxidant properties of linseed and sorghum flour.

The increase in pH was probably due to bacterial activity that resulted in the production of ammonia, amines and other alkaline substances **(Nychas *et al.*, 1998)**. Increasing trend in pH during storage maybe due to increase in bacterial count which results in proteolysis, breakdown products of proteins results in increase in pH value (**Jay, 1996**).In a study conducted by **Deepak *et al.* (2017)**, it was evident that the pH of chicken nuggets decreased with increased level of linseed flour. The results were in correlation to the study conducted by **Yogesh *et al.* (2013)** in which cooked meat batter incorporated with various level of cold milled flaxseed powder revealed lower pH values.

4.4.2 Thiobarbituric acid reactive substance (TBARS)

Mean ± SE values of TBARS during refrigeration storage of chicken nuggets are presented in Table 4.18, Fig 4.11 and ANOVA in table 4.23. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was also found to be highly significant (P<0.01).

Table 4.18: Means ± S.E value of TBARS of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	0.24±0.006aD	0.23±0.005aD	0.17±0.003bD	0.21±0.00D
5 DAYS	0.32±0.004aC	0.33±0.002aC	0.22±0.002bC	0.29±0.00C
10 DAYS	0.58±0.006aB	0.57±0.007aB	0.42±0.002bB	0.52±0.01B
15 DAYS	0.80±0.030aA	0.79±0.017aA	0.55±0.005bA	0.71±0.02A
STORAGE MEAN	0.49±0.01a	0.48±0.01a	0.34±0.00b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet (A, B, C, D) differ significantly (P<0.05)

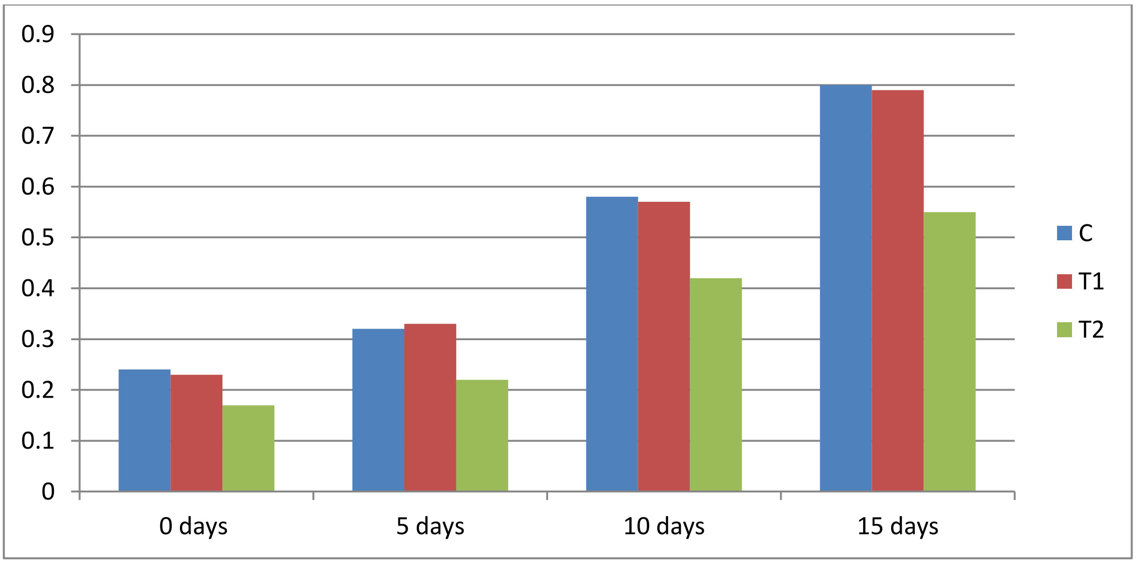

Fig 4.11: Comparison of TBARS (mg malonaldehyde/kg) value of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

TBARS (mg malonaldehyde/kg) increasedfrom0.24±0.006 to 0.80±0.03, 0.23±0.005 to0.79±0.017 and 0.17±0.003 to 0.55±0.005 for C, T1 and T2 respectively. There was a significant ($P<0.05$) increase in TBARS value with increase in storage period for all the treatments. It was observed that TBARS value of T2 was significantly lower than C and T1 at 0, 5, 10 and 15thday of storage. Also there was no significant ($P>0.05$) difference between TBARS value of C and T1 at 0th, 5th, 10thand 15th day of storage. The TBARS value was in limit stating the product is safe and fit for consumption. TBARS values are attributed to endogenous lipid oxidation and fatty acid degradation of chicken.

Tarladgis *et al*. (1960) reported that the value of the TBARS should be in the range of 0.5-1mg/kg of cooked meat product. A range of (0.6-2) mg was considered to be the detectable minimum level for off flavor by inexperienced panelists **(Greene and Cumuze, 1982)**. Sorghum contains more abundant and diverse phenolic compounds compared to other major cereal crops; it contains nearly all classes of phenolic compounds, with simple phenolic acids, flavonoids, and tannins being the dominant groups (**Dykes and Rooney, 2007**; **Shen *et al*., 2018).** Flaxseed is a rich source of different types of phenolic compounds such as phenolic acids, flavonoids, phenyl propanoids and tannins **(Kasote, 2013)**. Lower TBARS value of T2 was in accordance with that of **Deepak *et al.* (2018)** and **Malav *et al.* (2013)** which showed lower TBARS values in chicken nuggets incorporated with flaxseed flour and restructured chicken meat blocks extended with sorghum flour respectively.

4.4.3 Free fatty acid

Mean ± SE values of free fatty acid (% of oleic acid) during refrigeration storage of chicken nuggets are presented in Table 4.19, Fig4. 12 and ANOVA in table 4.23. Analysis of variance revealed a highly significant difference ($P<0.01$) in treatment and storage. Interaction of treatment and storage was also found to be highly significant ($P<0.01$).

FFA increased from 0.23±0.003 to 0.81±0.024, 0.24±0.002 to 0.66±0.004 and0.18±0.003 to 0.82±0.006for C, T1 and T2 respectively. There was a significant ($P<0.05$) increase in FFA value with increase in storage period for all the treatments. It was observed that FFA value of T2 was significantly ($P<0.05$) lower than C and T1 at

0^{th}, 5^{th}, 10^{th} and 15^{th} day of storage. There was no significant (P>0.05) difference between FFA value of C and T1 at 0^{th}, 5^{th}, 10th and 15^{th} day of storage.

Table 4.19: Means ± S.E value of free fatty acid (% of oleic acid)of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	0.23±0.003aD	0.24±0.002aD	0.18±0.003bD	0.22±0.00D
5 DAYS	0.48±0.004aC	0.46±0.005aC	0.27±0.002bC	0.40±0.00C
10 DAYS	0.65±0.006aB	0.66±0.007aB	0.57±0.002bB	0.62±0.01B
15 DAYS	0.81±0.024aA	0.82±0.006aA	0.66±0.004bA	0.76±0.01A
STORAGE MEAN	0.54±0.01a	0.54±0.01a	0.42±0.00b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet (A, B, C, D) differ significantly (P<0.05)

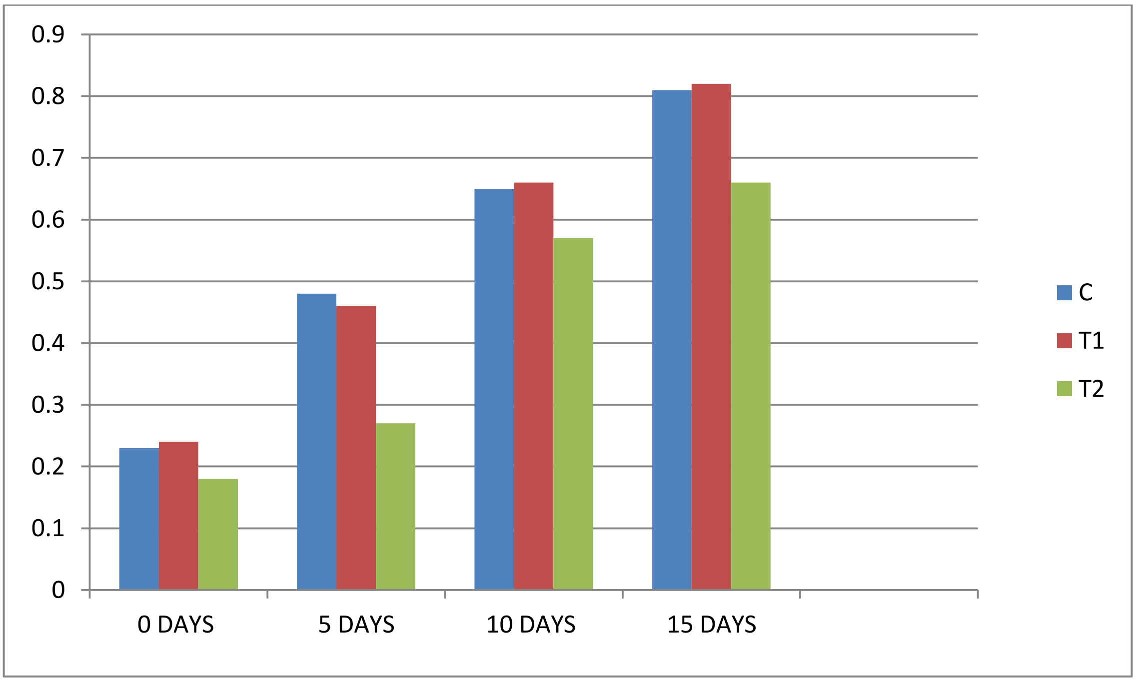

Fig. 4.12: Comparison of free fatty acid (% of oleic acid)of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

4.4.4 DPPH activity (% inhibition)

Mean ± SE values of DPPH during refrigeration storage of chicken nuggets are presented in Table 4.20, Fig 4.13 and ANOVA in table 4.23. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was also found to be highly significant (P<0.01).

Table 4.20: Mean± S.E value of DPPH activity (% inhibition) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	8.82±0.023bA	8.28±0.128cA	14.04±0.231aA	10.38±0.13A
5 DAYS	7.32±0.140bB	7.15±0.021bB	13.24±0.033aB	9.24±0.06B
10 DAYS	4.84±0.073bC	4.64±0.115bC	10.03±0.209aC	6.50±0.13C
15 DAYS	2.30±0.048bD	2.21±0.033bD	7.92±0.032aD	4.14±0.04D
STORAGE MEAN	5.82±0.07b	5.57±0.07c	11.31±0.13a	

n= 6, Mean±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

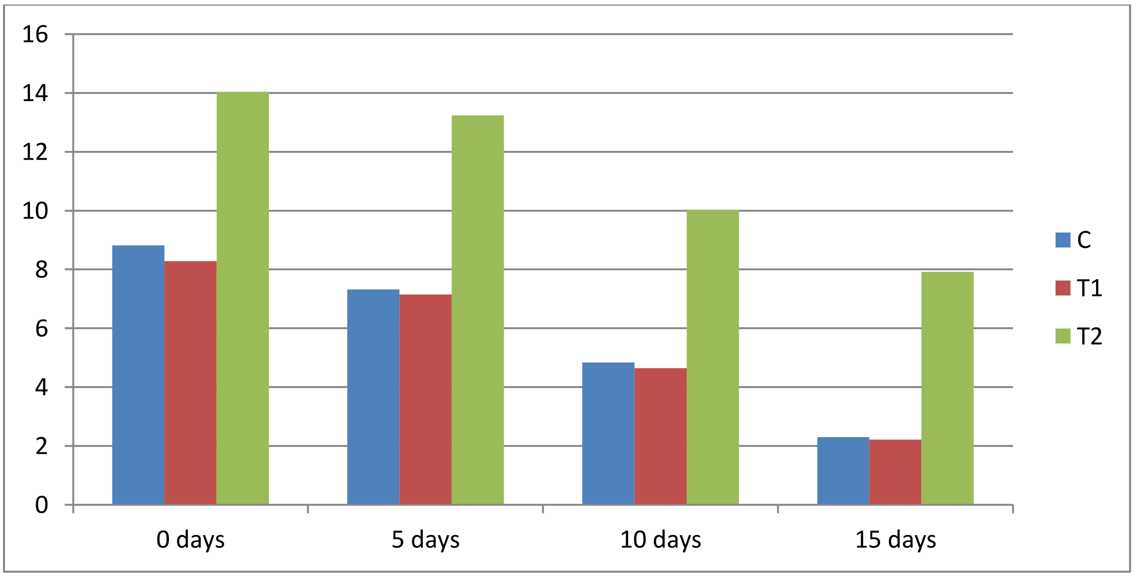

Fig. 4.13: Comparison of DPPH activity (% inhibition) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DPPH activity (% inhibition) decreased from 8.82±0.023to 2.30±0.048, 8.28±0.128 to 2.21±0.033 and 14.04±0.231 to 7.92±0.032 in C, T1 and T2 respectively from 0 to 15th day. The data of the current study revealed that there was a significant decrease in DPPH with increase in storage period for all the treatments. Although, there was a significant difference between DPPH value of C and T1 during 0th day but the values of C and T1 on 0, 5, 10 and 15th day were non significant (P>0.05). The DPPH value of T2 was significantly higher (P<0.05) than C and T1 throughout the storage period. Factors like release of free and bound phenols on increasing the storage days are responsible for decreasing the DPPH content of the sample **(Shan *et al*., 2005).** The higher DPPH value in T2 at the end of storage period indicated that it has higher free radical scavenging activity as compared to C and T1.

4.4.5 Peroxide Value

Mean ± SE values of PV during refrigeration storage of chicken nuggets are presented in Table 4.21, Fig 4.14 and ANOVA in table 4.23. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was also found to highly significant (P<0.01).

Table 4.21: Mean± S.E value of peroxide value (mEq/Kg of fat) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	0.12±0.004bD	0.14±0.004aD	0.12±0.001bD	0.13±0.00D
5 DAYS	0.31±0.007aC	0.31±0.013aC	0.17±0.002bC	0.26±0.01C
10 DAYS	0.49±0.005bB	0.52±0.009aB	0.32±0.005cB	0.44±0.01B
15 DAYS	0.99±0.003aA	0.96±0.010bA	0.65±0.008cA	0.87±0.01A
STORAGE MEAN	0.48±0.00a	0.48±0.01a	0.32±0.00b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet (A, B, C, D) differ significantly (P<0.05)

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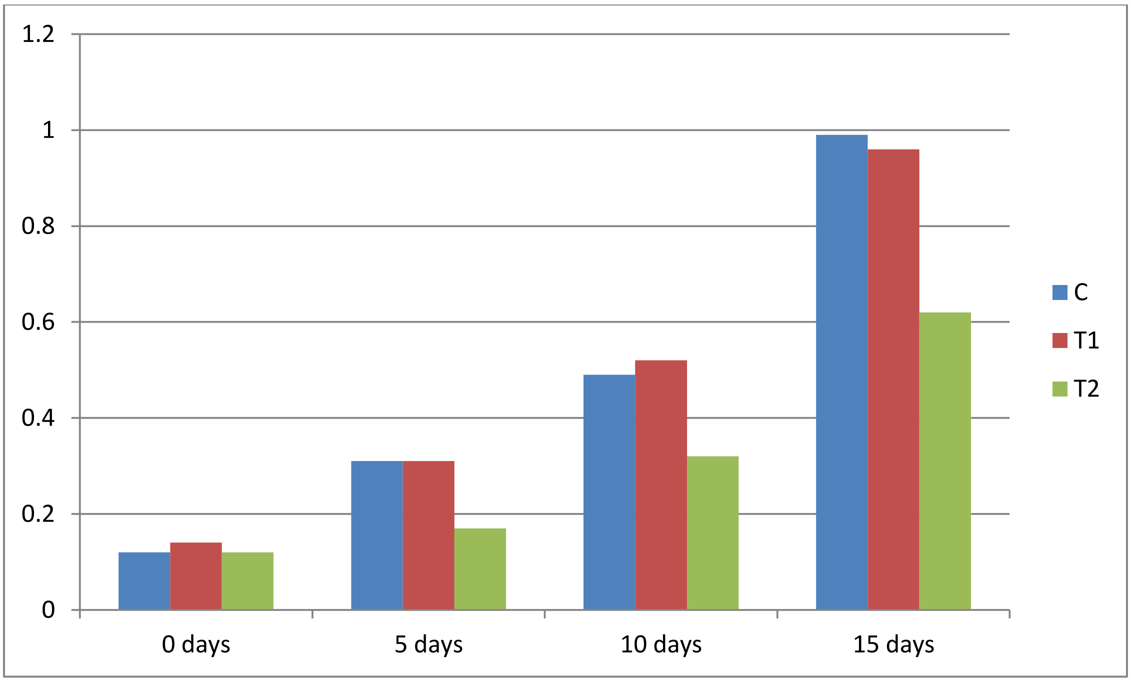

Fig. 4.14: Comparison of peroxide value (mEq/Kg of fat) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

PV increased from 0.12±0.004 to 0.99±0.003, 0.14±0.004 to 0.96±0.010 and 0.12±0.001 to 0.65±0.008 for C, T1 and T2 respectively. There was a significant ($P<0.05$) increase in PV value with increase in storage period for all the treatments. From the study it can be concluded that PV value of T2 was significantly lower than C and T1 at 5th, 10th and 15th day of storage can which can be contributed to the phenols present in sorghum and linseed. The overall mean revealed that the PV increased from 0.13±0.00 on 0th day to 0.87±0.01 on 15th day.

Hydro peroxides, are primary products of oxidative reaction. Peroxide value indicates the initial stages of lipid oxidation. The lipid oxidation products formed adversely affect the quality of food articles by altering their sensory properties and reducing their nutritive value (**Huber *et al*., 2009**). Phenolic compounds extracted from whole grains and from the cellular walls of red and white sorghum inhibited the oxidation of low-density lipoproteins and protected DNA against oxidative damage, which could be helpful in the prevention of cardiovascular diseases mediated by oxidative stress (**Salawu *et al*., 2014**)

4.4.6 Tyrosine Value

Mean ±SE of tyrosine value during refrigeration storage of chicken nuggets are presented in Table 4.22, Fig 4.15 and ANOVA 4.23 in table. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was also found to be highly significant (P<0.01).

Table 4.22: Mean± S.E value of tyrosine value (mg/g) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	0.23±0.005aD	0.21±0.003bD	0.17±0.001cD	0.20±0.00d
5 DAYS	0.34±0.005aC	0.34±0.007aC	0.25±0.004bC	0.31±0.01c
10 DAYS	0.49±0.007bB	0.52±0.008aB	0.41±0.002cB	0.47±0.01b
15 DAYS	0.67±0.004aA	0.67±0.004aA	0.61±0.002bA	0.65±0.00a
STORAGE MEAN	0.43±0.01b	0.44±0.01a	0.36±0.00c	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

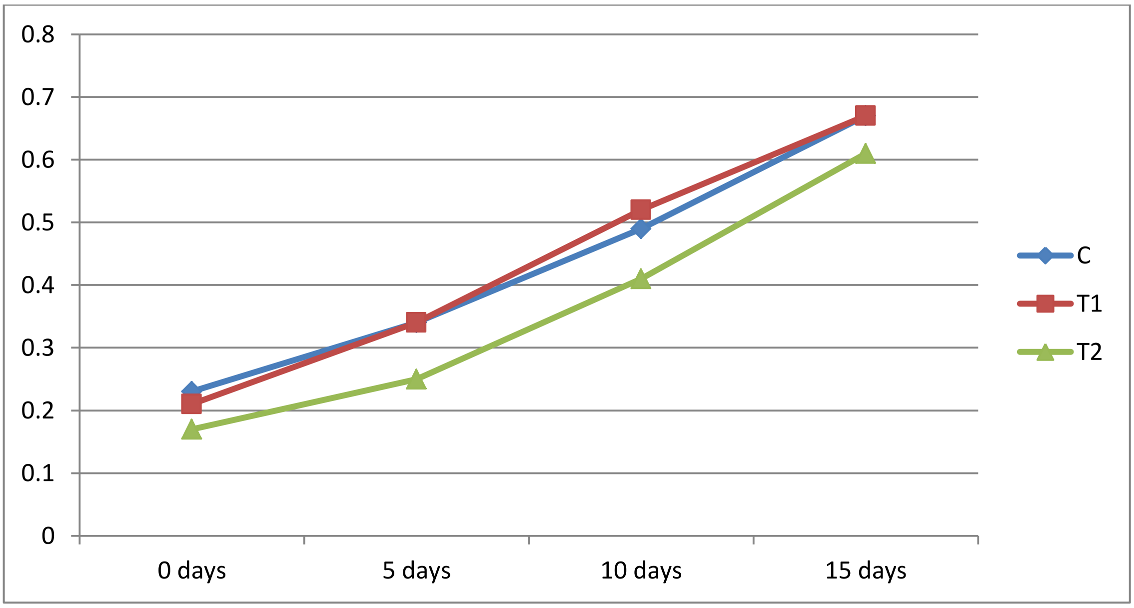

Fig. 4.15: Comparison of tyrosine value (mg/g) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Tyrosine value increased from 0.23±0.005 to 0.67±0.004, 0.21±0.003 to 0.67±0.004 and 0.17±0.001 to 0.61±0.002 for C, T1 and T2 respectively. There was a significant increase in tyrosine value with increase in storage period for all the treatments. From the study it can be concluded that tyrosine value of T2 was significantly lower than C and T1 throughout the storage period. There was no significant difference (P>0.05) between C and T1 at 5th and 15th day of storage. However, the Tyrosine value of T1 was significantly lower and significantly higher than C at 0th and 10th day respectively. The increase in tyrosine concentration could be attributed to hydrolytic changes in meat due to inherent tissue enzymes and bacterial proteolysis **(Strange *et al*., 1977).** The higher degree of tyrosine value in C and T1 can be attributed to proteolysis as tyrosine (aromatic amino acids) and α-amino acids are the product of proteolysis.

Table 4.23: ANOVA table of antioxidant parameters of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Parameters	Treatment (a) df=3		Storage periods df=2		Interaction (a*b) df=6		Error
	MS	F value	MS	F value	MS	F value	
pH	0.807	868.06**	0.107	115.45**	0.04298	46.20021**	0.00093
TBARS	0.933	1307.36**	0.157	220.78**	0.01316	18.43085**	0.00071
FFA	0.942	2353.7**	0.095	239.37**	0.0652	162.78**	0.0004
PV	1.867	6882.7**	0.211	780.09**	0.0346	127.76**	0.0002
DPPH	141.43	1791.02**	252.40	3196.2**	0.2378	3.0121*	0.0789
TV	0.691	5167.1**	0.042	315.5**	0.0014	10.906**	0.0001

Significant at (P < 0.05) and (P<0.01)

4.5 Microbiological Analysis

4.5.1 Total plate count

Mean ± SE values of TPC during refrigeration storage of chicken nuggets are presented in Table 4.24, Fig 4.16 and ANOVA in table 4.27. Analysis of variance revealed a highly significant (P<0.01) difference in treatment and storage. Interaction of treatment and storage was also found to be highly significant (P<0.01).

Table 4.24: Mean± S.E value of total plate count (log10 cfu/gm) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Storage days	C	T1	T2	Overall mean
0 days	1.36±0.028aD	1.34±0.031aD	1.32±0.022aD	1.34±0.03D
5 days	2.90±0.028aC	2.78±0.033bC	1.80±0.034cC	2.49±0.03C
10 days	3.52±0.024aB	3.52±0.024aB	2.34±0.017bB	3.13±0.02B
15 days	4.81±0.018aA	3.52±0.024aB	2.83±0.050bA	3.13±0.02B
Treatment mean	3.15±0.02a	3.11±0.03a	2.07±0.03b	

n= 6, Means ±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet (A, B, C, D) differ significantly (P<0.05)

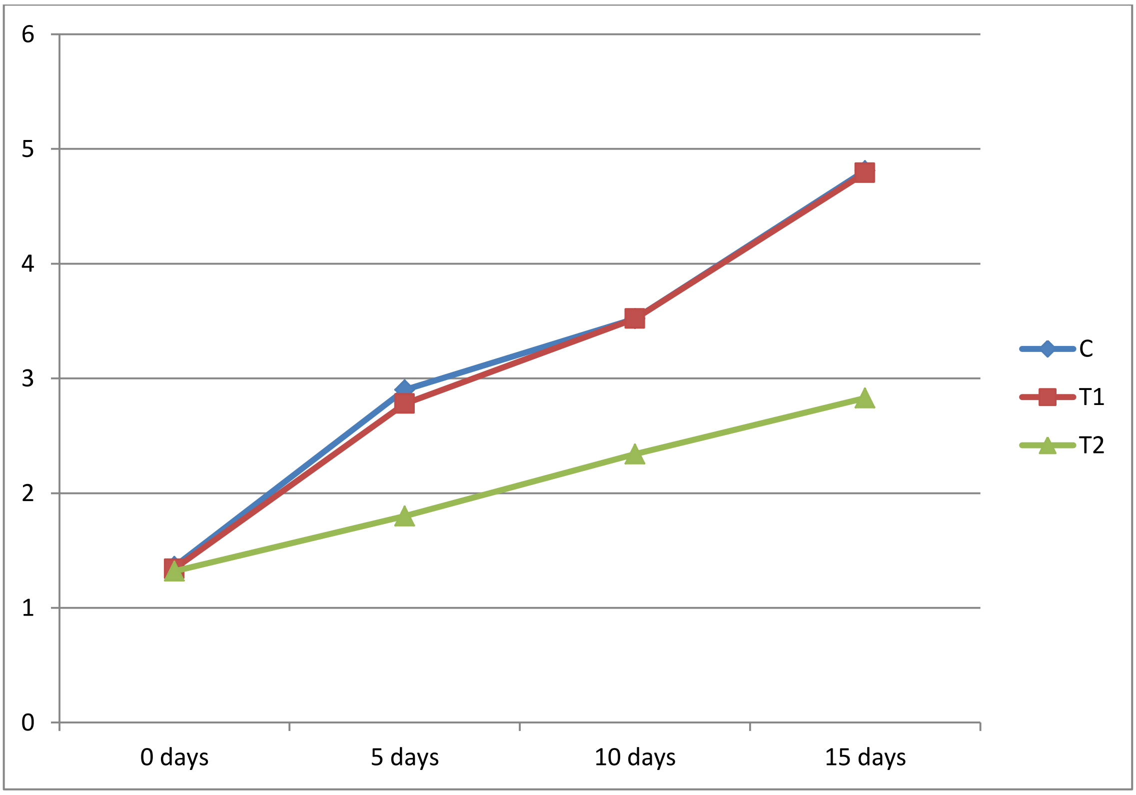

Fig. 4.16: Comparison of total plate count (log10 cfu/gm) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Total plate count (log10 cfu/gm) increased from 1.36±0.028 to 4.81±0.018, 1.34±0.031 to 3.52±0.024 and 1.32±0.022 to 2.83±0.05 for C, T1 and T2 respectively. The TPC increased significantly (P<0.05) with increase in storage period for all the treatments. There was no significant difference (P>0.05) in TPC of C, T1 and T2 on 0^{th} day. It was observed that C and T1 had significantly higher (P<0.05) TPC than T2 on 0^{th}, 10^{th} and 15^{th} days of storage. Similar increase in microbial counts during refrigerated storage period was also reported in chicken emulsion **(Kala *et al.*, 2007),** chicken meat nuggets (**Yavas *et al.*, 2010**), Meat products have been reported to get spoiled at a microbial load of more than 6 log cycles **(Frazier *et al.*, 1978).** It was observed from the above data that TPC counts were within the limits of 6 log cfu/g prescribed for safe cooked meat products **(Shapton *et al.*, 1991).**

4.5.2 Yeast and mould count

Mean ± SE values of Yeast and mould count during refrigeration storage of chicken nuggets are presented in Table 4.25, Fig 4.17 and ANOVA in table 4.27. Analysis of variance revealed a highly significant (P<0.01) difference in treatment and storage. Interaction of treatment and storage was also found to be highly significant (P<0.01).

Table 4.25: Mean± S.E value of Yeast and mould count (log 10 cfu/gm) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Storage days	C	T1	T2	Overall mean
0 days	0.51±0.021aD	0.50±0.024aD	0.22±0.012bD	0.41±0.02D
5 days	1.90±0.026aC	1.90±0.023aC	0.85±0.032bC	1.55±0.03C
10 days	2.48±0.036aB	2.44±0.041aB	1.53±0.023bB	2.15±0.03B
15 days	3.23±0.028aA	3.32±0.027aA	2.28±0.036bA	2.94±0.03A
Treatment mean	2.03±0.03a	2.04±0.05a	1.22±0.03b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

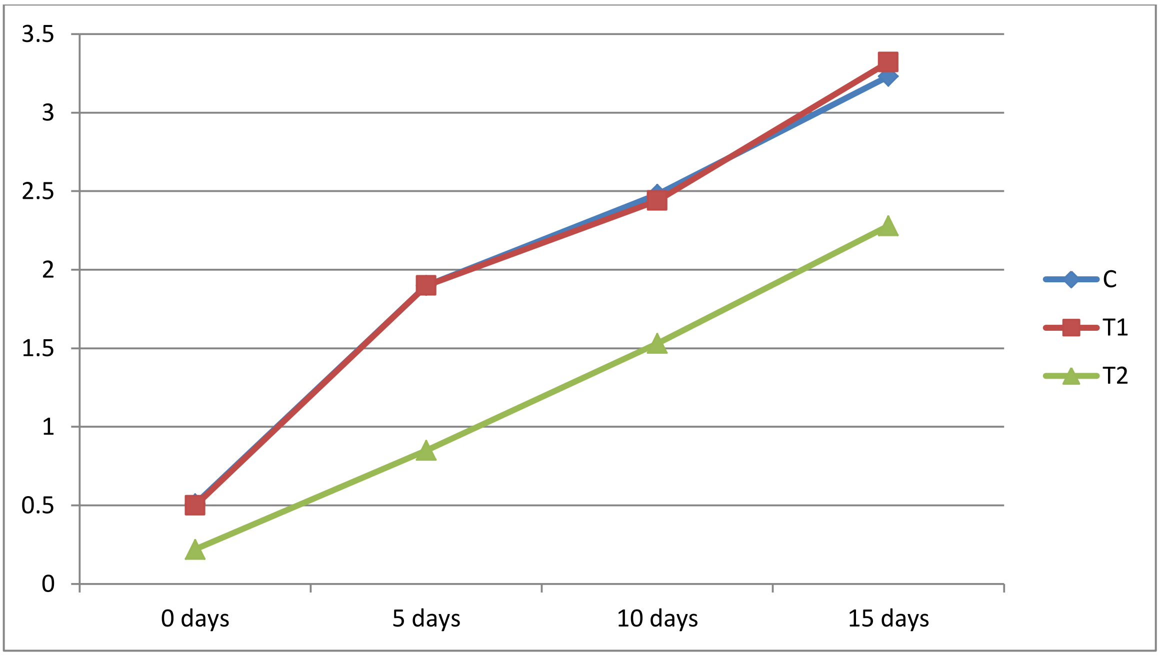

Fig. 4.17: Comparison of Yeast and mould count (log10 cfu/gm) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Yeast and mould count (log10 cfu/gm) increased from0.51±0.021to 3.23±0.028, 0.50±0.024 to 3.32±0.027 and 0.22±0.012 to 2.28±0.036for C, T1 and T2 respectively. Yeast and mould count increased significantly in the control as well as the treatments throughout the storage period. Yeast and mould count of T2was significantly lower than C and T1 on 0^{th}, 5^{th}, 10^{th} and 15^{th} day of storage. Treatment mean revealed that T2 had significantly lower yeast and mould count as compared to C and T1. There was no significant difference between C and T1 were non significant. Contamination of meat with molds generally originated from slaughter halls and surrounding environment **Mansour *et al.* (1990).** Overall mean increased from 0.41±0.02 on 0^{th} day to 2.94±0.03 on 15^{th} days of storage.

4.5.3 Coliform count

Coliforms were not detected throughout the storage period in the all the treatments. Coliforms is a group of organisms is also used as hygiene indicator organism. The results obtained in this study is similar to the finding of **Solberg *et al.* (1986**) reported that coliforms count more than 10^2/ gram of food products is indicative of dangerous contamination.

Table 4.26: Mean± S.E value of coliform count (log10 cfu/gm) of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Storage days	C	T1	T2	Overall mean
0 days	ND	ND	ND	ND
5 days	ND	ND	ND	ND
10 days	ND	ND	ND	ND
15 days	ND	ND	ND	ND
Treatment mean	ND	ND	ND	ND

Table 4.27: ANOVA table of antioxidant parameters of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oil seed during refrigerated storage (4±10°C)

Parameters	Treatment (a) df=3		Storage periods df=2		Interaction (a*b) df=6		Error
	MS	F value	MS	F value	MS	F value	
TPC	20.55656	4230.69**	5.323	1095.57**	0.255	52.5192**	0.0048
Yeast and mould count	24.88	4777.48**	8.9534	1719.1**	1.268970	243.658**	0.0052

4.6 SENSORY EVALUATION

4.6.1 Appearance

Mean ± SE values of appearance scores during refrigeration storage of chicken nuggets are presented in Table 4.28, Fig 4.18 and ANOVA in table 4.33. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. However interaction of treatment and storage was found to be non significant (P>0.01).

Table 4.28: Mean± S.E value of appearance scores of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	7.37±0.064aA	7.47±0.048aA	6.55±0.100bA	7.13±0.07A
5 DAYS	6.24±0.021aB	6.17±0.011aB	5.31±0.031bB	5.91±0.02B
10 DAYS	5.38±0.030aC	5.34±0.030aC	4.38±0.027bC	5.03±0.03C
15 DAYS	4.41±0.031aD	4.40±0.020aD	3.54±0.029bD	4.12±0.03D
STORAGE MEAN	5.85±0.04a	5.85±0.03a	4.95±0.05b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

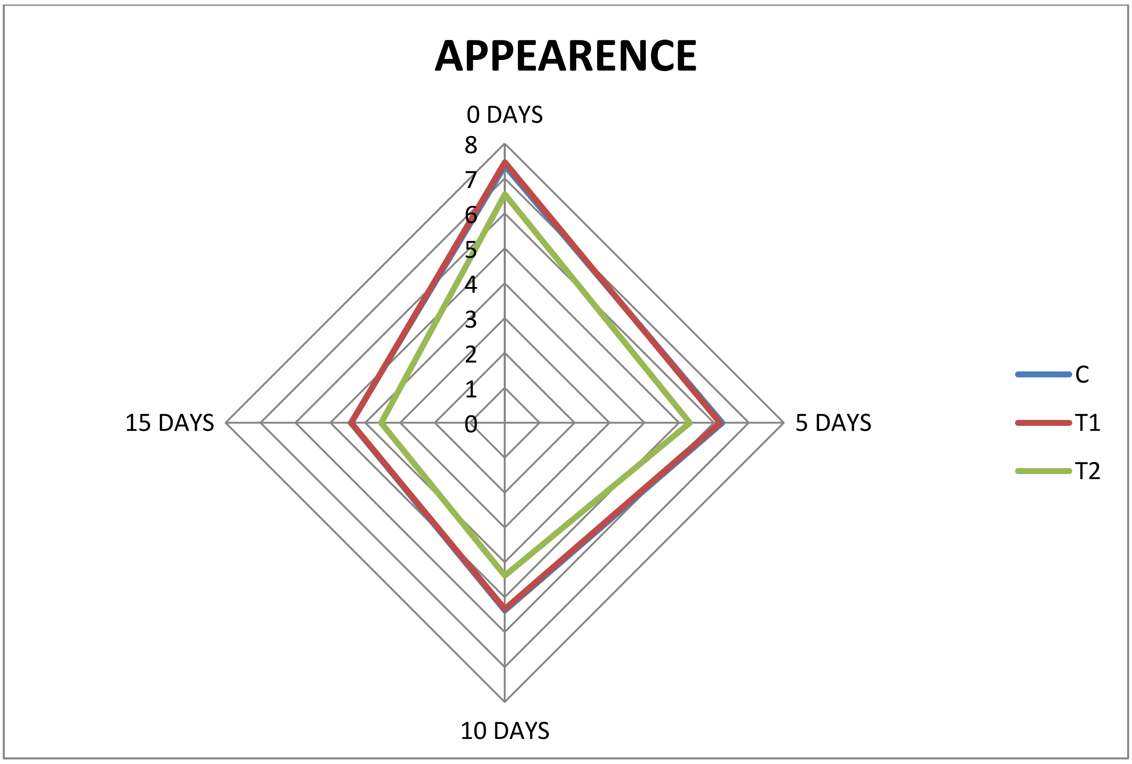

Fig. 4.18: Comparison of appearance score of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Appearance scores decreased from7.37±0.064 to 4.41±0.03, 7.47±0.048 to 4.40±0.020 and 6.55±0.1 to 3.54±0.029 for C, T1 and T2 respectively. The appearance score of C and T1 was significantly higher (P<0.05) than T2 throughout the storage period. There was no significant difference in the appearance score of C and T1 on 0^{th}, 5^{th}, 10^{th} and 15^{th}day of storage period. The reason for the lower score of T2 could be addition of sorghum flour and flaxseed which may have altered the usual appearance and color of the chicken nuggets. In a study conducted by **(Reddy *et al.*, 2018)** it was revealed that the appearance and colour score of chicken nuggets decreased with increasing the content of flaxseed. The overall mean revealed that the appearance scores decreased from 7.13±0.07 on 0^{th} day to 4.12±0.03 on 15^{th} day.

4.6.2 TEXTURE

Mean ± SE values of texture scores during refrigeration storage of chicken nuggets are presented in Table 4.29, Fig 4.19 and ANOVA in table 4.33. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was found to be non significant (P<0.01).

Table 4.29: Mean± S.E value of texture scores of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	7.39±0.068aA	7.42±0.046aA	6.56±0.100bA	7.12±0.07A
5 DAYS	6.31±0.023aB	6.16±0.011bB	5.31±0.031cB	5.93±0.02B
10 DAYS	5.31±0.032aC	5.41±0.024aC	4.40±0.024bC	5.04±0.03C
15 DAYS	4.51±0.016aD	4.41±0.021aD	3.50±0.012bD	4.14±0.02D
STORAGE MEAN	5.88±0.03a	5.85±0.03a	4.94±0.04b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

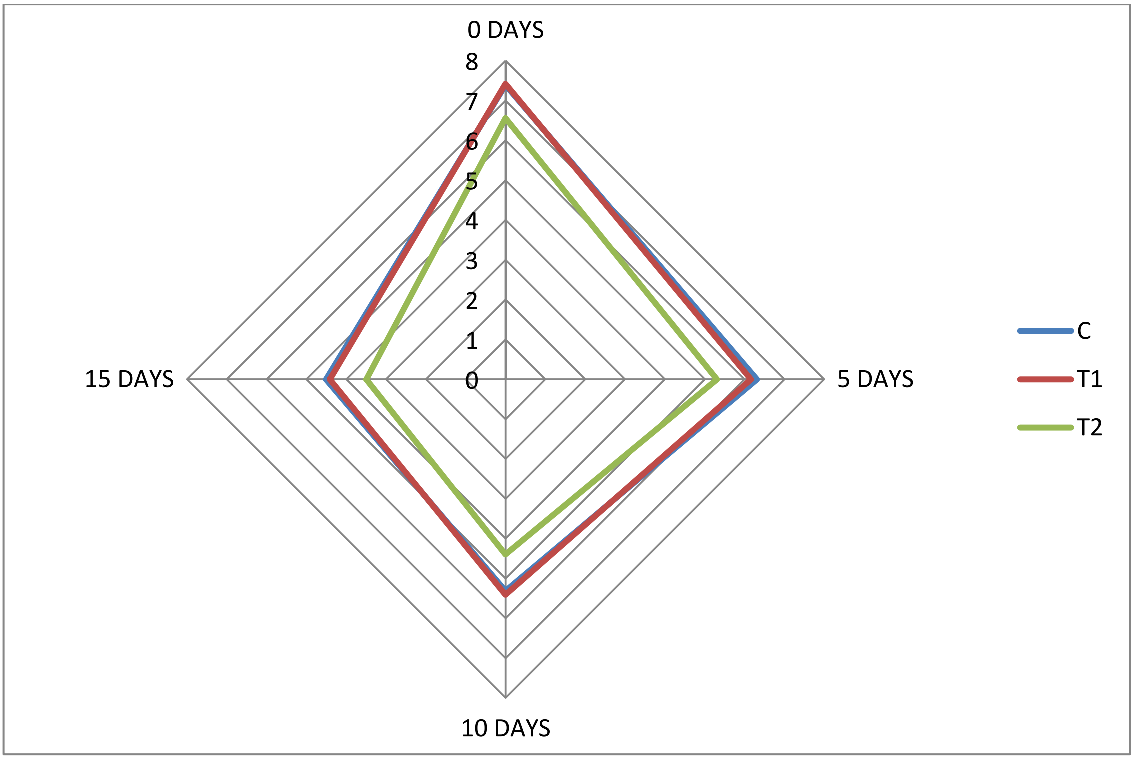

Fig. 4.19: Comparison of texture score of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Texture scores decreased from 7.39±0.068 to 4.51±0.016, 7.42±0.046 to4.41±0.021 and 6.56±0.1 to3.50±0.012 for C, T1 and T2 respectively. The texture score of C and T1 was significantly higher ($P<0.05$) than T2 throughout the storage period. There was no significant difference in the texture score of C and T1 on 0th, 10th and 15th day of storage period. There as on for the lower score of T2 could be addition of sorghum flour and flaxseed which may have altered the usual texture of the chicken nuggets. The overall mean revealed that the texture scores decreased from 7.12±0.07 on 0th day to4.14±0.02 on 15th day.

4.6.3 JUCINESS

Mean ± SE values of appearance scores during refrigeration storage of chicken nuggets are presented in Table 4.30, Fig 4.20 and ANOVA in table 4.33. Analysis of variance revealed a highly significant difference ($P<0.01$) in treatment and storage. Interaction of treatment and storage was found to be highly significant ($P<0.01$).

Table 4.30: Mean± S.E value of juiciness scores of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	7.28±0.046bA	7.24±0.044bA	7.48±0.046aA	6.99±0.05A
5 DAYS	6.28±0.025bB	6.23±0.018bB	6.31±0.031aB	6.99±0.05A
10 DAYS	5.38±0.017bC	5.41±0.025bC	5.86±0.029aC	5.05±0.02C
15 DAYS	4.36±0.032bD	4.41±0.021bD	4.96±0.029aC	4.08±0.03D
STORAGE MEAN	5.88±0.03b	5.85±0.03b	5.85±0.04a	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

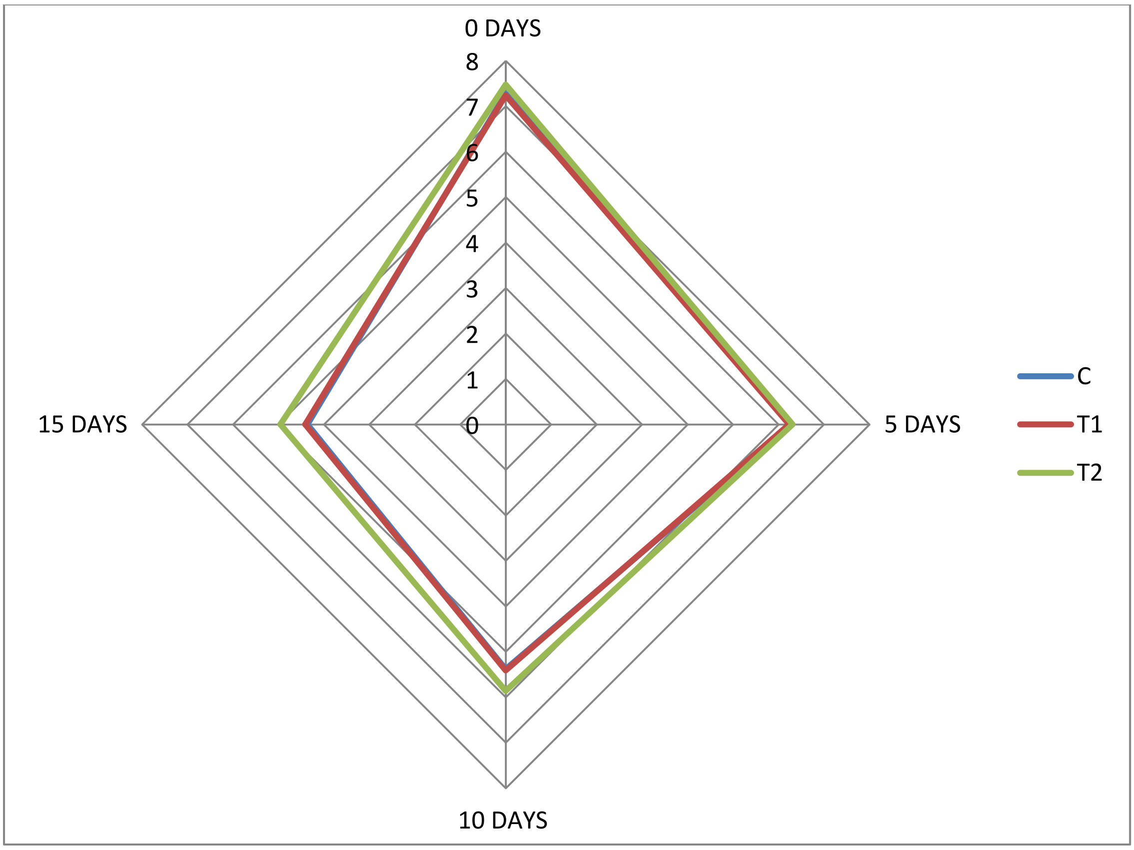

Fig. 4.20: Comparison of Juiciness score of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Juiciness score decreased from 7.28±0.046 to 4.36±0.032, 7.24±0.044 to 4.41±0.021 and 7.48±0.04 to 4.96±0.029 for C, T1 and T2 respectively. The juiciness score of T2 was significantly higher (P<0.05) than C and T1 on $0^{th,}$ 5^{th}, 10^{th} and 15^{th} day of storage period. However, there was non significant difference between juiciness scores of C and T1 on $0^{th,}$ 5^{th}, 10^{th} and 15^{th} day of storage. Higher juiciness scores might be due to increased moisture retention of the product during cooking due to addition of flours **(Reddy *et al.,* 2017).** The result were in correlation to a study conducted by **(Reddy *et al.,* 2018)** in which the juiciness of chicken nuggets increased with increase in the amount of flaxseed flour**.**

4.6.4 FLAVOUR

Mean ± SE values of appearance scores during refrigeration storage of chicken nuggets are presented in Table 4.31, Fig 4.21 and ANOVA in table 4.33. Analysis of variance revealed a highly significant difference (P<0.01) in treatment and storage. Interaction of treatment and storage was found to be highly significant (P<0.01).

Table 4.31: Mean± S.E value of flavor scores of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	7.47±0.048aA	7.45±0.064aA	7.49±0.112aA	7.44±0.07A
5 DAYS	6.08±0.017bB	6.02±0.018bB	6.27±0.032aB	6.25±0.02B
10 DAYS	5.42±0.027bC	5.44±0.026bC	6.09±0.024aC	5.65±0.03C
15 DAYS	4.51±0.019bD	4.45±0.016bD	5.46±0.031aD	4.80±0.02D
STORAGE MEAN	5.89±0.019b	5.90±0.03b	6.31±0.05a	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

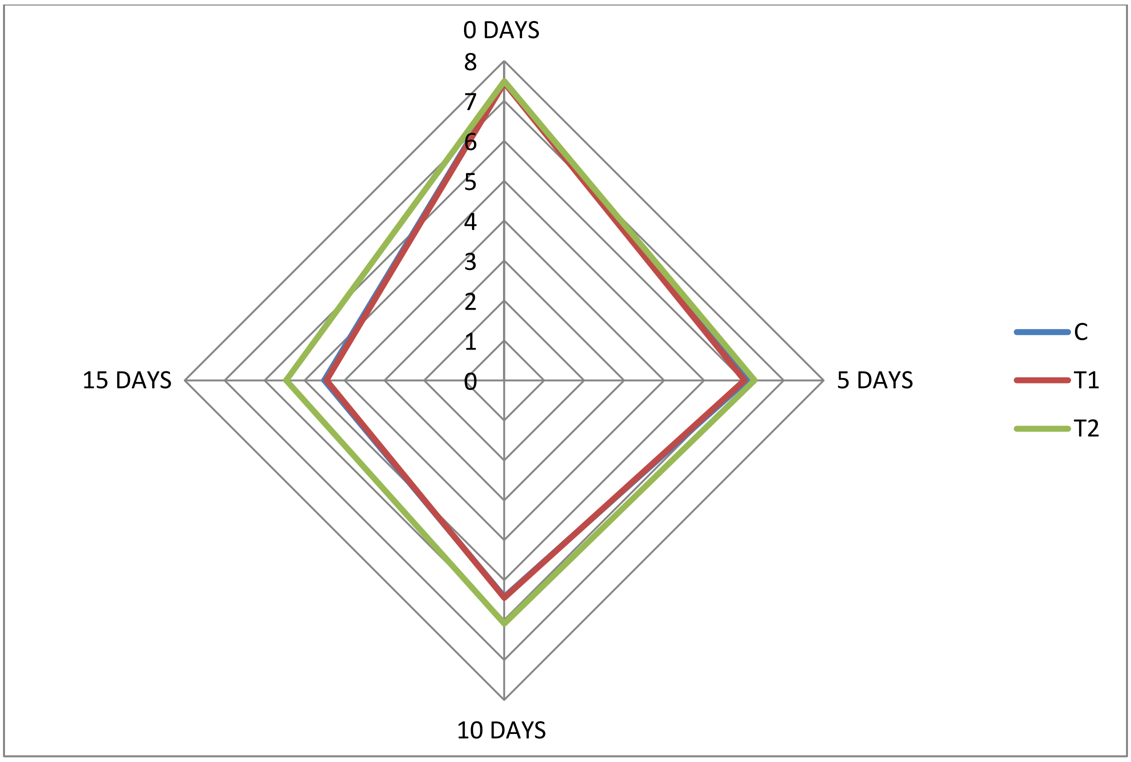

Fig. 4.21: Comparison of flavor score of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Flavor score decreased from 7.47±0.048 to 4.51±0.019, 7.37±0.064 to 4.45±0.016 and 7.49±0.112 to 5.46±0.031 for C, T1 and T2 respectively. The flavor score decreased with increase in storage period for all the treatments. The flavor score of C, T1 and T2 had non significant difference ($P>0.05$)on 0^{th} day of storage period. However, there was a significant difference between C, T1 and T2 on 5^{th}, 10^{th} and 15^{th} day of storage. The flavor score of T2 was significantly higher than C and T1 on 5^{th}, 10^{th} and 15^{th} day of storage. **Tarladgis *et al.* (1960)** reported that decrease in flavor score can be due to increase in TBARS and FFA content of the meat sample

4.6.5 Overall Acceptability

Mean ± SE values of appearance scores during refrigeration storage of chicken nuggets are presented in Table 4.32, Fig 4.21 and ANOVA in table 4.33. Analysis of variance revealed a highly significant difference ($P<0.01$) in treatment and storage. Interaction of treatment and storage was found to be highly significant ($P<0.01$).

Table 4.32: Mean± S.E value of overall acceptability scores of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

DAYS	C	T1	T2	OVERALL MEAN
0 DAYS	7.39±0.064bA	7.48±0.048bA	7.54±0.01aA	7.47±0.07a
5 DAYS	6.28±0.025bB	6.33±0.018bB	6.81±0.03aB	6.47±0.02b
10 DAYS	5.39±0.031bC	5.32±0.030bC	5.98±0.02aC	5.56±0.03c
15 DAYS	4.51±0.016bD	4.41±0.021bD	5.50±0.01aD	4.81±0.02d
STORAGE MEAN	5.89±0.03a	5.86±0.04a	6.45±0.04b	

n= 6, Means±S.E. values bearing different superscript in each row by small alphabet (a, b, c) and in each column by capital alphabet(A, B, C, D) differ significantly (P<0.05)

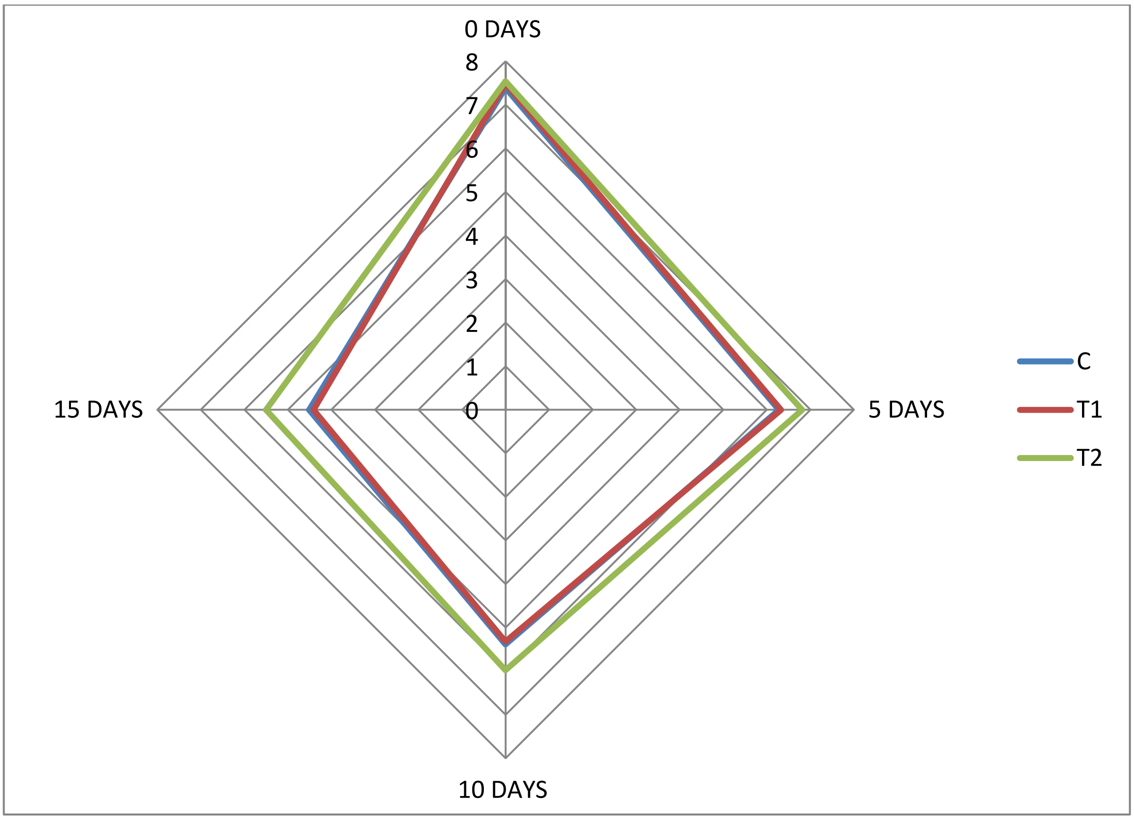

Fig. 4.22: Comparison of overall acceptability score of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oilseed during refrigerated storage (4±1°C)

Overall acceptability decreased from 7.39± 0.064 to 4.51± 0.016, 7.48± 0.048 to 4.41± 0.021 and 7.54± 0.01 to 5.50±0.01 for C, T1 and T2 respectively. The overall acceptability score decreased with increase in storage period for all the treatments. The study revealed that the there was a significant difference (P<0.05) between overall acceptability values C, T1 and T2 on 5th, 10th and 15th day of storage. The overall acceptability of T2 was significantly higher (P<0.05) than C and T1 and T2 on 0th, 5th, 10th and 15th day of storage. The result were in correlation to the study conducted by (**Reddy *et al*, 2018**) in which overall acceptability of nuggets incorporated with flaxseed flour was found to have better acceptability.

Table 4.33: ANOVA table of antioxidant parameters of chicken nuggets incorporated with chicken gizzard and chicken gizzard blend containing sorghum flour and oil seed during refrigerated storage (4±1°C)

Parameters	Treatment (a) df=3		Storage periods df=2		Interaction (a*b) df=6		Error
	MS	F value	MS	F value	MS	F value	
Appearance	1.584	103.135**	28.854	1.1777**	0.40	1.829	0.017
Texture	1.884	174.64**	42.00	7.78**	0.09	11.36	0.0008
Juiciness	0.242	23.7**	10.095	911.37**	0.652	62.78**	0.0012
flavour	0.867	182.7**	43.21	9.39**	0.0846	19.76**	0.0005
Overall acceptability	0.969	232.02**	53.40	1.293	0.5378	15.01**	0.0007

Highly significant (P<0.01)

Summary and Conclusions

Chapter 5 SUMMARY AND CONCLUSION

Chicken meat is one of the most common source of animal food in India**.** It is the most acceptable source of animal food and is consumed by all the religious communities because there is no religious taboo. The increase in poultry production from 2012 to 2019 is about 16.8%. The fast growing economy and improved living status of people demand food that is safe, nutritious, health friendly and economical. Poultry industry produces gizzard as a byproduct which can be utilized in chicken food products to a certain extent. Also in today's world there is increased demand of utilization of fiber rich foods in diet due to its health benefits.

This study aims to develop functional chicken nuggets incorporated with chicken gizzard blend containing sorghum flour and oilseed. Further evaluation of quality characteristics of this product was done to assess its cooking yield, WHC, proximate composition, texture profile analysis, sensory characteristics and storage stability at 4±1°C on 0^{th}, 5^{th}, 10^{th} and 15^{th} day of storage.

The following abbreviations were used in this experiment-

C – Control containing chicken nuggets with no chicken gizzard blend

T1- Treatment containing chicken gizzard at the rate of 8%

T2- Treatment containing chicken gizzard blend incorporated with sorghum 14% and oilseed (flaxseed) 12%

5.1 Standardization of level of incorporation of gizzard, sorghum flour and selected oilseed

5.1.1 Optimization of level of gizzard

8%, 14% and 20% level of gizzard were selected for final optimization in the product. TG8 had a better score in appearance, texture, juiciness, flavor and overall acceptability than TG14 and TG20.

5.1.2 Optimization of level of sorghum flour

8%, 14% and 20% level of sorghum flour were selected for final optimization in the product. TSF8 had a better score in appearance texture juiciness flavor and overall acceptability than TSF14 andTSF20. There was no significant (P>0.05) difference between TSF8 and Control.

5.1.3 Selection of oilseeds

Three oilseeds sesame, sunflower and flaxseed were incorporated in chicken nuggets at 8% level each and subjected to sensory evaluation. TF had a better score in appearance, juiciness, flavor and overall acceptability than TS and TSf. Chicken nuggets incorporated with sunflower seeds scored least for all the sensory parameters

5.1.4 Optimization of level of sorghum flour

8%, 14% and 20% level of flaxseed were selected for final optimization in the product. The sensory scores decreased with increase in the amount of flaxseed incorporated in chicken nuggets for appearance and texture. However the juiciness increased with increasing amount of incorporated flaxseed. TF12 had a better score in juiciness, flavor and overall acceptability thanTF14 and TF20.

5.2 Evaluation of proximate composition, cooking yield and water holding capacity of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed

The cooking yield and water holding capacity of T2 was significantly higher (P<0.05) than C and T1.The protein content decreased significantly (P<0.05) in T2 as compared to C and T1. There was no significant difference (P>0.05) in the protein content of C and T1 however numerically the protein content of T2 was greater than C. The fat content of T2 was significantly higher (P<0.05) than C and T1. There was no significant difference (P>0.05) between C and T1. The moisture content of T2 was significantly lower (P<0.05) than that of C and T1. There was no significant difference (P>0.05) between the moisture content of C and T1. Total ash content was significantly higher (P<0.05) in T2 as compared to C and T1. There was no significant difference in the total ash content (P>0.05) of C and T1. The crude fiber content of T2 was significantly higher (P<0.05) than C and T1. There was no significant (P>0.05) difference in fiber content of C and T1.

5.3 Evaluation of texture profile analysis of chicken nuggets incorporated with gizzard and gizzard blend containing sorghum flour and oilseed

Texture profile analysis revealed a significant difference ($P<0.05$) in the parameters of TPA analysis. The hardness value of T2 was significantly higher ($P<0.05$) than C and T1. The cohesiveness value of C and T1 were significantly higher ($P<0.05$) than higher than T2. The chewiness value of C and T1 was significantly higher ($P<0.05$) than T2. The springiness value of C and T1 was significantly higher ($P<0.05$) than T2. There was no significant ($P>0.05$) difference in the TPA parameters of C and T1.

5.4 Evaluation of storage stability of chicken nugget containing gizzard and chicken gizzard blend containing sorghum flour and oilseed (flaxseed) during refrigerated storage (4±10°C)

5.4.1pH

The pH of all the treatments increased significantly ($P<0.05$) with increase in storage period. There was a significant difference ($P<0.05$) in the pH value of C, T1 and T2 on 5th, 10th and 15th day of storage. The pH of C and was significantly higher ($P<0.05$) than T2 on 0th, 5th and 15th days of storage.

5.4.2TBARS

There was a significant ($P<0.05$) increase in TBARS value with increase in storage period for all the treatments. It was observed that TBARS value of T2 was significantly lower than C and T1 at 0, 5, 10 and 15th day of storage. Also there was no significant ($P>0.05$) difference between TBARS value of C and T1 at 0th, 5th, 10thand 15th day of storage.

5.4.3FFA

There was a significant ($P<0.05$) increase in FFA value with increase in storage period for all the treatments. It was observed that FFA value of T2 was significantly ($P<0.05$) lower than C and T1 at 0th, 5th, 10th and 15th day of storage. There was no significant ($P>0.05$) difference between FFA value of C and T1 at 0th, 5th, 10th and 15th day of storage.

5.4.4DPPH

there was a significant difference between DPPH value of C and T1 during 0 th day but the values of C and T1 on 0, 5, 10 and 15th day were non significant ($P>0.05$).

The DPPH value of T2 was significantly higher ($P<0.05$) than C and T1 throughout the storage period

5.4.5 PV

There was a significant ($P<0.05$) increase in PV value with increase in storage period for all the treatments. From the study it can be concluded that PV value of T2 was significantly lower ($P<0.05$) than C and T1 at 5th, 10th and 15th day of storage

5.4.6 TV

Tyrosine value of T2 was significantly lower than C and T1 throughout the storage period. There was no significant difference ($P>0.05$) between C and T1 at 5th and 15th day of storage. However, the Tyrosine value of T1 was significantly lower and significantly higher than C at 0th and 10th day respectively.

5.5 Evaluation of microbiological quality of chicken nugget containing gizzard and chicken gizzard blend containing sorghum flour and oilseed (flaxseed) during refrigerated storage (4±1°C)

5.5.1 Total plate count

The TPC increased significantly ($P<0.05$) with increase in storage period for all the treatments. There was no significant difference ($P>0.05$) in TPC of C, T1 and T2 on 0th day. It was observed that C and T1 had significantly higher ($P<0.05$) TPC than T2 on 0th, 10th and 15th days of storage

5.5.2Yeast and mould count

Yeast and mould count increased significantly in the control as well as the treatments throughout the storage period. Yeast and mould count of T2 was significantly lower than C and T1 on 0th, 5th, 10th and 15th day of storage.

5.5.3Coliform count

Coliforms were not detected throughout the storage period in the all the treatments.

5.6 Evaluation of sensory quality of chicken nugget containing gizzard and chicken gizzard blend containing sorghum flour and oilseed (flaxseed) during refrigerated storage (4±10°C)

5.6.1 Appearance

The appearance score of C and T1 was significantly higher (P<0.05) than T2 throughout the storage period. There was no significant difference in the appearance score of C and T1 on 0^{th}, 5^{th}, 10^{th} and 15^{th}day of storage period

5.6.2 Texture scores

The texture score of C and T1 was significantly higher (P<0.05) than T2 throughout the storage period. There was no significant difference in the texture score of C and T1 on 0^{th}, 10^{th} and 15^{th}day of storage period

5.6.3 Juiciness

The juiciness score of T2 was significantly higher (P<0.05) than C and T1 on $0^{th,}$ 5^{th}, 10^{th} and 15^{th} day of storage period. However, there was non significant difference between juiciness scores of C and T1 on $0^{th,}$ 5^{th}, 10^{th} and 15^{th} day of storage.

5.6.4 Flavor score

The flavor score decreased with increase in storage period for all the treatments. The flavor score of C, T1 and T2 had non significant difference (P>0.05) on 0^{th} day of storage period. However, there was a significant difference between C, T1 and T2 on 5^{th}, 10^{th} and 15^{th} day of storage. The flavor score of T2 was significantly higher than C and T1 on 5^{th}, 10^{th} and 15^{th} day of storage.

5.6.6 Overall acceptability

The study revealed that the there was a significant difference (P<0.05) between overall acceptability values C, T1 and T2 on 5^{th}, 10^{th} and 15^{th} day of storage. The overall acceptability of T2 was significantly higher (P<0.05) than C and T1 and T2 on 0^{th}, 5^{th}, 10^{th} and 15^{th} day of storage.

Conclusion

1. 8% gizzard, 14% sorghum flour and 12% of flaxseed was selected for formation of chicken gizzard blend and further incorporation in the chicken nuggets on the basis of sensory evaluation.

2. T2 had higher cooking yield and water holding capacity. C and T1 had almost similar cooking yield and water holding capacity. The protein content and moisture percent of T2 decreased significantly, however the fat content, ash content and crude fiber content increased significantly.

3. TPA analysis revealed that the functional T2 had significantly higher hardness and significantly lower chewiness, springiness and cohesiveness respectively in comparison to C and T1.

4. The pH of the nuggets incorporated with gizzard blend containing functional ingredients was significantly lower than C and T1.

5. In general the antioxidant properties of nuggets incorporated with gizzard blend containing functional ingredients was found to be better than C and T1.

6. The total plate count and yeast and mould count were lower in T2. Coliform count was zero throughout the storage period for all the treatments.

7. The sensory scores of T2 were found to be higher in case of juiciness, flavor and overall acceptability but lower in case of appearance and texture. The sensory scores of C and T1 were almost similar in every parameter.

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ABSTRACT

Present study was conducted to estimate the quality characteristics of functional chicken nuggets incorporated with chicken gizzard blend containing sorghum flour and oilseed. On the basis of sensory optimization trials 8% gizzard, 14% sorghum flour and 12% flaxseed were selected for incorporation in the nuggets. The cooking yield and WHC of the functional chicken nuggets was found to be significantly higher ($P<0.05$) than other treatments. The proximate analysis revealed a significant decrease ($P<0.05$) in protein and moisture content, however there was a significant increase ($P<0.05$) in fat, ash and crude fiber content of functional chicken nuggets. Texture profile analysis revealed a significant increase ($P<0.05$) in hardness and a significant decrease ($P<0.05$) in cohesiveness, chewiness and springiness of the functional chicken nuggets. The pH of functional chicken nuggets was significant lower ($P<0.05$) than other treatments. The functional chicken nuggets performed better for all the antioxidant parameters. TBARS, FFA, PV and TV were significantly lower ($P<0.05$) and DPPH value was significantly higher indicating a better antioxidant property. The microbiological analysis revealed that the total plate count and yeast and mould count were significantly lower ($P<0.05$) in functional chicken nuggets. The coliforms were absent throughout the storage period for all the treatments. Sensory evaluation revealed that the functional chicken nuggets scored better in terms of overall acceptability, flavor and juiciness but the appearance and texture scores were significantly lower. Hence, based on following results, we can conclude that the nuggets incorporated with gizzard blend containing sorghum flour and oilseeds has superior attributes in terms of cooking yield, water holding capacity, increased fiber and fat content, antioxidant activity, increased juiciness, flavor and overall acceptability.

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विभाग : पशुधन उत्पादन प्रौद्योगिकी
शोध शीर्षक : "ज्वार के आटे और तिलहन युक्त चिकन गिज़र्ड मिश्रण के साथ शामिल कार्यात्मक चिकन नगेट की गुणवत्ता विशेषताओं के प्रभाव का मूल्यांकन"
सलाहकार : डा. पी. के. सिंह

सारांश

वर्तमान अध्ययन में ज्वार के आटे और तिलहन युक्त चिकन गिज़र्ड मिश्रण के साथ शामिल कार्यात्मक चिकन नगेट की गुणवत्ता विशेषताओं का अनुमान लगाने के लिए आयोजित किया गया था। संवेदी अनुकूलन परीक्षणों के आधार पर कार्यात्मक चिकन नगेट में 8% चिकन गिज़र्ड, 14% ज्वार के आटे और 12% अलसी के चयन को शामिल किया गया। कार्यात्मक चिकन नगेट्स की खाना पकाने की उपज और पानी को रोकने की क्षमता अन्य उपचारों की तुलना में काफी अधिक ($P< 0.05$) पाया गया। समीपवर्ती विश्लेषण में प्रोटीन और नमी सामग्री में महत्वपूर्ण कमी ($P< 0.05$) का पता चला, हालांकि कार्यात्मक चिकन नगेट्स की वसा, राख और कच्चे फाइब रसामग्री में एक महत्वपूर्ण वृद्धि ($P< 0.05$) थी। बनावट प्रोफ़ाइल विश्लेषण से कठोरता में उल्लेखनीय वृद्धि ($P<0.05$) और कार्यात्मक चिकन नगेट्स के सामंजस्य, च्यूनेस और स्प्रिंगनेस में एक महत्वपूर्ण कमी ($P< 0.05$) का पता चला। कार्यात्मक चिकन नगेट्स का पीएच अन्य उपचारों की तुलना में महत्वपूर्ण कम ($P< 0.05$) था। कार्यात्मक चिकन नगेट्स सभी एंटीऑक्सिडेंट मापदंडों के लिए बेहतर प्रदर्शन करते थे। टीबीएआरएस, एफएफए, पीवी और टीवी काफी कम थे ($P< 0.05$) और डीपीपीएच मूल्य काफी बेहतर एंटीऑक्सीडेंट संपत्ति का संकेत देते थे। सूक्ष्मजीव विज्ञानी विश्लेषण से पता चला कि कुल प्लेट की गिनती और खमीर और मोल्ड की गिनती काफी कम थी ($P<0.05$)। संवेदी मूल्यांकन से पता चला कि कार्यात्मक चिकन नगेट ने समग्रस्वी कार्यता, स्वाद और रस के संदर्भ में बेहतर स्कोर किया, लेकिन अपील और बनावट के स्कोर काफी कम थे। इसलिए, निम्नलिखित परिणामों के आधार पर, हम यह निष्कर्ष निकाल सकते हैं कि गिगर्ड मिश्रण को ज्वार के आटे और तिलहन के साथ शामिल किए गए नगेट में खाना पकाने की उपज, पानी की धारण क्षमता, बढ़ी हुई फाइबर और वसा की मात्रा, एंटी ऑक्सिडेंट गतिविधि, बढ़े हुए रस, स्वाद और समग्ररूप में बेहतर गुण हैं।

(पी. के. सिंह)
सलाहकार

(दीपशिखा सिंह)
लेखिका