

TECHNOLOGY UPSCALING OF CERTAIN TRADITIONAL PORK PRODUCTS OF NAGALAND

A Thesis
Submitted to the
Assam Agricultural University

In partial fulfillment of the requirements for the Degree of

DOCTOR OF PHILOSOPHY
IN
LIVESTOCK PRODUCTS TECHNOLOGY



By

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*Affectionately
Dedicated
To My
Beloved Wife,
Loving Son
&
Daughter*

ASSAM AGRICULTURAL UNIVERSITY
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This is to certify that the thesis entitled “**TECHNOLOGY UPSCALING OF CERTAIN TRADITIONAL PORK PRODUCTS OF NAGALAND**” submitted to the Faculty of Veterinary Science, Assam Agricultural University, in partial fulfillment of the requirements for the Degree of **DOCTOR OF PHILOSOPHY** in **LIVESTOCK PRODUCTS TECHNOLOGY** is a record of research work carried out by **Dr. H. Moakum Sangtam**, under my personal supervision and guidance.

All kinds of help received by him have been duly acknowledged.

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ABSTRACT

Traditional pork products of Nagaland prepared with locally available plant based ingredients *viz.* *Anishi*, *Silam* and FDS (Fermented dried soya) were evaluated in the present study. Based on the popularity, a purposive survey was conducted in field level to evaluate the level of ingredients used and with an aim to refine and upscale the processing steps and to extend the shelf life of the products. Three formulations were prepared using pork with *Anishi*, *Silam* and FDS along with a control, prepared without adding the above ingredients. On the basis of pilot study, the level of incorporation for *Anishi*, *Silam* and FDS were selected as 5, 10 and 5 percent, respectively. The cooked products were packaged under two different systems *viz.* retort pouch and vacuum packaging. The retort pouched products were subjected to physicochemical, microbiological and sensory evaluation at ambient temperature (25-32°C) for 6 months whereas, the vacuum packaged products were evaluated at refrigeration temperature (4±1°C) for 15 days. The economics of products were also calculated. Under retort processing, the total heating time (min) was recorded to be highest in pork with FDS compared to control, pork with *Anishi* and *Silam*. The proximate composition i.e. percent moisture, crude protein, ether extract and total ash in retort pouch and vacuum packaging revealed highly significant ($p<0.01$) differences in control and the treated products. The pork with FDS revealed highest protein content in both retort and vacuum packaging. However, no significant differences were observed for different storage periods. For mean scores of pH, TBARS and tyrosine values highly significant ($p<0.01$) differences were observed among control and different product formulations and also during different storage periods. The TPC, coliform and yeast and mould were absent under retort pouch packaging during the entire storage period, conversely under vacuum packaging highly significant differences ($p<0.01$) were recorded in respect of TPC and psychrophilic count among control and all the treated products and at different storage periods. Coliform count was <3 and yeast and mould were absent in vacuum packaged products. The amino acid content in control and treated products were decreased with the increase in storage period. Highly significant ($p<0.01$) differences were observed in texture profile among control and the treated products as well as during different storage periods under retort pouch packaging. In respect of vacuum packaging significant ($p<0.05$) differences were observed during different storage periods among control and the treated products. Highly significant ($p<0.01$) differences were observed in colour profile under retort pouch and vacuum packaging in control and among the treated products and during storage period. The sensory evaluation showed highly significant ($p<0.01$) differences in appearance, flavour, juiciness, tenderness and overall acceptability in control and treated products and during storage period under retort pouch and vacuum packaging and revealed higher scores in pork with *Silam* and FDS compared to *Anishi* and control. The costs of productions were lower in all treated products compared to control under retort pouch and vacuum packaging. Based on the results obtained in the study it might be concluded that traditional pork products could be prepared economically by incorporating traditional ingredients like *Anishi*, *Silam* and FDS at 5, 10 and 5 percent levels using vacuum and retort packaging without any appreciable depreciation in nutritive values and sensory qualities till 15 days for vacuum packaging with refrigeration storage and for retort packaging till 180 days under ambient temperature.

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LIST OF ABBREVIATIONS & SYMBOLS

<u>ABBREVIATIONS</u>	<u>FULL FORM</u>
%	: Per cent
@	: At the rate of
°C	: Degree Celsius
<	: Less than
a*	: Redness
AOAC	: Association of Official Analytical Chemists
b*	: Yellowness
cfu/g	: Colony forming unit per gram
cm	: Centimetre
df	: Degrees of freedom
etc	: Et cetera
FDS	: Fermented Dried Soya
gm	: Gram
HDPE	: High Density Polyethylene
i.e.	: That is
kg	: Kilogram
L*	: Lightness
LAP	: Lactic Acid Bacteria
LS	: Lum sum
MAB	: Modified Atmosphere Package
mg	: Milligram
mins	: Minutes
ml	: Millilitre
MPN	: Most Probable Number
NEH	: North Eastern Hill
ND	: Not Detected
NS	: Non Significant
N/cm	: Newton per centimetre
N/cm ²	: Newton per centimetre square
Rs.	: Rupees
SE	: Standard error
TBARS	: Thiobarbituric Acid Reactive Substance
TPC	: Total plate count
viz.	: Videlicet
VP	: Vacuum Packaging

Chapter-I

INTRODUCTION

Traditions are customs or beliefs descend from one generation to the next, often by folklore, and they play an important role in cultural identification. Each culture, ethnic group or region has specific traditions such as religious customs, ethnic groups or regions. Specific eating habits play an important role in the traditional habits of many cultures. The use of particular food ingredients and food preparation methods has been passed on from generation to the next, and are nowadays referred to as traditional food (Weichselbaum *et al.*, 2009).

Traditional food products have a major role in the development and preservation of cultural heritage of different regions of the world/globe for thousands of years. They include foods that have been consumed locally and regionally for an extended time period (Grujic *et al.*, 2012). Preparation methods of traditional foods are part of the folklore of a country or a region. Due to changes occurring in the lifestyle of today's population, some of the traditional products are at a risk of disappearing. Therefore, it is very important that these products are researched, documented, and saved as part of a national, state or region culture (Weichselbaum *et al.*, 2009).

In most of the countries in the world, there are different traditional meat products and consumption habits and styles with different methods of preparation. Some of the traditional meat products includes *biltong* (South Africa), *jerky* (United States), *charqui* (South America), *pemmican* (North America), *pastirma* (Turkey, Egypt, Russia), *tasajo* (Cuba), *nikku* (Canadian Arctic), *sou nan* and *rou gan* (China), *carne seca* (Mexico), *fenalår* (Norway), (Burfoot *et al.*, 2010).

Most of the Northeast and Southeast Asian countries also have different meat-based traditional meat products and consumption cultures. Meat consumption culture in the East has not been well developed by its characteristic environment, religion, history, and main food staples. However, recently, the amount of meat production and consumption of the Eastern countries has grown rapidly by the globalization of food industry and rapid economic growth of the countries (Nam *et al.*, 2010). Some of the traditional meat products of Northeast and Southeast Asian countries are *dongpo rou* and

gulaorou (China), *bulgogi*, *galbi gui* and *makchang gui* (Korea), *korokke*, *tonkatsu* and *kakuni* (Japan), *phat kraphao*, *nham* and *sai oua* (Thailand), and *banh cuon*, *nem nuong* and *cha lua* (Vietnam).

Indian traditional meat products are very popular because of their ease of preparation and sensory attributes and they are unique to certain populations. The standardization of traditional meat products has made a considerable progress in India as the demand for traditional meat products is ever growing due to rapid urbanization and industrialization. Some important traditional meat products of India are *kababs*, *tandoori chicken*, *pickles*, *balls/koftas*, *curries*, *tikka*, *biryani* (Anjaneyulu *et al.*, 2008).

Northeastern India harbours a wide variety of traditional meat products prepared by the natives of the region, which reflects their social, cultural, spiritual, and ecological life. There is a wide variety of traditional meat products of Northeast India, which are prepared by using different ingredients. The method of preparation varies based on availability of materials, climate, culture and overall knowledge of process and methods (Kadirvel *et al.*, 2018). It is interesting to note that meat is processed and preserved in a variety of ways i.e., drying or by drying cum smoking or by salting and drying with local herbs or by fermentation. It is also observed that indigenous herbs, leaves of trees, roots, seeds, liquid vegetable extracts, spices and oils are used for preservation of some meat products. Certain herbal products used in meat preservation and processing has lipolytic, proteolytic, cholesterolytic and hepatoprotective properties. Based on popularity, pork stands first in the Northeast region followed by chicken, chevon and beef (Hazarika, 2013). Hazarika, (2013) documented some of the traditional meat products of the region which includes *adin*, *ngam phoat*, *tambe-akom*, *yoo-aso* and *ngam toongpak* (Arunachal Pradesh), *ar sa ret* and *dawng sa ret* (Mizoram), *bagjinam* and *ashi kioki* (Nagaland), *noau soum*, *cheu*, *sathu*, *saphak* and *eg-adin banum* (Assam), *doh klong*, *doh khleik*, *doh kpu*, *zadoh snam* and *doh pheret* (Meghalaya), *kheuri*, *suka ko maso* and *kargyong* (Sikkim), *pakku* (Tripura) and *sun/yen akangha* and *sun/yen ayaiba* (Minapur). Considering the diversities of the traditional meat products, the popular ones can be identified to explore its prospective potential in context to commercialization (Singh *et al.*, 2007).

In recent years, food scientists and nutrition specialists have agreed that daily consumption of fruits and vegetables contribute to reducing risk of certain diseases,

including cancer and cardio and cerebro-vascular diseases (Liu *et al.*, 2000). By-products from processing of fruit and vegetables offer a practical and economic source of potent antioxidants that could replace synthetic preservatives. These beneficial effects have been attributed to the various antioxidants present in fruits and vegetables such as polyphenol, ascorbic acid, carotenoids and tocopherols (Huxley *et al.*, 2003; Knekt *et al.*, 2002; Peschel *et al.*, 2006). Vegetables are also known to contain large amount of dietary fiber and phytochemicals that possess natural antioxidative properties (Yue, 2001).

Meat and meat products are of great demand in Nagaland. Among the meat, pork is one of the most preferred followed by beef and poultry. The consumption of pork is not only a delicacy it also occupies an important role in various religious and social occasions. Pork is an integral part of a Naga meal along with rice. Almost cent percent of the population consumes meat and there is no taboo associated with consumption of meat. Nagaland is known for its incomparable traditional and cultural heritage and for its unique cuisine. The local cuisine varies from tribe to tribe. Most of the cuisine that are prepared, both vegetables and meat are usually boiled. The meat used is often smoked, dried or fermented and various Naga tribes have their own cooking procedure especially the type of seasonings used. Some common dishes of Nagas are fermented bamboo shoot with fish and pork, *Axone* and *Anishi* with smoked pork. Naga food tends to be spicy usually with chillies, ginger and garlic. The garlic and ginger leaves are also used in meat cooking process.

Amongst the tribal and urban population of Nagaland the traditional pork and pork products consumption has been in rise. All the ingredients viz. *Anishi*, *Silam* and *Akhuni*/ Fermented Dried Soya (FDS) used in traditional pork products are readily available in the local market of Nagaland. Due to improvement of economic condition and rise in living standards of the people, there is tremendous scope for processing, value addition and marketing of pork and pork products. In addition, the preferences of traditional pork products have been gaining popularity and are in high demand in various markets in Nagaland. The increasing demand of Naga style cooked pork and pork products have resulted in opening of numbers of restaurants serving Naga cuisine in different towns and cities of northeast region.

It is therefore contemplated to undertake a study selecting certain popular traditional pork products of Nagaland with an aim to refine and upscale the processing steps using modern technology so that the same could be standardized and popularized for wider consumer acceptance and entrepreneurship development in future.

Keeping in view of the popularity and consumer preferences towards traditional pork products, the research work has been proposed to undertake with the following objectives:

1. To undertake a purposive survey in Dimapur district of Nagaland and to document the existing processing steps for the three commonly available traditional pork products in Nagaland viz. pork with *Anishi*, pork with *Silam* and pork with *Akhuni* /Fermented Dried Soya (FDS).
 2. To refine the formulation and processing steps in a pilot study to ensure uniformity in the processing of these products.
 3. To study the physicochemical, microbiological and sensory qualities of the products.
 4. To evaluate the shelf life of the products in different packaging systems under ambient and refrigeration storage temperature.
 5. To evaluate the economics of production for the above products.
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Chapter-II

REVIEW OF LITERATURE

2.1. IMPORTANCE OF TRADITIONAL INGREDIENTS IN MEAT PRODUCTS

India is a large country with different geo-climatic conditions having a large human population with various traditional, cultural and religious customs. A large variety of traditional food products are being prepared and consumed in India. Traditional processing of various meat products with locally available specific ingredients has resulted in the development of products with unique sensory attributes. Diversity in tradition and culture among different communities in NEH region has resulted in a large variety of traditional meat products (Kadirval *et al.*, 2018).

Hazarika (2014) observed that indigenous herbs, leaves of trees, roots, seeds, liquid vegetable extract, spices and oils are used for preservation of some meat products. It was also observed that tribal people claim certain herbal products used in meat preservation and processing has lypolytic, proteolytic, chloesterolitic and hepatoprotective properties. Some of the traditional fermented and spices mixed meat products are *bagjinam* by Sema Naga, *ashi kioki* by Naga tribes of Assam, *doh kpu* in Meghalaya, *yoo-Aso* by Apatani tribes of Arunachal Pradesh.

Varieties of products are being prepared from meat and fish with locally available vegetables, herbs and spices. Among them, indigenously produced blood sausage, animal by-products with rice flour, maize or fruits, dry meat powder with herbs and special preparation from animal fat preserved in dry gourd or bamboo containers are important (Lalthanpuii *et al.*, 2015).

Anishi is prepared from edible *Colocassia* species leaf mainly by Ao Naga tribe. The fresh mature green leaves are collected, washed and kept in a basket for a few days until the leaves turn yellow colour. These leaves are then pounded till they are well paste and cakes are made out of it. The cakes are dried over the fireplace in the kitchen. During grinding if desired, chillies, salt and ginger are added to it. The dried cakes are ready for use. It is cooked with dry meat especially pork, which is the favorite dish of Ao tribe (Mao and Odyuo, 2007).

Axone (*Akhuni*) is a traditional Nagamese fermented, sticky paste like product of soyabean with Umami flavour (slightly alkaline in taste with ammonical smell) resembling to fermented soyabean products used in other parts of North Eastern Himalayas including *hawaijar* of Manipur, *tungrymbai* of Meghalaya, *bekang* of Mizoram. It is quite similar to *natto* of Japan, *chungkukjang* of Korea, *thua nao* of Thailand, *pepok* of Myanmar and *sieng* of Cambodia in its preparation and culinary use. It is often eaten with food as chutney (side dish) or sometimes used for making curry as *kinema* of Sikkim (Singh *et al.*, 2014). *Axone* is often used as flavouring agent for preparing pork, fish and vegetable dishes in all parts of Nagaland (Singh *et al.*, 2009). Dried *axone* is made from matured *axone* when it got dried *in situ* after one or 2 months of storage, it is grounded and kept in airtight glass jars for use as curry powder (Singh *et al.*, 2009).

The quality of *axone* varies depending on variety of soyabean used, variation in environmental temperature, kitchen conditions, and finally the tribal liking for flavour. Lotha and Ao tribes like it mildly matured, Angami mostly like strongly fermented fresh *axone* while Sema and Chakhesang tribes prefer to consume brown fully matured *axone* (Singh *et al.*, 2009). Consumption of *axone* and *axone*-like fermented soyabean products is claimed to be associated with several health benefits despite of their very peculiar smell (Tamang, 2010). Traditionally these alkaline and smelly foods are considered good for health and enhancers of life span (Ohta, 1986).

The use of *Silam* seed (*Perilla frutescens*), which is slightly bigger than a mustard seed, is an exception to the traditional lack of the use of oil seeds in Naga cuisine. It has a rich taste and nutty flavour. Used extensively as a roasted and ground paste in curries and other ready- to-eat foods, it is most notably used in flavoring the Naga traditional bread (flat bread made from unleavened glutinous rice dough). In making bread, the seed is roasted and ground which is then mixed with hot water to form a dark liquid paste in which the bread is dipped.

The traditional food products are mostly prepared in individual households, which are not available commercially in food stalls of the region. The knowledge on the preparation method is generally passed on from one generation to the other through practice and word of mouth. Nowadays, food consumption pattern has been changing due

to increased income and livelihood of the people in the region, besides the high demand for ready to eat foods in the region (Kadirval *et al.*, 2018).

Tamang *et al.* (2009) documented various ethnic fermented soyabean foods prepared by Northeast women of India like *kinema* of Nepali, *hawaijar* of Meitei, *tungrymbai* of Khasi, *bekang* of Mizo, *aakhone* of Sema Naga and *peruyaana* of Apatani and observed that it is the cheapest source of plant protein as compared to animal and milk products on the basis of protein cost per kg, which is easily accessible to rural poor of Northeast region.

Chakrabarty *et al.* (2014) documented traditional knowledge, microbial profiles and nutritional value of some ethnic fermented foods and beverages of North Cachar (NC) Hills district of Assam with two popular ethnic fermented bamboo shoot products (wet-*Tuaitthur* and dry-*Tuairoi*), an ethnic fermented pork/boar meat product (*Honoheingrain*), a non-food dry mixed amylolytic starter (*Humao*), and an ethnic fermented beverage (*Judima*) and observed that the nutritional composition of ethnic fermented foods have the nutritional value essential for local people in their diet. Higher mineral contents in *judima* indicate contribution of mineral intake in the daily diet of the local people in NC Hills of Assam.

Tamang and Thapa (2014) studied some non-fermented ethnic foods of Sikkim in India by surveying the major ethnic communities, namely, Nepali, Bhutia and Lepcha by collecting on different types of non-fermented ethnic foods, as prepared and consumed by these inhabitants, the traditional method of preparation, mode of consumption, as well as culinary, socio-economic, and ethnic values and observed that the nutritional analysis, process technology development and packaging of these ethnic foods may boost ethnic food tourism in the region, which could in turn enhance the regional economy.

Thomas *et al.* (2014) studied on quality and shelf life evaluation of pork nuggets incorporated with fermented bamboo shoot (*Bambusa polymorpha*) mince and observed that bamboo shoot addition significantly improved the microbial and sensory qualities of the pork nuggets and also incorporation of fermented bamboo shoot at 8% level increased the shelf life of pork nuggets by at least two weeks i.e. from 21 days to 35 days at 4±1°C.

Longvah and Deosthale (1998) studied the effect of dehulling, cooking and roasting on the protein quality of *perilla frutescens* seed and observed that the potential of *perilla* seed protein can be increased by dehulling the seed, followed by cooking. Thus, consumption of *perilla* seed, in combination with cereal based diets, as is normally done by the tribal communities in Northeast India, could improve the dietary well being of these people. It is therefore necessary to preserve and promote a wider cultivation of such under exploited food plants.

Teramoto *et al.* (2002) studied the characteristics of a rice beer (*zutho*), a fermented product in Nagaland, India, and isolated one yeast from it. They have found volatile esters and higher alcohols, such as ethyl acetate and 3-methylbutanol in this indigenous alcoholic beverage, as detected by gas chromatography. Fermentation yeast isolated from *zutho* was identified as being a strain of *Saccharomyces cerevisiae* and was found to be suitable as the brewing yeast for ethanol fermentation.

Blandinob *et al.* (2003) studied some of the indigenous cereal-based fermented foods and beverages produced world-wide and observed that despite of the conventional foods and beverages largely produced from cereals in the Western world (breads, pastas and beers), there exists a wide variety of products produced worldwide that have not received the scientific attention they deserve. These products are often fermented, and have an improved self-life and nutritional properties in comparison with the raw materials used.

Llango and Antony (2004) studied the microbiological quality of *koozh*, a fermented millet beverage made with millet flour and rice consumed by ethnic communities in Tamil Nadu, India and observed that no *Staphylococcus* sp. and *Listeria* sp. were found high colony counts of *Clostridia* sp., *Salmonella* sp. and *Shigella* sp. were present in some samples. Pathogens were detected, indicating contamination following processing in the traditional fermented food. Lactic acid bacteria and yeasts were present in significant numbers.

Skowyra *et al.* (2014) studied the effect of *perilla frutescens* extract on the oxidative stability of model food emulsions and observed that it is a potential source of natural antioxidant to be used as a lipid oxidation inhibitor in food industry. In addition,

food emulsions appear to be useful vectors in supplying the daily dosage of *P. frutescens* extract in consumers, which may be suitable for use in the food matrix to help achieve potential health benefits.

Lee *et al.* (2015) studied the effects of *Perilla frutescens* var. *acuta* water extract (WEP) on the shelf life and physicochemical qualities of cooked beef patties and observed that addition of WEP to beef patties inhibited lipid oxidation and the growth of aerobic bacteria in beef patties during storage for 21 days at 4°C and can be used as a natural ingredient that improves the shelf life and sensory qualities of meat patties.

Freire *et al.* (2016) studied the double emulsions to improve frankfurter lipid content, impact of perilla oil and pork back fat reduced fat frankfurters involving the use of water-in-oil-in-water double emulsions (DEs) replacing pork back fat with two different DEs and observed that the *perilla* oil had a higher proportion of *n3* polyunsaturated fatty acids compared with all pork fat frankfurters. The replacement of pork back fat by *perilla* oil reduced the overall acceptability of products, water and fat binding properties.

2.2. IMPORTANCE OF CONVENIENT READY-TO-EAT MEAT PRODUCTS

“Ready-to-Eat” food is food that is offered or exposed for sale without additional cooking or preparation, which is packaged on the premises where they are being sold and are ready for consumption. Canned foods, convenience foods, fast foods, frozen foods, instant products, dried foods, preserved foods, etc. all come under Ready-to-Eat foods (Selvarajan, 2012) while “Ready to Cook” means that the food or a material in the food must be brought to a temperature sufficient to kill any pathogenic microorganisms before it is safe to consume. For example, gravy pouches added to boiling water to create gravy.

Defense Research Development Organization (2017) reported that they developed foods such as *aloo choley*, *sooji halwa*, fish curry, rice, dal curry, vegetable, and mutton *pulav*, etc., in retort amenable special kind of flexible polymeric films to achieve commercial sterility. The products are in a Ready-to-Eat (RTE) form and can be eaten as such, straight out of the packs or, if facilities exist, can be warmed up by dipping the pack in hot water or keeping in hot air microwave before being consumed. Such foods have better consumer appeal and acceptability as compared to their canned counterparts.

Convenience, ease of carrying and disposal after uses are the special appealing features for the consumers.

In the big cities, there is an increasing demand for fast foods where meat is regularly used. These are delicious, nutritious and if required easy to carry home. The growth of fast food parlours and restaurants is the indication of upward trend of entering our women into outdoor workforce. It might be noted that increasing in consumption of value added processed meat products is closely linked with increase in income and of urbanization (Sharma, 1999).

Recently, more attention is being paid to ready to eat or ready to cook meat products, because these are small packs of nutritious, instant, easy to open and convenient-to-store, reasonable price and attractive at first sight with acceptable flavour and colour will help to popularize these products (Prabhakar and Reddy, 2003).

Demographic variables and socio-economic characteristics of the consumers are also important variables, which decide the consumption pattern of food products in the family. Factors influencing the consumers' choice of RTE or RTC food are flavour, texture, appearance, advertising, a reduction in traditional cooking, fragmentation of family. Other factors positively influencing Ready to Eat food demand are rising income level, influence of western countries, more global trade, travelling, convenience in preparation due to lack of time and cost effectiveness (Selvarajan, 2012).

Incoronato *et al.* (2015) evaluated the synergic effects of MAP, essential oils (nutmeg and laurel) and Na-lactate on shelf-life extension of a ready-to-cook fresh meal based on meatloaf and semi-dried vegetables and increased the shelf life to more than 7 days during the storage at 4°C.

Now-a-days a large population has been migrating to different parts of India for education, job, and business. Commercialization of the ethnic meat products and adequate marketing can cater the palette of this population and address to the huge demand for different meat products in various regions of the country. Moreover, as the meat-processing sector has relatively high-value addition to products, commercialization of traditional meat products can enhance the income of the tribes from traditional engagement in home-based food processing. With the increase in the population of

working women in the urban sector, demand for processed products has increased to counter the time constraints of women for food preparation at home. Hence, commercialization of ethnic meat products can meet new consumer demands. The growing importance of meat and meat products in the NE region and property of the traditional meat products, with expected market potential, scope, roadmap, and opportunities for commercialization of traditional meat products in the NEH region of India (Kadirval *et al.*, 2018).

The pork consumption rate is highest in Northeastern region of India compared to other parts of the country. The demand of processed meat product is increasing in this region as evident by opening up of various meat products retail outlets in town and cities of this region. Presently Mac Donald's, Domino's etc. are operating retail fast food businesses in the urban areas of this region. Out of various processed meat products, pork occupies a unique place because of its popularity among the various tribes of Northeastern region. The consumers of Northeastern region mostly preferred locally prepared traditional products to satisfy their palate.

2.3. IMPORTANCE OF RETORT POUCHES PACKED MEAT PRODUCTS

Retort processing is the application of heat energy, for preservation of foods. It generally refers to a process during which a food product is subjected to high temperatures with the objective of inactivating undesirable microorganisms or enzymes (Vijayan, 1984).

Thermal processing of foods is a common operation in the food industry, ranging from pasteurization and blanching through cooking, to the relatively severe heat treatments to achieve sterilization (Cleland and Robertson, 1985).

Sterilization consists of heating food products at relatively higher temperatures (105°C to 125°C) to free the food from viable microorganisms. A viable organism being the one that is able to reproduce when exposed to conditions optimum for its growth. Temperatures slightly above the maximum for bacterial growth result in death of vegetative bacterial cells, whereas bacterial spores can survive much higher temperatures. Hence bacterial spores are of primary concern in sterilization processes (Sugisawa *et al.*, 1989).

Retort systems use steam or superheated water to cook food in its own package, extending shelf life and ensuring food safety. Retort flexible packaging is not new. In fact, it has been around since the late 1960s when the US Army began looking to replace its unpopular canned rations. That project led directly to Meal Ready-to-Eat (MRE) packaging, which the Army uses to this day. Since then, retort packaging has evolved from a mostly aluminum foil structure to a sophisticated multilayer, high barrier laminate package. There was virtually no resistance to the rapid adoption of the MRE. Because food packaged in the retort pouch tastes much better than canned rations (Hoss, 2002).

At present the processed meat foods are increasing in demand due to their high standards in quality of processing. Therefore, the food processing industries are aiming at the development and supply of food products that are sterile, nutritious and economical. Processed meat products are to be preserved in order to maintain their quality and nutritive value. By preserving meat products there should not be any changes in the appearance, flavour, taste, nutritive value and other quality characteristics. There are many methods of preservation of meat food products. One such method is thermal processing, which is a very effective method of processing foods (Karel *et al.*, 1975).

In a broad sense food, preservation is aimed at extending the shelf life of foods so that they are available whenever and wherever they are needed. Preservation also helps in preventing wastages and extending food supplies so as to meet the ever increasing needs of the burgeoning populations. From a technical view point, food preservation is to prevent undesirable changes in the wholesomeness nutritive value and /or sensory quality of food by economical methods, which control growth of microorganisms; produce chemical, physical, chemical and physiological changes of an undesirable nature; and obviate contamination (Rao, 2005).

The research efforts of Hu *et al.* (1955) have proved the technical and commercial feasibility of using retort pouches for thermo-processed foods. Retort pouches have several advantages such as shelf stability, less weight, less storage space, ease of opening and preparation. It has reduced heat exposure resulting in improved quality and packaging economy.

Satish (2005) reported that, thermally processed foods are in wide range and a variety of containers are used as packaging material. The processing techniques also differ from product to product and from package to package. Hence, the retort designs and operating procedures also vary.

Al-Baali *et al.* (2006) reported that the thermal sterilization is one of the most effective means of preserving a large part of everyday food supply. The main objective of sterilization is to extend the shelf life of food products and make the food safe for human consumption by destroying harmful microorganisms. A sterilizer is a unit in which food is heated at high temperature and then held at that temperature for a period sufficient to kill the microorganisms from the food product.

Retort pouch can be beautifully imprinted on, its size and shape are flexible, and it can be displayed on shelves to attract the attention of the consumers. It can be opened easily and the weight is light, food can get cooked using lesser time than in can and it also help to reduce the cost in delivery and storage (Dushyanthan, 2002).

Snyder and Handerson (1989) investigated the advantages of using a retort pouch to replace the conventional metal can. It was found that pouches gave greatly reduced process times for conduction heating products. Retort pouch is made from four layers of film that is polyester or polyamide 12 microns, nylon 15-25 microns, aluminum foil 7-9 microns and high density polyethylene or polyethylene-polypropylene copolymer 70-100 microns (Lu *et al.*, 1991).

Vijayalakshmi *et al.* (2003) reported that the product nearer the can wall is overcooked. Moreover, retort time is reduced from 30 per cent to 50 per cent and by as much as 57 per cent in a flexible pouch. If it is packaged in retort flexible packaging, no matter what it is, it tastes better, and the consumer absolutely loves that. In addition to better taste, the product looks better.

Hideshi (2007) reported that retort packaging is provided to the packager as pre-decorated ready-to-fill-pouch. The packager fills the pouch and then seals the package before it is retorted. Once again, this issue has been addressed and has been successfully dealt with. The critical seal is the one made at the top of the pouch after filling. The films

used on the inner sealing layer were developed specifically to survive the rigors of the retort chamber.

Retort pouch processing has several advantages over canning. At present, consumption of canned foods are declining (Nair and Girija, 1994), due to lack of reasonably priced tin for making cans acceptable to the market (Srivasta *et al.*, 1993). As an alternative to a metal can, the flexible laminated food package, the retortable pouch, which combines the advantages of metal can and the boil-in-bag and withstand thermal processing are being used.

2.4. VALIDATION OF RETORT PROCESSING

2.4.1. Fo value

Pressure was maintained at 20 psi throughout the retort process, using steam - air mixture while heating and water-air mixture while cooling. Rapid cooling was accomplished by recirculating cooling water. From thermal processing stand point, the recommended F_0 values for meat products is a minimum of 4 – 6 min (Mohan *et al.*, 2008).

The heat treatment given to the product in retort pouches are designated by F_0 value which is defined as the time in minutes at 121.1 °C assuming the whole can be raised simultaneously to this temperature & cooled instantaneously to a sub-lethal temperature afterwards, which would give the same degree of sterility as the process (Gillespy, 1951).

Salunkhe *et al.* (1978) studied the effect of storage temperature (37.8°C, 21.1°C and 4.4°C) on the quality of retort processed RTE foods showed accelerated deterioration at 37.8°C. Despite loss of quality, pouches stored at 21.1°C were acceptable for 54 months and the quality loss was negligible for the pouches stored at 4.4°C.

Ranganna (2000) reported that retort processed product had a core temperature of 121.1°C for 1.21 min. For meat with gravy in a can of all sizes, the F_0 value (lethal rate) of 12-15 was given for processing. For curried meat in a can size of up to 16 oz, the F_0 value (lethal rate) of 8-12 was given.

The heat penetration data of conduction or convection heated foods, can be represented in a single straight line on a semi logarithmic graph. Once the basic heat penetration data is obtained for a given product in a specific retort pouch or can size, the process time required to achieve a specified F_0 can be easily calculated (Stumbo, 1973).

In low acid foods processing could be based on inactivation of spores which is more heat resistant than *Clostridium botulinum* i.e. *Bacillus stearothermophilus*, a facultative anaerobe. Since spore forming bacteria do not grow at pH less than 4.5, hence process in acid foods are generally based on inactivation of Yeast and Moulds (Potter, 1968).

Gopal *et al.* (2001) maintained the retort temperature at 121.1°C and the traditional Kerala style fish curry, filled in pouches were heat processed to F_0 values of 6.56 and 8.43. Seer fish curry in retort pouches were heat processed at 121.1°C to F_0 value of 11.5 min.

2.5. MICROBIOLOGY QUALITY OF RETORT POUCHES PACKAGING

The microbial spoilage of processed products is either due to inadequate heat processing or due to post process leakage (Warth, 1978). He also reported that higher the temperature at which a spore forming organism can grow, the greater is the heat resistance of its spores. Hence, the spores of thermophilic organisms usually have heat resistance greater than the mesophilic group.

Bacteria which cause spoilage in canned and retort processed foods are, generally, organisms growing in the temperature range of 20-45°C, and may be aerobic, anaerobic, or facultative, with respect to oxygen requirements. In the processing of low –acid foods (pH >4.6), the process schedule is evolved on the basis of destruction of the most heat – resistant organism, likely to cause the spoilage above the botulinum cook (Food Processors Institute, 1975).

Spore forming mesophilic bacteria are of significance in foods that have a pH value greater than 4.6, in this group, toxigenic *Clostridium botulinum* is the most important. Thermal processing should destroy the spores of this organism (Ranganna, 2000).

From a thermal processing standpoint, foods are divided into three pH groups viz., high acid foods (pH < 3.7), acid or medium-acid foods (3.7-4.5) and low acid foods (pH > 4.5). The low acid foods are generally processed to 121°C for 2 to 3min, so that every particle of the food receives the above temperature, which provides a considerable safety factor for expected levels of contamination (Bryan, 1974). The recommended F₀ value for meat and meat products is a minimum of 6 min (Shapton and Shapton, 1997).

2.6. SHELF LIFE OF RETORT POUCH PROCESSED FOODS

Products with long shelf life are classified as shelf stable Ready-To-Eat (RTE) foods. RTE can be defined as foods that are ready to eat and have a long shelf life. They can be preserved at ambient temperatures without the aid of the refrigeration. All thermally processed foods that use the sterilization technique come under this category. Some of the pasteurized foods like fruit juices, jams and similar products also fall in to this category owing to their shelf stability with refrigeration. Canned foods that use metal containers, glass bottles, and retort pouches and aseptically processed (long life) and packaged foods also belong to this class (Ranganna, 2000).

A product processed under retort processing will have a long shelf life. Several authors reported varying shelf life from 90 days to 12 months (Rathnakumar and Shamasunder, 1998; Vijayan *et al.*, 1998; and Devadason, 2000) and some reported 24 months of shelf life with slight decrease in sensory scores (Chandrasekar *et al.*, 2004; Manju *et al.*, 2004; Bindu *et al.*, 2004 and Bindu *et al.*, 2007).

Worknic (2004) reported that retort pouches are suitable for Asian entrees. Asian style entrees were driven by consumer demand for convenience, variety and larger portion sizes.

Defense Research Development Organization (2018) reported that they prepared both vegetarian and non-vegetarian products having a shelf life of 12 months and are suitable for combat rations.

Kumar (2005) reported that though shelf stable RTE foods were available in the Indian market for a long time in package forms as cans, glass bottles, more recently, in

aseptic packages, the advent of retort pouch processing technology has made the availability of Indian preparations in shelf stable and ready to eat form a reality.

Rajkumar (2008) reported that *Chettinad* goat meat product processed in indigenous retort pouches using an indigenous retort machine with a total lethality (F_0) value of 12.10 had a shelf life of 10 months at ambient temperature ($32 \pm 2^\circ\text{C}$) without any appreciable depreciation in the nutritive values and sensory qualities.

2.7. VACUUM PACKAGED MEAT AND MEAT PRODUCTS

Vacuum packaging is recent innovations that have been gaining importance as preservation techniques to improve the shelf life of meat and poultry. In Vacuum Packaging, air is completely removed however; color is regained when meat is removed from Vacuum packets and exposed to air. Vacuum packaging offers several unique advantages for retaining the desirable market quality of meat and meat products. Vacuum packaging is a significant area of advancement to further improve the safety of meat and poultry products (Akhtar and Pandey, 2015).

Kim *et al.* (2014) (b) studied the effect of packaging method *viz.* Vacuum packaging and modified atmosphere packaging on various physico-chemical properties of dry cured pork neck stored at 10°C for 90 days and concluded that vacuum packaging was better than modified atmosphere packaging in maintaining the quality of the product during extended storage time.

Davies *et al.* (1995) described vacuum packaging, in which a pressure differential exists between the package exterior and interior. This differential can cause package collapse of rigid packages, but is well suited for some types of flexible packaging. The gaseous atmosphere is likely to change during storage due to respiration of the fresh food product (meat or plant) or the metabolism of microorganisms.

Vacuum packaging is accomplished by evacuating all the air within a package and not replacing with another gas, then sealing that package (Davies, 1995, Brody, 1989). In the process of vacuum packaging, a pressure differential exists between the package exterior and interior. This differential can cause package collapse of rigid packages, but is well suited for some types of flexible packaging. The gaseous atmosphere is likely to

change during storage due to respiration of the fresh food product (meat or plant) or the metabolism of microorganisms.

2.8. QUALITY CHANGES IN VACUUM PACKED MEAT AND MEAT PRODUCTS DURING STORAGE

Bhattacharyya, *et al.* (2013) reported that the optimum storage condition throughout the retail chain of duck sausage. PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging stored in refrigerator ($4\pm 1^{\circ}\text{C}$) and freezer ($-18\pm 1^{\circ}\text{C}$). TBA value, pH, Tyrosine value, TPC, TPSC and YMC of the samples increased with the storage period whereas a decreasing trend in case of moisture and all the sensory parameters throughout the storage period was observed. Irrespective of the packaging material, duck sausages were acceptable upto 30th and 50th day of refrigerated storage and 4th and 6th month of freezer storage in aerobic and vacuum packaging respectively.

Ozpolat *et al.* (2014) studied the effect of vacuum packing on shelf-life of sausages produced from *capoeta umbla*. Microbial, chemical and sensory were analyzed throughout the storage time. *E. coli*, *Staph. aureus* and coliforms were not detected in the sausage sample. Total volatile basic nitrogen (TVB-N) and thiobarbituric acid (TBA) increased gradually with storage period and vacuum packing at $4\pm 1^{\circ}\text{C}$ extended the shelf life of sausage for 30 days.

Devi and Singh (2018) studied the effect of vacuum packaging on physico-chemical and sensory attributes of guinea fowl meat sausages during storage at refrigeration temperature ($4\pm 1^{\circ}\text{C}$). Physico-chemical and sensory attributes were analyzed on 0th, 3rd, 7th, 14th, 17th, 21th and 30th day. pH of the aerobically packaged product was found to be non-significantly higher than vacuum packaged product during storage. Highly significant ($P<0.01$) reduction was observed in scores for sensory attributes with advancement of storage period. Vacuum packaged product showed significantly higher ($P<0.01$) score for appearance/colour, flavour, texture, juiciness and overall acceptability throughout the storage period. Vacuum packaging was found to be much more effective to preserve the physico-chemical and sensory quality of the product. Vacuum packaged product maintained a higher score till 21st day, however, scores decreased significantly

($P < 0.05$) with advancement in storage period, but the product was within the acceptable range.

Mathew *et al.* (2016) investigated the effect of vacuum packaged shelf life of chicken at different storage temperatures with different Low density polyethylene (LDPE) packaging materials for 60 days and analyzed for chemical and microbial parameters. Vacuum packaging effectively retarded the growth of microbial spoilage at freezing temperature and there was a gradual reduction in protein and fat levels.

Naveena *et al.* (2015) studied the effect of aging on the physicochemical, textural, microbial and proteome characteristics of emu (*Dromaius novaehollandiae*) meat under aerobic packaging (AP) and vacuum packaging (VP) conditions at $4 \pm 1\text{C}$ for 9 and 15 days, respectively. Improvement ($P < 0.05$) in water-holding capacity, myofibrillar fragmentation index and protein extractability with aging was observed in emu meat cubes under both AP and VP conditions. Reduction ($P < 0.05$) in Warner-Bratzler shear force values was observed on the 6th and 15th day of aging compared with the 0th day in the AP and VP samples, respectively. The sodium dodecyl sulfate-polyacrylamide gel electrophoresis analysis revealed the appearance of 30-kDa protein bands, indicating extensive proteolysis on the 6th day and 9th day of aging in the AP and VP samples, respectively. Proteome analysis using two-dimensional gel electrophoresis revealed significant ($P < 0.01$) changes in the number of differentially expressed protein spots in the AP and VP samples during aging.

Naveena *et al.* (2014) described the effect of different cooking methods *viz.*, moist cooking (nuggets), dry cooking (patties) and deep-fat frying (croquettes) on lipid oxidation and microbial quality of few emulsion-based meat products from chicken under vacuum packaging conditions during refrigerated storage. When different cooking methods were studied, croquettes were the most affected ($P < 0.05$) by lipid oxidation as indicated by thiobarbituric acid reactive substances, peroxide value and free fatty acids compared with nuggets or patties. Croquettes had lower ($P < 0.05$) water activity than nuggets and patties. Total plate counts and psychrotrophic counts remained lower ($P < 0.05$) throughout the storage for croquettes compared with nuggets or patties. Based on lipid oxidation and microbial quality, it was concluded that moist-cooked nuggets, dry-cooked patties and

deep-fat fried croquettes were stable for 40, 60 and 80 days at refrigerated storage under vacuum packaging.

Sharma *et al.* (2017) studied chevon *tikkis* under vacuum and aerobically packaged and stored at $4\pm 1^{\circ}\text{C}$ in refrigeration temperature. The storage stability of vacuum packaged (VP) *tikkis* was evaluated. Physicochemical properties, microbiological studies and sensory properties were evaluated on 0, 7, 14 and 21 days of storage. The VP product showed a significantly ($P<0.01$) lower TBA value. Microbiological studies revealed that in VP products TVC, anaerobic count, proteolytic count, yeast and mold count and lipolytic count increased significantly ($P<0.01$) with the advancement of storage period, with significantly lower ($P<0.01$) microbial counts observed for VP product throughout the observation period. Significantly ($P<0.01$) higher scores for appearance, colour, flavour, texture and overall acceptability were noticed throughout the storage period for VP product. Sensory attributes decreased significantly ($P<0.01$) with advancement of storage period and demonstrated that vacuum packaging was effective to preserve the physicochemical, microbiological and sensory attributes of the chevon *tikki* up to 14 days of storage at refrigeration temperature ($4\pm 1^{\circ}\text{C}$).

Bingol *et al.* (2013) investigate the effect of vacuum packaging on the meat quality of frozen cooked doner kebab. Packaged doner kebabs were stored at $-18\pm 1^{\circ}\text{C}$ for up to 12 months and examined monthly for microbiological (total aerobe *mesophilic* bacteria and *Pseudomonas* spp.), physicochemical (pH, moisture, fat, TBARS, and instrumental color L^* , a^* , b^* , and ΔE^*), and sensorial characteristics during the storage period. As a result, the quality and shelf-life of vacuum-packaged and frozen cooked doner kebabs were preserved throughout the storage period of 12 months. Microbial growth in doner meat was delayed due to the lack of O_2 in the package, which prevented the increase of lipid oxidation and improved the consumer acceptance for up to 9 months. However, loss of colour and leakage of fat during long storage may adversely affect consumer preferences.

Deuri *et al.* (2016) studied on ready-to-eat *Vawksa rep* (smoked pork product) and effect of curing ingredients and vacuum packaging on the physico-chemical and storage quality during refrigerated storage at ($4^{\circ}\text{C}\pm 1^{\circ}\text{C}$) for 15 days and reported that higher cooking yield, favorable pH, lower TV, and lower TBA values, sensory properties (higher odour scores, higher colour, flavour, texture, juiciness, and overall acceptability scores)

and microbiological properties (lower TPC, absence of colititer, and *E. coli* count) throughout the storage period of 15-day. RTE *Vawksa rep* could be prepared easily with little technology up-gradation and with a negligible escalation of production cost.

Kumar *et al.* (2016) developed novel chicken sausage with the incorporation of paneer and oats that had good sensory appeal and health promoting properties. The quality characteristics of the novel sausages were studied under both aerobic and vacuum packaging in chiller conditions ($4\pm 1^{\circ}\text{C}$) on days 0, 3, 5, 7 and 10 and compared with control sausages. Results of the study revealed that sausages incorporated with paneer and oats showed significantly lower dimension shrinkage and cooking gain was observed when compared to control. Proximate principles like protein, fat and ash were similar in both control and treatment sausages. Vacuum packaging was found to be effective in reducing thiobarbituric acid reactive substances and tyrosine values and aerobic plate counts in both sausages. Treatment sausages had similar sensory scores as control sausages. Aerobically packed control and treatment sausages were spoiled on day 10, whereas the vacuum packed sausages maintained their quality on day 10. Vacuum packed novel chicken sausage containing paneer and oats can be considered as a novel functional meat product which can be manufactured and marketed commercially.

2.9. CHANGES IN MICROBIOLOGICAL CHARACTERISTICS OF VACUUM PACKED MEAT PRODUCTS

The presence or change in microbial load in stored meat product is influenced by many factors like temperature, nutrient present in meat, oxygen, pH, water activity, humidity and packaging system which affect the growth and multiplication of bacteria (Forrest *et al.*, 1975; Locker *et al.*, 1975; Lawrie, 1979; Panda, 1980; Fung *et al.*, 1981).

Jeremiach (2001) reported that vacuum packaging inhibits the microbiological growth and delays the development of spoilage due to a slow proliferation of bacteria capable of tolerating anaerobic conditions.

Lactic acid bacteria (LAB) are the major bacterial group associated with the spoilage of vacuum-packed meat products (Lyhs *et al.*, 1999; Samelis *et al.*, 2000 a,b; Sakala *et al.*, 2002; Jones, 2004).

Meldruma *et al.* (2014) reported the variation in the microbiological quality of commercially produced vacuum-packed cooked sliced meat between production and the end of shelflife. Samples were examined for aerobic colony count (ACC), *Enterobacteriaceae*, *Escherichia coli*, *Listeria*, and *Salmonella*. When compared to current UK guidelines for the quality of ready to eat food, samples were found to be unsatisfactory for ACC, *Enterobacteriaceae*, and *E. coli*. Unsatisfactory rates increased at the end of shelf-life compared to the unsliced meat sample results. No samples were positive for *Listeria monocytogenes* or *Salmonella*.

Bhattacharyya *et al.* (2013) estimated the optimum storage condition throughout the retail chain of duck sausage. PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging stored in refrigerator ($4\pm 1^{\circ}\text{C}$) and freezer ($-18\pm 1^{\circ}\text{C}$) condition were considered in the experiment. They found that TPC, TPSC and YMC of the samples increased with the storage period.

Pavankumar *et al.* (2003) investigated the effects of vacuum packaging on the microbiological quality of tandoori chicken stored at $4 \pm 1^{\circ}\text{C}$ or -18°C . Chicken stored without vacuum packaging served as a control. Microbiological quality of tandoori chicken under vacuum was unacceptable after 15 days storage at $4 \pm 1^{\circ}\text{C}$, compared to 6 days storage without vacuum packaging. Aerobic plate counts (APC) increased from an initial level (log cfu/g) of 3.67 to 6.75 by the 15th day in vacuum packaging and to 6.18 in control packs by the 6th day of storage at $4 \pm 1^{\circ}\text{C}$. Psychrotroph counts (log cfu) also increased markedly from an initial level of 0.05 to 6.18 in control packs by the 6th day and 5.69 in vacuum packaging by the 15th day. APC (log cfu/g) of the tandoori chicken increased marginally in vacuum packs during the storage period of 40 days at -18°C to reach a level of 4.75 from an initial count of 4.44 and indicated that the shelf-life of tandoori chicken was extended considerably at lower temperature under vacuum.

Anderson *et al.* (1989) reported 29 packages of precooked, vacuum-packaged beef and pork products purchased at local and regional supermarkets along with 110 packages of precooked, vacuum-packaged, sliced roast beef obtained from a major meat processor did not disclose the presence of *Escherichia coli*, coagulase-positive *Staphylococcus aureus*, *Clostridium perfringens* or *Salmonella*. The effects of storage temperature and length of storage on the microflora of 110 packages of sliced roast beef were determined at

specific intervals of storage up to 84 days at 1°C and 5°C, and up to 28 days at 10°C. The microflora of samples stored at 1°C and 5°C was dominated by *Lactobacillus spp.* Precooked; sliced roast beef had a longer shelf life in laboratory controlled evaluations when stored at 1°C as opposed to 5°C or 10°C.

Patterson *et al.* (1984) reported that, Vacuum packaging and gas packaging (CO₂:N₂; 1:9 or 2:8) gave useful extensions to the shelf-lives of both breast and leg and

thigh portions of chicken. Extension of shelf-life was more marked at 1°C than at 4 to 5°C

and with breast portions rather than leg and thigh portions. Psychrotrophic *Enterobacteriaceae* was more likely to be a problem at the higher storage temperature on breast portions and *Alteromonas putrefaciens* on leg and thigh portions. Lactic acid and

potassium sorbate pre-treatments were of value in controlling multiplication of *Alt.*

putrefaciens on leg and thigh portions.

Naveena *et al.* (2014) studied the microbial quality of few emulsion-based meat products from chicken under vacuum packaging conditions during refrigerated storage. They found that Total plate counts and psychrotrophic counts remained lower ($P < 0.05$) throughout the storage for croquettes compared with nuggets or patties. Based on lipid oxidation and microbial quality, it was concluded that moist-cooked nuggets, dry-cooked patties and deep-fat fried croquettes were stable for 40, 60 and 80 days at refrigerated storage under vacuum packaging.

Rajkumar *et al.* (2004) found that Patties prepared from goat's meat packed in HDPE under vacuum (VP) and aerobically (AP). It was observed that vacuum and aerobically packed patties were stored at $4\pm 1^{\circ}\text{C}$ and evaluated for microbiological changes on days 0, 5, 10, 15, 20 and 25 days. The packaging method had no significant effect, storage period influenced microbial counts. The standard plate counts (SPC), which were initially $\log 5.98$ CFU/g decreased significantly.

Nowak and Krysiak (2005) reported that microbial quality of vacuum-packed frankfurters stored for 18 days contained *ca.* 10^1 - 10^2 cfu/g aerobic bacteria. The storage at 4°C , 8°C and 15°C caused an increase in the population of bacteria and largest was observed from 4-5 log.

Plavsic *et al.* (2015) conducted a study to determine the microbiological quality of an artisanal dried smoked meat product, manufactured in a domestic household and reported that the yeast counts were approximately 1.0×10^7 cfu/g while mould counts were 1.2×10^6 cfu/g. Two commonly present *Penicillium* species were identified: *P. aurantiogriseum* and *P. commune*.

Petit *et al.* (2013) studied the microbiological characteristics of several biltong samples from South Africa and in analysis of yeast and mould, yeast showed a strong predominance than moulds, highest concentration was observed in moist biltong i.e. above 7.0 log cfu/g.

Rao *et al.* (2003) have reported that meat processed by intermediate moisture technology could inhibit the growth of bacteria and yeast and moulds and the product became shelf stable at ambient temperature for varying periods of time.

2.10. SENSORY CHARACTERISTICS OF VACUUM PACKAGED MEAT AND MEAT PRODUCTS

Pavankumar *et al.* (2003) observed that sensory quality of vacuum packed tandoori chicken deteriorated significantly during storage at $4\pm 1^{\circ}\text{C}$; however, it was still acceptable on the 15th day of storage.

Bhojar *et al.* (1997) found that vacuum packaged products were rated higher in colour, flavor, juiciness, texture and overall acceptability score compared to LDPE packed

products during frozen storage. Sensory evaluation showed significant reduction in colour, flavor, texture and overall acceptability score with slight off flavor after 7th day of packaging in air and after 10th day of vacuum packaging.

Singh *et al.* (2002) observed that the product packed under vacuum or nitrogen gas remain organoleptically acceptable for 10 and 15 days under refrigerated and frozen storage as against 8 and 10 days long shelf life of aerobically packed samples under same storage conditions.

Bhoyar *et al.* (1998) reported that sensory evaluation of both aerobically packaged and vacuum packaged restructured chicken steak sample showed that the product from both packaging group were quite acceptable at the end of day 60 during frozen storage. However, vacuum packaged product were rated higher in colour, flavor, juiciness, texture and overall acceptability, whereas, finding of Rajkumar *et al.* (2004) proposed that vacuum packaging has definite advantages in preserving the sensory quality of patties but not enable extension of shelf life beyond 15 days.

Sahoo *et al.* (1998) described the sensory quality of frozen ground buffalo meat by preblending with natural antioxidant and vacuum packaging and they observed that, vacuum packaging samples had lower amount of salt extractable proteins and colour and odour score as compared to aerobically packed samples.

Zhao *et al.* (1996) studied the physical chemical and sensory characteristics of irradiated pork loin cut and reported that improvement of surface colour and odour in irradiated pork can be achieved by suitable packaging environment i.e. vacuum and CO₂ atmospheres.

Bhattacharyya *et al.* (2013) found that all the sensory parameters of aerobic and vacuum packed duck sausage during the storage period were observed. They observed that duck sausages were acceptable upto 30th and 50th day of refrigerated storage and 4th and 6th month of freezer storage in aerobic and vacuum packaging respectively. Freezer temperature enhanced the product quality upto 3rd and 5th month against 20th and 40th day of refrigerated storage in aerobic and vacuum packaging respectively.

Rajkumar *et al.* (2004) evaluated the sensory quality of vacuum package (VP) and aerobically (AP) patties. Patties prepared from goats meat and both packed patties were stored at $4\pm 1^{\circ}\text{C}$ and evaluated for sensory quality changes on days 0, 5, 10, 15, 20 and 25. All samples of AP patties revealed swollen, greasy and sticky surface with spongy texture on day 20 whereas only some of the VP patties shown such changes on day 20. Results indicated that vacuum packaging had definite advantage in preserving the sensory quality of patties than aerobic packaging but it did not help in extending the shelf-life beyond 15 days.

2.11. USE OF NON MEAT INGREDIENTS IN MEAT AND MEAT PRODUCTS

Rai *et al.* (2009) studied the indigenous meat products, production, traditional knowledge of preparation and socio-economy of the products prepared by Himalayan people by surveying in different places (Kunaun hills, Sikkim, Darjeeling hills, Bhutan in the Eastern Himalayas and Nepal of the central Himalayas) and observed that fermented meat and sausages are considered safe for consumption due to low pH and water activity which inhibit the growth of pathogenic bacteria.

Kanatt *et al.* (2007) used mint leaf extract @0.1% in lamb meat and kept at chilled temperature for four weeks and found that there is reduction in TBARS value and mint leaf extract showed antioxidant activity equivalent to BHT.

Akarpat *et al.* (2008) used myrtle, rosemary, nettle and lemon balm extract in beef patties wrapped in PE films and reported reduced lipid oxidation during storage period.

Biswas *et al.* (2012) investigated different solvent extracts of curry and mint leaf for their effect on oxidative stability and colour of raw ground meat stored at $4\pm 1^{\circ}\text{C}$ and reported that ethanol extract of curry leaf and water extract of mint leaf showed higher DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis) activity. There is reduction in TBARS values in treated values when compared to control samples during storage periods.

Nam *et al.* (2016) conducted a study to compare antioxidant activities of sun-dried venison amended with green tea powder (T1-3: 0, 0.5 and 1%) and beef jerky and reported that venison jerky amended with green tea powder was better than beef jerky at inhibiting of microbial growth and retarding lipid oxidation.

Rohlik *et al.* (2013) in a research study reported that rosemary extracts and lycopene appear to be efficient antioxidants in dry fermented sausages (pork), addition of

these two has positively affected the colour and suppressed lipid oxidation in both meat and lard particles of the product.

2.12. USE OF VEGETABLES AND CONDIMENTS

Ginger rhizome has been shown to possess an antioxidative agent that prevents lipid oxidation in foods (Lee *et al.*, 1986) and also contains a powerful enzyme which can be used as tenderizing agent. (Thompson *et al.*, 1973; Syed *et al.*, 1992a; Meena and Vijay Sethi, 1994).

Eugenol, an essential oil found in clove was determined to be spore static at the concentration of 0.05-0.6 per cent (v/v) (Al-Khayat and Blank, 1985).

Park *et al.* (2008) found that garlic and onion powders were effective in reducing TBARS values in fresh pork belly.

Cao *et al.* (2013) reported that there is reduction in lipid oxidation during addition of garlic, ginger and onion extract in stewed pork when kept at 4°C for 12 days.

Zhang *et al.* (2016) studied the effect of black pepper essential oil on TBARS value, meat colour, percentage of metmyoglobin, microbiological parameters and total volatile basic nitrogen of pork loins stored at 4°C for 9 days and reported lower TBARS value, retardation in formation of Metmyoglobin, yellowness values, lower *Pseudomonas spp.* and *Enterobacteriaceae* count and total volatile basic nitrogen values but higher redness and lightness values than control sample.

Three widely consumed Mexican condiments (mole sauce, achiote, and pasilla hot pepper) were analyzed for their total phenols, flavonoids and proanthocyanidins, antioxidant activity, and protective effect against lipid oxidation in chopped pork meat. All samples showed high antioxidant activity, and good correlations with phenolic compounds and flavonoids, while no correlation was observed in the case of condensed tannins. Mole sauce methanolic extract showed the highest inhibition of pork meat oxidation, followed by pasilla pepper, and finally achiote paste extracts. These results suggest that these condiments are useful to prevent meat lipid oxidation during storage (Parrilla *et al.*, 2014).

Shan *et al.* (2009) used cinnamon stick extract, oregano extract and clove extract @ 100ml/ 25g in aerobically packaged raw pork and kept for 9 days at -20°C and it resulted in reduction of lipid oxidation and clove was most effective antioxidant among all.

Several studies have shown antimicrobial and antioxidant potential of spices and herbs such as basil, thyme, rosemary, garlic, clove, coriander, ginger, mustard and pepper (Sebranek *et al.*, 2005).

2.13. USE OF SALT

Salt is the most commonly used functional ingredient in meat product manufacture. It is used primarily for flavour with microbial inhibition, extension of shelf-life and increased protein hydration as secondary functions (Mills, 2004).

Petit *et al.* (2013) studied the microbiological physicochemical characteristics of several commercial beef, kudu and biltong samples and reported that commercial dry biltong with low moisture content, low water activity and high salt (NaCl) content showed a low TPC content, high level of LAB as compared to moist biltong with low salt content.

The growth rate and total population of *Clostridium botulinum*, *Clostridium perfringens*, *Clostridium sporogens* and *Staphylococcus aureus* were inhibited by 0.7-1.2 per cent salt (Tanner and Evans, 1993).

Salt (sodium chloride) is used for preservation, reduce water activity and to impart taste to the processed meat products. Salt is the most common and important non-meat ingredient in the meat products. It serves as preservatives, controls moisture level, enhance product texture and provide obvious effect on flavour (Anon, 1980).

Salt (sodium chloride) in cured meat products stabilizes myofibrillar protein (Mardsen, 1980). These salt soluble protein forms a matrix upon which coagulation during heat processing results in acceptable product yield, texture, moisture, appearance, overall quality and products identity (Schmidt *et al.*, 1981).

During salting meat undergoes physico-chemical and biochemical processes that influence the raw material components, sometimes associated with antimicrobial activity (Gutierrez, 2008).

Ferreira *et al.* (2013) studied the effect of different sodium chloride level (0%, 2.5%, 5%, 7.5% and 10%) on physicochemical and microbiological qualities of dried salted pork and found that 5% NaCl can be used in pork meat in order to maintain the qualities.

On the other hand, sodium chloride can have technological functions difficult to be found in a single product, such as protein solubilization, flavor enhancement, preservation of food, and increased shelf life (Weiss, 2010).

2.14. PHYSICO-CHEMICAL CHARACTERISTICS

2.14.1. pH

The pH changes during heating may be caused by charge changes or hydrogen bonding, or both, within myofibrillar proteins (Hamm and Deatherge, 1960), by splitting of hydrogen bonds, which released additional positive charges.

The pH of normal meat varies from approximately 5.2-6.6 owing mostly to difference in amount of glycogen available for transformation into lactic acid at the time of slaughter (Watts, 1954).

Mittal and Blaisdell (1984) reported a pH increase of 0.16 to 0.30 units during cooking.

The heating may also cause the formation of new hydrogen bonds around the isoelectric point of actomyosin. During heat coagulation of tissue myofibrils, actomyosin and the number of dye binding acidic groups of protein decreased (Correia and Mittal, 1991).

Meat with pH range of 6.0 and 6.5 is more susceptible to bacterial spoilage than meat with pH 5.3-5.7 (Evans and Niven, 1960).

Most of the bacteria have an optimum growth near neutrality i.e. pH 7.0 with maximum and minimum being pH 8.0 and 5.0 respectively (Lechowich, 1970).

Devatkal *et al.* (2004) reported significant ($P < 0.05$) decrease in pH with increased storage period.

The fall in pH was noted initially and gradual increase thereafter up to 21st day of storage in all the methods of packaging (Rajkumar *et al.*, 2007a).

Mutton packed under vacuum; in multi layer material stored up to 120 hour indicated lowest pH (Dushyanthan *et al.*, 2005).

Reddy *et al.* (2015) reported that pH values of chicken meat patties added with tomato paste had lower values but observed increased significantly ($p < 0.05$) during refrigerated storage for 11 days.

Bennani *et al.* (1995) reported that the pH of salted dried meat product (Traditional Kandid) in Morocco ranged from 5.2-5.4.

Cobos and Diaz (2007) studied effects of vacuum cooking on dry cured pork foreleg and found the pH of dry cured, desalted, and unpacked cooking, desalted and vacuum cooking pork foreleg as 6.07 ± 0.14 , 6.01 ± 0.16 , 6.11 ± 0.24 and 6.07 ± 0.19 .

The pH of dry cured pork neck was higher in MAP than in vacuum packaging as found by Kim *et al.* (2014) (b).

Nam *et al.* (2016) reported that the pH values in venison jerky ranged from 5.64 to 5.82.

Vasanthi *et al.* (2007) reported that there was gradual increase in pH when cooked the buffalo meat at 80°C, 90°C and 100°C for different times in the water bath.

Ahmad and Srivastava (2007) stated that different levels of fat significantly ($P < 0.05$) increased the pH of the meat product samples.

2.14.2. TBARS (Thiobarbituric Acid Reactive Substance) value

Since meat products contain a high amount of fat, therefore oxidation of fat or rancidity occurs if sufficient measures are not adopted to prevent the same. Normally meat

fat oxidizes to form peroxides and thus a rancid flavor is developed if storage is prolonged. The Thio-barbituric acid value determines the extent of lipid oxidation, the TBA value of 1.0 is considered as threshold level considered for rancidity of pork (Ockerman, 1985).

Thio-barbituric acid (TBA) value is an index of secondary lipid oxidation. Lowest TBA number in vacuum packed mutton is attributed to the absence of oxygen under vacuum and prevented oxidative rancidity (Dushyanthan *et al.*, 2001).

The mean TBA number of turkey meat packed under aerobic, vacuum and modified atmosphere methods gradually increased from the day of packaging to the 21st day of storage (Rajkumar *et al.*, 2005).

TBARS value should be related to the concentration of polyunsaturated fatty acids, natural antioxidants and enzymes (Gatellier *et al.*, 2004; Descalzo *et al.*, 2005), which depend on many factors such as gender, age, production region (Hoffman *et al.*, 2007) and diet (Warren *et al.*, 2008).

In the case of clams (Bindu *et al.*, 2007) the TBA content significantly ($P < 0.05$) increased during the storage period. This was due to the fact that the processed clam product used in the study contained only solids and there was no liquid medium. Hence there has been no dilution of the TBARS and as a result there was a gradual increase on storage.

Several workers like Patton and Kurtz (1951); Schwarts and Watts (1957) and Fennings (1975) reported TBA test as one of the method to access rancidity of fat. At times, samples with higher TBA values were not considered rancid (McCallum *et al.*, 1956; Slabyj and True, 1978). Significant positive correlation between TBA values and organoleptic scores had been observed (Turner *et al.*, 1954; Greene and Cumuze, 1982).

Ogunsola and Omojola (2008) (a) studied the qualitative effects of different oil types (docolourised palm oleic oil-T₁, local bleached palm oil-T₂ and pure ground nut oil-T₃) used in processing of dambunama, a dehydrated shredded meat product. The lipid oxidation in T₃ (0.70 ± 0.01) was significantly higher at week six while T₁ (0.81 ± 0.01) recorded a significantly higher value at week nine.

Abdullah (2007) reported a high TBA value in retort processed luncheon meat. The phospholipids fraction of the lipid has been shown to contribute approximately 90% of the TBARS value in chicken fat and Mechanically Derived Chicken Meat (MDCM) contributes high phospholipid content. However, use of MDCM in meat products should be limited, because of the presence of bone marrow that contributes high levels of copper, iron and magnesium. These metals act as catalysts in the oxidation of lipids, causing off-flavours. Furthermore, when frozen fat was used at high levels, oxidative rancidity occurred during long storage.

Souza *et al.* (2013) studied the lipid and protein oxidation in Charqui and Jerked beef and at first day of processing, the TBARS results did not show any difference ($p < 0.05$). However, from the 8th days of storage, the TBARS values increased gradually, reaching its maximum at the 60th day of the storage in the Charqui and in Jerked beef samples.

Sahoo *et al.* (2003) found that minced mutton treated with natural antioxidants (sodium ascorbate and tocopherol acetate) showed lower TBARS than the control one.

Wilkinson *et al.* (2001) studied the antioxidants (tocopherols and sodium erythrostate) effects of TBARS value in fresh and freeze dried beef and chicken and found that the TBARS values were lower in both fresh and freeze died samples containing antioxidants.

Baishya (1997) reported that the overall TBA values (mg malonaldehyde/ kg) recorded were 0.370, 0.445, 0.290, 0.557 and 0.231 for salami, sausage, ham, bacon and frankfurter respectively.

Mangilal (1994) found that the TBA values for Intermediate moisture meat products of pork increased from an average of 0.062 to 0.153 at the end of 56 days of storage.

Chen and Jones (1988) recorded TBA value of 0.19 for cured pork ham products and 0.24 for products containing pork and turkey blends (75:25).

The 2-thiobarbituric acid assay technique measures the quantity of malonaldehyde present in meat and meat products. With increase in storage period of meat and meat products, there is a corresponding increase in TBA value (Younathan *et al.*, 1980).

Warmed over Flavour (WOF) describes an oxidized or rancid flavor, which develops rapidly during the refrigerated or frozen storage of pre-cooked or partially cooked meat products (Pearson and Grey, 1983).

The compound malonaldehyde is formed in meat as an end product of lipid oxidation. This chemical is harmful to human health (Shamberger *et al.*, 1977; Buege and Aust, 1978) and is also responsible for off flavor and causes unpleasant odour in stored meat (Caldironi and Bazan, 1982).

Thomas *et al.* (2006) stated that there was an increase in TBARS value with storage and this might be due to increased fat oxidation and the slightly higher TBARS value of emulsion nuggets might be due to its higher fat content.

2.14.3. Tyrosine value (TV)

Tyrosine value is an indicator of proteolysis as it measures tyrosine and tryptophan in the extract of meat. An intrinsic change of meat by autolysis has affected the protein degradation (Strange *et al.*, 1977).

Manimaran (2007) reported a progressive increase in TV of buffalo meat sausage during refrigerated storage.

Mean TV of the samples packaged in aerobic, vacuum and modified atmosphere increased gradually from the day of packaging up to 21st day of storage (Rajkumar *et al.*, 2007a).

Dushyanthan *et al.* (2001) reported that the storage time increased the protein breakdown and hence the TV increased in packed mutton stored at 5±2°C.

Kulkarni *et al.* (1993) reported that the TV of stored buffalo meat sausages were increased during storage.

2.14.4. Amino acid profile

Meat and meat products are a good source of amino acids and their proteins are considered of high biological quality. After consumption of meat, free amino acids are rapidly absorbed, while proteins are easily hydrolysed into peptides and amino acids, which in turn are also absorbed. The amino acid content of meat includes Isoleucine, Leucine, Lysine, Methionine, Cystine, Phenylalanine, Valine, Threonine, Tryptophan, Arginine, and Histidine. Alanine among others which makes it better than other foods as source of protein (Lawrie, 1985).

In general, lysine, methionine and tryptophan are the three essential amino acids that are most important in evaluating the nutritive quality of a protein (Neilands *et al.*, 1949). A deficiency of these amino acids is frequently encountered in natural food materials.

According to Witte *et al.* (2002), glycine together with other essential amino acids such as alanine, proline, arginine, serine, isoleucine and phenyl alanine form a poly peptide that will promote growth and tissue healing. Apart from their nutritional importance, amino acids also influence meat palatability (Pikielna and Kostyra, 2007) and flavour (Chiang *et al.*, 2006), through the generation of volatile compounds by Maillard reactions and Strecker degradations (Ruiz *et al.*, 1999; Martin *et al.* 2001; Carrapiso *et al.*, 2002; Toldra, 2006).

Amino acids are important component for healing and protein synthesis processes, any deficiency in these essential components will hinder the recovery process (Zuraini *et al.*, 2006).

Arias *et al.* (2004) studied the changes in the nutrient composition, amino acid due to retort processing and storage. Amino acid composition of canned tuna and cooked showed no major changes compared to raw tuna.

Storksdieck *et al.* (2007) concluded that the peptides responsible for “meat factor” could have enriched with aspartic and glutamic acid and possibly originated from myosin.

Eke *et al.* (2013) studied the amino acid composition of Beef Based Dambu-Nama (dried meat product) and reported that the amino acid composition of Dambu-nama

contains most predominant essential amino acid Valine (653.33 to 712.07 mg/100 g) and followed by Lysine (586.50 to 722.57 mg/100 g). The non essential amino acid is glutamic acid (1138.00 to 1232.70 mg/100 g), which is followed closely by aspartic acid (766.00 to 995.00 mg/100 g) respectively.

Srinivasan and Moorjani (1974) studied the presence of essential amino acids in various dehydrated meat and reported that the protein score for pork was 90, 84 for both mutton and chevon and 89 for beef.

Wilkinson *et al.* (2014) showed that 12 out of 17 amino acids measured in samples of pork longissimus muscle changed significantly with cooking with all amino acids increasing, except for histidine and taurine.

Palacios *et al.* (2015) studied for a rapid and accurate extraction procedure for analysing free Amino Acids in meat samples by GC-MS in fresh pork loin and dry-cured ham and detected twenty-one free amino acids in dry-cured samples: alanine, glycine, valine, leucine, isoleucine, proline, methionine, serine, threonine, phenylalanine, aspartic acid, hydroxyproline, cysteine, glutamic acid, asparagine, lysine, glutamine, arginine, histidine, tyrosine, and tryptophan, while fresh loin samples presented 18 free amino acids, the same as dry-cured hams except for arginine, histidine, and tryptophan.

Higher isoleucine, leucine, lysine, methionine, threonine and valine and lower histidine and arginine contents were noticed in the product of Mohan *et al.* (2008) due to retort processing. No significant ($P>0.05$) effect on phenylalanine was noticed due to retort processing.

Glutamic acid and phenylalanine have been found to be the major amino acids in fresh meat, while in dry-cured pork products glutamic acid, arginine, and lysine have shown the highest levels (Martin *et al.*, 2014).

The changes in the amino acid content during storage could be due to the diffusion process occurring between the meat portion and the gravy portion (Mohan *et al.*, 2008).

2.15. TEXTURE PROFILE

Most of the instrumental methods of texture evaluation are based on mechanical tests, which include the measurements of resistance the food presents to force greater than gravity that are acting on it. The mechanical texture measurement is usually destructive, because the applied force exceeds the strength of the tested sample, thereby destroying it in the process (Krkoskova, 1986).

Two types of texture measurements exist - physiological, or sensory texture testing, and instrumental texture testing. Sensory texture testing is used to quantify the acceptability of food texture. Sensory tests require a panel of trained assessors, panel size depending on the amount of difference between samples, and repetitive testing to ensure accurate results. Because of the difficulties associated with human sensory panels and the need to quantify texture measurements,

Instrumental texture testing is also used by researchers to measure food texture (Rajkumar, 2008).

Although difficult for researchers to quantify, meat texture is important to the consumer. A multitude of instrumental texture tests can be used to quantify meat texture. A survey of 82 public and private organizations involved in production, quality control, and processing meat of United States of America showed that 78% used the Warner-Bratzler shear test for texture testing (Lepetit and Culioli, 1994).

Texture is an important aspect of meat quality, sometimes even more important than colour or flavour. Of the textural characteristics, the most frequently mentioned are hardness (toughness), cohesiveness and juiciness. The methods applied to evaluate texture can be divided into three groups: sensory methods, instrumental methods (also known as objective, physical or mechanical) and indirect methods (e.g. determination of collagen content in meat, amount of dry matter, etc.) (Kamdem and Hardy, 1995; Combes *et al.*, 2003).

Although popular, Warner-Bratzler shear force test method only gives shear force perpendicular to the muscle fibers. Like beef texture methods, other fish texture measurement methods include single or double compression (Texture Profile Analysis),

puncture, and shear strength (punch and die, Kramer shear cell) (Hyldig and Nielsen, 2001).

Texture profile analysis (TPA) is one of the methods that simulate the conditions that the meat is exposed to in the mouth (Xiong *et al.*, 2006).

The decreasing trend of texture profile parameters due to retort pouch processing was also observed in the reports of Manju *et al.* (2004), Bindu *et al.* (2007) and Sreenath *et al.* (2007).

Kovacevic *et al.* (2010) studied texture profile of ten traditional Croatian dry sausages (Slovanian kulen) of different brands which are dried and smoked pork sausage and results showed that there were significant difference among different sausages. The variability of hardness between different brands of Slovanian kulen (C.V. between brands was 17.24%). Very low differences in springiness, cohesiveness and chewiness between ten brands were observed (C.V. =5.93%, 7.67%, 9.47%).

Hardness is mainly due to retort processing which causes conversion of collagen to gelatin and dissociation of muscle protein of meat (Bindu *et al.*, 2007). There has been a decrease in hardness 1 from 2.07 kgf to 1.93 kgf and from 1.67 kgf to 1.66 kgf in hardness 2 of the raw clam meat when thermal processing was done.

Springiness is the elastic recovery property of meat. In a raw condition, the meat is more elastic in nature, but on heat processing the elasticity is lost hence low scores in the product were observed by Bindu *et al.* (2007).

Chewiness refers to the amount of work done. In raw meat the work done is more, whereas in thermal processed products the work done is less which was evident in the product as reported by Sreenath *et al.* (2007). This can be attributed to the gelatinization of muscle collagen and destruction of muscle cells during the cooking.

Cohesiveness is an indication of the internal bonding between muscle proteins of the goat meat. Due to the heat processing a breakage in the water bond of the muscle occurred (Mohan *et al.*, 2008).

Kim *et al.* (2014) (b) reported that the textural studies (Warner Bratzler shear force) showed no significance difference between the samples of dry cured pork neck which were stored by Vacuum packaging and Modified Atmospheric packaging.

Mohan *et al.* (2008) reported the products packed in pouches were found to be superior to canned products with regard to sensory and textural attributes such as colour, firmness, hardness, chewiness, and overall acceptability. The hardness 1 and 2 scores were significantly higher in pouched samples than in the canned samples. Higher springiness and chewiness were also reported in pouches compared to the canned samples. Cohesiveness and resilience were relatively unchanged due to processing.

2.16. COLOUR PROFILE

The visual appearance of meat products triggers a reaction in the consumer that leads to a decision to buy or not to buy, to consume or not to consume, a particular item. The colour is probably one of the most important visual factors in purchasing decisions concerning meat and meat products (Hunt *et al.*, 1991; Wulf and Wise, 1999). Colour, as seen by the consumer, is a physical interaction of light with the meat registered by the human eye and interpreted by the brain. Colours are therefore perceived subjectively.

Fat is known to influence the colour of meat products (Marquez *et al.*, 1989; Hughes *et al.*, 1997 and Pietrasik, 1999). A reduction in the fat level decreases the L*, a*, b* and chroma values.

The CIE LAB colour system is one of the most commonly used colour spaces to measure the colour of an object. CIELAB was created in 1976 in an effort to deal with one of the great problems of the original XYZ space, where equal distances on the x and y axes in the chromatic diagram did not correspond to chromatic coordinates (Konica Minolta, 2006). CIELAB is the counterpart of a colour system based on a previous (1942) system devised by Richard Hunter, called "Lab".

Correia and Mittal (1991) reported that the insoluble carbohydrates, hemicelluloses and cellulose present in the soy protein concentrate filler contributed to the lower L* values. They added that due to thermal processing of frankfurter, lightness (L*) values decreased and concluded that the effect of heating influenced the amount of reflected light.

Kovacevic *et al.* (2010) studied the colour profile of ten traditional Croatian dry sausage (Slovanian kulen) which are dried and smoked pork sausage and found that the Lightness (L^*) values of all brands ranged from 30.7 to 42.42, the redness (a^*) of all brands ranged from 15.12 to 25.34 and the yellowness (b^*) from 13.57 to 26.4.

Bindu *et al.* (2007) analyzed the colour data like L^* (darkness to lightness), a^* (redness to green) and b^* (blue to yellowness) of the clam product from the initial sample to the final (after twelve months of storage). There was no significant decrease in the L^* values of the samples indicating that the lightness of the samples did not change. The a^* values showed a slight decrease. However, there is a considerable decrease in b^* values. This may be due to the maillard reaction between the sugar and amino acid.

Kim *et al.* (2014) (b) studied the colour profile of dry cured pork neck and reported that the L^* -value of samples with both VP and MAP tended to increase with storage time, significantly lower a^* -values were found in both VP and MAP samples after 60 days of storage ($p < 0.05$) and the b^* -values of all samples increased significantly with storage time.

Abdullah (2007) claimed that the higher lean meat content, the higher the colour quality of the end product.

Manimaran (2007) reported that there was a reduction in the L^* , a^* and b^* , values due to refrigerated storage of buffalo nuggets. Bentley *et al.* (1987) reported a higher ($P < 0.01$) b^* colour value and L^* and a^* colour values showed no significant differences over storage of sausages under refrigeration.

Nam *et al.* (2016) studied the qualities of sun-dried Venison jerky with green tea powder {Control: beef, T1: venison, T2: venison + green tea (0.5%), T3: venison + green tea (1%)}. Beef jerky (control) samples showed significantly higher L^* , a^* and b^* values than all other jerky samples at day 0 ($p < 0.05$). Moreover, the T2 and T3 (green tea addition) groups showed significantly lower a^* and b^* values than the other groups at day 0 ($p < 0.05$).

Mohan *et al.* (2008) reported that colour assessment of the canned samples were generally darker in colour than the pouched samples. Longer heat processing with the

canned products may have caused an increase in browning reactions which were responsible for the darker colour.

2.17. PROXIMATE COMPOSITION

Heat treatment of meat denatures, solubilizes, and coagulates proteins, and releases water. Three major textural proteins in beef are myosin, collagen, and actin. In beef, the denaturing and coagulation of myosin and actin are thought to be responsible for toughening with cooking, while collagen solubilization and gelatinization are thought responsible for tenderizing with cooking (Kramer and Szczesniak, 1973).

Webb (2003) studied the pre control parameters of retort pouch processing of tuna and summarized that protein and moisture contents decreased due to hydrothermal cooking.

Rahman *et al.* (2005) conducted a study on thirty longissimus dorsi (LD) muscles from Omani male goats were dried by five methods (sun, air, vacuum, freeze and modified atmosphere drying) and the moisture content was 22.95%, 9.31%, 10.43%, 5.51% and 0.406% respectively immediately after drying.

Borpuzari *et al.* (1996) studied on Adin, a traditional smoked dried meat product of Arunachal Pradesh and found 20.60% of moisture.

Most water in meat is located within the myofibrils, in the narrow channels between thick and thin filaments; therefore water lost during cooking is a result of protein denaturation and coagulation (Bertola *et al.*, 1994).

Water exists in bound form and free form in meat. Of these, bound water is unavailable as solvent (Fennema and Powrie, 1964) whereas, the free water is utilized for microbial growth and biochemical reaction (Prior, 1979).

Bindu *et al.* (2004) estimated that the fried mussel meat had a moisture content of 42.62%, protein 22.94%, fat 30.14% and ash 4.6%. The water activity of the mussels ranged from 0.85 to 0.92.

Kaur *et al.* (2015) reported that in chicken nuggets incorporated with grape seed extract there was significant increase ($p < 0.05$) in moisture content however no significant ($p > 0.05$) difference was observed in fat, protein and ash.

Arias *et al.* (2004) studied the changes in the nutrient composition due to retort processing and storage. The process of sterilization and storage time led to a decline in the percentage content of moisture and protein. Neither protein digestibility nor biological value of the tuna cooked, canned and stored showed any deterioration.

Ogunsola and Omojola (2008b) studied the qualitative characteristics of *Kilishi* prepared from beef and pork and reported *Kilishi* from beef and pork gave lower moisture values of 10.00 ± 0.15 and $9.92 \pm 0.22\%$ as against 35.85 ± 0.24 and $46.51 \pm 0.30\%$ for dried raw beef and pork respectively.

Abdullah (2007) reported a significantly higher ($P < 0.01$) moisture content for the luncheon meat. They also concluded that the chemical composition (moisture, protein and fat) does not appear to have greatly influenced the overall acceptability of the different formulations after retort processing.

Bindu *et al.* (2007) reported that the moisture, protein, fat, carbohydrate and ash contents of black clam product were 45.00, 22.30, 22.72, 9.50 and 2.22 percent, respectively.

Petit *et al.* (2013) studied the physicochemical characteristics of commercial biltong and reported that the moisture content of dry biltong was 25.2g/100g whereas the moist biltong contained 35.1-42.8g/100g of sample.

Kim *et al.* (2014) (b) studied the physicochemical characteristics of dry cured pork neck packaged in Vacuum and Modified Atmospheric Packaging and there was no significant difference in moisture content in any packaging system until 60 days of storage; however, the moisture content of the MAP samples was significantly lower ($p < 0.05$) than that of the VP samples after 90 days of storage.

Kim *et al.* (2014) (a) studied the physicochemical characteristics of beef jerky marinated with salted and fermented fish (SFF) including salted and fermented anchovy (SFA) and shrimp (SFS) and among the treatments, SFS1 and SFS2 were the highest in

moisture content but SFA1 and SFA2, on the other hand, had lower moisture content. The moisture contents of beef jerky were within the range of 23.52-27.04%.

Rajkumar *et al.* (2004) reported that the ether extract content of goat meat patties were increased up to 14 days, which decreased further under refrigerated storage.

Akhter *et al.* (2009) studied effects of different drying methods (sun drying, oven drying & rural cooker smoking) and meat size (block, flat & mince) on the nutrient content of beef was investigated with cooked cured (CC) or non cooked cured (NC) beef. The protein value gradually decreased with increasing preservation time. At the end of storage time there were also significant differences ($P < 0.01$) among three drying methods. At 120 days, the loss of protein in sun dried, oven dried and rural smoked were 3.22%, 3.19% and 2.08%, respectively.

Protein denaturation is first to occur with heating. Parsons and Patterson, (1986) showed that raw beef had three characteristic protein denaturation peaks, located at 55°C, 66°C, and 79°C. After proteins denature, they either solubilize and/or coagulate. The mechanism for meat texture changes with heating are not well established, however some actomyosin complexes form and collagen first solubilizes then gelatinizes.

Protein loss during heating is a result of proteins solubilized and expelled with the water leaving the meat. Beef cook losses as a function of temperature have been reported by Martens *et al.* (1982). These researchers found losses of 5 to 35% occurred over 45 to 85°C.

Meat products hardness decreases with increase in fat level and increase in moisture level (Mittal and Barbut, 1992).

Eke *et al.* (2013) studied the proximate composition of Beef Based Dambu-nama (dried meat product of Nigeria) and found that the fat content was low i.e. 11.2-17.84%.

Fat contributes to juiciness by sustained stimulation of salivary glands and release of saliva while chewing (Wier, 1960) and to flavor while meat is cooked or heated (Ledward, 1979).

When meat is cooked, water, soluble proteins, and fats are expelled from the tissue (Leander *et al.*, 1980).

Fatty tissues are more susceptible to spoilage by microorganisms. Lipases that occur naturally in fatty tissues usually get inactivated by heat during processing (Libby, 1975).

Sawyer (1974) reported that the total ash contents were 1.1-3.2 per cent for pork sausages and 3.1 per cent for frankfurter.

Nam *et al.* (2016) studied the quality characteristics of Venison jerky (sun-dried) with green tea powder during storage and reported the ash content ranged from 9.10-8.39%.

Kolar (1992) estimated the ash content of meat and meat products, which was found to vary from 1.0-5.4gram/100gram.

2.18. SHELF-LIFE

The types of spoilage that meat products undergo during storage can be divided as aerobic and anaerobic spoilage. Spoilage by mould occurs under aerobic condition resulted in defects like whiskers, off-flavour, odour and taste, colour defects, stickiness, fat breakdown. Spoilage by aerobic bacteria includes surface slime, change in colour of meat pigments, various surface colours (red spot, blue spot, yellow discolouration, greenish blue, brownish black and purple “stamping ink” discolouration), off-odour and taints. Anaerobic bacteria cause spoilage like taints, souring and purification (Zottola, 1972).

The changes that take place in the micro flora, protein, fat, colour pigments, pH and organoleptic characteristics of meat during storage are good measurements of shelf-life of meat (Kontou *et al.*, 1966; Pearson, 1968; Reddy *et al.*, 1975).

The shelf-life of the stored meat product is determined by number of factors *viz.* oxygen, microbial inhibitors, pH, moisture, nutrient and temperature. In addition to microbial spoilage, shelf-life is also limited by autolytic changes which include protein breakdown and fat degradation (Zottola, 1972).

Degradation of protein and fat causes production of such compounds as amines and free fatty acids, which leads to changes in organoleptic characteristics, thereby limiting the shelf-life of meat (Pearson, 1968).

Abhishek *et al.* (2014) studied the shelf life and safety of ethnic Indian food product namely soya peas curry packed under laminated retort pouches and analyzed for microbiological, sensory and chemical characteristics under refrigerated (4-5°C, ambient (27-30°C) and accelerated temperature (45°C) and found that the product was in good condition even after 9 months of storage

Kumar *et al.* (2015) studied the shelf life and safety of ethnic Indian food product namely egg curry and egg burji packed in four layer laminated retort pouches and processed in a steam-air retort with overriding pressure and analyzed for microbiological, sensory and chemical characteristics under ambient (27-30°C) and accelerated temperature (45°C) for a period of 12 months and found that the product was in good condition even after 12 months of storage under ambient condition

Ogunsola and Omojola (2008) (b) reported that in the evaluation of shelf life stability of Kilishi product in different packaging media showed the foil packaged product gave the highest microbial load while polyvinyl chloride bags and the plastic packaged Kilishi had lower microbial loads.

Cobos and Diaz (2007) reported that the sous-vide cooking (vacuum cooking) of dry-cured pork foreleg pieces significantly reduces the microbial growth at storage temperatures of 2°C, 10°C and 20°C, and it is able to extend the product shelf life to 28 days even at 20°C. On the contrary, unpacked pieces showed considerable spoilage and became unsatisfactory after only 14 days of storage at either 10 or 20°C.

Sharma *et al.* (2017) studied vacuum and aerobically packaged of chevon *tikkis* (Traditional patties) under refrigeration temperature (4±1°C) on 0, 7, 14 and 21 days of storage. The storage stability of vacuum packaged (VP) *tikkis* and aerobic packaged (AP) *tikkis* was evaluated. VP product showed lower TBA value than AP. Microbiological revealed that VP and AP products TVC, anaerobic count, proteolytic count, yeast and mold count and lipolytic count increases significantly (p<0.01) with the advancement of storage period and sensory attributes also decreased with the advancement of storage

period. The vacuum packaging was effective to preserve the chevon *tikkis* upto 14 days of storage at refrigeration temperature ($4\pm 1^{\circ}\text{C}$).

Meat products have been reported to get spoiled when microbial population exceeds 10^6 /gram or more (Frazier and Westhoff, 1978).

2.19. SENSORY EVALUATION

The appearance and colour of a product is determined by the state and stability of any natural or added pigments and the development of any discolouration during processing and storage. In addition, oxidation and the maillard reaction can produce colours during the process and storage (Nambiar, 2005).

Colour, flavor, juiciness, tenderness and texture are the most important eating quality attributes desired by the producer and consumer of meat and upon which largely depends meat palatability (Wier, 1960).

Sensory evaluation is a valuable tool in solving the problems of food acceptability and is useful in product improvement, quality maintenance, new product development and, market research (Larmond, 1974).

Bindu *et al.* (2007) reported that colour scores were remained same during the first six months of storage of retort processed black clam meat.

The colour, flavor and texture of restructured pork decreased during storage period (Schwartz and Mandigo, 1976).

Addition of flavour enhancing spices such as kadal pasi, nutmeg, star anise and bay leaf could be the reason for the highest flavour scores of a product. The essential oil of the spices gives flavour to the product (Rajkumar and Berwal, 2003) and their breakdown results due to oxidation.

Ogunsola and Omojola (2008) (b) in a study revealed that *Kilishi* from beef and pork differed significantly ($P > 0.05$) in colour and juiciness in their organoleptic studies. *Kilishi* from pork gave higher ($P < 0.05$) values of 3.70 ± 0.32 and 3.93 ± 0.21 as against values of 2.33 ± 0.22 and 2.93 ± 0.30 for *Kilishi* from beef in respect to colour and juiciness, respectively.

Nambiar (2005) reported that volatile compounds such as nitrogen heterocyclics, cyclic enolones, polycarbonyls and monocarbonyls produced via maillard reaction have a significant effect on the flavour of the foods.

Eke *et al.* (2013) studied about the sensory qualities of beef based dambu-nama and reported that it was highly acceptable in all sensory parameters.

The highest scores for juiciness were reported by Shankar *et al.* (2002) and Manju *et al.* (2004) due to retort treatment.

Nam *et al.* (2016) studied the sensory qualities of sun-dried Venison jerky with green tea powder {Control: beef, T1: venison, T2: venison + green tea (0.5%), T3: venison + green tea (1%)}. The control showed the highest sensory test results; tenderness and juiciness scored better in the control than other samples. Green tea powder treatments resulted in significant differences in tenderness and juiciness ($p < 0.05$). Sensory scores for colour, flavour, saltiness and acceptability in the control were similar to those for T2, indicating that sensory evaluation was affected by the addition of 0.5% green tea powder to venison jerky.

The juiciness scores arose as a consequence of moisture released from the meat during chewing (Winger and Hagyard, 1994).

Kim *et al.* (2014) (b) studied the effect of packaging method and storage time on sensory qualities of Dry-Cured pork neck products at 10°C. They observed that as storage time increased, aroma, flavour and juiciness scores of meat decreased significantly ($p < 0.05$) regardless of packaging methods; however, no significant difference in aroma, flavour, colour and juiciness scores between the two packaging systems was observed.

A decrease in sensory scores on increase in storage was reported by Shankar *et al.* (2002); Chandrasekar *et al.* (2004); Abdullah (2007) and Bindu *et al.* (2007).

2.20. COST OF PRODUCTION

Varalakshmi (2016) studied and analyzed the cost, returns and feasibility of chicken nuggets production on different categories of processing units and indicated that the cost of production of nuggets was highest on small units compared to medium and

large scale units. An economy of scale is evident from all perspectives like production costs, profits, discounting measures and breakeven point. Sensitivity analysis showed that variable costs and selling price had more impact on profitability and viability of processing plants.

The value of a new product is determined on the basis of its demand and access to the market, secured supply and suitable price of raw material, working capital, and proximity to the road and availability to the means of transport (Bist and Illyas, 2001).

Stanciu *et al.* (2015) studied and analysis of the local meat processing industry in terms of production, consumption and trade transactions, assessed in the international context of the meat market in Romania. Except the poultry meat and mutton sectors, in which the export value exceeds imports, the other sectors show a deficit. The low concentration degree of the companies from the meat processing industry show a continued market fragmentation and a growth potential for the existing companies.

Konwar (2001) considered cost of raw materials, processing cost and transportation cost in order to determine the cost of production of sausages prepared from slaughter house by-product.

Malav *et al.* (2013) studied the production of low-cost meat products utilizing vegetative extenders (*viz.*, lentil flour, sorghum flour, potato, water chestnut flour and extender blend) and comparison of production cost of extended products with the control product and concluded that formulation with extension of 15% extender blend at the cost of lean meat was most economic among the tested vegetative extenders.

Milev (2015) investigate the cost of production in one of the branches of the food industry, namely “production and processing of meat and meat products” in 7 companies in Stara Zagora, Bulgaria. Cost analysis includes consideration of the isolated influence of each factor, the amount of output, costs of materials, costs for external services, depreciation and costs for salaries and benefits on the cost by using regression analysis.

Chapter-III

MATERIALS AND METHODS

3.1. PURPOSIVE SURVEY

A purposive field survey was conducted in 6 (six) different villages of Dimapur district of Nagaland representing the major ethnic communities, namely, Ao, Sumi and Angami tribes. Thirty numbers of households from six villages were included in the survey. Information were collected on existing traditional methods of preparation of pork product with *Anishi*, *Silam* and Fermented dried soya (FDS) and the level of the ingredients used, mode of consumption, as well as culinary and ethnic values using questionnaires and direct observation. The collected data's were documented (Appendix-I, evaluation sheet).

3.2. SAMPLE COLLECTION AND SENSORY ANALYSIS

From the six villages 30 no. of samples of pork product were collected, 10 samples each were of *Anishi*, *Silam* and Fermented Dried Soya (FDS) with pork in HDPE packaging material of 100-200 gm. Samples were collected aseptically and transported in ice box. The samples were stored at refrigerated temperature ($4\pm 1^{\circ}\text{C}$) for overnight and sensory analysis was conducted on the next day based on level of ingredients used and on the basis of 7-point hedonic scale *viz.* appearance, flavour, juiciness, tenderness and overall acceptability.

3.3. SAMPLE SELECTION AND STANDARDIZATION

Based on the sensory evaluation, the pork products were selected from the sample incorporated with *Anishi*, *Silam* and FDS for standardization. The standardization was carried out with different levels of incorporation of ingredients. For *Anishi*, the levels were 1, 2, 3, 4, 5 and 6 percent. For *Silam* the levels were 2, 4, 6, 8, 10, and 12 percent and for FDS the levels were 1, 2, 3, 4, 5 and 6 percent. From the levels of incorporation in all three pork products, the best level of incorporation were selected on the basis of sensory scores and standardized at AICRP on PHET (Post Harvest Engineering and Technology) laboratory of College of Veterinary Science, AAU, Khanapara.

3.4. REFINEMENT OF FORMULATION

3.4.1. Source of raw material

The ham portion of Hampshire and Ghungroo cross breed pig of 8-10 months old was procured from the ICAR-NRC on pig-Rani. The meat was packed in HDPE packs and frozen in small unit packs of 1 kg each and stored in deep freezer (-18°C) until use. The required portion of the frozen meat for the experiment was taken out and kept at refrigeration temperature (4±1°C) overnight for thawing and subsequently used.

3.4.2. Deboning

After separation of fat and skin, deboning of meat was done manually maintaining hygienic condition in the laboratory. The meat was cut into 2 cm cubes and use for further processing.

3.4.3. Selection of non meat ingredients

After conducting the preliminary trails the non meat ingredients were selected and used for preparation of pork products *viz.* *Anishi* (*Colosasia esculenta* [L] Schott), *Silam* (*Perilla frutescens* [L] Britton seed) and Fermented dried soya (*Glycine max* [L] Merr). All the above ingredients were procured from local market of Dimapur town, Nagaland.

3.4.4. Selection of condiment and vegetables

After conducting preliminary trails on the types and proportions of condiments and vegetables to be incorporated in the preparation, following condiments and vegetables were selected *viz.* onion, garlic, ginger, tomato and fresh green chillies which were procured from local market and paste were prepared in the laboratory.

3.5. PRELIMINARY TRIAL

3.5.1. Selection of level of ingredients

Different percent levels were prepared and standardized during pilot study. The percent levels of the ingredients for *Anishi* were 1, 2, 3, 4, 5, and 6. For *Silam* the levels were 2, 4, 6, 8, 10, and 12 and for FDS the levels were 1, 2, 3, 4, 5 and 6 respectively. Each level of the ingredients was prepared for five trails. The selections were done based

on the sensory evaluation by semi trained sensory panel. The selected ingredients levels were 5% for pork with *Anishi*, 10% for pork with *Silam* and 5% for pork with FDS.

3.6. PRODUCT PREPARATION

3.6.1. Method of preparation for pork with *Anishi*

The *Anishi* cakes were cleaned with potable water thoroughly in order to remove any surface dirt and oven dried at 100°C for 15 minutes. The dried cakes were grounded into powder form. Salt, water and condiments in required proportions were used in the product formulation. The lean meat was mixed thoroughly with *Anishi*, green chillies, tomato, onion, garlic, ginger, salt and water in a bowl and pressure cooked for 20 minutes.

3.6.2. Method of preparation for pork with *Silam*

The *Silam* seeds were cleaned thoroughly for removal of any extraneous matter. The seeds were then dried in the oven at 60°C for 10 minutes and grounded to make a paste. The lean meat was mixed thoroughly with *Silam* paste, fresh green chillies, tomato, onion, garlic, ginger, salt and water in a bowl and pressure cooked for 20 minutes.

3.6.3. Method of preparation for pork with FDS

The fermented dried soya was cleaned thoroughly to remove any extraneous matters and were pulverized and directly applied to the pork product. The lean meat was mixed thoroughly with fermented dried soya, fresh green chillies, tomato, onion, garlic, ginger, salt and water in a bowl and pressure cook for 20 minutes.

Along with all the treatment samples, one control sample was also prepared parallel with all the above condiments but without addition of the ingredients *viz.* *Anishi*, *Silam* and FDS.

3.7. PACKAGING

The products were subjected to 2 (two) different types of packaging *viz.* retort packaging and vacuum packaging.

Retort packaging was done in retort pouches made of four layers namely cast polypropylene, biaxially oriented nylon, aluminum foil and polyester. The retort packaging

was done with the laboratory model (Model No. LEW/25/2005 – 25 pouches capacity, M/s. Lakshmi Engineering, Chennai) over pressure autoclave. The retort temperature was maintained at 121.1°C. Pressure was maintained at 20 psi throughout the process, using steam-air mixture while heating and water-air mixture while cooling. Rapid cooling was accomplished by recirculating cooling water. By maintaining the product core temperature, the desired F_0 values were obtained. 200g of the products were packed in the retort pouch (120g meat and 80g gravy) and kept at ambient temperature (25-32°C). The samples were assessed for a period of 6 months at monthly interval and the shelf life and other quality parameters were determined.

Vacuum packaging was done in vacuum packaging machine Sevana's (Sevol V, Model No. QS500VMG-MC) packaging machine and the products were packed in High Density Polyethylene (HDPE) packaging material. The quantity of product in each package was 200g (120g meat and 80g gravy) and the packages were kept under refrigerated temperature ($4\pm 1^\circ\text{C}$) maintaining their identity. The samples were assessed at 0, 5, 10 and 15 day for shelf life stability and other quality parameters.

3.8. RETORT POUCHES

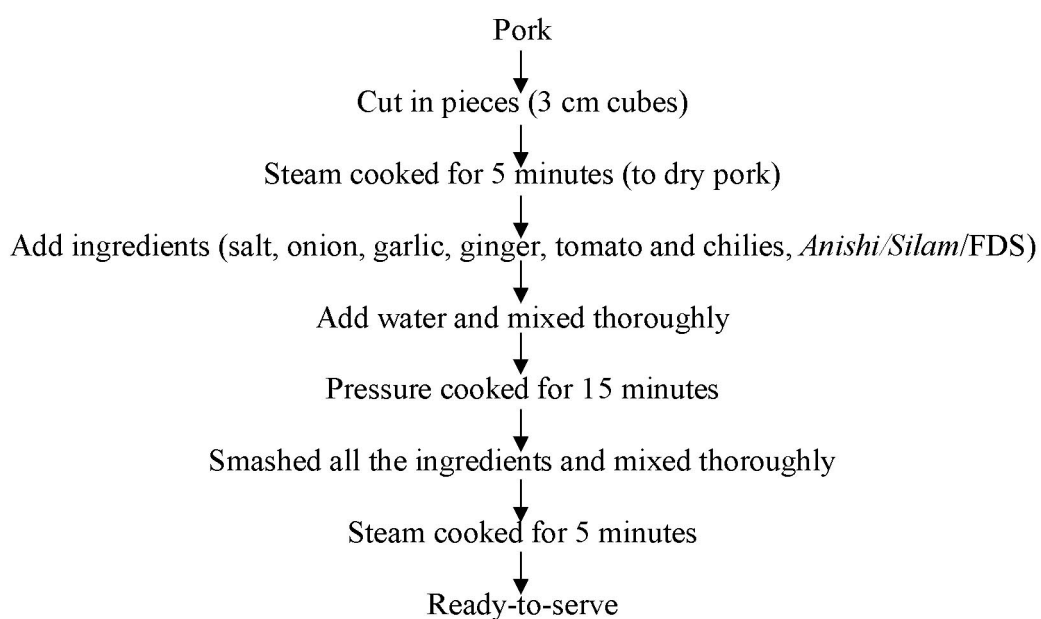
Retort pouches (Specification: M/s. Pradeep Laminators, Pune) having a three layer laminated configuration and a dimension of 20 cm × 15 cm were utilized for this study.

TABLE 3.1: PHYSICAL PROPERTIES OF RETORT POUCHES

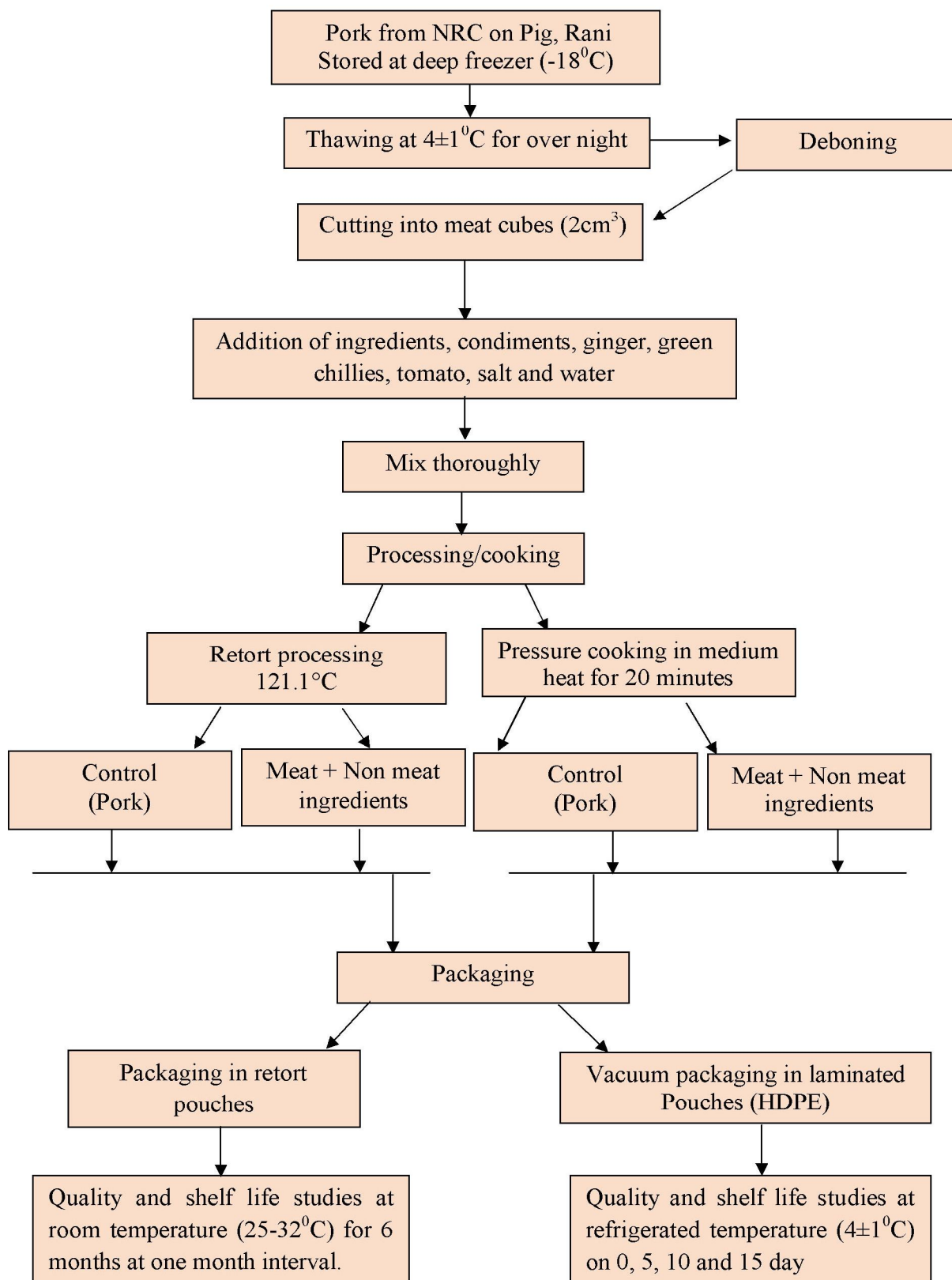
Sl. No	Parameters	Value
1	Total thickness	114 micron
2	Pouch length	200 mm
3	Pouch width	150 mm
4	Pouch weight	7.86 g
5	Seal width (side)	10 mm
6	Seal width (bottom)	9 mm
7	Tensile strength (Lengthwise)	574.05 kg/cm ²
8	Tensile strength (Widthwise)	523.73 kg/cm ²
9	Heat seal strength (Lengthwise)	7.74 kgf/15 mm
10	Heat seal strength (Widthwise)	7.319 kgf/ 15 mm
11	Peel bond strength	228.71 gf/15 mm

TABLE 3.2: FORMULATIONS USED FOR PREPARATION OF TRADITIONAL PORK PRODUCTS OF NAGALAND

Ingredients	Amount (%) Control	Amount (%) <i>Anishi</i>	Amount (%) <i>Silam</i>	Amount (%) FDS
Pork	55	55	55	55
Non meat ingredients				
a) <i>Anishi</i> (<i>Colosasia esculenta</i> [L] Schott)	-	5	-	-
b) <i>Silam</i> (<i>Perilla frutescens</i> [L] Britton seed)	-	-	10	-
c) FDS (<i>Glycine max</i> [L] Merr)	-	-	-	5
d) Salt	1.5	1.5	1.5	1.5
e) Onion and Garlic (4:1)	4.5	4.5	4.5	4.5
f) Ginger	2	2	2	2
g) Green chillies	4	4	4	4
h) Tomato	3	3	3	3
i) Portable water	30	30	30	30

3.9. FLOW DIAGRAM OF COOKING METHOD IN FIELD LEVEL OF TRADITIONAL PORK PRODUCTS OF NAGALAND

3.10. FLOW DIAGRAM FOR PROCESSING OF TRADITIONAL PORK PRODUCTS



3.11. QUALITY TRAITS STUDY

The following quality parameters of the traditional pork products were studied in retort and vacuum packaging system.

3.11.1. Determination of pH

The pH of the samples was determined as per the method of Pippen *et al.* (1965) by using a digital pH meter (Make: Metrohm, Switzerland; Model: 780).

Fifteen grams of the samples was blended with 30 ml of distilled water and the homogenate was poured through Whatman No. 1 filter paper. The filtrate obtained was used to measure the pH by using the digital pH meter. Five replicates of the same sample were taken and the average was calculated out.

3.11.2. TBARS (Thiobarbituric Acid Reactive Substance) value

The TBA value was determined as per the method of Witte *et al.* (1970).

Ten (10) grams of sample was blended at full speed for 15 minutes in a mechanical blender with 25 ml of 4°C extracting solution containing 20 percent trichloroacetic acid (TCA) in 2M orthophosphoric acid. The resulting solution was transferred quantitatively into a 50ml volumetric flask, made up to 50ml distilled water, and mixed thoroughly by shaking. A 25ml portion was filtered through Whatman No. 1 filter paper. 5ml of the filtered was transferred to a tube followed by 5ml of 2-thiobarbituric acid (0.05M in distilled water). The tube was stoppered and the solution was mixed by inversion and kept in the dark for 12-15 h at room temperature. The resulting colour was measured at 530nm in a Systronics Visible-Spectro 105. The TBA value was calculated by multiplying the absorbance by the K value (5.2) for extraction.

3.11.3. Tyrosine value (TV)

The tyrosine value was determined as described by Strange *et al.* (1977).

Twenty (20) grams of sample was blended in a mincer with 50 ml of cold 20% trichloroacetic acid for 2 minutes. The blended content is rinsed in 50 ml distilled water. It is mixed together and filtered through the Whatman No. 1 filter paper (18.5 cm diameter)

and the volume of the filtrate is collected in a 100 ml measuring cylinder. The filtrate is known as trichloroacetic acid extract.

Two and half ml (2.5) of trichloroacetic acid extract is diluted with equal quantity of distilled water in a test tube. To this 10 ml of 0.5N sodium hydroxide is added followed by 3 ml of diluted folin ciocalteu phenol reagent (1 part of folin ciocalteu phenol reagent 2 parts distilled water). After mixing and keeping it for 15 minutes at room temperature the developed blue colour was measured as absorbance at 660 nm in a Systronics Visible-Spectro 105 using a blank for comparison. With reference to the standard graph, the tyrosine value was calculated and expressed as milligram of tyrosine/100g of the sample.

3.11.4. Standard graph for estimation of tyrosine value

One hundred mg of tyrosine was dissolved in 500 ml of 5 percent TCA in a volumetric flask. The following volumes of the above tyrosine solution were then transferred to a series of 100 ml volumetric flasks: 0, 1, 3, 5, 7, 9, 10, 12, 20 and 25 ml. They were made up to the mark with distilled water and mixed thoroughly. 10 ml of 0.5 N NaOH and 3 ml of diluted folin ciocalteu's phenol reagent and mixed well. They are kept for 15 min. at room temperature. The developed colour is measured as absorbance at 660nm in a Systronics Visible-Spectro 105 as described earlier. The values of absorbance recorded for dilution of tyrosine and plotted on the graph sheet. The standard graph was prepared with known concentration of tyrosine in the solutions and their corresponding absorbance values following the least square method.

3.12. AMINO ACID PROFILE

The amino acid of the products was determined by using an NIR Analyser (Perten Instruments) at ICAR-NRC on Pig.

3.13. TEXTURE AND COLOUR ANALYSIS

The textural properties of the products were determined using a food texture analyzer i.e. TA HD plus texture analyzer. The samples were placed on the uniform platform of texture analyzer. An aluminum cylindrical probe (32mm) which was compressed to 70% of its original height was used twice in two cycles.

Hardness (N/cm²), springiness (cm), cohesiveness (ratio), and chewiness (N/cm) were the texture parameters studied in this experiment.

The colour of the finished products was determined by using Hunter Colour Lab. Colour was described as coordinates, e.g. L^* , a^* and b^* where L^* measures relative lightness, a^* represents relative redness and b^* represents relatively yellowness.

3.14. PROXIMATE COMPOSITION

The moisture, Crude Protein (CP), Ether Extract (EE) and Total Ash (TA) of the products of the control and the treated groups were estimated as per the standard procedure laid down by the AOAC (2005).

3.14.1. Moisture

Ten (10) grams of samples were weighed in aluminum moisture cups and transferred to hot air oven maintained at 100°C for 16 h with the lids kept slightly open. After completion of the drying period, the cups were removed from the hot air oven and placed in a desiccators to cool. The moisture cups with dried meat sample and the lid was weighed and again transferred to the hot air oven. The process was repeated until constant weight of the sample was obtained. The percentage of moisture was calculated by following formula:

Weight of solids = Weight of the dried sample with container – Weight of the container

$$\text{Solids (\%)} = \frac{\text{Weight of solids}}{\text{Weight of original sample}} \times 100$$

$$\text{Moisture (\%)} = 100 - \% \text{ solids}$$

3.14.2. Crude Protein

Crude protein contents of the samples were determined by Micro-Kjeldahl method by estimating at first the amount of nitrogen in the sample and thereafter multiplying the amount nitrogen by the factor 6.25.

For the purpose, 0.2 gm of moisture free samples were digested in the Kjeldahl flask in presence of 20 ml concentrated H₂SO₄ and pinch of digestion mixture

(K₂SO₄:CuSO₄=10:1). The digestion was carried out by placing the flask in the digestion unit of KEL PLUS KES 6L (Make: Pelican Equipment, Chennai). The temperature was fixed at 400°C and the samples were boiled for 1½ to 2h until the solution's colour turn into clear green. The digested samples were allowed to cool to room temperature and distilled in the distillation unit of the instrument (KEL PLUS CLASSIC DX; Make: Pelican Equipment, Chennai). The distillate containing methyl red was titrated against 0.1N HCl.

From the titer of each sample, the total protein content was calculated by using the following formula:

$$\text{Crude protein (\%)} = \frac{14 \times \text{Normality of the acid} \times \text{titration value} \times 6.25 \times 100}{\text{Weight of the sample} \times 1000}$$

The total protein content of the samples was converted into fresh weight or as such basis.

3.14.3. Ether Extract

One gram of each oven dried samples were weighed and put into thimbles made of Whatman No. 1 filter paper. The thimbles with samples were then put inside the oil flask of the SOCS INFRA SIS 6 Ether Extractor (Make: Pelican Equipments). Petroleum ether having a boiling point of 80-100°C was poured into the upper chamber of the extractor and allowed to come down to the oil flasks. The temperature was fixed at 95°C for the initial 1 h and thereafter raised to 180°C. Ether was collected at the upper chamber of the extractor. The oil flasks containing fat at the bottom were subsequently transferred to a hot air oven to evaporate the residual ether. Oil flasks were then cooled in desiccators and weighed.

$$\text{Ether Extract (\%)} = \frac{\text{Weight of the oil flask with extract} - \text{Weight of oil flask} \times 100}{\text{Weight of the sample}}$$

The total fat content of the samples were converted into fresh weight or as such basis.

3.14.4. Total Ash

One gram of each of the oven dried sample was weighed in a silica crucible and was made smoke free by placing the crucible over an electric heater. The crucible was then placed in a muffle furnace and operated at 525°C for 10 - 12 h till the sample is converted into white ash. On removal from the muffle furnace, the samples were cooled to room temperature by placing the crucibles in desiccators. On cooling the weight of the crucibles containing ash were recorded. The percent total ash was calculated as follows:

$$\text{Weight of ash} = \text{Weight of ash with crucible} - \text{Weight of crucible}$$

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

The total ash content of the samples were converted into fresh weight or as such basis.

3.15. MICROBIOLOGY QUALITY

Total plate count (TPC), psychrophilic, coliform and yeast and mould counts of retort packaged product stored under room temperature and vacuum packaged product stored under refrigerator were determined by the method as per AOAC (2005).

3.15.1. Preparation of sample

Five grams of meat sample were taken aseptically and homogenized with 45 ml of 0.1 per cent sterile peptone water, using a sterile pestle and mortar to detain an initial dilution of 10^{-1} . Ten-fold serial dilutions were made up to 10^{-10} in pre-sterilized tubes containing 9 ml of 0.1 per cent peptone water. The inoculums of 1ml was transferred to petridish, poured with standard plate count agar and mixed properly by 5 times to and fro, 5 times clockwise, 5 times to and fro at right angles to the first and 5 times anti-clock wise. The sample preparation and plating were carried out under laminar flow.

3.15.2. Total plate count (TPC)

Enumeration of the total viable plate count of the samples was done in standard plate count agar medium in both the control and treated samples for both retort and vacuum packaged products. The microbiological quality for retort packaging was evaluated on 0, 30, 60, 90, 120, 150 and 180 day and for vacuum packed product stored under refrigeration temperature at 0, 5, 10 and 15 day. Plates were incubated at 37°C up to

72h for enumeration. Counting was done by using a bacteriological colony counter and the plates yielding >25 and < 250 bacterial colonies were taken into account. The total viable plate count was expressed as \log_{10} cfu/g of the sample.

Total plate count of the samples was enumerated in standard plate count agar medium (pH 7.0 \pm 0.1) by following the pour plate technique as described by Harrigan and McCance (1976).

3.15.3. Psychrophilic count

Enumeration of psychrophilic count of the samples was done in both the control and treated samples at 5-10 days for vacuum packed products under 4 \pm 1°C. The microbiological quality was evaluated on 0, 5, 10 and 15 day stored under refrigeration temperature (4 \pm 1°C). Psychrophilic count of the samples was enumerated in standard plate count agar medium (pH 7.0 \pm 0.1) by following the pour plate technique.

3.15.4. Coliform count

Test for the presence of coliforms was made at similar time interval as that of the TPC by following the 'multiple tube technique' as described by Harrigan and McCance (1976). Serial dilutions of the samples up to 10⁻³ were inoculated into 2% Brilliant Green Lactose Bile broth, pH 7.4 \pm 0.1 (Mackenzie *et al.*, 1948) and incubated at 37°C up to 72h. The results were expressed as most probable number per gm by using the conversion table designed by AOAC (2005).

3.15.5. Yeasts and moulds count

Yeasts and moulds counts of the meat samples were made at similar time intervals as that of the total viable plate count by inoculating the appropriate dilution of the sample on Rose Bengal Agar Base, pH 7.2 \pm 0.1 and on incubation at 37°C upto 48 h (Harrigan and McCance, 1976). Counting was done by using a bacteriological colony counter.

3.16. SHELF-LIFE STUDY

Shelf-life studies were conducted on the basis of microbiological quality, proximate analysis, TBARS value, tyrosine value and sensory evaluation of the products at room temperature.

The maximum shelf life was assured as soon as the products exceeded the microbial load of 10^5 /g. Simultaneously, TBA values and other physical changes like development of off-odour, sliminess, discolouration of the product were also recorded.

3.17. SENSORY EVALUATION

The traditional meat products were subjected to evaluation for organoleptic qualities by serving the products to a 7- member panel of semi trained judges of different age group and sexes. Panel members were allowed to sit in a well lighted and ventilated room. A clean glass of drinking water was provided to each member for rinsing the mouth before and after testing of each product. They were neither informed about the identity of the product nor allowed any conversation or discussion among themselves during the evaluation process. All the samples were evaluated for appearance, flavour, juiciness, tenderness and overall acceptability by using a 7-points hedonic scale score card as described by Ingham *et al.* (2002). Since, the developed traditional products were new to the consumers, so relatively it is difficult to differentiate minutely the sensory qualities of the products. So, 7-points hedonic scale was adopted in order to minimize the difference.

3.18. COST OF PRODUCTION

In order to determine the cost of production of the products, the following parameters were considered such as raw materials (pork, condiments and vegetables), processing cost (water, electricity and labour cost), transportation and packaging cost.

3.19. STATISTICAL ANALYSIS

The results were analyzed statistically following the standard statistical method as described by Snedecor and Cochran (1995) and the calculation by using SAS version-9.2.



FIG. 3.1. NON MEAT INGREDIENTS IN DIMAPUR MARKET



FIG. 3.2. Anishi (*Colosasia esculenta* [L] Schott)



FIG. 3.3. Silam (*Perilla frutescens* [L] Britton seed)



FIG. 3.4. FERMENTED DRIED SOYA (*Glycine max* [L] Merr)



a) Meat cutting



b) Pork with Non meat ingredients



c) Pressure cooking



d) Steam cooking



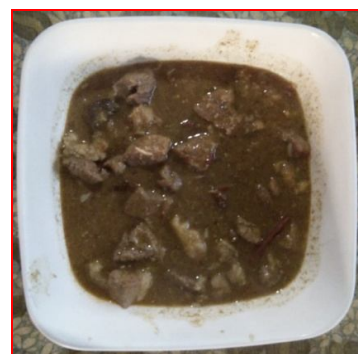
e) Smashing of cooked ingredients



f) Pork with *Anishi*



g) Pork with *Silam*



h) Pork with FDS

FIG. 3.5. PHOTOGRAPHIC ILLUSTRATIONS OF THE VARIOUS STEPS INVOLVED IN PREPARATION OF TRADITIONAL PORK PRODUCTS WITH NON MEAT INGREDIENTS IN FIELD LEVEL



FIG. 3.6. RETORT PACKAGING MACHINE



FIG. 3.7. VACUUM PACKAGING MACHINE



a) Packed Pork (Ham)



b) Pork cutting (2cm³)



c) Pork with non meat ingredients



d) Mix pork with ingredients



e) Pre-cooking before retort packaging



f) Pressure cooking of pork products

FIG. 3.8: PHOTOGRAPHIC ILLUSTRATIONS OF THE VARIOUS STEPS INVOLVED IN PREPARATION OF TRADITIONAL PORK PRODUCTS WITH NON MEAT INGREDIENTS FOR RETORT AND VACUUM PACKAGING



a) Traditional pork products ready for packaging



b) Weighing product for retort packaging



c) Pork products in retort pouch



d) Retort pouch sealing



e) Inside chamber of retort processing machine



f) Retort processed package

FIG. 3.9. PHOTOGRAPHIC ILLUSTRATIONS OF THE VARIOUS STEPS INVOLVED IN RETORT PROCESSING OF TRADITIONAL PORK PRODUCTS



a) Control

b) Pork with *Anishi*

c) Pork with *Silam*

d) Pork with FDS

FIG. 3.10. PHOTOGRAPHIC ILLUSTRATIONS OF THE TRADITIONAL PORK PRODUCTS WITH CONTROL FOR VACUUM PACKAGING

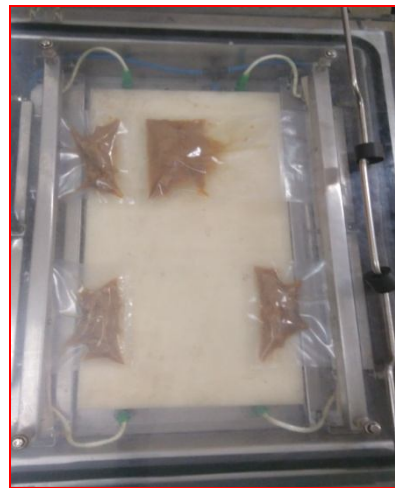


FIG. 3.11: VACUUM PACKAGING OF TRADITIONAL PORK PRODUCTS



FIG. 3.12: VACUUM PACKAGE OF TRADITIONAL PORK PRODUCTS

Chapter-IV

RESULTS AND DISCUSSION

4.1. PURPOSIVE SURVEY

A purposive survey was carried out in 6 (six) different villages namely Aoyimti, Aoyimkim, Ekranipathar, Medziphema, Toluvi and Sovima of Dimapur district representing three different tribes (Ao, Sema and Angami) of Nagaland. A questionnaire was developed for the survey and 30 numbers of household were involved for the survey. Three traditional pork products with incorporation of *Anishi* (*Colosasia esculenta* [L] Schott), *Silam* (*Perilla frutescens* [L] Britton seed) and Fermented dried soya (*Glycine max* [L] Merr) were surveyed for their steps of preparation, amount of ingredients used and consumption pattern.

A total of 30 numbers of households were surveyed, 10 each for each product. All the respondents were females (Table 4.1). It was observed that, most of the time the preparations of traditional products in the household are done by the female members only. Table 4.2 indicates the educational qualifications and community of the respondent in percentage where the 10th class standard were 10, class 12 standards 13.34 and graduate 76.66, respectively. The percent of respondents belonging to three tribes were 30 Ao tribe, 30 Angami tribe and 40 Sumi tribe, respectively. The mean values for family size (Table 4.3) indicated 1.40 ± 0.13 for male, 1.77 ± 0.21 for female and for children 3.28 ± 0.47 , respectively.

Table 4.4 indicated the cost of pork and source of pork. The mean cost of pork was recorded Rs. 223.33 ± 1.56 and source of pork in percentage were recorded 20 from local market and 80 from meat shop.

Non meat ingredients and vegetables used for the products like, onion, garlic, ginger, tomato, green chilies and local peppers were mostly procured from the local market. These ingredients were used for the preparation of pork with *Anishi*, pork with *Silam* and pork with Fermented Dried Soya (FDS).

The non meat ingredients used for cooking per kg of the pork products with *Anishi*, *Silam* and FDS by the respondents are presented in Table 4.5.

The mean values for salt (gm/kg product) used for pork with *Anishi*, *Silam* and FDS recorded were 22.00 ± 1.11 , 22.50 ± 1.12 and 24.00 ± 1.94 , respectively. The mean values for ginger (gm/kg product) were 16.50 ± 1.07 , 18.00 ± 0.82 and 19.00 ± 1.63 , respectively. For onion (gm/kg product), the mean values were 30.54 ± 1.18 , 34.12 ± 1.21 and 32.25 ± 1.31 , respectively. The mean values for garlic (gm/kg product) were 9.00 ± 0.67 , 7.00 ± 0.82 and 11.00 ± 1.00 , respectively. For green chilies (gm/kg product), the mean values were 22.50 ± 1.12 , 20.00 ± 1.05 and 31.50 ± 1.07 , respectively. The mean values for tomato (gm/kg product) were 33.00 ± 1.53 , 30.50 ± 1.17 and 34.00 ± 1.63 respectively and for water (ml/kg product), the mean values were 525.00 ± 25.00 , 550.00 ± 33.33 and 625.00 ± 67.19 , respectively.

Table 4.6 indicated the sources of ingredients for preparation of the traditional pork products. The sources of ingredients for pork with *Anishi*, were 20, 30 and 50 percent and for pork with *Silam* were 30, 40 and 30 respectively from home preparation, local market and villages. For pork with FDS the sources of ingredients were 80 and 20 percent from home preparation and local market, respectively.

The mean values for frequency of preparation of products in a week times (Table 4.6) for pork with *Anishi*, pork with *Silam* and pork with FDS were 2.50 ± 0.17 , 2.40 ± 0.22 and 2.60 ± 0.31 , respectively. The mean values for preparation of products and consumed during lunch in a week times for pork with *Anishi*, pork with *Silam* and pork with FDS were 3.00 ± 0.00 , 2.90 ± 0.10 and 3.00 ± 0.00 . The quantities of pork used by the respondents per cooking were recorded as 90 percent used 0.5 kg in pork with *Anishi* and 10 percent used for 1 kg. For pork with *Silam* 80 percent respondents used 0.5 kg and 20 percent used 1 kg. Whereas, for pork with FDS, 60 percent used 0.5 kg, 20 percent used 1 kg and remaining 20 percent used 2 kg, respectively.

Mostly the lean and fat portions of pork were used for cooking the traditional pork products and the non-meat ingredients were used in the form of paste, powder or both (Table 4.6). For preparation of the pork with *Anishi*, 40 percent *Anishi* was used in the form of paste and 60 percent in the form of both powder and paste. Similarly, for pork with *Silam*, 40 percent *Silam* was used in the form of paste and 60 percent in the form of

powder and paste. Whereas, the percent used were 30 as paste and 70 in the form of powder and paste for preparing pork with FDS.

The ingredients were procured from the local market, garden and other sources (Table 4.6). The percent of the source of ingredient for *Anishi* were 70 from local market and 30 from garden. The of source of *Silam* and FDS were 90 percent from local market and 10 percent from other sources. The mean values for the cost of ingredients for *Anishi*, *Silam* and FDS were Rs. 410.00±10.00, Rs. 400.00±0.00 and Rs. 100.00±0.00, respectively.

The percent of ingredients used in the product before cooking were 90 for pork with *Anishi*, 50 for pork with *Silam* and 50 for pork with FDS (Table 4.6). The percent of ingredients used during cooking for pork with *Anishi*, *Silam* and FDS were 10, 50 and 50, respectively. The non-meat ingredients are mostly used in traditional pork products to enhance flavour and taste. *Anishi*, *Silam* and FDS were used by percent of respondents for flavour was 100, 30 and 100 respectively. Whereas, 70 percent respondents used *Silam* with pork for taste. The traditional pork products are mostly cooked at home by housewives only.

Table 4.6 indicated the mean values for cooking time (minutes) of the pork products with *Anishi*, *Silam* and FDS were 22.50±2.14, 30.00±0.00 and 30.00±0.00, respectively. The percent of product cooked by pressure cooking for pork with *Anishi* and FDS were 60 and 20, respectively. The percent of products cooked by steam cooking for pork with *Anishi*, *Silam* and FDS were 40, 80 and 50, respectively. The percent of pressure and steam cooking applied for pork with *Silam* and FDS were 20 and 30, respectively. The percent of traditional pork products prepared during festivals for pork with *Anishi*, *Silam* and FDS were 100, 80 and 100, respectively. Whereas, 20 percent respondents do not prepare pork with *Silam* during festival. The percent of cooked traditional pork products consumed as hot cooked products for pork with *Anishi*, *Silam* and FDS were 90, 90 and 90, respectively. Whereas, the percent of cooked traditional pork products consumed after cooling for pork with *Anishi*, *Silam* and FDS were 10, 10 and 10, respectively.

TABLE 4.1. GENDER RESPONDENT

Products	Gender (%)		Total
	Male	Female	
Pork with <i>Anishi</i>	-	100.00 (10)*	10
Pork with <i>Silam</i>	-	100.00 (10)*	10
Pork with fermented dried soya	-	100.00 (10)*	10
Total	-	30	30

*Figures in the parenthesis indicates number of respondent

TABLE 4.2. EDUCATIONAL QUALIFICATION AND COMMUNITY OF THE RESPONDENTS

Educational qualification	Percent (%)
10 standard	10.00 (3)*
12 standard	13.34 (4)*
Graduate	76.66 (23)*
Community	Percent (%)
Ao	30.00 (9)*
Angami	30.00 (9)*
Sumi	40.00 (12)*

*Figures in the parenthesis indicates no. of respondent

TABLE 4.3. FAMILY SIZE OF THE RESPONDENT

Family size	Mean±SE
Male	1.40±0.13
Female	1.77±0.21
Children	3.28±0.47
Overall	2.15±0.27

TABLE 4.4. COST AND SOURCE OF PORK

Cost of pork (Rs)	Source/purchase of pork (%)		
Mean±SE	Local market	Meat shop	Slaughter house
223.33±1.56	20.00	80.00	--

TABLE 4.5. NON-MEAT INGREDIENTS USED FOR COOKING PER KG OF PRODUCTS (Mean±SE)

Products	Salt (gm)	Ginger (gm)	Onion (gm)	Garlic (gm)	Green Chilies (gm)	Tomato (gm)	Water (ml)
Pork with <i>Anishi</i>	22.00±1.11	16.50±1.07	30.54±1.18	9.00±0.67	22.50±1.12	33.00±1.53	525.00±25.00
Pork with <i>Silam</i>	22.50±1.12	18.00±0.82	34.12±1.21	7.00±0.82	20.00±1.05	30.50±1.17	550.00±33.33
Pork with fermented dried soya	24.00±1.94	19.00±1.63	32.25±1.31	11.00±1.00	31.50±1.07	34.00±1.63	625.00±67.19

TABLE 4.6. RESPONDENT SURVEY QUESTIONNAIRES OF TRADITIONAL PORK PRODUCTS

Questionnaires	Source	Pork with <i>Anishi</i>	Pork with <i>Silam</i>	Pork with fermented dried soya
Source of ingredients for the product preparation (%)	Home preparation	20	30	80
	Local market	30	40	20
	Village	50	30	-
Preparation of products in a week (Mean±SE)	No. of times	2.50±0.17	2.40±0.22	2.60±0.31
Prepared products and consumed during lunch and dinner in a week times (Mean±SE)	Lunch	3.00±0.00	2.90±0.10	3.00±0.00
	Dinner	--	--	--
Quantity of pork used per cooking (%)	½ kg	90	80	60
	1 kg	10	20	20
	2 kg	--	--	20
Type of pork used for cooking (%)	Fresh pork	40	40	10
	Smoked pork	60	60	90
Type of pork portion used for cooking (%)	Both lean and fatty portion	100	100	100
Form of ingredients used for cooking (%)	Powder and paste	60	60	70
	Paste	40	40	30
Procurement of ingredients (%)	Local market	70	90	90
	Garden	30	--	--
	Other source	--	10	10
Cost of ingredients (Rs/kg) (Mean±SE)	--	410.00±10.00	400.00±0.00	100.00±0.00

How ingredient are used in the product (%)	Before cooking	90	50	50
	During cooking	10	50	50
Reason for ingredients used in the products (%)	Flavour	100	30	100
	Taste	--	70	--
Who cook the product at home (%)	Mother	100	100	100
Cooking time of the products (minutes) (Mean±SE)	--	22.50±2.14	30.00±0.00	30.00±0.00
How the product are cooked (%)	Pressure	60	--	20
	Steam cooking	40	80	50
	Both	--	20	30
Prepare products during occasion /festivals (%)	Yes	100	80	100
	No	--	20	--
When the cooked products are consumed (%)	During hot	90	90	90
	After cooling	10	10	10

TABLE 4.7. COST OF PRODUCTION OF TRADITIONAL PORK PRODUCTS AT FIELD LEVEL: COST FOR 2 KG

Ingredients	Pork with <i>Anishi</i>	Pork with <i>Silam</i>	Pork with FDS
Pork 2 kg @ Rs. 220/kg	440.00	440.00	440.00
Additives (Salt, condiments, tomato, green chillies) LS	40.00	40.00	40.00
<i>Anishi</i> 100g @ Rs. 400/kg	40.00	-	-
<i>Silam</i> 200g @ Rs. 400/kg	-	80.00	-
FDS 200g @ Rs. 400/kg	-	-	80.00
Processing cost (Labour, LPG gas etc.)	40.00	40.00	40.00
Total cost (Rs)	560.00	600.00	600.00
Final product (Kg)	1.60	1.60	1.60
Cost of production (Rs/Kg)	350.00	375.00	375.00

Considering all aspects like cost of raw materials, production, processing, labour and LPG gas cooking, the cost of production for traditional pork products at field level per kilogram were found to be Rs. 350.00 for pork with *Anishi*, Rs. 375.00 for pork with *Silam* and Rs. 375.00 for pork with FDS. The result indicates that the costs of final products were lower for pork with *Anishi*, compared to pork with *Silam* and FDS incorporated pork products. Among the pork products, the cost of pork with *Anishi* was lower than pork with *Silam* and FDS.

4.2. STANDARDIZATION OF LEVEL OF INGREDIENTS IN TRADITIONAL PORK PRODUCTS

Based on results of the sensory evaluation, pork products with the highest sensory scores (Table 2.1) were selected from the sample incorporated with *Anishi*, *Silam* and Fermented Dried Soya (FDS) for standardization. The standardization was done with incorporation of different levels of ingredients. For both *Anishi* and FDS the percent levels were 1, 2, 3, 4, 5, and 6, respectively. The percent levels of *Silam* were 2, 4, 6, 8, 10, and 12, respectively. For all the three pork products, the level of incorporation of *Anishi*, *Silam* and FDS with highest sensory scores were selected for standardization of the respective products.

The mean values for different sensory parameters with various levels of ingredients for standardization of the traditional pork products are presented in table 2.1. The mean values for appearance of pork incorporated with *Anishi* at 1, 2, 3, 4, 5 and 6 percent levels were 5.29 ± 0.09 , 5.34 ± 0.09 , 5.51 ± 0.09 , 5.83 ± 0.06 , 6.49 ± 0.09 and 6.11 ± 0.08 , respectively. The mean values for appearance for pork incorporated with FDS at 1, 2, 3, 4, 5 and 6 percent levels were 5.11 ± 0.05 , 5.46 ± 0.09 , 5.57 ± 0.08 , 6.00 ± 0.08 , 6.57 ± 0.08 and 5.23 ± 0.07 and for pork incorporated with *Silam* at 2, 4, 6, 8, 10 and 12 percent levels were 5.03 ± 0.08 , 4.91 ± 0.05 , 5.23 ± 0.07 , 5.83 ± 0.06 , 6.40 ± 0.08 and 5.91 ± 0.10 , respectively.

The mean values for flavour score for pork incorporated with *Anishi* at 1, 2, 3, 4, 5 and 6 percent levels were 5.37 ± 0.10 , 5.34 ± 0.09 , 5.40 ± 0.10 , 5.66 ± 0.09 , 6.77 ± 0.07 and 6.23 ± 0.12 , respectively. The mean values for pork incorporated with FDS at 1, 2, 3, 4, 5 and 6 percent levels were 5.23 ± 0.07 , 5.54 ± 0.09 , 5.63 ± 0.08 , 6.23 ± 0.11 , 7.00 ± 0.00 and

6.23±0.12 and for pork incorporated with *Silam* at 2, 4, 6, 8, 10 and 12 percent levels were 5.17±0.12, 5.31±0.13, 5.51±0.10, 6.11±0.11, 6.83±0.06 and 6.03±0.13, respectively.

For juiciness scores the mean values for pork incorporated with *Anishi* levels at 1, 2, 3, 4, 5 and 6 percent levels were 5.49±0.10, 5.34±0.09, 5.46±0.10, 5.89±0.05, 6.74±0.07 and 6.26±0.09, respectively. The mean values for pork incorporated FDS at 1, 2, 3, 4, 5 and 6 percent levels were 5.29±0.08, 5.60±0.08, 5.60±0.08, 6.14±0.10, 6.86±0.06 and 6.51±0.09 and for pork incorporated *Silam* at 2, 4, 6, 8, 10 and 12 percent levels were 5.15±0.09, 5.06±0.11, 5.26±0.07, 6.26±0.10, 6.93±0.04 and 6.09±0.10, respectively.

For tenderness scores the mean values for pork incorporated with *Anishi* at 1, 2, 3, 4, 5 and 6 percent levels were 5.51±0.10, 5.43±0.09, 6.60±0.09, 5.91±0.06, 6.80±0.07 and 6.20±0.09, respectively. The mean values for pork incorporated FDS at 1, 2, 3, 4, 5 and 6 percent levels were 5.11±0.05, 5.37±0.08, 5.66±0.08, 6.11±0.08, 6.77±0.07 and 6.29±0.08 and for pork incorporated *Silam* at 2, 4, 6, 8, 10 and 12 percent levels were 5.06±0.07, 5.26±0.09, 5.34±0.09, 6.31±0.10, 6.98±0.03 and 6.34±0.10, respectively.

The mean values for overall acceptability of pork incorporated with *Anishi* at 1, 2, 3, 4, 5 and 6 percent levels were 5.50±0.09, 5.40±0.08, 5.63±0.10, 6.11±0.08, 6.89±0.05 and 6.06±0.04, respectively. The mean values for pork incorporated with FDS at 1, 2, 3, 4, 5 and 6 percent levels were 5.11±0.05, 5.23±0.07, 5.63±0.08, 6.11±0.08, 6.94±0.04 and 6.14±0.06 and for pork incorporated with *Silam* at 2, 4, 6, 8, 10 and 12 percent levels were 4.74±0.07, 4.94±0.09, 5.31±0.08, 6.11±0.08, 7.00±0.00 and 6.03±0.06, respectively.

Analysis of variance (Table 2.2) revealed highly significant ($P < 0.01$) difference in all the levels of the products with the ingredients *Anishi*, *Silam* and Fermented Dried Soya in the traditional pork products. The percent of higher sensory scores was observed in 5 percent level of incorporation for *Anishi* and FDS, while higher score were recorded in *Silam* at 10 percent level of incorporation. Accordingly, 5 percent level each of incorporation were selected in the products containing *Anishi* and FDS and 10 percent level in *Silam* for further studies.

TABLE 4.8. STANDARDIZATION OF LEVEL OF INGREDIENTS IN TRADITIONAL PORK PRODUCTS ON THE BASIS OF SENSORY SCORES

Parameters	Products	Level of ingredients (Mean±SE)								
		1%	2%	3%	4%	5%	6%	8%	10%	12%
Appearance	Pork with <i>Anishi</i>	5.29±0.09 ^a	5.34±0.09 ^a	5.51±0.09 ^a	5.83±0.06 ^c	6.49±0.09 ^d	6.11±0.08 ^b	-	-	-
	Pork with FDS	5.11±0.05 ^a	5.46±0.09 ^c	5.57±0.08 ^c	6.00±0.08 ^b	6.57±0.08 ^d	5.23±0.07 ^c	-	-	-
	Pork with <i>Silam</i>	-	5.03±0.08 ^{ac}	-	4.91±0.05 ^a	-	5.23±0.07 ^c	5.83±0.06 ^b	6.40±0.08 ^d	5.91±0.10 ^b
Flavour	Pork with <i>Anishi</i>	5.37±0.10 ^a	5.34±0.09 ^a	5.40±0.10 ^{ac}	5.66±0.09 ^c	6.77±0.07 ^d	6.23±0.12 ^b	-	-	-
	Pork with FDS	5.23±0.07 ^c	5.54±0.09 ^a	5.63±0.08 ^a	6.23±0.11 ^c	7.00±0.00 ^d	6.54±0.10 ^b	-	-	-
	Pork with <i>Silam</i>	-	5.17±0.12 ^a	-	5.31±0.13 ^{ac}	-	5.51±0.10 ^c	6.11±0.11 ^b	6.83±0.06 ^d	6.03±0.13 ^b
Juiciness	Pork with <i>Anishi</i>	5.49±0.10 ^a	5.34±0.09 ^a	5.46±0.10 ^a	5.89±0.05 ^c	6.74±0.07 ^d	6.26±0.09 ^b	-	-	-
	Pork with FDS	5.29±0.08 ^c	5.60±0.08 ^a	5.60±0.08 ^a	6.14±0.10 ^c	6.86±0.06 ^d	6.51±0.09 ^b	-	-	-
	Pork with <i>Silam</i>	-	5.14±0.09 ^c	-	5.06±0.11 ^c	-	5.26±0.07 ^c	6.26±0.10 ^b	6.93±0.04 ^d	6.09±0.10 ^b
Tenderness	Pork with <i>Anishi</i>	5.51±0.10 ^a	5.43±0.09 ^a	5.60±0.09 ^a	5.91±0.06 ^c	6.80±0.07 ^d	6.20±0.09 ^b	-	-	-
	Pork with FDS	5.11±0.05 ^c	5.37±0.08 ^a	5.66±0.08 ^c	6.11±0.08 ^b	6.77±0.07 ^d	6.29±0.08 ^b	-	-	-
	Pork with <i>Silam</i>	-	5.06±0.07 ^a	-	5.26±0.09 ^{ac}	-	5.34±0.09 ^c	6.31±0.10 ^b	6.98±0.03 ^d	6.34±0.10 ^b
Overall acceptability	Pork with <i>Anishi</i>	5.50±0.09 ^{ac}	5.40±0.08 ^a	5.63±0.10 ^c	6.11±0.08 ^b	6.89±0.05 ^d	6.06±0.04 ^b	-	-	-
	Pork with FDS	5.11±0.05 ^a	5.23±0.07 ^a	5.63±0.08 ^c	6.11±0.08 ^b	6.94±0.04 ^d	6.14±0.06 ^b	-	-	-
	Pork with <i>Silam</i>	-	4.74±0.07 ^e	-	4.94±0.09 ^a	-	5.31±0.08 ^c	6.11±0.08 ^b	7.00±0.00 ^d	6.03±0.06 ^b

Mean having different superscript in the row (small letter) differ significantly (P<0.01).

SE=Standard Error, n=5

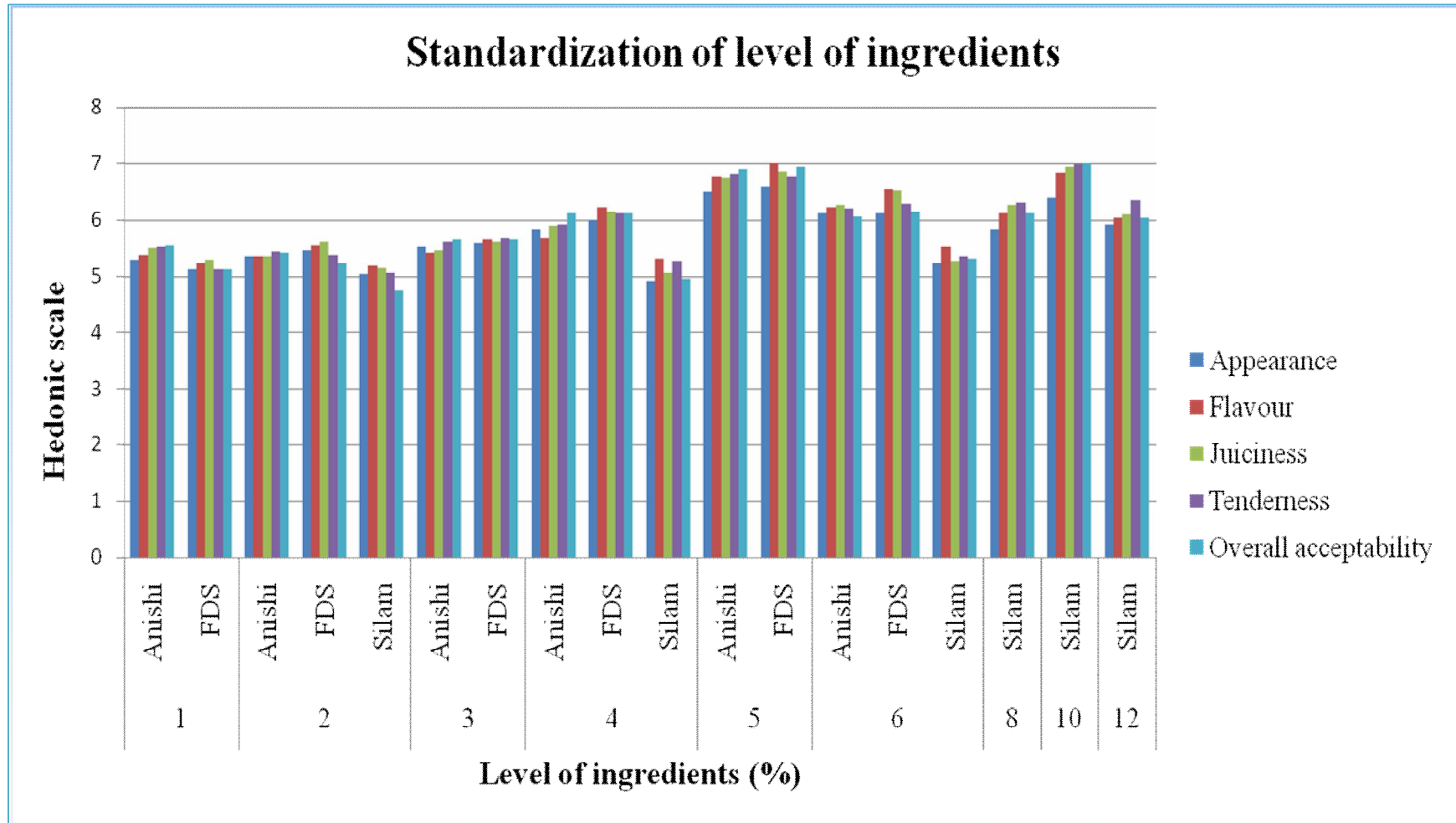


FIG 4.1. GRAPHICAL REPRESENTATION OF THE LEVEL OF INGREDIENTS IN TRADITIONAL PORK PRODUCTS ON THE BASIS OF SENSORY EVALUATION

TABLE 4.9. ANALYSIS OF VARIANCE FOR SENSORY PARAMETERS FOR STANDARDIZATION OF LEVEL OF INGREDIENTS IN TRADITIONAL PORK PRODUCTS

Products	Source	df	Mean sum of squares				
			Appearance	Flavour	Juiciness	Tenderness	Overall acceptability
Pork with <i>Anishi</i>	Level	5	7.8133**	11.9019**	10.5533**	9.5247**	10.3933**
	Error	204	0.2403	0.3268	0.2560	0.2630	0.2070
Pork with FDS	Level	5	9.6161**	15.9885**	12.9485**	13.3600**	16.2790**
	Error	204	0.2005	0.2445	0.2414	0.1983	0.1549
Pork with <i>Silam</i>	Level	5	12.6865**	14.3381**	21.0994**	21.8557**	26.9254**
	Error	209	0.1971	0.4284	0.2825	0.2337	0.1752

df= degree of freedom, **= Significant at 1 percent level (p<0.01)

4.3. RETORT POUCH PROCESSING OF TRADITIONAL PORK PRODUCTS

The retort temperature and the product core temperature before processing was 32°C and 30°C, respectively. The product core temperature reached its first lethality rate of 0.001, when the product core temperature was 90°C and the retort temperature was 121.1°C in the treatments. These findings were similar to the results observed by Rajkumar (2008) in *Chettinad* goat meat product; Gopal *et al.* (2001) in traditional Kerala style fish curry; Devadason (2004) in retort pouch processing of buffalo nuggets; Sreenath *et al.* (2007) in ready-to-eat squid masala in indigenous polymer-coated tin-free steel cans and Mohan *et al.* (2008) in thermal processing of prawn '*kuruma*' in retortable pouches and aluminum cans.

The total heating time for control, pork with *Anishi*, pork with *Silam* and pork with FDS were recorded 23, 22, 20 and 24 minutes, respectively based on the time taken for the products core temperature to reach 121.1°C. Cooling time for control, pork with *Anishi*, pork with *Silam* and pork with FDS were 8, 7, 8 and 10 minutes, respectively after attaining necessary core temperature of 121°C. After cooling, the retort temperature was 45°C and the product core temperature was 60°C. The above results are in agreement with Rajkumar (2008); Devadason (2004) and Bindu *et al.* (2007).

Total lethality (F_0) received for the traditional pork products for control, pork with *Anishi*, pork with *Silam* and pork with FDS were 10.88, 11.24, 10.63 and 10.27 minutes respectively. The results were in agreement with the findings of Ranganna (2000), who reported total lethality (F_0) values between 8-12 minutes, Rajkumar (2008) who recorded total lethality (F_0) values of 5.85, 7.89 and 12.10 in *Chettinad* goat meat product and Shankar *et al.* (2002) who recorded the total lethality (F_0) value of 11.5 minutes in heat processed seer fish curry.

The processing time for control, pork with *Anishi*, pork with *Silam* and pork with FDS were 34, 32, 32 and 34 minutes, respectively. Total processing time was highest for control and pork with FDS. Rajkumar (2008) also reported that total processing time was recorded at 46, 49 and 55 minutes for three different treatments in *Chettinad* goat meat product.

4.3.1. Proximate composition of traditional pork products under retort packaging

4.3.1.1. Moisture

The mean moisture content of control and traditional pork products under retort pouch packaging are presented in Table 4.10. The analysis of variance is presented in Table 4.11. The graphical representation is presented in Fig. 4.2.

The mean percent moisture content recorded for the control product under retort pouch packaging on 0 day was 69.52 ± 0.31 and in case of the treated products were 68.55 ± 0.43 , 69.77 ± 0.11 and 68.65 ± 0.10 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean moisture content recorded for control product were 68.90 ± 0.16 , 67.51 ± 0.08 , 67.33 ± 0.10 , 66.92 ± 0.10 , 66.61 ± 0.14 and 65.97 ± 0.17 percent. These mean values for percent moisture content in pork with *Anishi* were 68.66 ± 0.33 , 67.70 ± 0.15 , 67.47 ± 0.09 , 67.03 ± 0.09 , 66.86 ± 0.05 and 65.90 ± 0.31 , for pork with *Silam* were 68.86 ± 0.16 , 68.41 ± 0.09 , 67.84 ± 0.09 , 67.29 ± 0.23 , 66.80 ± 0.22 and 66.13 ± 0.27 and for pork with FDS were 68.36 ± 0.09 , 67.65 ± 0.18 , 67.44 ± 0.08 , 67.04 ± 0.07 , 67.02 ± 0.16 and 66.59 ± 0.15 , respectively. The decreasing trend in moisture content in control and all the traditional pork products incorporated with *Anishi*, *Silam* and FDS during entire storage period was observed in all the traditional pork products on retort packaging.

The analysis of variance revealed highly significant ($p < 0.01$) differences in percent moisture content in control and treated products during storage days. These differences might be due to used of different ingredients in the pork products incorporated with *Anishi*, *Silam* and FDS. Lower moisture contents were also noticed by Rajkumar (2008) in retort pouch processed *Chettinad* goat meat product. Abdullah (2007) reported a significantly higher ($p < 0.01$) moisture content for the luncheon meat. Similar finding was also observed by Chandirasekaran and Rajan (2016) in *Chettinad* chicken product at storage period of 0 to 180 days.

4.3.1.2. Ether extract

The mean ether extract content of control and traditional pork products under retort packaging are presented in Table 4.10. The analysis of variance is presented in Table 4.11. The graphical representation is presented in Fig. 4.3.

The mean percent ether extract content recorded for the control product under retort pouch packaging on 0 day was 9.37 ± 0.14 and the treated products were 9.31 ± 0.43 , 8.03 ± 0.10 and 8.99 ± 0.08 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean ether extract content recorded for control product were 9.83 ± 0.28 , 9.94 ± 0.38 , 10.10 ± 0.34 , 10.22 ± 0.35 , 10.41 ± 0.57 and 10.64 ± 0.71 percent. These mean values for percent ether extract content in pork with *Anishi* were 9.76 ± 0.32 , 9.86 ± 0.38 , 9.98 ± 0.37 , 10.14 ± 0.40 , 10.20 ± 0.56 and 10.60 ± 0.86 , for pork with *Silam* were 9.24 ± 0.33 , 9.69 ± 0.17 , 9.93 ± 0.42 , 10.11 ± 0.54 , 10.33 ± 0.71 and 10.83 ± 0.76 and for pork with FDS were 9.32 ± 0.16 , 9.58 ± 0.42 , 9.98 ± 0.46 , 10.00 ± 0.63 , 10.47 ± 0.53 and 10.88 ± 0.74 , respectively. Higher fat contents were observed in control and all the traditional pork products on 180 days of storage.

Analysis of variance revealed highly significant ($p < 0.01$) differences in ether extract content among control and treated products during different storage periods. Rajkumar *et al.* (2004) reported that the ether extract content of goat meat patties was increased up to 14 days. Rajkumar (2008) also observed the increase in fat content of retort pouch processing of *Chettinad* goat meat product. The decrease in moisture content in the products during storage might have attributed to the increase in the fat content of the products.

4.3.1.3. Total ash

The mean percent total ash content of control and traditional pork products under retort packaging are presented in Table 4.10. The analysis of variance is presented in Table 4.11. The graphical representation is presented in Fig. 4.4.

The mean percent total ash content recorded for the control product under retort pouch packaging on 0 day was 4.20 ± 0.08 and in the treated products were 5.32 ± 0.20 , 5.26 ± 0.17 and 4.34 ± 0.07 for pork with *Anishi*, pork with *Silam* and for pork with FDS,

respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean total ash content recorded for control product were 4.33 ± 0.12 , 4.83 ± 0.14 , 5.05 ± 0.02 , 5.33 ± 0.09 , 6.00 ± 0.12 and 6.72 ± 0.22 percent. These mean values for percent total ash content in pork with *Anishi* were 5.28 ± 0.11 , 5.45 ± 0.09 , 5.64 ± 0.03 , 6.10 ± 0.03 , 6.70 ± 0.09 and 7.02 ± 0.11 , for pork with *Silam* were 5.12 ± 0.08 , 5.50 ± 0.10 , 6.15 ± 0.25 , 6.31 ± 0.23 , 6.69 ± 0.19 and 7.09 ± 0.22 and for pork with FDS were 4.39 ± 0.14 , 4.96 ± 0.13 , 5.96 ± 0.39 , 6.50 ± 0.21 , 6.87 ± 0.12 and 7.20 ± 0.20 , respectively.

The analysis of variance showed highly significant ($p < 0.01$) differences in different days of storage periods in control and treated products. The increase in total ash content was observed in all the products during storage period. Similar trend of increasing in total ash content of *Chettinad* goat meat product during storage under retort packaging was also observed by Rajkumar (2008).

4.3.1.4. Crude protein

The mean crude protein content of control and traditional pork products under retort packaging are presented in Table 4.10. The analysis of variance is presented in Table 4.11. The graphical representation is presented in Fig.4.5.

The mean percent crude protein content recorded for the control product under retort pouch packaging on 0 day was 16.35 ± 0.19 and in the treated products were 15.18 ± 0.22 , 16.57 ± 0.13 and 17.08 ± 0.04 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean crude protein content recorded for control product were 15.93 ± 0.14 , 15.72 ± 0.15 , 15.55 ± 0.20 , 15.54 ± 0.14 , 15.21 ± 0.12 and 14.91 ± 0.13 percent. These mean values for percent crude protein content in pork with *Anishi* were 14.57 ± 0.17 , 14.52 ± 0.16 , 14.47 ± 0.15 , 14.19 ± 0.04 , 14.10 ± 0.05 and 14.91 ± 0.13 , for pork with *Silam* were 15.49 ± 0.29 , 15.27 ± 0.29 , 15.32 ± 0.28 , 14.99 ± 0.10 , 14.81 ± 0.11 and 14.59 ± 0.13 and for pork with FDS were 16.71 ± 0.15 , 16.38 ± 0.09 , 16.29 ± 0.02 , 16.15 ± 0.03 , 15.64 ± 0.16 and 15.38 ± 0.11 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and the treated formulations. The control and other treated formulations also revealed

significant decrease ($p < 0.01$) during increased storage periods. There was decreasing trends in crude protein contents as the storage period increases. However, the crude protein contents were recorded highest in pork with FDS compared to control, pork with *Anishi* and *Silam* from 0 to 180 days. The lowest crude protein contents were observed in pork with *Anishi* in all the storage period of study. The decrease in protein content on storage periods might influence the moisture and the protein percentage. The decreased in protein content might also be due to breakdown of protein during storage of the products due to enzymatic actions. Rajkumar (2008) also reported highly significant ($p < 0.01$) difference of crude protein content in retort pouch processing of *Chettinad* goat meat products. The significant difference in percent protein content might be due to differences in protein content of the different ingredients incorporated in the traditional pork products.

TABLE 4.10. EFFECT OF PROXIMATE COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Parameters	Products	Mean± SE of different days						
		0	30	60	90	120	150	180
Moisture (%)	Control	^a 69.52±0.31 ^A	^b 68.90±0.16 ^A	^c 67.51±0.08 ^A	^{cd} 67.33±0.10 ^A	^{de} 66.92±0.10 ^A	^e 66.61±0.14 ^A	^f 65.97±0.17 ^A
	Pork with <i>Anishi</i>	^a 68.55±0.43 ^B	^a 68.66±0.33 ^A	^b 67.70±0.15 ^A	^{bc} 67.47±0.09 ^A	^{bc} 67.03±0.09 ^A	^c 66.86±0.05 ^A	^d 65.90±0.31 ^A
	Pork with <i>Silam</i>	^a 69.11±0.11 ^{AB}	^{ab} 68.86±0.16 ^A	^b 68.41±0.09 ^B	^c 67.84±0.09 ^B	^d 67.29±0.23 ^A	^d 66.80±0.22 ^A	^e 66.13±0.27 ^A
	Pork with FDS	^a 68.65±0.10 ^A	^a 68.36±0.09 ^A	^b 67.65±0.18 ^A	^b 67.44±0.08 ^A	^c 67.04±0.07 ^A	^c 67.02±0.16 ^A	^d 66.59±0.15 ^A
Ether extract (%)	Control	^a 9.37±0.14 ^A	^a 9.83±0.28 ^A	^a 9.94±0.38 ^A	^a 10.10±0.34 ^A	^a 10.22±0.35 ^A	^a 10.41±0.57 ^A	^a 10.64±0.71 ^A
	Pork with <i>Anishi</i>	^a 9.31±0.43 ^A	^a 9.76±0.32 ^A	^a 9.86±0.38 ^A	^a 9.98±0.37 ^A	^a 10.14±0.40 ^A	^a 10.20±0.56 ^A	^a 10.60±0.86 ^A
	Pork with <i>Silam</i>	^b 8.03±0.10 ^B	^{ab} 9.24±0.33 ^A	^a 9.69±0.17 ^A	^a 9.93±0.42 ^A	^a 10.11±0.54 ^A	^a 10.33±0.71 ^A	^a 10.83±0.76 ^A
	Pork with FDS	^b 8.99±0.08 ^A	^{ab} 9.32±0.16 ^A	^{ab} 9.58±0.42 ^A	^{ab} 9.98±0.46 ^A	^{ab} 10.00±0.63 ^A	^{ab} 10.47±0.53 ^A	^a 10.88±0.74 ^A
Total Ash (%)	Control	^a 4.20±0.08 ^A	^a 4.33±0.12 ^A	^d 4.83±0.14 ^A	^{cd} 5.05±0.02 ^A	^c 5.33±0.09 ^A	^b 6.00±0.12 ^A	^e 6.72±0.22 ^A
	Pork with <i>Anishi</i>	^{ae} 5.32±0.20 ^B	^e 5.28±0.11 ^B	^{ae} 5.45±0.09 ^B	^a 5.64±0.03 ^{AB}	^c 6.10±0.03 ^B	^b 6.70±0.09 ^B	^d 7.02±0.11 ^A
	Pork with <i>Silam</i>	^a 5.26±0.17 ^B	^a 5.12±0.08 ^B	^a 5.50±0.10 ^B	^b 6.15±0.25 ^B	^b 6.31±0.23 ^B	^{ab} 6.69±0.19 ^B	^c 7.09±0.22 ^A
	Pork with FDS	^a 4.34±0.07 ^A	^{ad} 4.39±0.14 ^A	^d 4.96±0.13 ^A	^c 5.96±0.39 ^B	^{bc} 6.50±0.21 ^B	^{bc} 6.87±0.12 ^B	^c 7.20±0.20 ^A
Crude Protein (%)	Control	^a 16.35±0.19 ^A	^{ab} 15.93±0.14 ^A	^b 15.72±0.15 ^A	^{bc} 15.55±0.20 ^A	^{bc} 15.54±0.14 ^A	^{cd} 15.21±0.12 ^A	^d 14.91±0.13 ^A
	Pork with <i>Anishi</i>	^a 15.18±0.22 ^B	^b 14.57±0.17 ^B	^{bc} 14.52±0.16 ^B	^{bc} 14.47±0.15 ^B	^{bcd} 14.19±0.04 ^B	^{cd} 14.10±0.05 ^B	^d 13.90±0.13 ^B
	Pork with <i>Silam</i>	^a 16.57±0.13 ^A	^b 15.49±0.29 ^A	^{bc} 15.27±0.29 ^A	^{bc} 15.32±0.28 ^A	^{bcd} 14.99±0.10 ^C	^{cd} 14.81±0.11 ^C	^d 14.59±0.13 ^A
	Pork with FDS	^a 17.08±0.04 ^C	^b 16.71±0.15 ^C	^c 16.38±0.09 ^C	^c 16.29±0.02 ^C	^c 16.15±0.03 ^D	^d 15.64±0.16 ^D	^d 15.38±0.11 ^C

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.11. ANALYSIS OF VARIANCE OF PROXIMATE COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Source	df	Mean±SE			
		Moisture	Ether Extract	Total Ash	Crude Protein
Products	3	0.6814*	0.7087 ^{NS}	4.6093**	19.9374**
Days	6	20.2561**	6.8731**	15.1327**	5.4059**
Error	130	0.2066	1.0384	0.1671	0.1227

df= degree of freedom, NS= Non Significant, **= Significant at 1 percent level, *= Significant at (p<0.05)

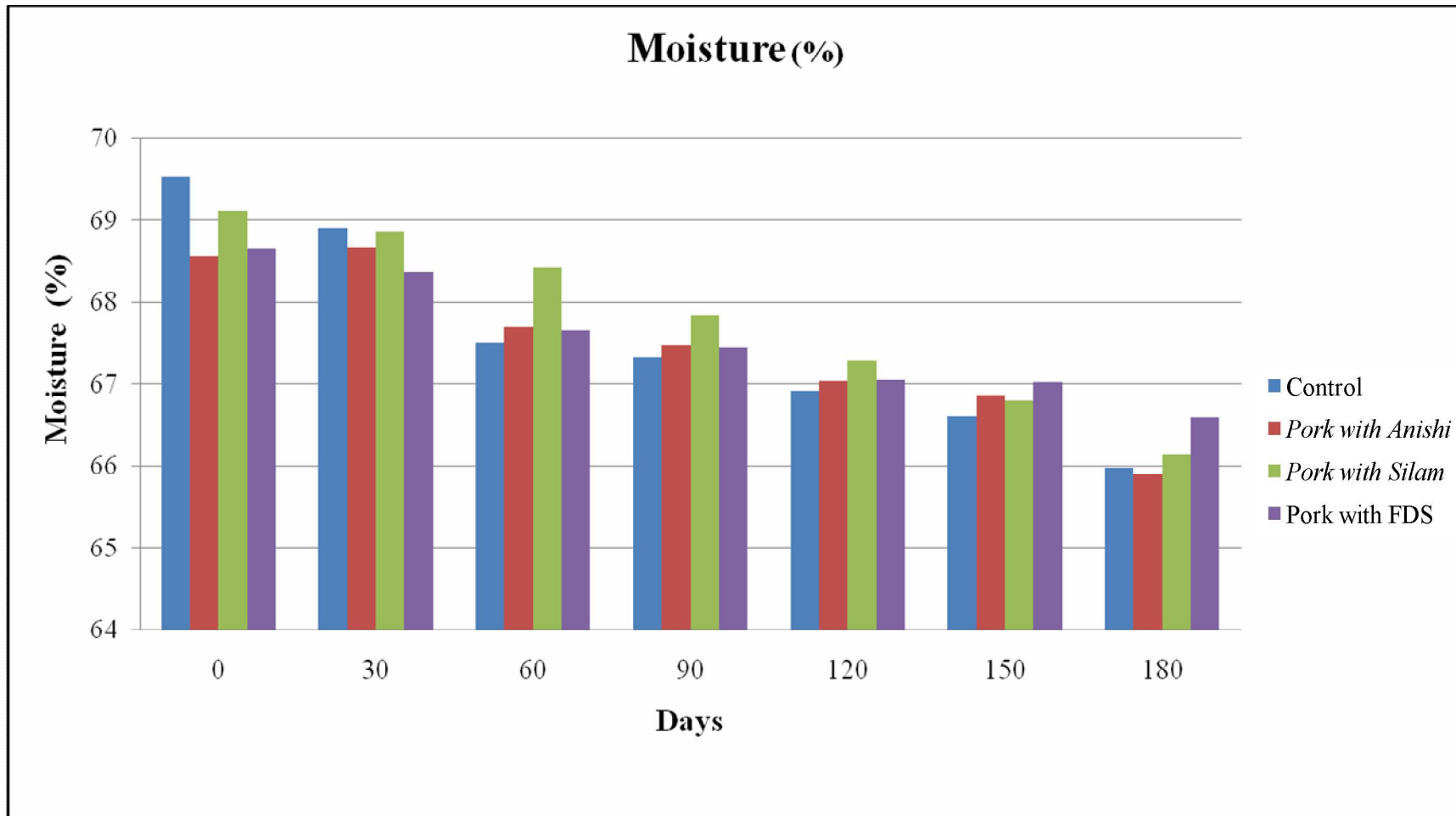


FIG 4.2. GRAPHICAL REPRESENTATION OF EFFECT OF MOISTURE CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

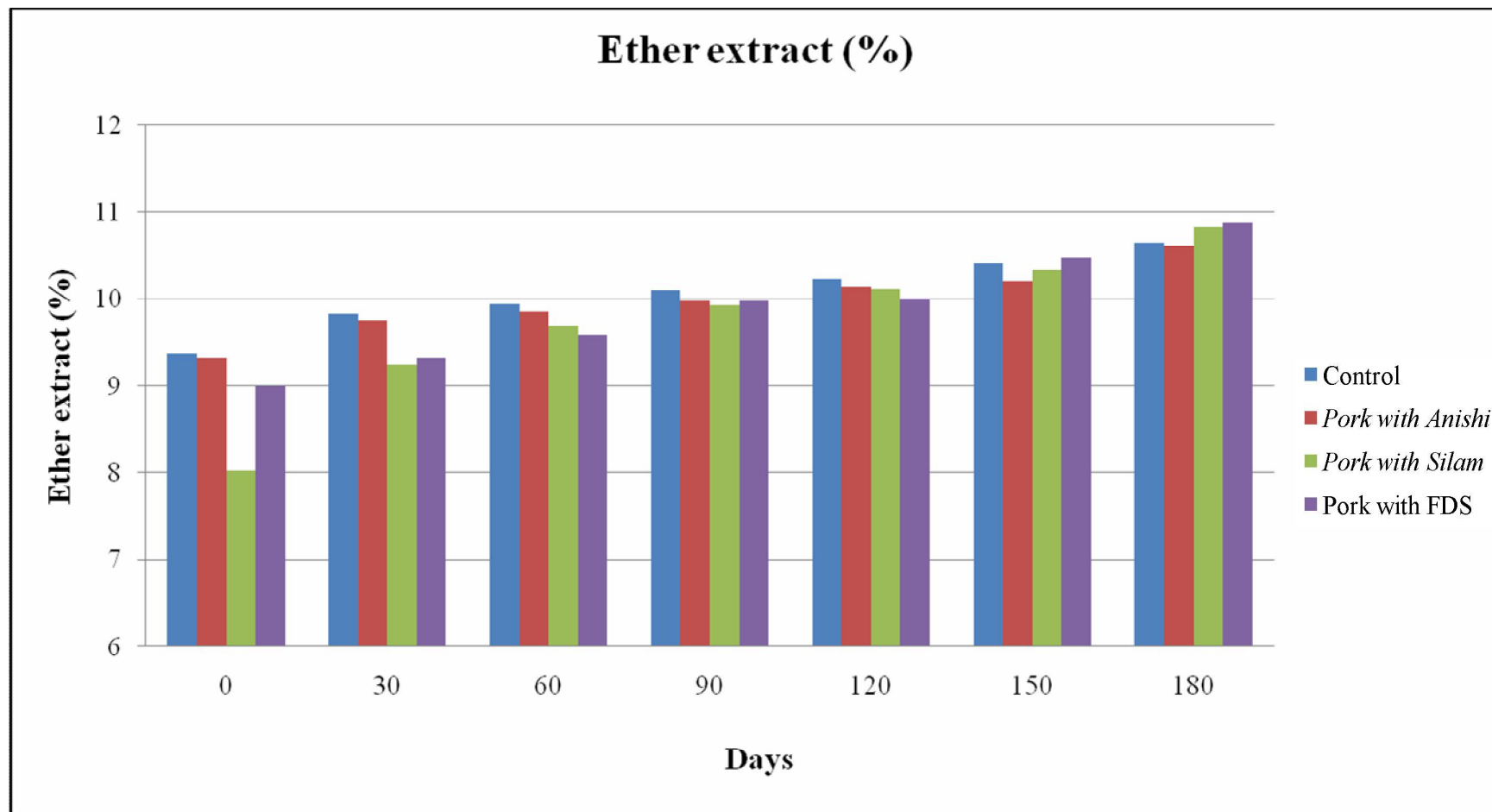


FIG 4.3. GRAPHICAL REPRESENTATION OF EFFECT OF ETHER EXTRACT CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

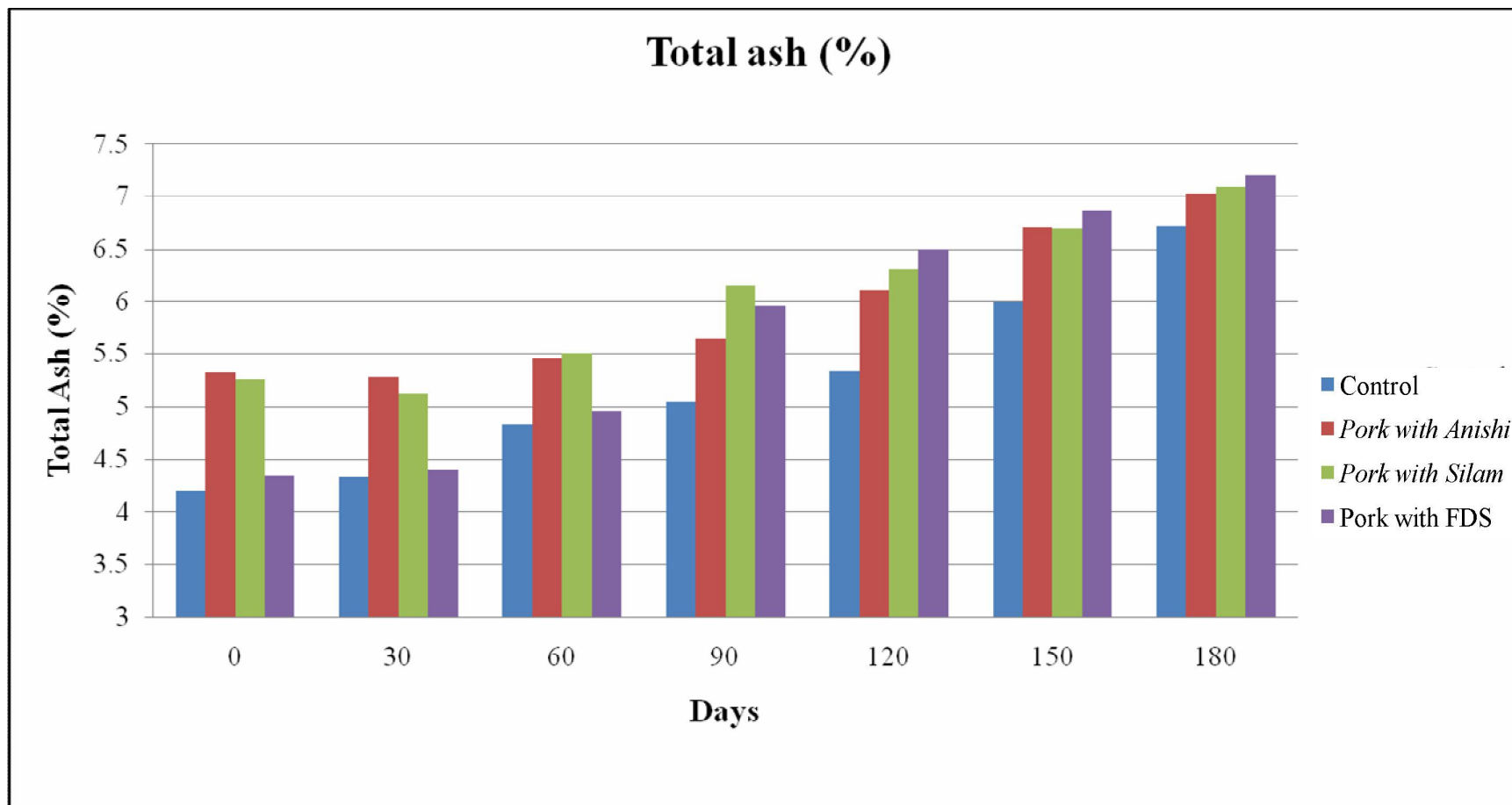


FIG 4.4. GRAPHICAL REPRESENTATION OF EFFECT OF TOTAL ASH CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

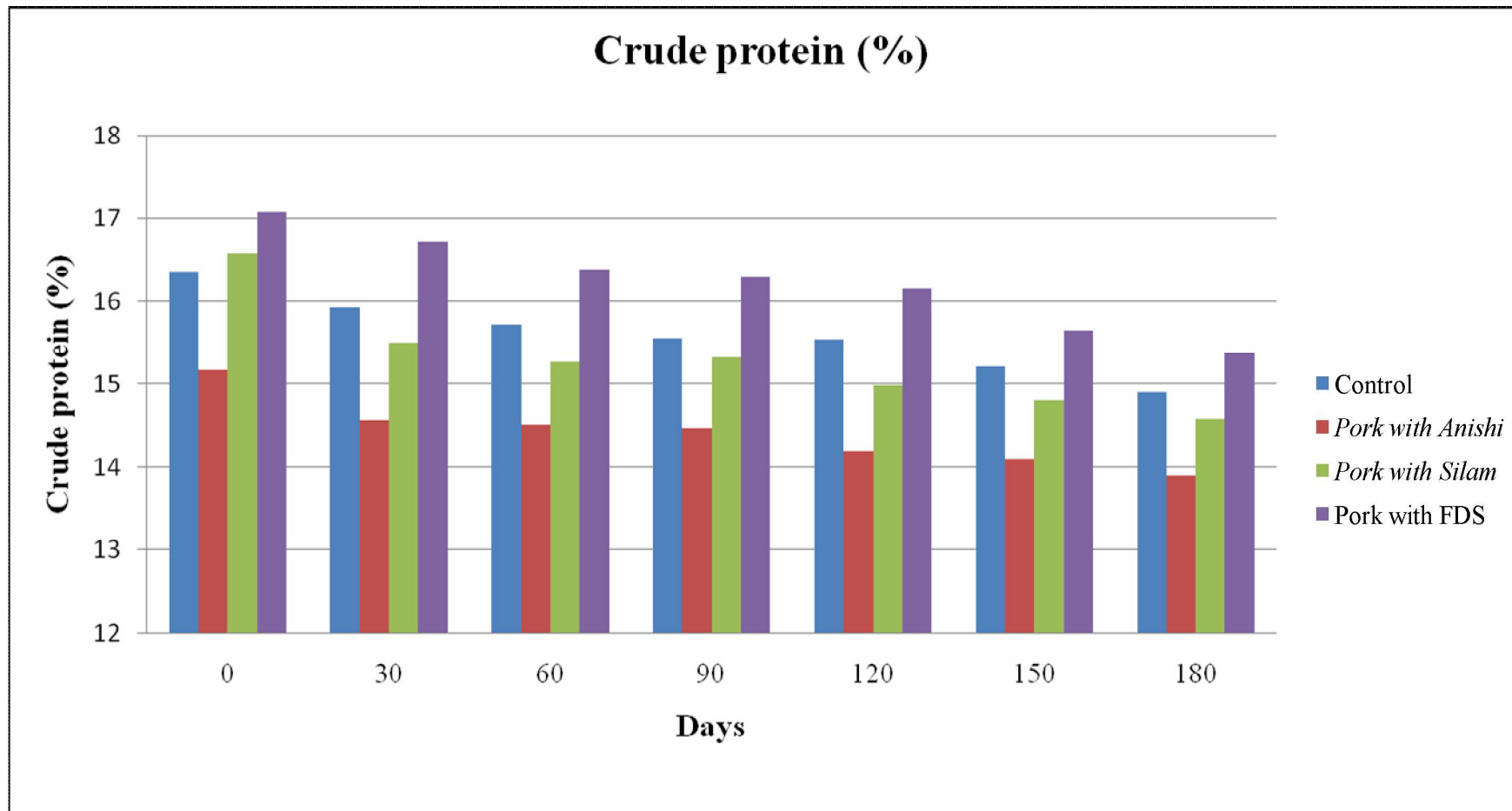


FIG 4.5. GRAPHICAL REPRESENTATION OF EFFECT OF CRUDE PROTEIN CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

4.3.2. Physicochemical composition of traditional pork products under retort packaging

4.3.2.1. pH

The mean pH values of control and traditional pork products under retort packaging are presented in Table 4.12. The analysis of variance is presented in Table 4.13. The graphical representation is presented in Fig 4.6.

The mean pH values recorded for the control product under retort pouch packaging on 0 day was 5.88 ± 0.08 and in case of the treated products were 5.62 ± 0.12 , 5.86 ± 0.08 and 5.87 ± 0.10 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean pH values recorded for control product were 5.85 ± 0.05 , 5.76 ± 0.03 , 5.68 ± 0.01 , 5.62 ± 0.03 , 5.54 ± 0.08 and 5.37 ± 0.09 . These mean values for pH in pork with *Anishi* were 5.66 ± 0.06 , 5.52 ± 0.05 , 5.45 ± 0.04 , 5.42 ± 0.03 , 5.37 ± 0.02 and 5.20 ± 0.03 , for pork with *Silam* were 5.88 ± 0.04 , 5.66 ± 0.05 , 5.58 ± 0.06 , 5.53 ± 0.06 , 5.45 ± 0.04 and 5.37 ± 0.04 and for pork with FDS were 5.76 ± 0.07 , 5.63 ± 0.06 , 5.54 ± 0.05 , 5.45 ± 0.07 , 5.31 ± 0.05 and 5.24 ± 0.03 , respectively. It was observed that there was decreasing trend in pH values in the storage periods in control and treated products. However, pork with *Anishi* and pork with *Silam* showed an increase in pH on day 30 compared to 0 day.

The analysis of variance revealed highly significant ($p < 0.01$) differences in pH in control and treated formulations during increased storage periods. The decrease in pH values might be due to degradation of proteins and liberation of free amino acids. Rajkumar (2008) also reported decrease trend of pH as the storage period increases in retort processed *Chettinad* goat meat and Chandirasekaran and Ranjan (2016) in retort processed traditional *Chettinad* chicken product.

4.3.2.2. TBARS value

The mean TBARS (Thio-Barbituric Acid Reacting Substances) values of control and traditional pork products under retort packaging are presented in Table 4.12. The analysis of variance is presented in Table 4.13. The graphical representation is presented in Fig.4.7.

The mean TBARS values recorded for control product under retort pouch packaging on 0 day was 0.12 ± 0.01 and in case of the treated products were 0.14 ± 0.01 , 0.13 ± 0.01 and 0.14 ± 0.01 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean TBARS values recorded for control product were 0.13 ± 0.00 , 0.21 ± 0.00 , 0.25 ± 0.01 , 0.29 ± 0.01 , 0.35 ± 0.01 and 0.40 ± 0.02 , respectively. These mean values for TBARS values in pork with *Anishi* were 0.16 ± 0.01 , 0.17 ± 0.01 , 0.21 ± 0.01 , 0.25 ± 0.01 , 0.35 ± 0.03 and 0.40 ± 0.02 , for pork with *Silam* were 0.15 ± 0.01 , 0.48 ± 0.03 , 0.51 ± 0.02 , 0.50 ± 0.05 , 0.55 ± 0.02 and 0.57 ± 0.02 and for pork with FDS were 0.16 ± 0.00 , 0.43 ± 0.01 , 0.47 ± 0.01 , 0.60 ± 0.06 , 0.60 ± 0.02 and 0.68 ± 0.03 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in TBARS values in control and treated formulations during increased storage periods. Devadason (2000) reported a significant and linear increase in TBARS values during storage in retort processed buffalo meat block and Rajkumar (2008) in retort processed *Chettinad* goat meat, respectively. The increase in TBARS values might be due to residual oxygen remaining in the pouch, as the pouches were not vacuum sealed. The development of slow oxidative rancidity was also reported by Chia *et al.* (1983) in fish products with retort packaging. The difference in TBARS values among different products may be due to difference in product formulations.

4.3.2.3. Tyrosine value

The mean tyrosine values of control and traditional pork products under retort packaging are presented in Table 4.12. The analysis of variance is presented in Table 4.13. The graphical representation is presented in Fig. 4.8.

The mean tyrosine values recorded for control product under retort pouch packaging on 0 day was 64.62 ± 0.18 and in case of the treated products were 81.82 ± 1.77 , 75.51 ± 1.73 and 82.72 ± 1.10 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean tyrosine values recorded for control product were 70.46 ± 0.11 , 71.87 ± 0.32 , 73.50 ± 0.45 , 77.36 ± 0.78 , 79.33 ± 0.74 and 80.77 ± 0.50 , respectively. These mean values for tyrosine values in pork with *Anishi* were 88.57 ± 0.18 , 89.22 ± 0.25 , 89.79 ± 0.20 , 90.25 ± 0.21 , 90.47 ± 0.16 and 91.60 ± 0.33 , for pork with *Silam* were 77.68 ± 0.19 , 78.48 ± 0.12 , 79.18 ± 0.18 , 80.16 ± 0.17 , 82.20 ± 0.21 and 83.37 ± 0.10 and for pork with FDS were 83.23 ± 0.94 , 84.76 ± 0.53 , 85.33 ± 0.22 , 86.18 ± 0.20 , 86.62 ± 0.36 and 87.61 ± 0.36 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and treated formulations during increased storage periods. The increased in tyrosine values during storage was in agreement with the observation of Chandirasekaran and Ranjan (2016) in retort processed traditional type *Chettinad* chicken product and Rajkumar (2008) in retort processed *Chettinad* goat meat. Tyrosine value increases during storage time until demination of amino acid limits the formation of free amino acids (Pearson, 1968). Similarly, an increase of tyrosine value during storage was also reported in buffalo meat patties (Kulkarni *et al.*, 1993).

TABLE 4.12. EFFECT OF PHYSICOCHEMICAL COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Parameters	Products	Mean± SE of different days						
		0	30	60	90	120	150	180
pH	Control	^a 5.88±0.08 ^A	^{ab} 5.85±0.05 ^A	^{abc} 5.76±0.03 ^A	^{bcd} 5.68±0.01 ^A	^{cd} 5.62±0.03 ^A	^d 5.54±0.08 ^A	^e 5.37±0.09 ^A
	Pork with <i>Anishi</i>	^{ab} 5.62±0.12 ^A	^a 5.66±0.06 ^B	^{abc} 5.52±0.05 ^B	^{bc} 5.45±0.04 ^B	^c 5.42±0.03 ^B	^{cd} 5.37±0.02 ^B	^d 5.20±0.03 ^B
	Pork with <i>Silam</i>	^a 5.86±0.08 ^A	^a 5.88±0.04 ^A	^b 5.66±0.05 ^{AB}	^{bc} 5.58±0.06 ^{AB}	^{bc} 5.53±0.06 ^{AB}	^{cd} 5.45±0.04 ^{AB}	^d 5.37±0.04 ^A
	Pork with FDS	^a 5.87±0.10 ^A	^{ab} 5.76±0.07 ^{AB}	^{bc} 5.63±0.06 ^{AB}	^c 5.54±0.05 ^{AB}	^{cd} 5.45±0.07 ^B	^{de} 5.31±0.05 ^B	^e 5.24±0.03 ^A
TBARS value (mg malonal -dehyde /kg)	Control	^a 0.12±0.01 ^A	^a 0.13±0.00 ^A	^c 0.21±0.00 ^A	^d 0.25±0.01 ^A	^c 0.29±0.01 ^A	^b 0.35±0.01 ^A	^f 0.40±0.02 ^A
	Pork with <i>Anishi</i>	^a 0.14±0.01 ^A	^a 0.16±0.01 ^A	^a 0.17±0.01 ^A	^c 0.21±0.01 ^A	^c 0.25±0.01 ^A	^b 0.35±0.03 ^A	^d 0.40±0.02 ^A
	Pork with <i>Silam</i>	^c 0.13±0.01 ^A	^c 0.15±0.01 ^{AB}	^b 0.48±0.03 ^B	^{ab} 0.51±0.02 ^B	^{ab} 0.50±0.05 ^B	^{ab} 0.55±0.02 ^A	^a 0.57±0.02 ^B
	Pork with FDS	^c 0.14±0.01 ^A	^c 0.16±0.00 ^B	^b 0.43±0.01 ^C	^b 0.47±0.01 ^B	^a 0.60±0.06 ^B	^a 0.60±0.02 ^B	^a 0.68±0.03 ^C
Tyrosine value (mg/100gm)	Control	^e 64.62±0.18 ^A	^a 70.46±0.11 ^A	^a 71.87±0.32 ^A	^c 73.50±0.45 ^A	^b 77.36±0.78 ^A	^d 79.33±0.74 ^A	^d 80.77±0.50 ^A
	Pork with <i>Anishi</i>	^a 81.82±1.77 ^B	^b 88.57±0.18 ^B	^b 89.22±0.25 ^B	^{ab} 89.79±0.20 ^B	^{ab} 90.25±0.21 ^B	^{ab} 90.47±0.16 ^B	^c 91.60±0.33 ^B
	Pork with <i>Silam</i>	^a 75.51±1.73 ^C	^c 77.68±0.19 ^C	^{bc} 78.48±0.12 ^C	^{bc} 79.18±0.18 ^C	^b 80.16±0.17 ^C	^d 82.20±0.21 ^C	^d 83.37±0.10 ^C
	Pork with FDS	^a 82.72±1.10 ^B	^{ac} 83.23±0.94 ^D	^{bc} 84.76±0.53 ^D	^b 85.33±0.22 ^D	^{ab} 86.18±0.20 ^D	^{ab} 86.62±0.36 ^D	^d 87.61±0.36 ^D

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.13. ANALYSIS OF VARIANCE OF PHYSICOCHEMICAL COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Source	df	Mean±SE		
		pH	TBARS	Tyrosine
Products	3	0.2815**	0.9744**	1482.6193**
Days	6	0.7052**	0.8642**	209.3555**
Error	130	0.0165	0.2151	4.1833

df= degree of freedom, **= Significant at 1 percent level

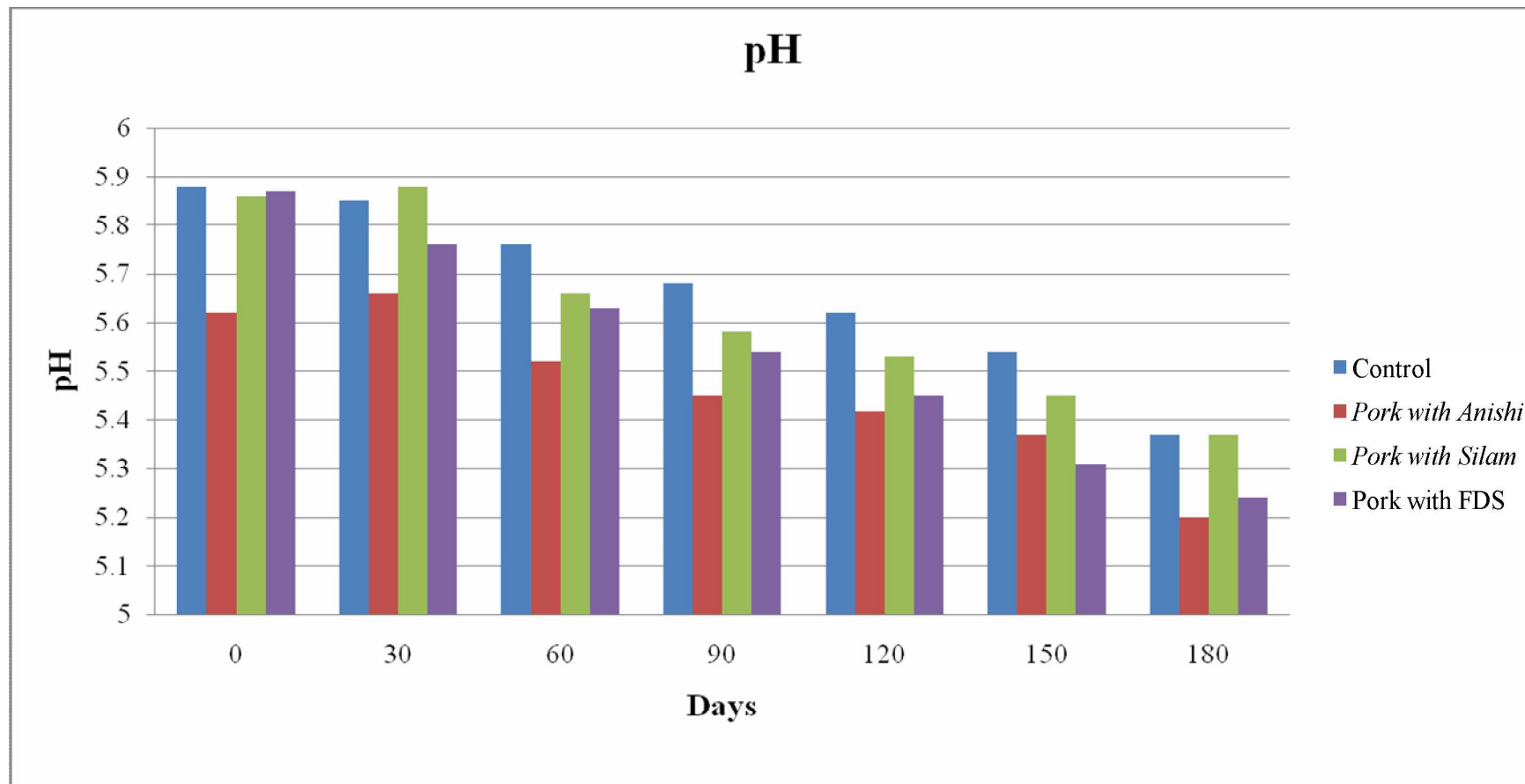


FIG 4.6. GRAPHICAL REPRESENTATION OF EFFECT OF pH OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

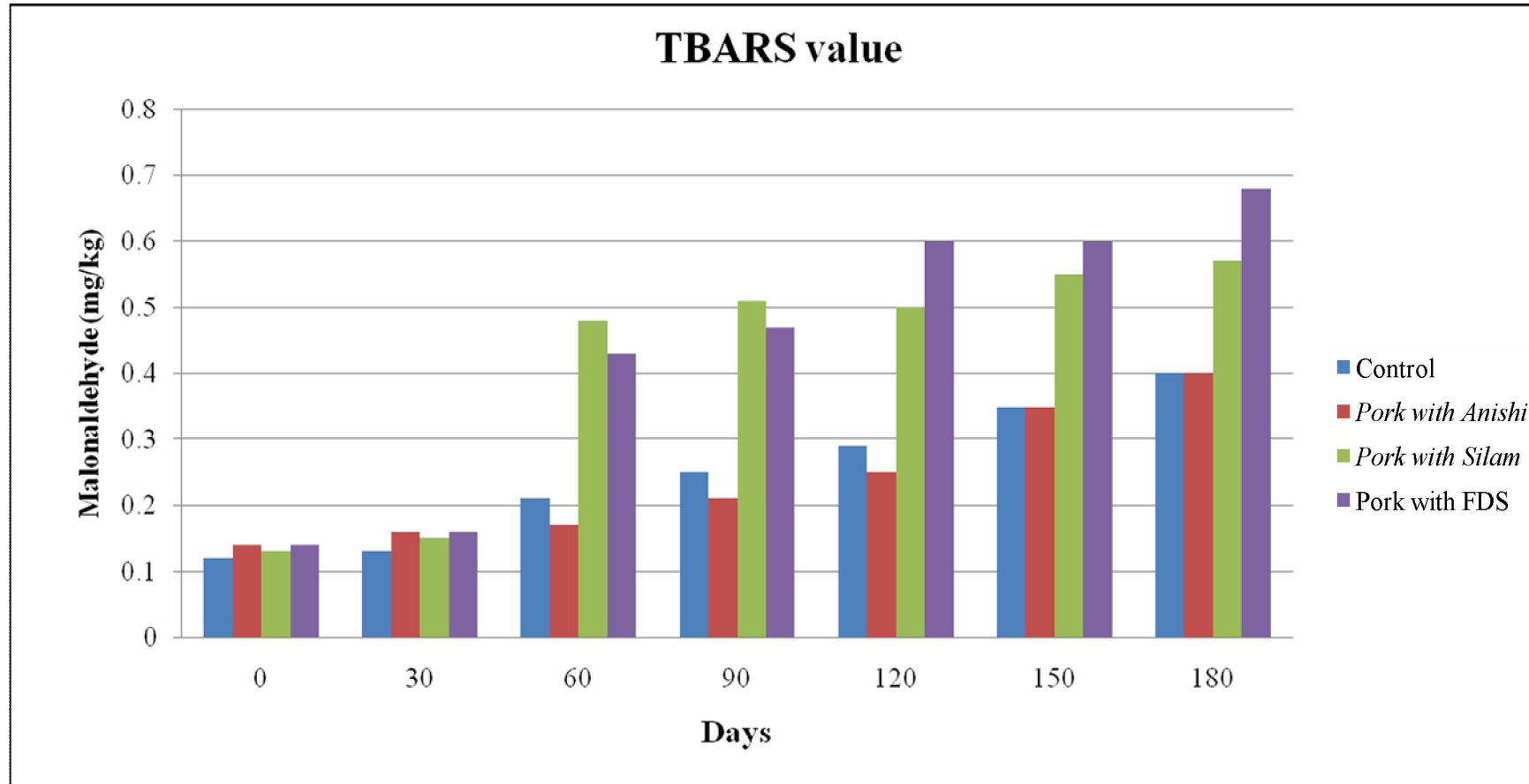


FIG 4.7. GRAPHICAL REPRESENTATION OF EFFECT OF TBARS VALUES OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

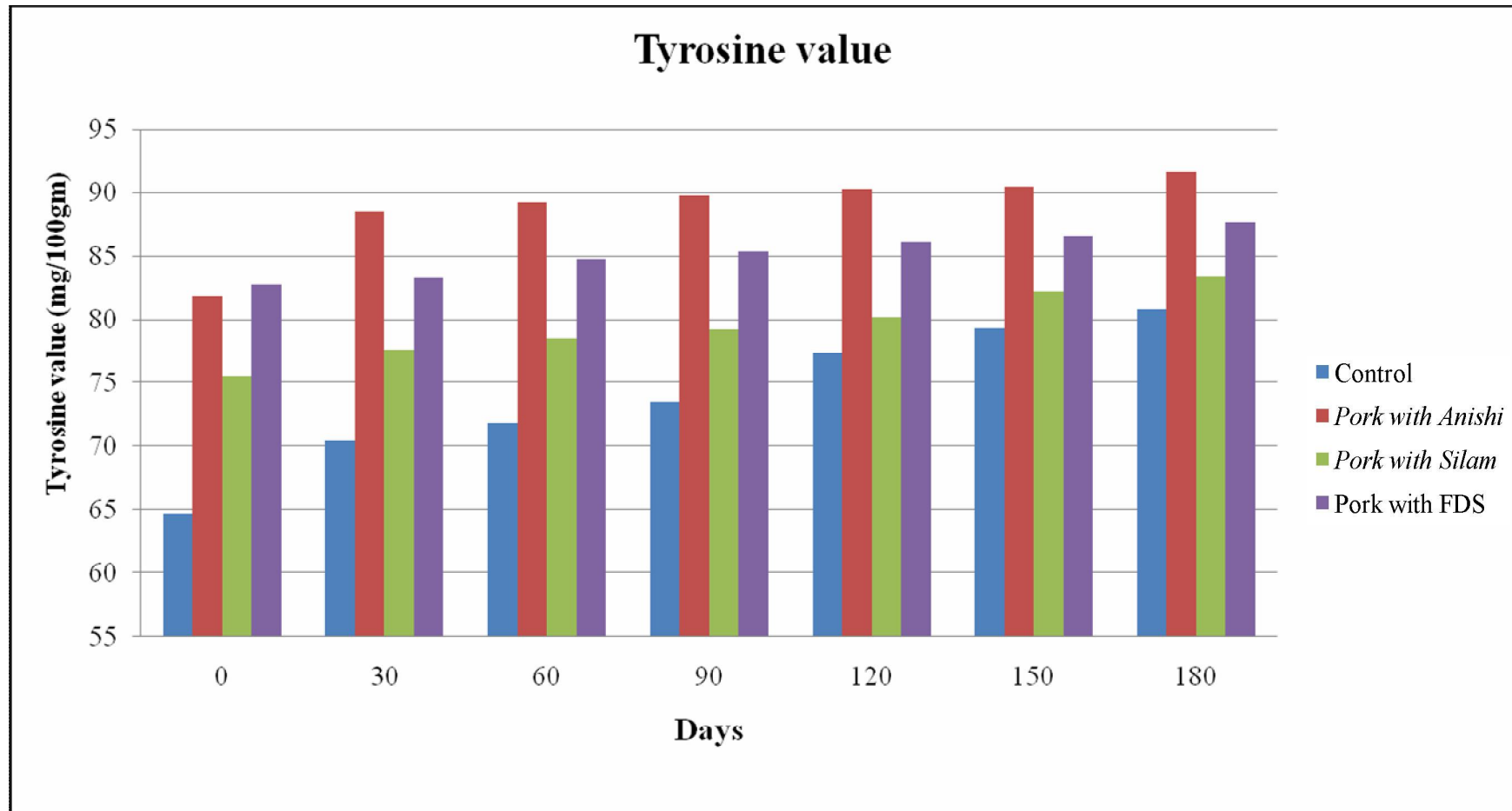


FIG 4.8. GRAPHICAL REPRESENTATION OF EFFECT OF TYROSINE VALUES OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

4.4. AMINO ACID CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The results pertaining to changes in amino acid contents in control and all the treated pork products were recorded under retort packaging on 0 and 180 day of storage and are presented in Table 4.14.

The results of amino acid content in control product and traditional pork products on 0 day indicated that control sample; pork with *Anishi* and FDS had higher amino acid content. However, on 180 day the result showed decrease in amino acid content in control and traditional pork products. The decrease in amino acid content might be due to quantitative reduction of total crude protein. Among the traditional pork products incorporated with FDS was recorded highest content of amino acid as compared to pork incorporated with *Anishi* and *Silam* products.

In general, lysine, methionine and tryptophan are the three essential amino acids that are important in evaluating the nutritive quality of a protein (Neilands *et al.* 1949). A deficiency of these amino acids is frequently encountered in natural food materials. Pork with *Silam* and FDS products were recorded high content of lysine and methionine compared with pork with *Anishi* and control products. However, there were slight decreased in amino acid contents in all the traditional pork products during storage period.

Millward *et al.* (2008) and Boye *et al.* (2012) have pointed out that processing methods can influence many changes in protein quality, including formation of Maillard compounds, oxidized sulphur amino acids, and cross-linked peptide chains, among others, all of which can limit protein bioavailability.

TABLE 4.14. TREND OF CHANGES IN AMINO ACID (mg/100gm) CONTENT OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Amino acid	Traditional pork products (Retort packaging)							
	Control		Pork with <i>Anishi</i>		Pork with <i>Silam</i>		Pork with FDS	
	0 Day	180 Day	0 Day	180 Day	0 Day	180 Day	0 Day	180 Day
L-Alanine	0.54	0.51	0.47	0.45	0.54	0.54	0.58	0.49
L-Arginine	2.13	1.92	1.95	2.15	2.25	2.11	2.18	2.14
L-Aspartic Acid	1.37	1.27	1.28	1.41	1.46	1.36	1.42	1.39
L-Cystine	0.19	0.18	0.18	0.20	0.20	0.19	0.20	0.19
L-Glutamic Acid	2.81	2.64	2.47	2.41	2.79	2.81	3.02	2.57
L-Glycine	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.01
L-Histidine	1.92	1.79	1.75	1.84	1.98	1.89	2.03	1.85
L-Isoleucine	0.52	0.49	0.48	0.51	0.56	0.52	0.56	0.52
L-Leucine	1.07	0.98	1.00	1.11	1.16	1.07	1.11	1.09
L-Lysine	1.16	1.06	1.07	1.19	1.26	1.15	1.20	1.18
L-Methionine	0.37	0.34	0.34	0.36	0.39	0.37	0.39	0.36
L-Phenylalanine	0.57	0.52	0.53	0.59	0.61	0.57	0.59	0.58
L-Proline	1.20	1.13	1.05	1.02	1.20	1.20	1.29	1.10
L-Serine	0.74	0.70	0.65	0.63	0.74	0.74	0.81	0.67
L-Threonine	0.72	0.67	0.65	0.68	0.76	0.72	0.76	0.7
L-Tyrosine	0.61	0.57	0.52	0.49	0.61	0.61	0.67	0.55
L-Valine	0.69	0.65	0.6	0.58	0.69	0.69	0.75	0.63
L-Tryptophan	0.32	0.31	0.29	0.28	0.3	0.32	0.33	0.29

4.5. TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The texture profile parameters of control and traditional pork products under retort packaging were studied on 0, 90 and 180 day and the results obtained are analyzed and discussed below.

4.5.1. Hardness

The mean hardness (N/cm²) of control and traditional pork products under retort packaging are presented in Table 4.15. The analysis of variance is presented in Table 4.16. The graphical representation is presented in Fig. 4.9.

The mean hardness recorded for control product under retort pouch packaging on 0 day was 2606.92±178.59 and in case of the treated products were 2652.78±161.70, 2962.68±55.40 and 4025.90±69.71 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean hardness recorded for control product were 2685.71±242.36 and 4986.32±29.68, respectively. These mean hardness in pork with *Anishi* were 3207.73±89.51 and 4012.26±25.15 for pork with *Silam* were 3145±180.47 and 4578.43±23.24 and for pork with FDS were 4578.83±23.30 and 6933.68±88.36, respectively.

The analysis of variance revealed no significant differences in control and treated formulations under retort packaging and during storage periods. The results exhibited increasing trend on the storage period. Rajkumar *et al.* (2010); Selvin, (2010) also reported similar increasing trend of hardness in retort processed *Chettinad* chicken meat and retort processed *Chettinad* style goat meat. Hardness is mainly due to retort processing, which causes conversion of collagen to gelatin and dissociation of muscle protein. The analysis of texture becomes even more important in case of canned products, which are intended for long periods of storage as storage period is one of the determinants in texture (Ahmed *et al.*, 1972).

4.5.2. Springiness

The mean springiness (cm) of control and traditional pork products under retort packaging are presented in Table 4.15. The analysis of variance is presented in Table 4.16. The graphical representation is presented in Fig.4.10.

The mean springiness recorded for control product under retort pouch packaging on 0 day was 0.39 ± 0.00 and in case of the treated products were 0.31 ± 0.02 , 0.33 ± 0.01 and 0.35 ± 0.03 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean springiness recorded for control product were 0.41 ± 0.00 and 0.45 ± 0.01 , respectively. These mean springiness in pork with *Anishi* were 0.40 ± 0.00 and 0.43 ± 0.01 , for pork with *Silam* were 0.39 ± 0.00 and 0.50 ± 0.02 and for pork with FDS were 0.40 ± 0.00 and 0.51 ± 0.02 , respectively.

Springiness is the elastic recovery of meat. In raw condition, the meat is more elastic in nature but on heat processing the elasticity is lost, hence low scores in the products was observed as by reported by Bindu *et al.* (2007) in ready-to-eat black clam (*Villorita cyprinoides*) product with retort processing.

The analysis of variance revealed no significant differences in control and treated formulations under retort packaging during storage periods. The springiness values changed significantly ($p < 0.01$) during storage periods at room temperature. Similar result was also reported by Nalini *et al.* (2018) in ready-to eat processed pepper chicken. Springiness behavior varies significantly with the processing techniques and it could be correlated with the influence of moisture in the product (Hsu and Yu, 1999). Similar observation was also reported by Kim *et al.* 2014 where there was increased springiness in the products could be observed. The differences in springiness values in different traditional pork products might be due to differences in product formulations.

4.5.3. Cohesiveness

The mean cohesiveness (ratio) of control and traditional pork products under retort packaging are presented in Table 4.15. The analysis of variance is presented in Table 4.16. The graphical representation is presented in Fig. 4.11.

The mean cohesiveness recorded for control product under retort pouch packaging on 0 day was 0.21 ± 0.00 and in case of the treated products 0.21 ± 0.00 , 0.26 ± 0.00 and 0.28 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean cohesiveness recorded for control product were 0.23 ± 0.00 and 0.29 ± 0.00 respectively. These mean values for cohesiveness in pork with

Anishi were 0.22 ± 0.00 and 0.28 ± 0.00 , for pork with *Silam* were 0.29 ± 0.00 and 0.34 ± 0.00 and for pork with FDS were 0.33 ± 0.00 and 0.40 ± 0.00 , respectively.

The analysis of variance showed no significant differences in control and the treated formulations and during storage periods. There was significant ($p<0.01$) increased of cohesiveness values during storage periods. Similar finding was also reported by Nalini *et al.* (2018) in ready-to eat retort processed pepper chicken. Cohesiveness is the indication of internal bonding between muscle proteins in the meat. Due to heat processing a breaking in the water bond of the muscle occurred as reported by Mohan *et al.* (2008).

4.5.4. Chewiness

The mean chewiness (N/cm) of control and traditional pork products under retort packaging are presented in Table 4.15. The analysis of variance is presented in Table 4.16. The graphical representation is presented in Fig. 4.12.

The mean chewiness recorded for control product under retort pouch packaging on 0 day was 248.73 ± 10.85 and in case of the treated products 239.20 ± 21.86 , 261.36 ± 14.07 and 379.88 ± 17.55 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean chewiness recorded for control product were 339.75 ± 9.29 and 713.15 ± 2.07 , respectively. These mean values for chewiness in pork with *Anishi* were 268.28 ± 10.76 and 447.83 ± 3.83 , for pork with *Silam* were 306.48 ± 9.47 and 881.22 ± 16.98 and for pork with FDS were 603.24 ± 23.94 and 1224.29 ± 90.42 , respectively.

The analysis of variance showed no significant differences in control and treated formulations. The control and other treated formulations also revealed significant ($p<0.01$) increase during increased storage periods. Chewiness refers to the amount of work done. In raw meat the work done is more, whereas in thermal processed products the work done is less as reported by Sreenath *et al.* (2007) for ready-to-eat squid masala in indigenous polymer-coated tin-free steel cans. This may be attributed to the gelatinization of muscle collagen and destruction of muscle cells during the cooking (Ando, 1997).

TABLE 4.15. EFFECT OF TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Parameters	Products	Mean± SE of different days		
		0	90	180
Hardness (N/cm ²)	Control	^a 2606.92±178.59 ^A	^b 2685.71±242.36 ^A	^c 4986.32±29.68 ^A
	Pork with <i>Anishi</i>	^a 2652.78±161.70 ^A	^b 3207.73±89.51 ^A	^c 4012.26±25.15 ^A
	Pork with <i>Silam</i>	^a 2962.68±55.40 ^A	^b 3145.00±180.47 ^A	^b 4578.43±23.24 ^A
	Pork with FDS	^a 4025.90±69.71 ^A	^b 4578.83±23.30 ^A	^c 6933.68±88.36 ^A
Springiness (cm)	Control	^c 0.39±0.00 ^B	^b 0.41±0.00 ^B	^a 0.45±0.01 ^B
	Pork with <i>Anishi</i>	^b 0.31±0.02 ^B	^a 0.40±0.00 ^B	^a 0.43±0.01 ^B
	Pork with <i>Silam</i>	^c 0.33±0.01 ^B	^b 0.39±0.00 ^B	^a 0.50±0.02 ^B
	Pork with FDS	^b 0.35±0.03 ^B	^b 0.40±0.00 ^B	^a 0.51±0.02 ^B
Cohesiveness (Ratio)	Control	^c 0.21±0.00 ^B	^b 0.23±0.00 ^B	^a 0.29±0.00 ^B
	Pork with <i>Anishi</i>	^b 0.21±0.00 ^B	^b 0.22±0.00 ^B	^a 0.28±0.00 ^B
	Pork with <i>Silam</i>	^c 0.26±0.00 ^B	^b 0.29±0.00 ^B	^a 0.34±0.00 ^B
	Pork with FDS	^c 0.28±0.00 ^B	^b 0.33±0.00 ^B	^a 0.40±0.00 ^B
Chewiness (N/cm)	Control	^c 248.73±10.85 ^C	^b 339.75±9.29 ^C	^a 713.15±2.07 ^C
	Pork with <i>Anishi</i>	^b 239.20±21.86 ^C	^b 268.28±10.76 ^C	^a 447.83±3.83 ^C
	Pork with <i>Silam</i>	^a 261.36±14.07 ^C	^b 306.48±9.47 ^C	^a 881.22±16.98 ^C
	Pork with FDS	^c 379.88±17.55 ^C	^b 603.24±23.94 ^C	^a 1224.29±90.42 ^C

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.16. ANALYSIS OF VARIANCE OF TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Source	df	Mean±SE			
		Hardness	Springiness	Cohesiveness	Chewiness
Products	3	11708127.20**	0.0055**	0.0314**	465102.077**
Days	2	24242167.31**	0.0817**	0.0384**	1620255.719**
Error	54	178594.57	0.0013	0.0001	15009.677

df= degree of freedom, **= Significant at 1 percent level

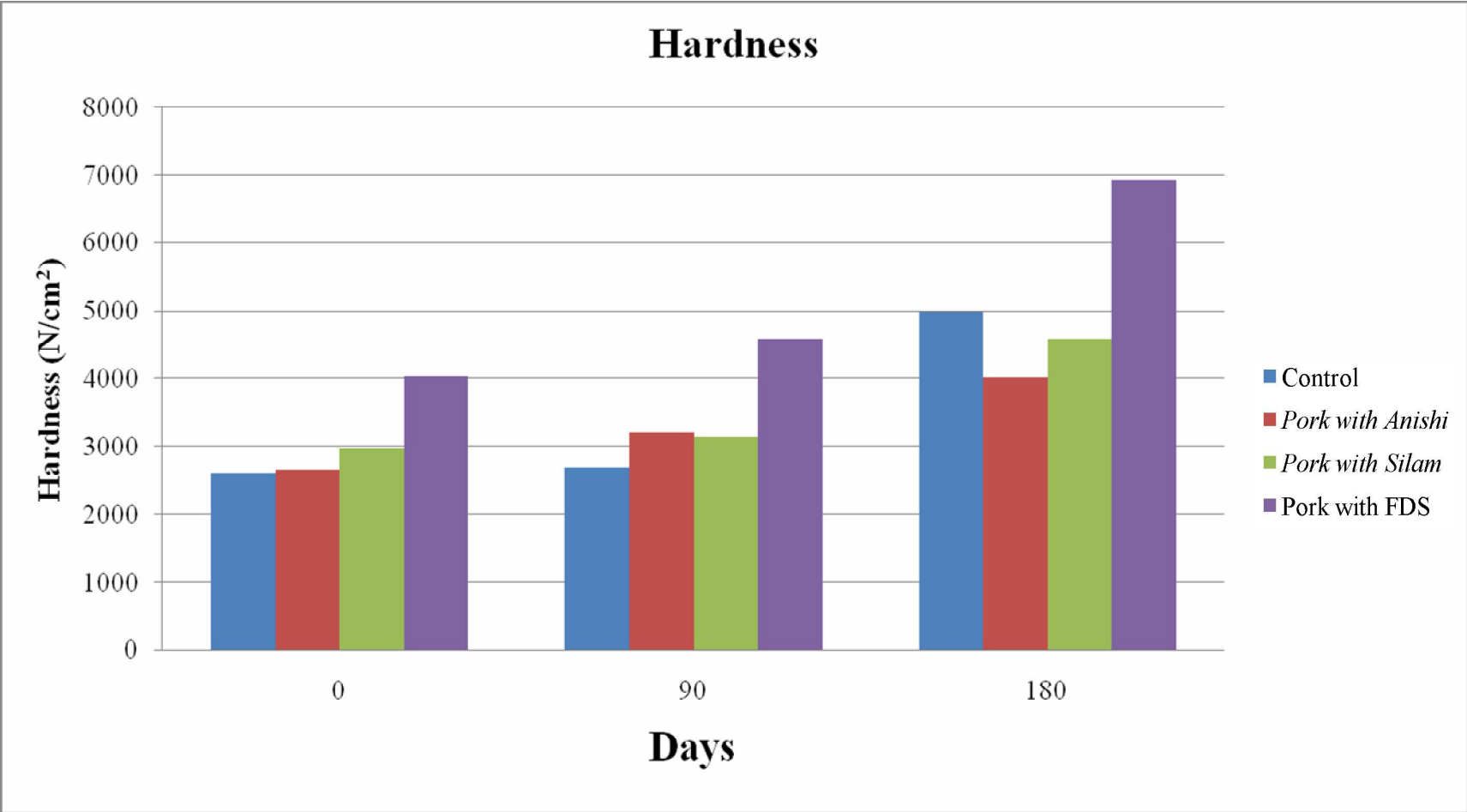


FIG 4.9. GRAPHICAL REPRESENTATION OF EFFECT OF HARDNESS OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

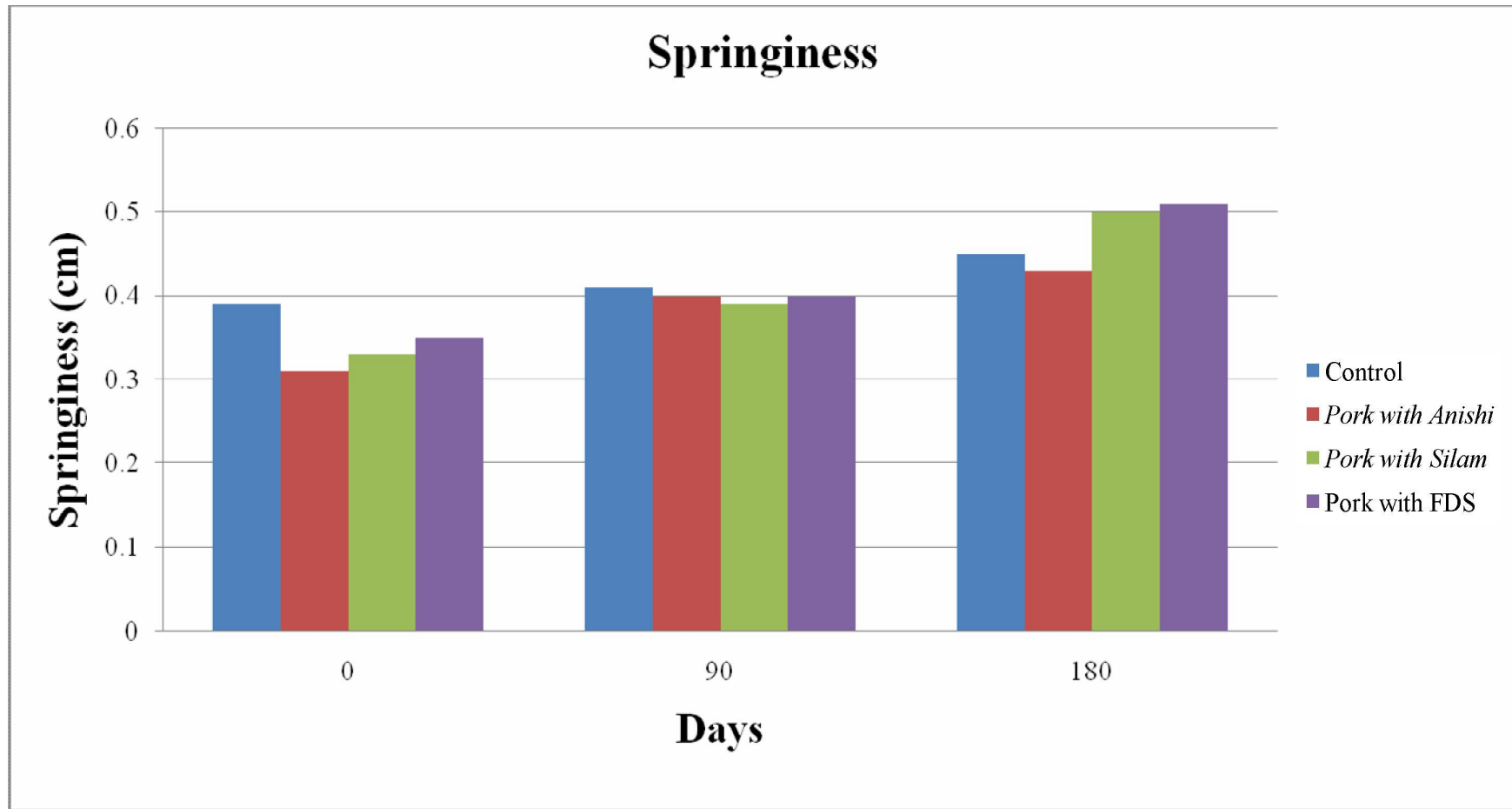


FIG 4.10. GRAPHICAL REPRESENTATION OF EFFECT OF SPRINGINESS OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

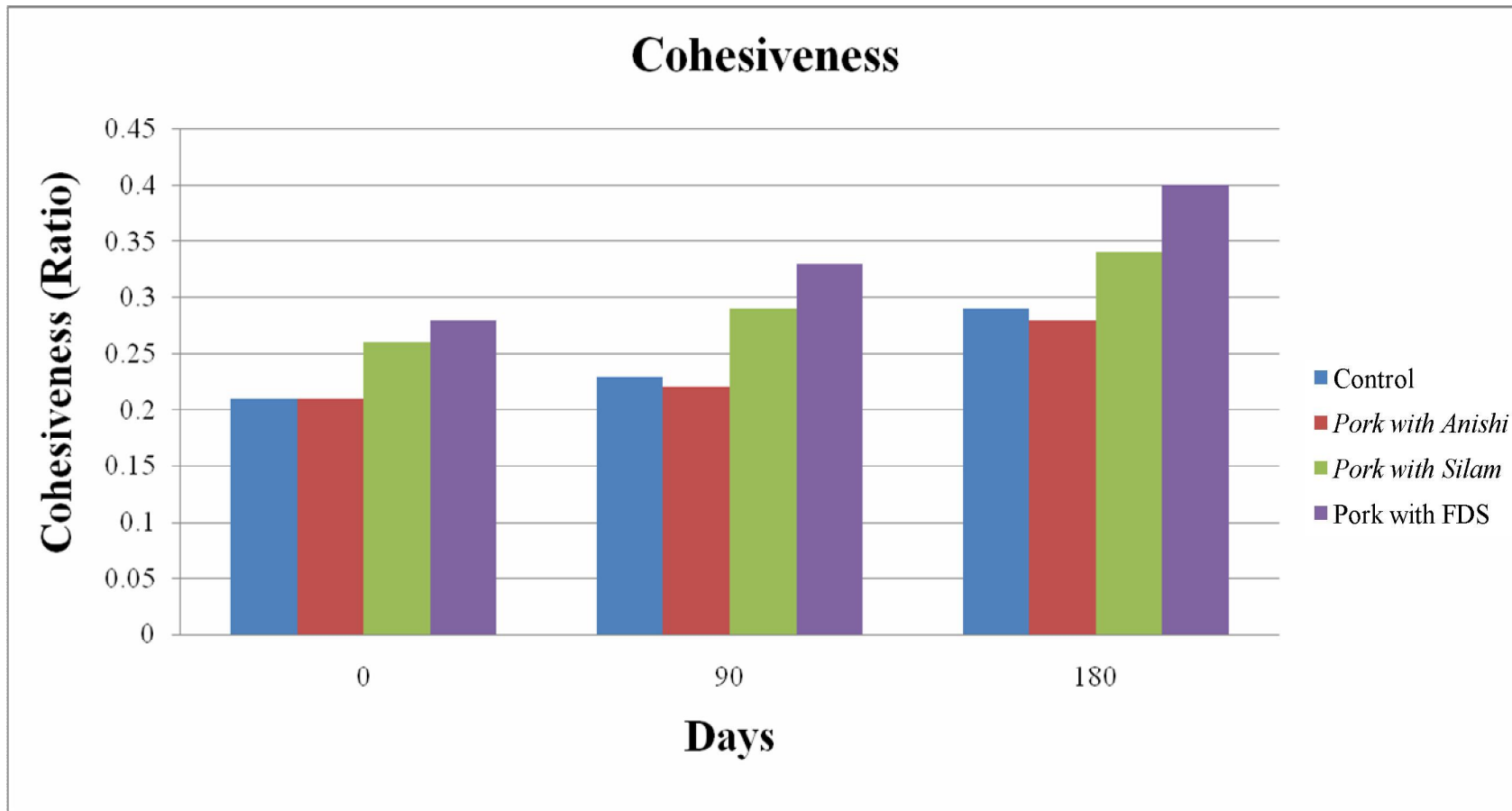


FIG 4.11. GRAPHICAL REPRESENTATION OF EFFECT OF COHESIVENESS OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

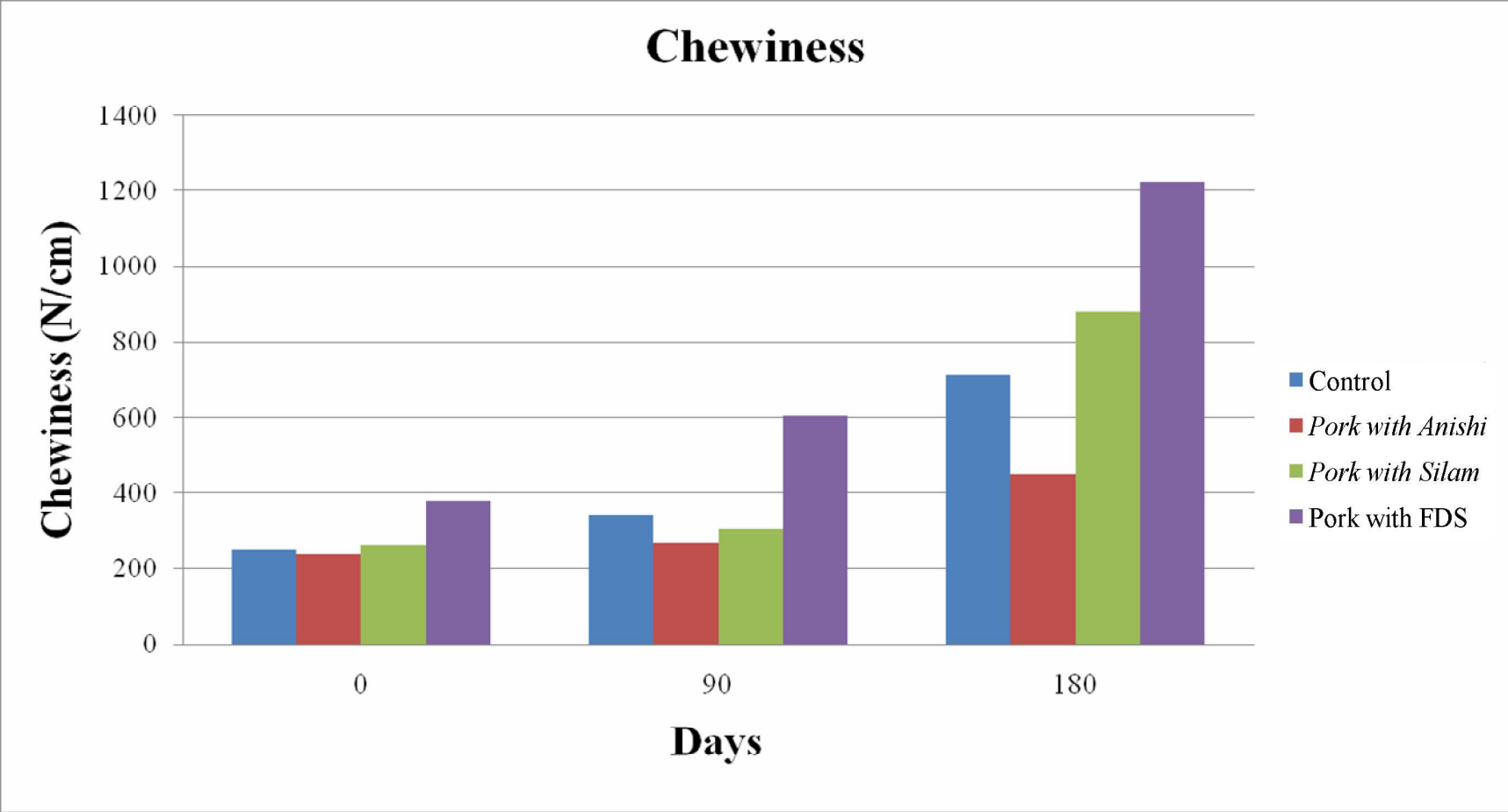


FIG 4.12. GRAPHICAL REPRESENTATION OF EFFECT OF CHEWINESS OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

4.6. COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The colour profile parameters of control and the traditional pork products under retort packaging were studied on 0, 90 and 180 day and the results obtained are analyzed and discussed below.

4.6.1. Lightness (L*)

The mean values for lightness (L*) of control and traditional pork products under retort packaging are presented in Table 4.17. The analysis of variance is presented in Table 4.18. The graphical representation is presented in Fig. 4.13.

The mean values for lightness recorded for control product under retort pouch packaging on 0 day was 59.71 ± 0.02 and in the treated products were 38.26 ± 0.41 , 54.80 ± 0.01 and 56.73 ± 0.02 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean values for lightness recorded for control product were 57.77 ± 0.77 and 54.01 ± 0.34 respectively. These mean values for lightness in pork with *Anishi* were 34.74 ± 0.13 and 31.55 ± 0.05 , for pork with *Silam* were 52.43 ± 0.09 and 46.75 ± 0.13 and for pork with FDS were 55.34 ± 0.35 and 52.72 ± 0.74 , respectively.

The analysis of variance revealed no significant differences in control and treated formulations and during storage periods. The L* value decreased significantly ($p < 0.01$) from 0 to 180 day due to retort processing. The decrease in L* can be attributed to the reduction in light reflection influenced by heating. Similar decrease in L* value result was also reported by Rajkumar *et al.* (2010) in retort processed *Chettinad* style goat meat.

4.6.2. Redness (a*)

The mean values for redness (a*) of control and traditional pork products under retort packaging are presented in Table 4.17. The analysis of variance is presented in Table 4.18. The graphical representation is presented in Fig. 4.14.

The mean values for redness recorded for control product under retort pouch packaging on 0 day was 6.71 ± 0.07 and in the treated products were 6.65 ± 0.06 , 5.54 ± 0.13

and 7.67 ± 0.09 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean values redness recorded for control product were 5.68 ± 0.45 and 4.52 ± 0.37 , respectively. These mean redness in pork with *Anishi* were 5.26 ± 0.04 and 4.59 ± 0.17 , for pork with *Silam* were 5.15 ± 0.00 and 4.60 ± 0.24 and for pork with FDS were 7.23 ± 0.01 and 6.26 ± 0.35 , respectively.

The analysis of variance revealed no significant differences in control and treated formulations and during storage periods on instrumental colour value of a^* . Redness of the products were found to decrease significantly ($p < 0.01$) with increased in storage periods. The decreased in value of a^* was also reported by Bindu *et al.* (2007). Rajkumar *et al.* (2010) also reported a^* value decreased significantly in retort processed *Chettinad* style goat meat.

4.6.3. Yellowness (b^*)

The mean values for yellowness (b^*) of control and traditional pork products under retort packaging are presented in Table 4.17. The analysis of variance is presented in Table 4.18. The graphical representation is presented in Fig. 4.15.

The mean values for yellowness recorded for control product under retort pouch packaging on 0 day was 19.88 ± 0.54 and in the treated products were 22.32 ± 0.44 , 18.52 ± 1.31 and 23.39 ± 0.51 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 90 and 180 day of storage the mean yellowness values recorded for control product were 18.28 ± 0.07 and 17.75 ± 0.37 , respectively. These mean values of yellowness in pork with *Anishi* were 19.79 ± 1.04 and 17.95 ± 0.30 , for pork with *Silam* were 16.75 ± 0.10 and 16.22 ± 0.14 and for pork with FDS were 22.12 ± 0.16 and 21.67 ± 0.15 , respectively.

The analysis of variance revealed no significant differences in control and treated formulations due to retort processing of traditional pork products. The control and other treated formulations revealed significant decrease ($p < 0.01$) during increased storage periods. Rajkumar *et al.* (2010) also reported b^* value decreased significantly in retort processed *Chettinad* style goat meat. Similar results were also reported by Bently *et al.* (1987) and Manimaran (2007). The differences in b^* values during storage could be related to oxidation process of unsaturated fat in the products during storage.

TABLE 4.17. EFFECT OF COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Parameters	Products	Mean± SE of different days		
		0	90	180
L*	Control	^a 59.71±0.02 ^A	^b 57.77±0.77 ^A	^c 54.01±0.34 ^A
	Pork with <i>Anishi</i>	^a 38.26±0.41 ^B	^b 34.74±0.13 ^B	^c 31.55±0.05 ^B
	Pork with <i>Silam</i>	^a 54.80±0.01 ^C	^b 52.43±0.09 ^C	^c 46.75±0.13 ^C
	Pork with FDS	^a 56.73±0.02 ^D	^a 55.34±0.35 ^D	^b 52.72±0.74 ^D
a*	Control	^a 6.71±0.07 ^A	^a 5.68±0.45 ^A	^b 4.52±0.37 ^A
	Pork with <i>Anishi</i>	^a 6.65±0.06 ^A	^b 5.26±0.04 ^A	^c 4.59±0.17 ^A
	Pork with <i>Silam</i>	^a 5.54±0.13 ^B	^a 5.15±0.00 ^A	^b 4.60±0.24 ^A
	Pork with FDS	^a 7.67±0.09 ^C	^a 7.23±0.01 ^B	^b 6.26±0.35 ^B
b*	Control	^a 19.88±0.54 ^{A B}	^b 18.28±0.07 ^{A B}	^b 17.75±0.37 ^A
	Pork with <i>Anishi</i>	^a 22.32±2.44 ^{A B}	^a 19.79±1.04 ^A	^a 17.95±0.30 ^A
	Pork with <i>Silam</i>	^a 18.52±1.31 ^A	^a 16.75±0.10 ^B	^a 16.22±0.14 ^B
	Pork with FDS	^a 23.39±0.51 ^B	^b 22.12±0.16 ^C	^b 21.67±0.15 ^C

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.18. ANALYSIS OF VARIANCE OF COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Source	df	Mean±SE		
		L*	a*	b*
Products	3	1530.8337**	10.9258**	74.1539**
Days	2	190.7943**	13.5812**	36.1635**
Error	54	1.0993	0.2755	3.7576

df= degree of freedom, **= Significant at 1 percent level

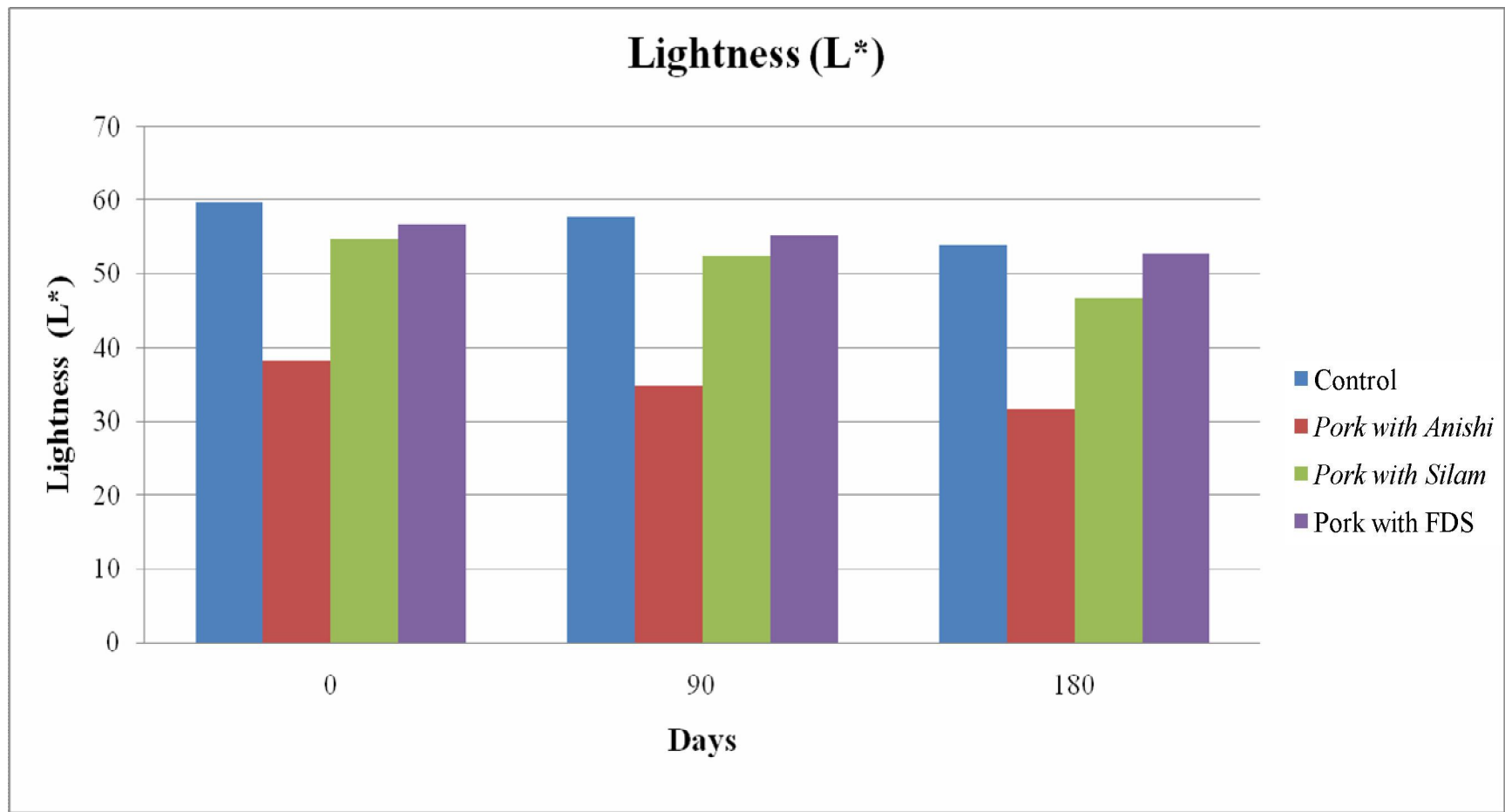


FIG 4.13. GRAPHICAL REPRESENTATION OF EFFECT OF LIGHTNESS (L*) OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

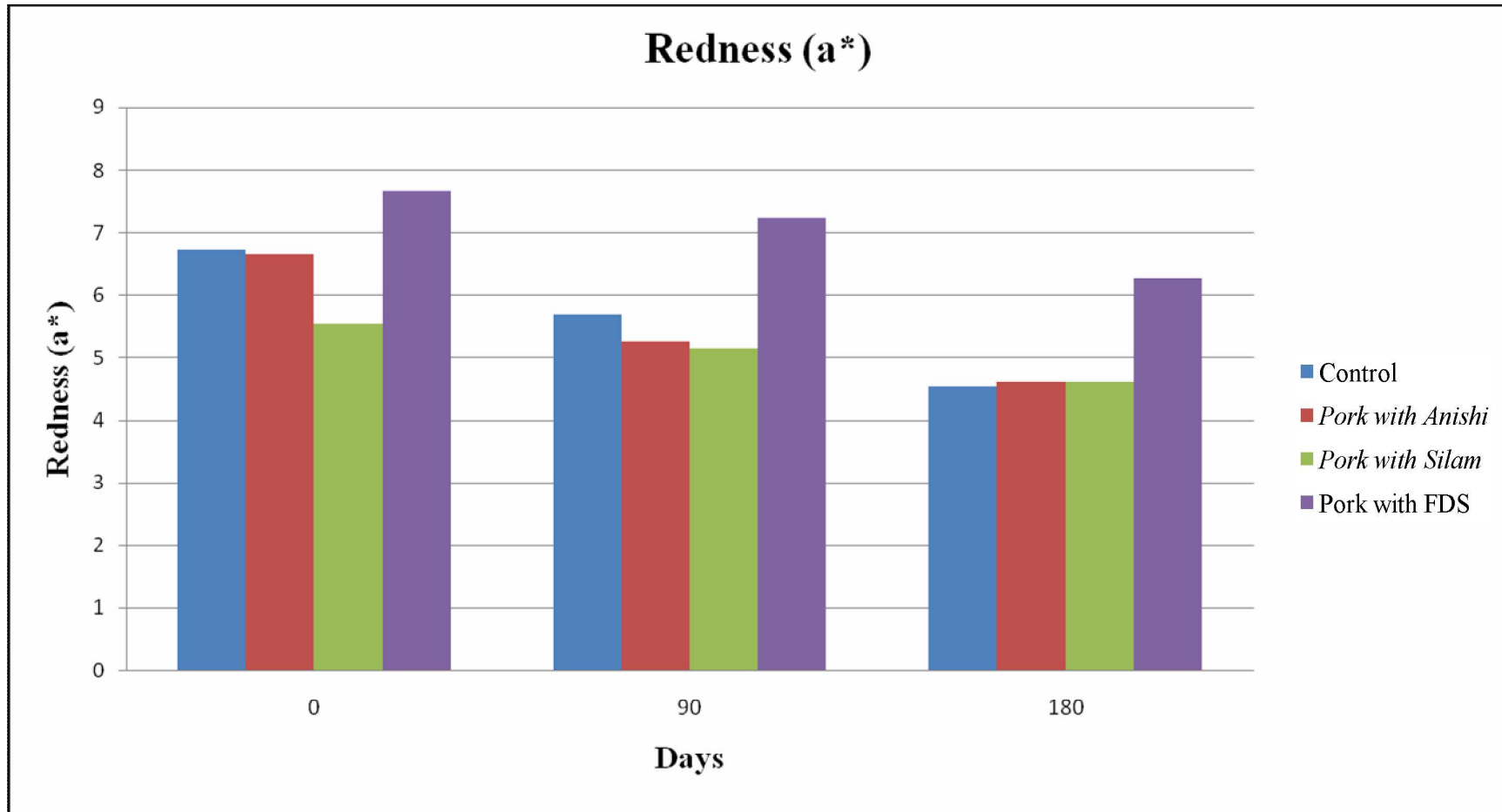


FIG 4.14. GRAPHICAL REPRESENTATION OF EFFECT OF REDNESS (a*) OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

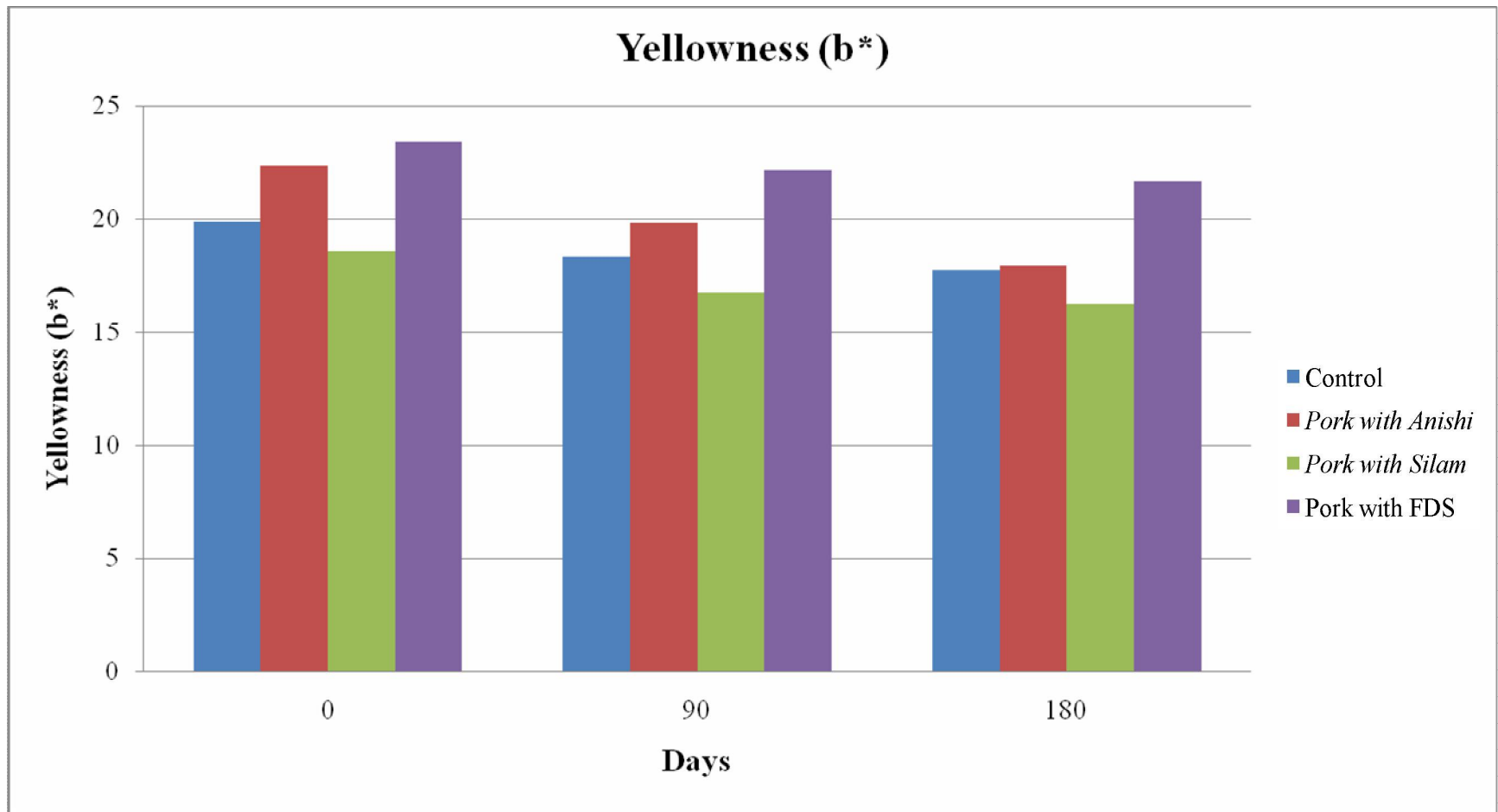


FIG 4.15. GRAPHICAL REPRESENTATION OF EFFECT OF YELLOWNESS (b*) OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

4.7. MICROBIOLOGICAL QUALITIES OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The results of microbiological studies are presented in Table 4.19.

The results on microbiological quality revealed that there was absence of total viable count, coliform count and yeast and mould counts in control and all the traditional pork product during the entire storage period of study.

The absence of microorganisms may be due retort processing where the destruction of microorganism might have occurred during the thermal processing. Thermal processing is undertaken to bring the food as rapidly as possible to a temperature at which unwanted microorganisms are killed and to hold the food at that temperature long enough to render the food “commercially sterile” (Satish, 2005). Rao (2005) opined that heat treatment is designed to reduce the probability of the microbial survival and foods which have been heat processed with this criterion are referred as “commercially sterile”. On this basis the control product and traditional pork product incorporated with *Anishi*, *Silam* and FDS were rendered as “commercially sterile” upto 6 months of storage.

TABLE 4.19. EFFECT OF MICROBIOLOGICAL QUALITIES OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Sl no.	Parameters	Results
a)	TPC (cfu/g)	ND at any storage period in all samples
b)	Coliform (MPN/g)	ND at any storage period in all samples
c)	Yeast and mould (cfu/g)	ND at any storage period in all samples

ND= Not detected

4.8. SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The mean values for different parameters of sensory evaluation of control and treated pork products under retort packaging are presented in Table 4.20. The analysis of variance is presented in Table 4.21. The graphical representation is presented in Fig. 4.16.

4.8.1. Appearance

The mean appearance recorded for the control product under retort pouch packaging on 0 day was 6.57 ± 0.08 and in the treated products were 6.40 ± 0.10 , 6.43 ± 0.08 and 6.40 ± 0.08 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean appearance recorded for control product were 5.91 ± 0.09 , 5.69 ± 0.08 , 5.60 ± 0.08 , 5.43 ± 0.14 , 5.34 ± 0.12 and 5.09 ± 0.10 , respectively. These mean values for appearance in pork with *Anishi* were 6.26 ± 0.07 , 6.11 ± 0.05 , 6.11 ± 0.05 , 5.46 ± 0.10 , 5.34 ± 0.08 and 4.89 ± 0.05 , for pork with *Silam* were 5.89 ± 0.05 , 6.00 ± 0.08 , 5.86 ± 0.10 , 5.43 ± 0.08 , 5.14 ± 0.11 and 5.26 ± 0.10 and for pork with FDS were 6.31 ± 0.08 , 5.97 ± 0.09 , 5.74 ± 0.09 , 5.83 ± 0.10 , 5.20 ± 0.08 and 5.06 ± 0.09 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in appearance in control and treated formulations during storage periods under retort packaging. There was also significant ($p < 0.05$) differences in appearance in control and treated formulations. The appearance score on 0 day was highest in control compared to pork with *Anishi*, *Silam* and FDS. The scores appearance revealed a decreasing trend with increase in storage period. The appearance of a product is determined by the state and stability of any natural or added pigment and the development of any discolouration during processing and storage. In addition, oxidation and the millard reaction can produce colours during the process and storage (Nambiar, 2005). In contrast, Bindu *et al.* (2007) reported that colour scores were remained same during the first six months of storage of retort processed black clam meat.

4.8.2. Flavour

The mean flavour recorded for the control product under retort pouch packaging on 0 day was 6.77 ± 0.07 and in the treated products were 6.69 ± 0.08 , 6.77 ± 0.07 and 6.77 ± 0.07

for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean flavour recorded for control product were 6.29 ± 0.10 , 5.54 ± 0.09 , 5.57 ± 0.08 , 5.31 ± 0.09 , 5.23 ± 0.09 and 4.94 ± 0.09 , respectively. These mean values for flavour in pork with *Anishi* were 6.63 ± 0.10 , 6.34 ± 0.08 , 5.66 ± 0.08 , 5.74 ± 0.09 , 5.29 ± 0.08 and 4.54 ± 0.10 , for pork with *Silam* were 6.14 ± 0.08 , 6.34 ± 0.08 , 5.60 ± 0.10 , 5.29 ± 0.08 , 5.26 ± 0.07 and 5.14 ± 0.09 and for pork with FDS were 6.40 ± 0.10 , 6.14 ± 0.11 , 5.94 ± 0.09 , 5.14 ± 0.10 , 5.40 ± 0.12 and 4.69 ± 0.10 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in flavour in control and treated formulations during storage periods under retort packaging. There was also highly significant ($p < 0.01$) difference in flavour in control and treated formulations. Higher flavour scores were recorded in control, pork with *Silam* and FDS on 0 day of storage. The differences in flavour score in control and treated products might be due to incorporation of different ingredients in the treated products. The flavour scores gradually decreases on increase in days of storage in control and the treated products. Nambiar (2005) reported that volatile compounds such as nitrogen heterocyclics, cyclic enolones, poly carbonyls and mono carbonyls produced via millard reaction have a significant effect on the flavour of the foods. The essential oil of the spices gives flavour to the product (Rajkumar and Berwal, 2003) and their breakdown results due to oxidation.

4.8.3. Juiciness

The mean juiciness recorded for the control product under retort pouch packaging on 0 day was 6.80 ± 0.07 and in the treated products were 6.89 ± 0.05 , 6.97 ± 0.03 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean juiciness recorded for control product were 6.20 ± 0.07 , 5.71 ± 0.08 , 5.51 ± 0.09 , 5.54 ± 0.09 , 5.17 ± 0.11 and 4.91 ± 0.08 , respectively. These mean values for juiciness in pork with *Anishi* were 6.80 ± 0.07 , 6.51 ± 0.09 , 6.06 ± 0.07 , 5.71 ± 0.10 , 5.29 ± 0.08 and 4.83 ± 0.08 , for pork with *Silam* were 6.49 ± 0.09 , 6.23 ± 0.07 , 5.89 ± 0.09 , 5.63 ± 0.08 , 5.37 ± 0.10 and 5.37 ± 0.08 and for pork with FDS were 6.71 ± 0.08 , 6.17 ± 0.08 , 5.94 ± 0.07 , 5.60 ± 0.08 , 5.23 ± 0.10 and 4.74 ± 0.10 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in juiciness in control and treated formulations during storage periods under retort packaging. There was also highly significant ($p < 0.01$) differences in juiciness in control and treated formulations. Highest juiciness score was recorded in pork with FDS on 0 day compared to control, pork with *Anishi* and *Silam*. The juiciness scores gradually decreases on increase in days of storage in control and treated products. The juiciness scores arose as a consequence of moisture released from the meat during chewing (Winger and Hagyard, 1994). The flavour compounds released from the ingredients in the pork products could have influenced the juiciness scores of the panelists.

4.8.4. Tenderness

The mean tenderness recorded for the control product under retort pouch packaging on 0 day was 6.94 ± 0.04 and in the treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean tenderness recorded for control product were 6.29 ± 0.08 , 5.74 ± 0.08 , 5.40 ± 0.12 , 5.46 ± 0.09 , 5.37 ± 0.08 and 5.00 ± 0.06 , respectively. These mean values for tenderness in pork with *Anishi* were 6.86 ± 0.06 , 6.23 ± 0.07 , 6.06 ± 0.04 , 5.89 ± 0.08 , 5.37 ± 0.08 and 4.89 ± 0.07 , for pork with *Silam* were 6.57 ± 0.08 , 6.31 ± 0.08 , 6.09 ± 0.08 , 5.71 ± 0.08 , 5.40 ± 0.10 and 5.17 ± 0.09 and for pork with FDS were 6.77 ± 0.07 , 6.20 ± 0.07 , 6.37 ± 0.09 , 5.69 ± 0.10 , 5.11 ± 0.11 and 4.91 ± 0.10 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in tenderness in control and treated formulations during storage periods under retort packaging. There was also highly significant ($p < 0.01$) differences in tenderness in control and treated formulations. This might be due to differences in product formulations. Higher tenderness scores were recorded on 0 day in pork with *Anishi*, *Silam* and FDS compared to control product. There was decreasing trend in tenderness scores on increase in days of storage in control and the treated products. Similar to the present finding Rajkumar (2008) also observed that the tenderness scores of the *Chettinad* goat meat processed in retort pouch decreased from 8.20 to 7.07 during storage up to 10 months.

4.8.5. Overall acceptability

The mean overall acceptability recorded for the control product under retort pouch packaging on 0 day was 7.00 ± 0.00 and in the treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 30, 60, 90, 120, 150 and 180 day of storage the mean overall acceptability recorded for control product were 6.20 ± 0.07 , 5.77 ± 0.07 , 5.63 ± 0.08 , 5.49 ± 0.09 , 5.09 ± 0.08 and 4.91 ± 0.08 , respectively. These mean values for overall acceptability in pork with *Anishi* were 6.80 ± 0.07 , 6.23 ± 0.07 , 6.00 ± 0.00 , 6.00 ± 0.00 , 5.51 ± 0.09 and 5.03 ± 0.03 , for pork with *Silam* were 6.46 ± 0.09 , 6.29 ± 0.08 , 6.00 ± 0.06 , 5.91 ± 0.05 , 5.51 ± 0.09 and 5.46 ± 0.09 and for pork with FDS were 6.83 ± 0.06 , 6.11 ± 0.05 , 6.17 ± 0.06 , 5.83 ± 0.09 , 5.17 ± 0.06 and 5.11 ± 0.05 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in overall acceptability in control and treated formulations during storage periods under retort packaging. There was also highly significant ($p < 0.01$) differences in overall acceptability in control and treated formulations. On 0 day higher overall acceptability scores were recorded in control and pork with *Anishi*, *Silam* and FDS. There was decreasing trend in overall acceptability scores on increase in days of storage in control and the treated products. However the overall acceptability scores in pork with *Anishi*, *Silam* and FDS were rated moderately desirable upto 6 months of storage periods compared to control. Rajkumar (2008) reported that *Chettinad* goat meat processed in retort pouch have scores ranged from 7.77 to 7.33 (very acceptable) up to 10 months of storage under ambient temperature.

The scores for all the sensory parameters revealed a decreasing trend with increase in storage periods however the scores were within acceptable limit. Similar results were also reported by Gopal *et al.* (2001) in traditional Kerala style fish curry in retort pouch, Shankar *et al.* (2002) in seer fish curry in retort pouches, Chandrasekar *et al.* (2004) in mushrooms in brine processed in retort pouches and Bindu *et al.* (2007) in ready-to-eat black clam (*Villorita cyprinoides*) products in retort pouches.

TABLE 4.20. SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Parameters	Products	Mean±SE of different days						
		0	30	60	90	120	150	180
Appearance	Control	^a 6.57±0.08 ^A	^b 5.91±0.09 ^A	^{bc} 5.69±0.08 ^A	^{cd} 5.60±0.08 ^A	^{cd} 5.43±0.14 ^A	^{de} 5.34±0.12 ^A	^e 5.09±0.10 ^{AB}
	Pork with <i>Anishi</i>	^a 6.40±0.10 ^A	^{ab} 6.26±0.07 ^B	^b 6.11±0.05 ^B	^b 6.11±0.05 ^B	^c 5.46±0.10 ^A	^c 5.34±0.08 ^A	^d 4.89±0.05 ^B
	Pork with <i>Silam</i>	^a 6.43±0.08 ^A	^b 5.89±0.05 ^A	^b 6.00±0.08 ^B	^b 5.86±0.10 ^C	^c 5.43±0.08 ^A	^d 5.14±0.11 ^A	^{cd} 5.26±0.10 ^A
	Pork with FDS	^a 6.40±0.08 ^A	^a 6.31±0.08 ^B	^b 5.97±0.09 ^B	^b 5.74±0.09 ^{AC}	^b 5.83±0.10 ^B	^c 5.20±0.08 ^A	^c 5.06±0.09 ^{AB}
Flavour	Control	^a 6.77±0.07 ^A	^b 6.29±0.10 ^A	^c 5.54±0.09 ^A	^c 5.57±0.08 ^A	^{cd} 5.31±0.09 ^A	^d 5.23±0.09 ^A	^e 4.94±0.09 ^{AB}
	Pork with <i>Anishi</i>	^a 6.69±0.08 ^A	^a 6.63±0.10 ^B	^b 6.34±0.08 ^B	^c 5.66±0.08 ^A	^c 5.74±0.09 ^B	^d 5.29±0.08 ^A	^e 4.54±0.10 ^C
	Pork with <i>Silam</i>	^a 6.77±0.07 ^A	^b 6.14±0.08 ^A	^b 6.34±0.08 ^B	^c 5.60±0.10 ^A	^d 5.29±0.08 ^A	^d 5.26±0.07 ^A	^d 5.14±0.09 ^A
	Pork with FDS	^a 6.77±0.07 ^A	^b 6.40±0.10 ^{AB}	^{bc} 6.14±0.11 ^B	^c 5.94±0.09 ^B	^d 5.14±0.10 ^A	^d 5.40±0.12 ^A	^e 4.69±0.10 ^{BC}
Juiciness	Control	^a 6.80±0.07 ^A	^b 6.20±0.07 ^A	^c 5.71±0.08 ^A	^c 5.51±0.09 ^A	^c 5.54±0.09 ^A	^d 5.17±0.11 ^A	^e 4.91±0.08 ^A
	Pork with <i>Anishi</i>	^a 6.89±0.05 ^{AB}	^a 6.80±0.07 ^B	^b 6.51±0.09 ^B	^c 6.06±0.07 ^B	^d 5.71±0.10 ^A	^e 5.29±0.08 ^A	^f 4.83±0.08 ^A
	Pork with <i>Silam</i>	^a 6.97±0.03 ^B	^b 6.49±0.09 ^C	^c 6.23±0.07 ^C	^d 5.89±0.09 ^B	^e 5.63±0.08 ^A	^f 5.37±0.10 ^A	^f 5.37±0.08 ^B
	Pork with FDS	^a 7.00±0.00 ^B	^b 6.71±0.08 ^B	^c 6.17±0.08 ^C	^d 5.94±0.07 ^B	^e 5.60±0.08 ^A	^f 5.23±0.10 ^A	^g 4.74±0.10 ^A
Tenderness	Control	^a 6.94±0.04 ^A	^b 6.29±0.08 ^A	^c 5.74±0.07 ^A	^d 5.40±0.12 ^A	^d 5.46±0.09 ^A	^d 5.37±0.08 ^A	^e 5.00±0.06 ^{AB}
	Pork with <i>Anishi</i>	^a 7.00±0.00 ^A	^a 6.86±0.06 ^B	^b 6.23±0.07 ^B	^{bc} 6.06±0.04 ^B	^c 5.89±0.08 ^B	^d 5.37±0.08 ^A	^e 4.89±0.07 ^B
	Pork with <i>Silam</i>	^a 7.00±0.00 ^A	^b 6.57±0.08 ^C	^c 6.31±0.08 ^B	^d 6.09±0.08 ^B	^e 5.71±0.08 ^B	^f 5.40±0.10 ^A	^g 5.17±0.09 ^A
	Pork with FDS	^a 7.00±0.00 ^A	^a 6.77±0.07 ^{BC}	^b 6.20±0.07 ^B	^b 6.37±0.09 ^C	^c 5.69±0.10 ^{AB}	^d 5.11±0.11 ^A	^d 4.91±0.10 ^B
Overall acceptability	Control	^a 7.00±0.00 ^A	^b 6.20±0.07 ^A	^c 5.77±0.07 ^A	^{cd} 5.63±0.08 ^A	^d 5.49±0.09 ^A	^e 5.09±0.08 ^A	^e 4.91±0.08 ^A
	Pork with <i>Anishi</i>	^a 7.00±0.00 ^A	^b 6.80±0.07 ^B	^c 6.23±0.07 ^B	^d 6.00±0.00 ^B	^d 6.00±0.00 ^B	^e 5.51±0.09 ^B	^f 5.03±0.03 ^{AB}
	Pork with <i>Silam</i>	^a 7.00±0.00 ^A	^b 6.46±0.09 ^C	^b 6.29±0.08 ^B	^c 6.00±0.06 ^B	^c 5.91±0.05 ^B	^d 5.51±0.09 ^B	^d 5.46±0.09 ^C
	Pork with FDS	^a 7.00±0.00 ^A	^b 6.83±0.06 ^B	^c 6.11±0.05 ^B	^c 6.17±0.06 ^B	^d 5.83±0.09 ^B	^e 5.17±0.06 ^A	^e 5.11±0.05 ^B

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.21. ANALYSIS OF VARIANCE OF SENSORY EVALUATIONS OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

Source	df	Mean±SE				
		Appearance	Flavour	Juiciness	Tenderness	Overall acceptability
Products	3	1.0023*	1.3588**	5.2010**	5.0530**	7.2989**
Days	6	32.6544**	62.9200**	67.1329**	68.5263**	60.5258**
Error	970	0.2966	0.3152	0.2426	0.2280	0.1542

df= degree of freedom, **= Significant at 1 percent level, *= Significant at 5 percent level

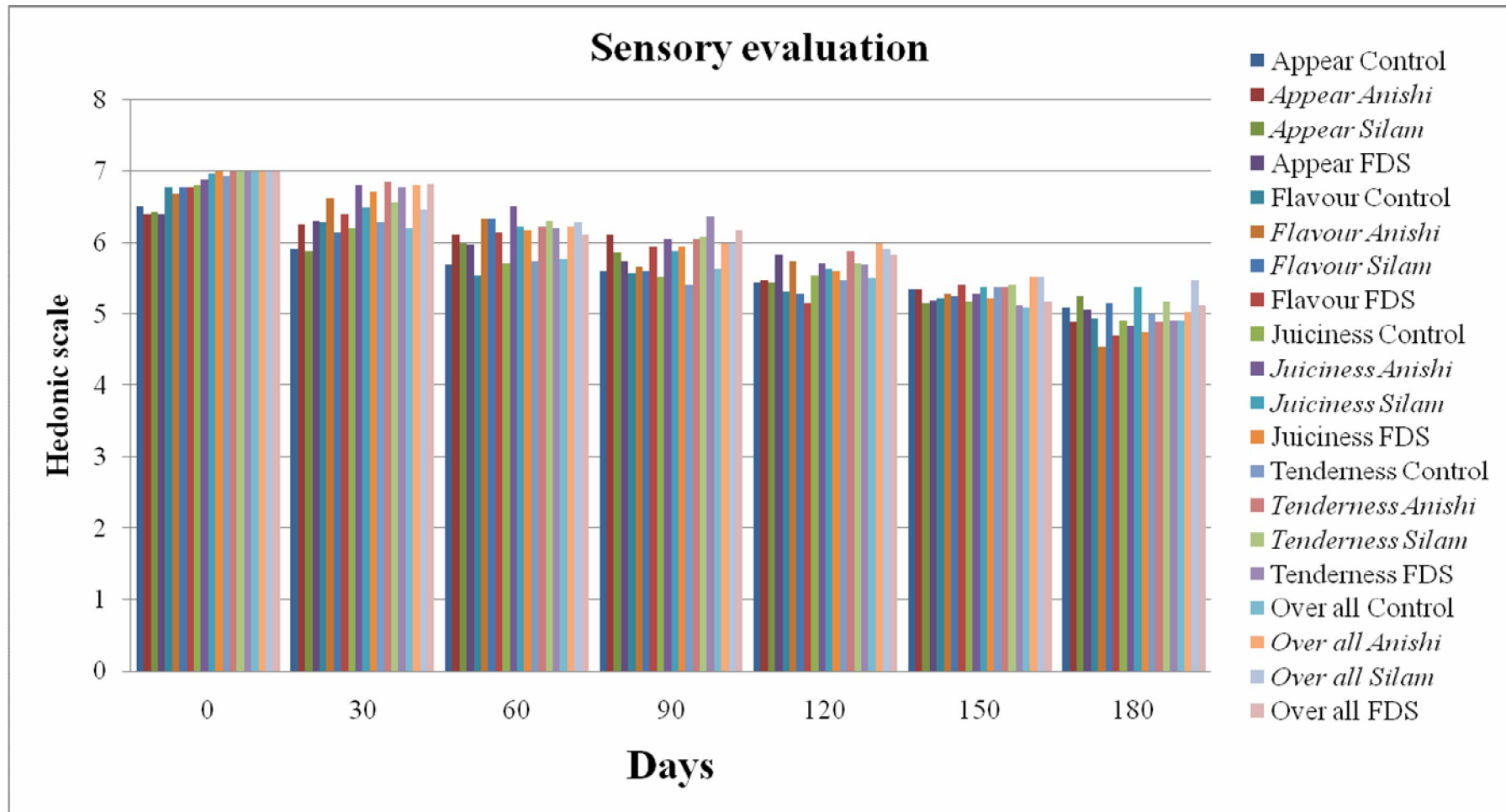


FIG 4.16. GRAPHICAL REPRESENTATION OF SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

4.9. COST OF PRODUCTION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING

The cost of production for control and treated pork products under retort processing are presented in Table 4.22.

Considering all aspects like cost of raw materials, production, processing, labour, transportation, electricity, the cost of production for retort packaging of traditional pork products per kilogram were found to be Rs. 519.00 for control, Rs. 512.00 for pork with *Anishi*, Rs. 506.00 for pork with *Silam* and Rs. 512.00 for pork with FDS by processing in retort packaged traditional pork products. The result indicates that the costs of final products were lower for pork with *Anishi*, *Silam* and FDS incorporated pork products. Among the pork products, the cost of pork with *Silam* was lower than pork with *Anishi* and FDS. Whereas, the cost of control was higher compared to all the pork products incorporated with *Anishi*, *Silam* and FDS. The study indicates that incorporation of ingredients viz. *Anishi*, *Silam* and FDS in pork products could be produced with economic benefit for production of traditional pork products under retort packaging.

(* The cost of machineries were not included in calculating cost of production).

TABLE 4.22. COST OF PRODUCTION OF TRADITIONAL PORK PRODUCTS UNDER RETORT PACKAGING: COST FOR 2 KGS

Ingredients	Control	Pork with <i>Anishi</i>	Pork with <i>Silam</i>	Pork with FDS
Pork 2 kg @ Rs. 260/kg	520.00	520.00	520.00	520.00
Additives (Salt, condiments, tomato, green chillies) LS	50.00	50.00	50.00	50.00
<i>Anishi</i> (5%) @ Rs. 400/kg	-	40.00	-	-
<i>Silam</i> (10%) @ Rs. 400/kg	-	-	80.00	-
FDS (5%) @ Rs. 400/kg	-	-	-	40.00
Processing cost (Labour, water etc.)	120.00	120.00	120.00	120.00
Electricity cost (Rs.) LS	100.00	100.00	100.00	100.00
Total cost (Rs)	830.00	870.00	910.00	870.00
Final product (Kg)	1.60	1.70	1.80	1.70
Cost of production (Rs/Kg)	519.00	512.00	506.00	512.00

4.10. VACUUM PACKAGING OF TRADITIONAL PORK PRODUCTS

Various types of food packaging in combination with different storage techniques can be used in order to extend the shelf life meat. The causes of product deterioration are microbial spoilage, moisture loss, colour change and oxidative rancidity (Sinhamahapatra *et al.*, 2013). Vacuum packaging, a form of modified atmosphere packaging, is often used to extend the shelf life of meat and meat products and is being increasingly applied for product distribution and retail sale (Stiles, 1990).

Vacuum packaging represents a static form of hypobaric storage, which is widely used in food industry due to its effectiveness in reducing oxidative reactions in the product at relatively low costs (Gopal *et al.*, 1999). In vacuum packaging, the product is contained in a package made of a material having low oxygen permeability and is sealed airtight after evacuating the air.

During refrigeration, the vacuum allows the shelf life of meat to be extended by reducing oxidation and the growth of aerobic microorganisms. Vacuum packaging has proven to be efficient in extending shelf life, preserving the sensory characteristics inherent to the product for a period sufficiently long for its turnover (Maria *et al.*, 2011).

4.10.1. Proximate composition of traditional pork products under vacuum packaging

4.10.1.1. Moisture

The mean moisture content of control and traditional pork products under vacuum packaging are presented in Table 4.23. The analysis of variance is presented in Table 4.24. The graphical representation is presented in Fig. 4.17.

The mean percent moisture content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 71.34 ± 0.48 and in case of the treated products 70.90 ± 0.81 , 68.97 ± 0.86 and 69.59 ± 0.23 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean moisture content recorded for control product were 70.76 ± 0.65 , 70.48 ± 0.39 and 69.92 ± 0.25 percent. These mean values for percent moisture content in pork with *Anishi* were 70.81 ± 0.93 , 70.80 ± 0.62 and 70.50 ± 0.50 , for pork with *Silam* were 68.83 ± 0.89 , 68.45 ± 0.86 and 68.31 ± 0.27 and for pork with FDS were 69.18 ± 0.29 , 68.87 ± 0.30 and 68.06 ± 0.30 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in moisture percent in control and traditional pork products with different formulations under vacuum packaging at refrigeration storage. Highest moisture content was recorded in control on 0 day compared to the treated samples and the lowest percent of moisture content was recorded on day 15 in pork with FDS.

There was no significant difference in moisture content of the vacuum packaged products during different storage days. During entire storage periods, the moisture content recorded a decreasing trend in control and pork with *Anishi*, *Silam* and FDS from 0 to 15 day. Similar decreasing trend in moisture content during storage period was also reported by earlier workers on vacuum packaged pork products (Pulgar *et al.* 2012) and in restructured buffalo meat products by Anandh (2015).

4.10.1.2. Ether extract

The mean ether extract content of control and traditional pork products under vacuum packaging are presented in Table 4.23. The analysis of variance is presented in Table 4.24. The graphical representation is presented in Fig. 4.18.

The mean percent ether extract content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 5.92 ± 0.44 and in case of the treated products 6.45 ± 0.18 , 8.03 ± 0.79 and 6.68 ± 0.05 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the mean ether extract content recorded for control product were 6.11 ± 0.24 , 7.02 ± 0.37 and 9.56 ± 0.28 percent. These mean values for percent ether extract content in pork with *Anishi* were 6.67 ± 0.24 , 7.40 ± 0.12 and 8.98 ± 0.33 , for pork with *Silam* were 8.19 ± 0.38 , 9.43 ± 0.34 and 10.04 ± 0.29 and for pork with FDS were 7.90 ± 0.30 , 8.53 ± 0.42 and 9.19 ± 0.13 , respectively. Highest fat content was observed in pork with *Silam* on 15 day of refrigeration storage.

The analysis of variance revealed highly significant ($p < 0.01$) differences in ether extract content among different formulations under vacuum packaging at refrigeration storage. The lowest ether extract content was recorded in control on 0 day and the highest ether extract was recorded in pork with *Silam* on 15 day of storage.

Ether extract values were found to increase with the advancement of storage periods of vacuum packaged refrigerated products. There was highly significant ($p < 0.01$) difference in ether extract content of the vacuum packaged products during different storage days. This increase in fat content might be due to oxidation of fat and the decrease in moisture content of the products. As meat ages the fat deteriorates through microbial attack and tissue enzyme activity, which causes the development of free fatty acid and oxidation of unsaturated fatty acids. Contrary to finding of the present study Bhoyar *et al.* (1998) observed no change in ether extract content of chicken meat with storage time in either type of packaging, free fatty acid values in meat progressively increases with storage time (Pearson, 1968) i.e. vacuum packaging and normal atmospheric packaging.

4.10.1.3 Total ash

The mean total ash content of control and traditional pork products under vacuum packaging are presented in Table 4.23. The analysis of variance is presented in Table 4.24. The graphical representation is presented in Fig. 4.19.

The mean percent values of total ash content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 6.57 ± 0.29 and in case of the treated products 6.40 ± 0.18 , 6.29 ± 0.18 and 6.18 ± 0.305 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the mean total ash content recorded for control product were 6.09 ± 0.43 , 6.06 ± 0.27 and 5.78 ± 0.11 percent. These mean values for percent total ash content in pork with *Anishi* were 6.37 ± 0.27 , 6.01 ± 0.40 and 5.49 ± 0.15 , for pork with *Silam* were, 6.19 ± 0.34 , 6.11 ± 0.34 and 5.55 ± 0.11 and for pork with FDS were 5.82 ± 0.32 , 5.41 ± 0.15 and 5.25 ± 0.06 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and traditional pork products with different formulations during refrigeration storage periods. However, significant ($p < 0.05$) differences was observed in control and treated formulations. In all the storage period, the total ash content from 0 to 15 day revealed decreasing trend in control and pork with *Anishi*, *Silam* and FDS. On 0 day of storage period the ash content recorded highest in control and all the treated samples compared to 15 day. Whereas, the lowest total ash content was recorded on 15 day in pork with FDS. Akhter *et al.* (2009) who observed decreasing trend in ash content during storage of dried

preservation technique on nutrient content of beef. Contrary to the finding of the present study, Devi *et al.* (2018) reported no significant difference in ash content of vacuum-packed guinea fowl meat sausage during storage at refrigerated temperature ($4\pm 1^{\circ}\text{C}$). The disagreement with the finding of earlier workers regarding the total ash content might be due to addition of different ingredients in the products formulations in the present study.

4.10.1.4. Crude protein

The mean crude protein content of control and traditional pork products under vacuum packaging are presented in Table 4.23. The analysis of variance is presented in Table 4.24. The graphical representation is presented in Fig. 4.20.

The mean percent values of crude protein content recorded for control product under vacuum packaging at refrigeration storage on 0 day was 16.77 ± 0.49 and in case of the treated products 15.56 ± 0.43 , 16.01 ± 0.16 and 17.55 ± 0.28 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the mean crude protein content recorded for control product were 16.59 ± 0.37 , 16.48 ± 0.13 and 15.49 ± 0.48 percent. These mean values for percent crude protein content in pork with *Anishi* were 15.04 ± 0.31 , 14.73 ± 0.29 and 14.43 ± 0.35 , for pork with *Silam* were, 15.02 ± 0.26 , 14.76 ± 0.25 and 14.81 ± 0.33 and for pork with FDS were, 17.35 ± 0.41 , 16.86 ± 0.18 and 16.24 ± 0.23 , respectively. Decreasing trend in percent of crude protein were observed in control and all the treated products during the storage period under vacuum packaged traditional pork products.

The analysis of variance revealed highly significant ($p < 0.01$) differences in products and storage periods in control, pork with *Anishi*, *Silam* and FDS under vacuum packaging. The highest crude protein content was recorded in FDS incorporated pork product on 0 day of storage and lowest protein content was recorded in pork with *Anishi*. The decreased in crude protein content on storage periods might have influence on the moisture and the protein percentage. Ockerman (1985) who reported that as the moisture content of meat increased, protein and dry matter contents decreased reciprocally. Another reason might be due to breakdown of protein during storage of the products due to enzymatic action of microbes.

TABLE 4.23. EFFECT OF PROXIMATE COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean±SE of different days			
		0	5	10	15
Moisture (%)	Control	^a 71.34±0.48 ^A	^a 70.76±0.65 ^A	^a 70.48±0.39 ^{AB}	^a 69.92±0.25 ^A
	Pork with <i>Anishi</i>	^a 70.90±0.81 ^{AB}	^a 70.81±0.93 ^A	^a 70.80±0.62 ^A	^a 70.50±0.50 ^A
	Pork with <i>Silam</i>	^a 68.97±0.86 ^B	^a 68.83±0.89 ^A	^a 68.45±0.86 ^C	^a 68.31±0.27 ^B
	Pork with FDS	^a 69.59±0.23 ^{AB}	^a 69.18±0.29 ^A	^{ab} 68.87±0.30 ^{BC}	^b 68.06±0.30 ^B
Ether extract (%)	Control	^c 5.92±0.44 ^B	^{bc} 6.11±0.24 ^B	^b 7.02±0.37 ^B	^a 9.56±0.28 ^{AB}
	Pork with <i>Anishi</i>	^c 6.45±0.18 ^B	^c 6.67±0.24 ^B	^b 7.40±0.12 ^B	^a 8.98±0.33 ^B
	Pork with <i>Silam</i>	^b 8.03±0.79 ^A	^b 8.19±0.38 ^A	^{ab} 9.43±0.34 ^A	^a 10.04±0.29 ^A
	Pork with FDS	^c 6.68±0.05 ^{AB}	^b 7.90±0.30 ^A	^{ab} 8.53±0.42 ^A	^a 9.19±0.13 ^B
Total Ash (%)	Control	^a 6.57±0.29 ^A	^a 6.09±0.43 ^A	^a 6.06±0.27 ^A	^a 5.78±0.11 ^A
	Pork with <i>Anishi</i>	^a 6.40±0.18 ^A	^a 6.37±0.27 ^A	^{ab} 6.01±0.40 ^A	^b 5.49±0.15 ^{AB}
	Pork with <i>Silam</i>	^a 6.29±0.13 ^A	^a 6.19±0.34 ^A	^a 6.11±0.34 ^A	^a 5.55±0.11 ^{AB}
	Pork with FDS	^a 6.18±0.30 ^A	^{ab} 5.82±0.32 ^A	^b 5.41±0.15 ^A	^b 5.25±0.06 ^B
Crude Protein (%)	Control	^a 16.77±0.49 ^{AB}	^{ab} 16.59±0.37 ^A	^{ab} 16.48±0.13 ^A	^b 15.49±0.48 ^{AB}
	Pork with <i>Anishi</i>	^a 15.56±0.43 ^C	^{ab} 15.04±0.31 ^B	^{ab} 14.73±0.29 ^B	^b 14.43±0.35 ^B
	Pork with <i>Silam</i>	^a 16.01±0.16 ^{BC}	^b 15.02±0.26 ^B	^b 14.76±0.25 ^B	^b 14.81±0.33 ^B
	Pork with FDS	^a 17.55±0.28 ^A	^a 17.35±0.41 ^A	^{ab} 16.86±0.18 ^A	^b 16.24±0.23 ^A

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.24. ANALYSIS OF VARIANCE OF PROXIMATE COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE			
		Moisture	Ether extract	Total Ash	Protein
Products	3	24.5853**	12.7013**	0.8751*	19.1833**
Days	3	3.5836 ^{NS}	27.7765**	2.5686**	5.3291**
Error	73	1.5935	0.6660	0.3198	0.5050

df= degree of freedom, NS=Non-significant, **= Significant at 1 percent level, *= Significant at 5 percent level

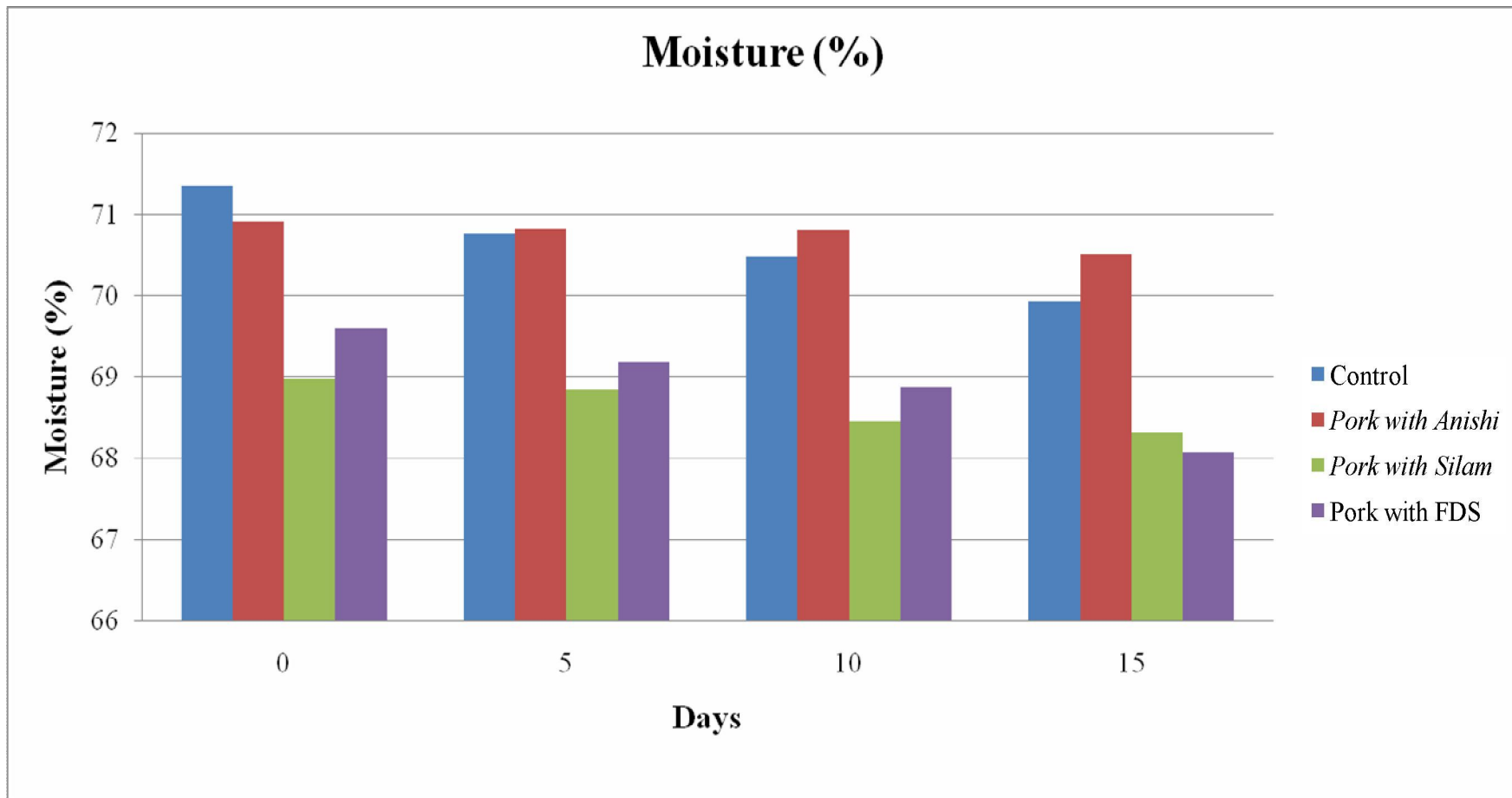


FIG 4.17. GRAPHICAL REPRESENTATION OF EFFECT OF MOISTURE CONTENT OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

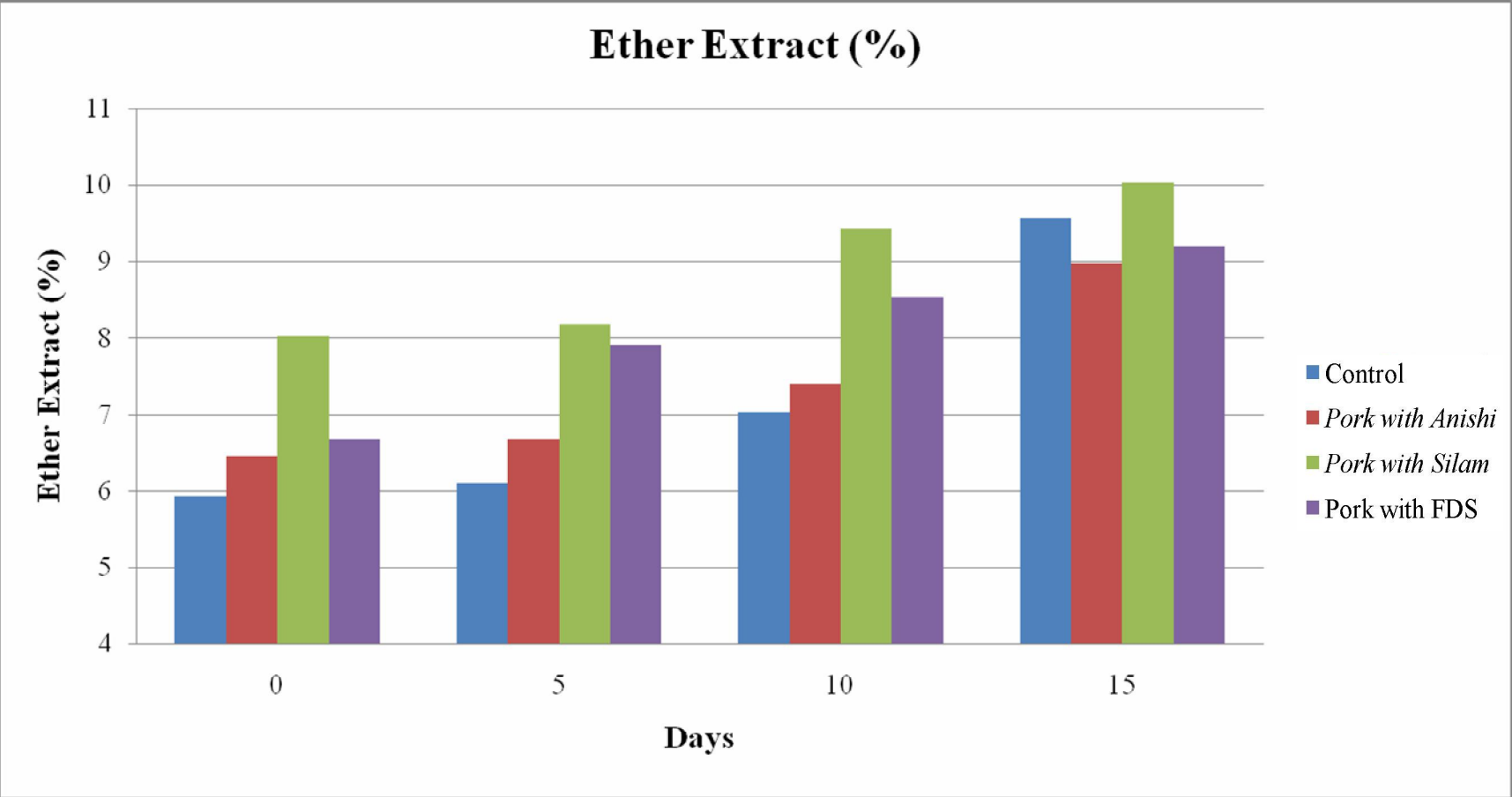


FIG 4.18. GRAPHICAL REPRESENTATION OF EFFECT OF ETHER EXTRACT CONTENT OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

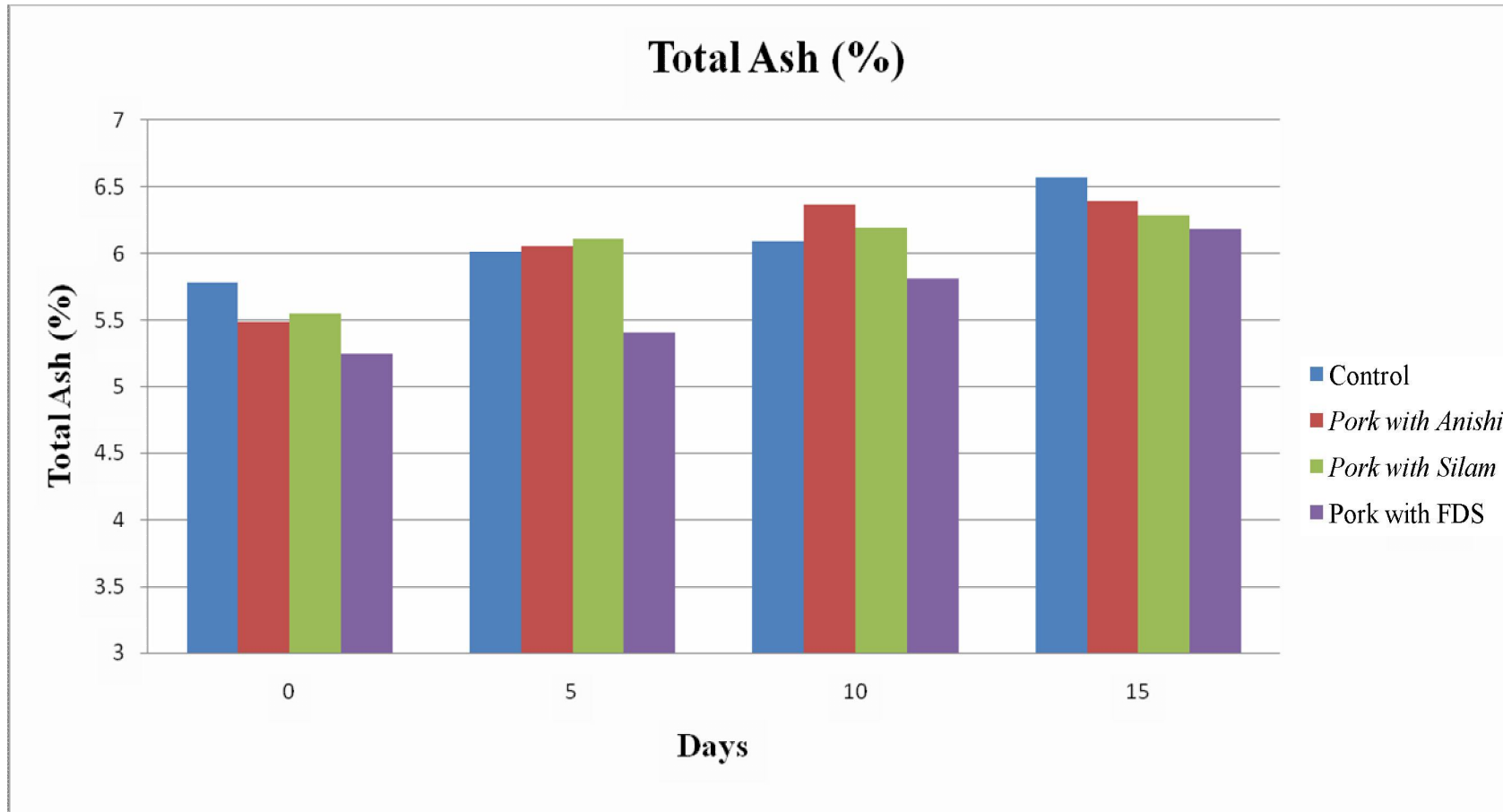


FIG 4.19. GRAPHICAL REPRESENTATION OF EFFECT OF TOTAL ASH CONTENT OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

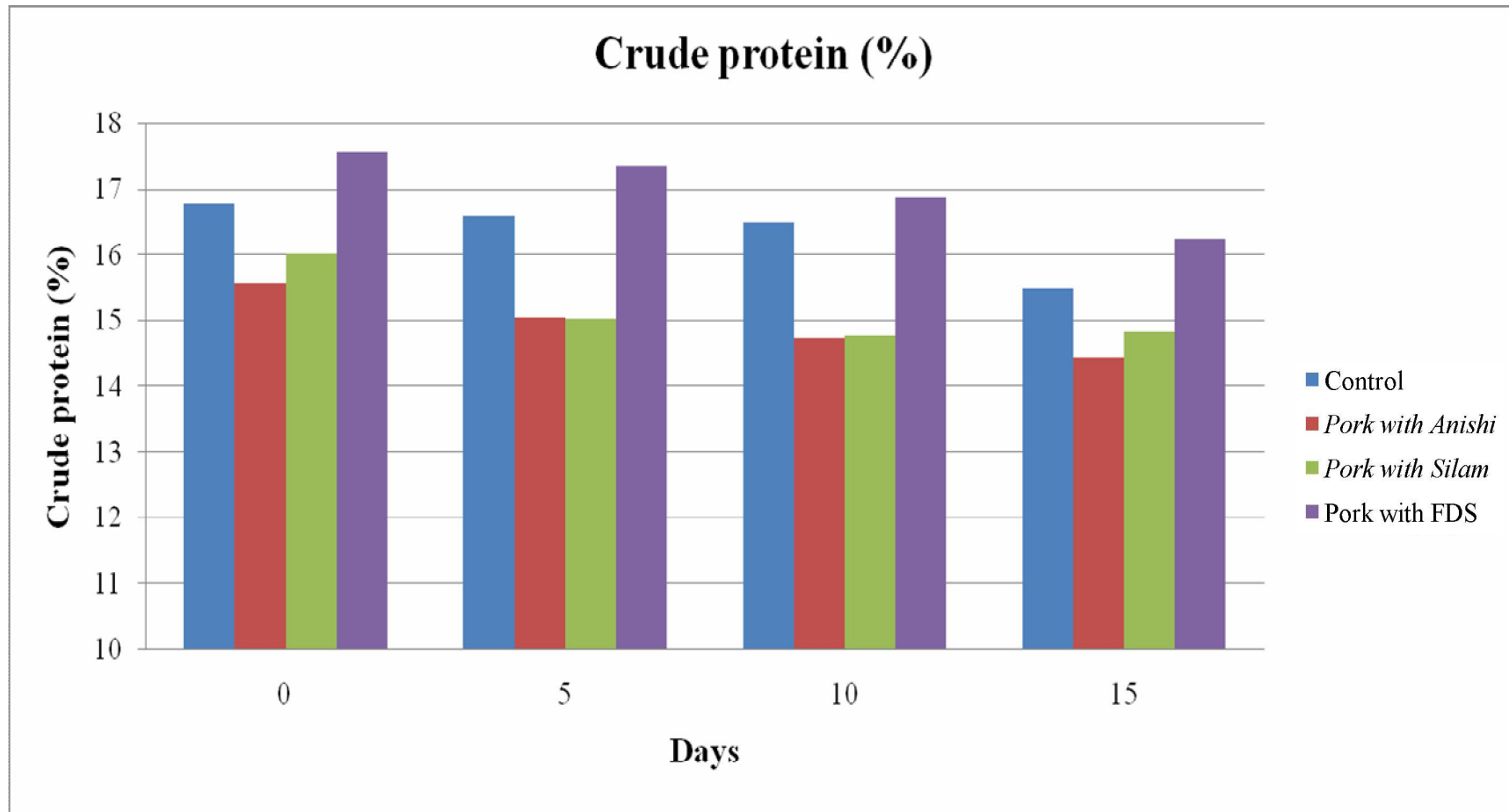


FIG 4.20. GRAPHICAL REPRESENTATION OF EFFECT OF CRUDE PROTEIN CONTENT OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.10.2. Physicochemical properties of traditional pork products under vacuum packaging

4.10.2.1. pH

The mean pH of control and traditional pork products under vacuum packaging are presented in Table 4.25. The analysis of variance is presented in Table 4.26. The graphical representation is presented in Fig. 4.21.

The mean values of pH recorded for control product under vacuum packaging at refrigeration storage on 0 day was 5.86 ± 0.01 and in case of the treated products 5.81 ± 0.02 , 5.89 ± 0.01 and 5.98 ± 0.03 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the mean pH values recorded for control product were 5.86 ± 0.03 , 5.59 ± 0.09 and 5.45 ± 0.04 , respectively. These mean values for pH in pork with *Anishi* were 5.73 ± 0.03 , 5.43 ± 0.11 and 5.24 ± 0.04 , for pork with *Silam* were 5.90 ± 0.03 , 5.62 ± 0.09 and 5.52 ± 0.15 and for pork with FDS were 5.96 ± 0.04 , 5.70 ± 0.08 and 5.46 ± 0.11 , respectively. There was decrease in pH of control and all the treated products during the storage period. However, the highest pH was recorded on 0 day in pork with FDS compared to control, pork with *Anishi* and *Silam*. The lowest pH value was recorded in pork with *Anishi* from 0 day of storage compared to control, pork with *Silam* and FDS.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations and during storage periods. The decline of pH with increasing storage periods up to 15 days was reported by Anandh (2015) in boiled restructured buffalo meat rolls in refrigerated storage under vacuum packaging condition. Ockonkwo *et al.* (1992) reported that the cross-linking reaction, by removing amino groups from the meat cause a decrease in pH. Incze (1992) also reported that decrease in the pH values might be due to significant increase in microbial count during storage periods producing lactic acid by breakdown of carbohydrates. The resultant pH changes of the present study were also seemed to be governed by the relative rates of above reactions.

4.10.2.2. TBARS value

The mean TBARS values of control and traditional pork products under vacuum packaging are presented in Table 4.25. The analysis of variance is presented in Table 4.26. The graphical representation is presented in Fig. 4.22.

The mean TBARS values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 0.86 ± 0.02 and in case of the treated products 0.78 ± 0.04 , 0.65 ± 0.03 and 0.74 ± 0.03 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the TBARS values recorded for control product were 0.89 ± 0.02 , 1.03 ± 0.01 and 1.07 ± 0.02 , respectively. These mean TBARS values in pork with *Anishi* were, 1.14 ± 0.18 , 1.20 ± 0.05 and 1.38 ± 0.06 , for pork with *Silam* were, 0.88 ± 0.11 , 1.21 ± 0.05 and 1.38 ± 0.02 and for pork with FDS were, 1.06 ± 0.05 , 1.23 ± 0.03 and 1.36 ± 0.04 , respectively.

Increasing trend of TBARS values were recorded in control and treated products on storage periods of the study. The increase in TBARS values of all the products were within the threshold limit of 1-2 mg malonaldehyde/kg meat. The increase in TBARS values during storage might be attributed to the oxidation of meat lipid under vacuum-package refrigerated storage.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated products and during storage. Increase of microbial load in meat samples could have caused increased oxidative changes. These changes might be attributed to increase in TBA value (Jay, 1996). Kumar and Sharma (2003) observed a linear increase in TBA value throughout the storage periods while studying the quality characteristics of low-fat ground pork patties containing milk co-precipitate. Lalchamliani *et al.* (2015) also observed increasing trends in TBA values of *Vawksa* rep samples and in buffalo meat rolls (Anandh, 2015) under vacuum packaging during refrigerated storage. The TBA value 1.0 is considered as the threshold level for rancidity in pork products (Ockerman, 1985).

4.10.2.3. Tyrosine value

The mean tyrosine values of control and traditional pork products under vacuum packaging are presented in Table 4.25. The analysis of variance is presented in Table 4.26. The graphical representation is presented in Fig. 4.23.

The mean tyrosine values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 60.00 ± 0.14 and in case of the treated products 60.07 ± 0.24 , 58.00 ± 0.25 and 55.44 ± 0.28 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the tyrosine values recorded for control product were 60.75 ± 0.55 , 76.40 ± 0.48 and 88.79 ± 0.48 , respectively. These mean tyrosine values in pork with *Anishi* were, 60.57 ± 0.55 , 62.57 ± 0.09 and 78.78 ± 0.46 , for pork with *Silam* were, 58.47 ± 0.29 , 67.64 ± 0.18 and 73.39 ± 0.59 and for pork with FDS were 56.09 ± 1.80 , 70.42 ± 0.35 and 87.61 ± 0.60 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations and during storage periods. The increasing trends of tyrosine values were observed in control and all the treated products from 0 to 15 day during refrigerated storage period. The highest tyrosine value was recorded in pork with *Anishi* on 0 day and the lowest tyrosine value was recorded in pork with FDS.

The increase in tyrosine value during storage might be due to denaturation and subsequent proteolysis (Daly *et al.*, 1976). The findings are in agreement with the statement of Pearson (1967) who reported the increased tyrosine value in beef during storage due to the formation of free amino acids from denaturation process. Lalchamliani *et al.* (2015) reported similar results in *Vawksa* rep samples stored under different aerobic vacuum packaging condition at $4^{\circ}\text{C}\pm 1^{\circ}\text{C}$. Anandh (2015) also reported that tyrosine values increase on vacuum packaged, boiled restructured buffalo meat rolls during refrigerator storage ($4^{\circ}\text{C}\pm 1^{\circ}\text{C}$).

TABLE 4.25. EFFECT OF PHYSICOCHEMICAL COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean±SE of different days			
		0	5	10	15
pH	Control	^a 5.86±0.01 ^{BC}	^a 5.86±0.03 ^B	^b 5.59±0.09 ^A	^b 5.45±0.04 ^A
	Pork with <i>Anishi</i>	^a 5.81±0.02 ^C	^a 5.73±0.03 ^C	^b 5.43±0.11 ^A	^c 5.24±0.04 ^A
	Pork with <i>Silam</i>	^a 5.89±0.01 ^B	^a 5.90±0.03 ^{AB}	^{ab} 5.62±0.09 ^A	^b 5.52±0.15 ^A
	Pork with FDS	^a 5.98±0.03 ^A	^a 5.96±0.04 ^A	^b 5.70±0.08 ^A	^c 5.46±0.11 ^A
TBARS (mg malonaldehyde/kg)	Control	^a 0.86±0.02 ^A	^a 0.89±0.02 ^A	^b 1.03±0.01 ^B	^b 1.07±0.02 ^B
	Pork with <i>Anishi</i>	^a 0.78±0.04 ^{AB}	^b 1.14±0.18 ^A	^b 1.20±0.05 ^A	^b 1.38±0.06 ^A
	Pork with <i>Silam</i>	^c 0.65±0.03 ^C	^a 0.88±0.11 ^A	^b 1.21±0.05 ^A	^b 1.38±0.02 ^A
	Pork with FDS	^d 0.74±0.03 ^{BC}	^c 1.06±0.05 ^A	^a 1.23±0.03 ^A	^b 1.36±0.04 ^A
Tyrosine value (mg/100gm)	Control	^a 60.00±0.14 ^A	^a 60.75±0.23 ^A	^b 76.40±0.48 ^A	^c 88.79±0.48 ^A
	Pork with <i>Anishi</i>	^a 60.07±0.24 ^A	^a 60.57±0.55 ^A	^b 62.57±0.09 ^B	^c 78.78±0.46 ^B
	Pork with <i>Silam</i>	^a 58.00±0.25 ^B	^a 58.47±0.29 ^{AB}	^b 67.64±0.18 ^C	^c 73.39±0.59 ^C
	Pork with FDS	^a 55.44±0.28 ^A	^{ab} 56.09±1.80 ^A	^b 70.42±0.35 ^A	^b 87.61±0.06 ^B

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.26. ANALYSIS OF VARIANCE OF PHYSICOCHEMICAL COMPOSITION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE		
		pH	TBARS	Tyrosine
Products	3	0.1899**	0.1078**	195.1380**
Days	3	1.0218**	1.0955**	2487.1978**
Error	73	0.0222	0.0238	13.3464

df= degree of freedom, **= Significant at 1 percent level

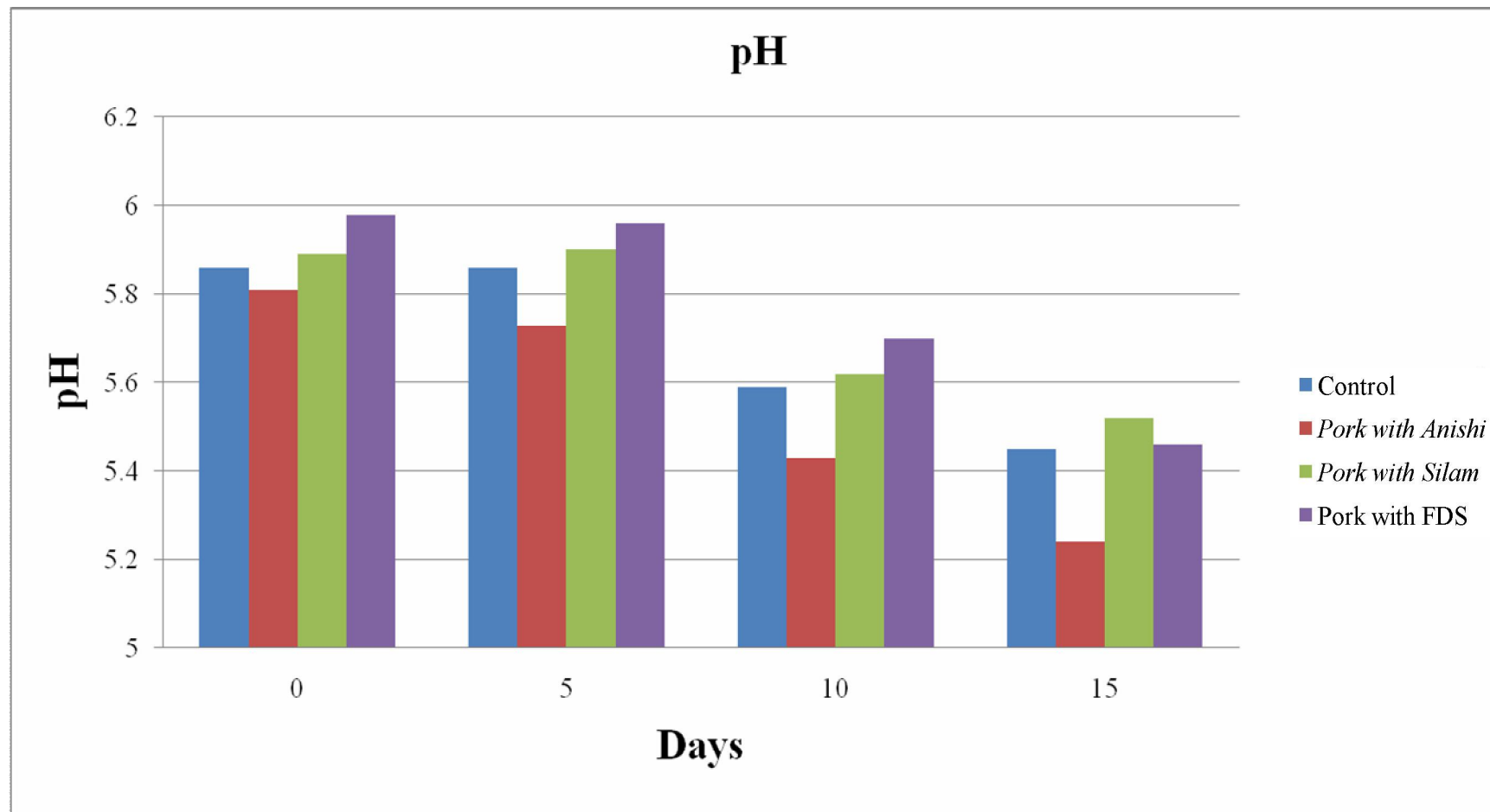


FIG 4.21. GRAPHICAL REPRESENTATION OF EFFECT OF pH OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

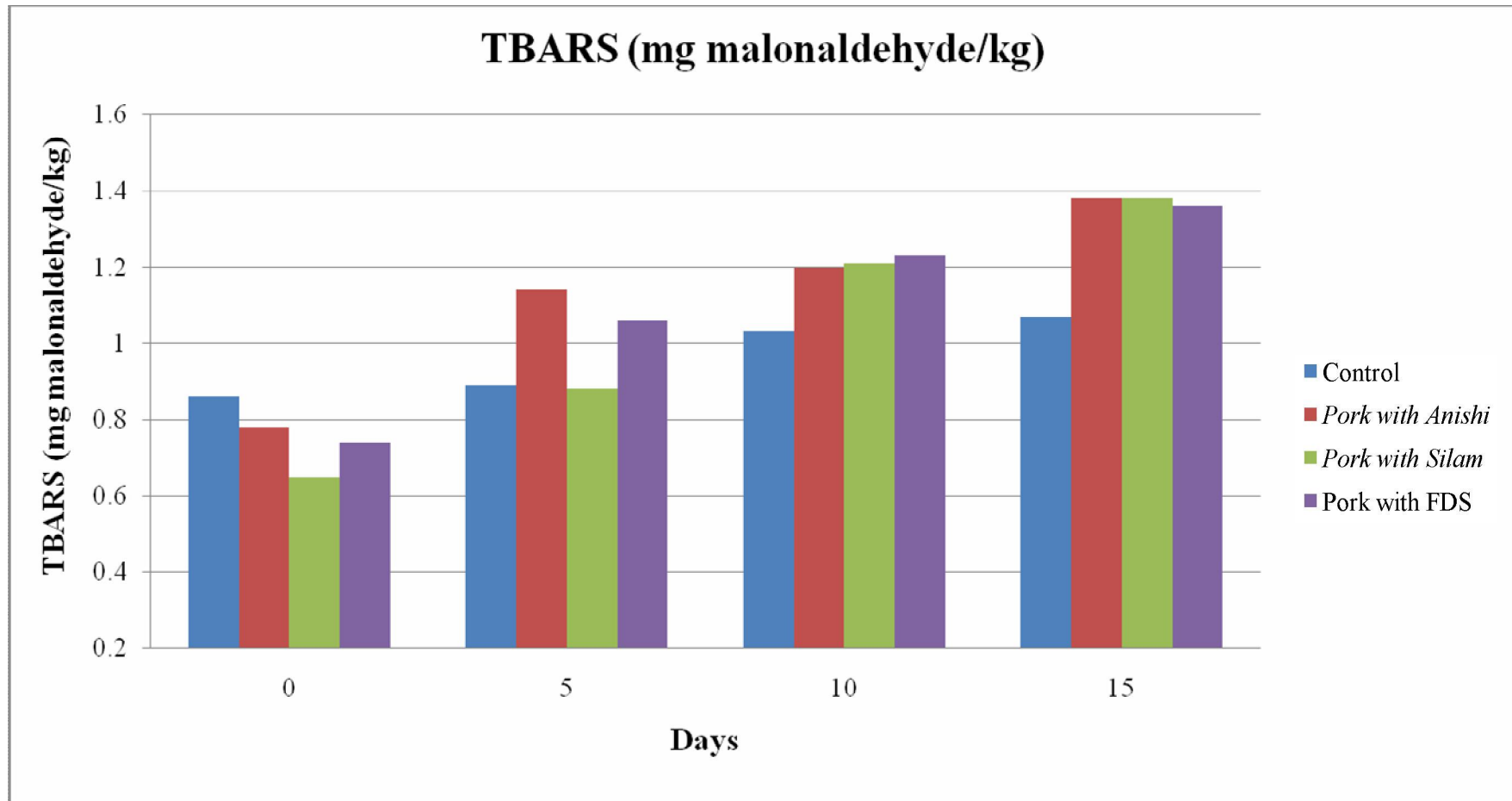


FIG 4.22. GRAPHICAL REPRESENTATION OF EFFECT OF TBARS VALUE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

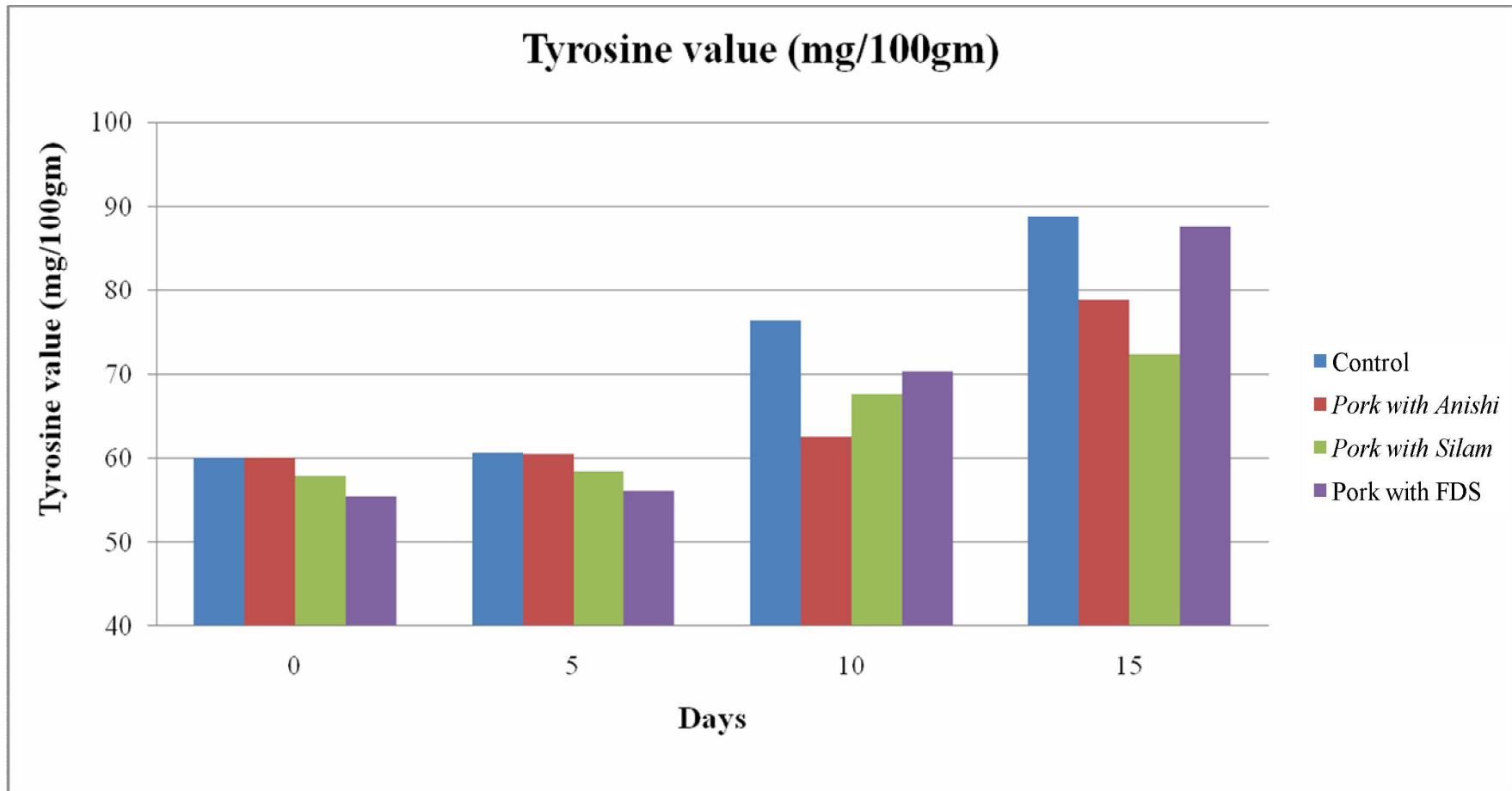


FIG. 4.23. GRAPHICAL REPRESENTATION OF EFFECT OF TYROSINE VALUE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.11. MICROBIOLOGICAL QUALITIES OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.11.1. Total viable plate count (TPC)

The mean TPC values of control and traditional pork products under vacuum packaging are presented in Table 4.27. The analysis of variance is presented in Table 4.28. The graphical representation is presented in Fig. 4.24.

The mean TPC values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 1.92 ± 0.06 and in case of the treated products 1.84 ± 0.09 , 1.98 ± 0.05 and 1.93 ± 0.06 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the TPC values recorded for control product were 2.21 ± 0.03 , 2.55 ± 0.03 and 3.44 ± 0.22 , respectively. These mean TPC values in pork with *Anishi* were 2.12 ± 0.04 , 2.47 ± 0.08 and 3.18 ± 0.29 , for pork with *Silam* were 2.27 ± 0.02 , 2.58 ± 0.05 and 3.21 ± 0.24 and for pork with FDS were 2.20 ± 0.04 , 2.53 ± 0.02 and 3.10 ± 0.17 , respectively. The increasing trend of TPC was recorded in control and all the treated products under vacuum packaging refrigeration storage. On 0 day, the highest TPC value was recorded in pork with *Silam* compared to control, pork with *Anishi* and FDS. On the other hand on 15 day of storage the highest TPC value was recorded in control compared to pork with *Anishi*, *Silam* and FDS.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations during storage periods. However, no significant difference was observed in control and the treated products. The products did not show any symptoms of spoilage such as off odour and surface slime on day 15 of storage. Jay (1996) also observed the microbiological counts were way below the standards for cooked poultry and fish products. Kumar *et al.* (2007) reported gradual but significant increase in total viable counts throughout the storage periods in pork nuggets. Increases of microbial counts were also observed in meat products as the refrigerated storage advanced (Thomas *et al.*, 2006). The low microbial counts of present study were in accordance with Sinhamahapatra *et al.* (2013) on vacuum-packed chicken meatballs and Anandh (2015) in boiled restructured buffalo meat rolls in refrigerated storage under vacuum packaging condition.

4.11.2. Psychrophilic count

The mean psychrophilic count of control and traditional pork products under vacuum packaging are presented in Table 4.27. The analysis of variance is presented in Table 4.28. The graphical representation is presented in Fig. 4.25.

The mean psychrophilic counts recorded for control product under vacuum packaging at refrigeration storage on 0 day was 1.86 ± 0.10 and in case of the treated products 1.76 ± 0.10 , 1.78 ± 0.11 and 1.76 ± 0.09 for pork with *Anishi*, pork with *Silam* and for pork with FDS respectively. On 5, 10 and 15 day of storage the psychrophilic counts recorded for control product were 2.08 ± 0.03 , 2.24 ± 0.08 and 2.53 ± 0.06 , respectively. These mean psychrophilic counts in pork with *Anishi* were 1.95 ± 0.08 , 2.30 ± 0.04 and 2.56 ± 0.04 , for pork with *Silam* were 2.08 ± 0.03 , 2.32 ± 0.02 and 2.56 ± 0.03 and for pork with FDS were 1.92 ± 0.07 , 2.27 ± 0.05 and 2.53 ± 0.06 , respectively. The increasing trend of psychrophilic counts was observed in control and all the treated products during the storage periods. On 0 day of storage the highest psychrophilic count was recorded in control. However, the products did not show any symptoms of spoilage during the entire periods of storage studies. Similar to the finding of present study Jay, (1996) also observed lower microbiological counts well below the standard for cooked poultry and fish product during the storage periods.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations during storage periods. However, no significant differences were observed in control and the treated products. Higher psychrophilic counts were observed on 15 day of storage in pork with *Anishi* and *Silam*. Similar increase in psychrophilic count during storage were also reported by Anandh (2015) in boiled restructured buffalo meat rolls on refrigerated storage under vacuum packaging condition and Sinhamahapatra *et al.* (2013) on vacuum-packed chicken meatballs. The increase in psychrophilic counts during the storage periods could be due to increased in enzymatic activity of psychrotrophs at low temperature.

4.11.3. Coliform (MPN/g) and Yeast and mould (cfu/g)

Coliform (MPN/g) was recorded <3 (Table 4.27) in control and all the treated pork products during the entire periods of studies on 0, 5, 10 and 15 day. Whereas, in case of yeast and mould (cfu/g) it was not detected in control and all the treated pork products during the entire days of study under refrigeration storage ($4\pm 1^{\circ}\text{C}$).

Vacuum packaging inhibits the microbiological growth and delays the development of spoilage due to a slow proliferation of bacteria capable of tolerating anaerobic condition (Jeremiach, 2001). Lactic acid bacteria (LAB) are the major bacterial group associated with the spoilage of vacuum-packed meat products (Lyhs *et al.*, 1999; Samelis *et al.*, 2000 a,b; Sakala *et al.*, 2002; Jones, 2004).

TABLE 4.27. EFFECT OF MICROBIOLOGICAL QUALITIES OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean±SE of different days			
		0	5	10	15
TPC (cfu/g)	Control	^a 1.92±0.06 ^A	^{ab} 2.21±0.03 ^{AB}	^b 2.55±0.03 ^A	^c 3.44±0.22 ^A
	Pork with <i>Anishi</i>	^a 1.84±0.09 ^A	^{ab} 2.12±0.04 ^A	^b 2.47±0.08 ^A	^c 3.18±0.29 ^A
	Pork with <i>Silam</i>	^a 1.98±0.05 ^A	^{ab} 2.27±0.02 ^B	^b 2.58±0.05 ^A	^c 3.21±0.24 ^A
	Pork with FDS	^a 1.93±0.06 ^A	^a 2.20±0.04 ^{AB}	^b 2.53±0.02 ^A	^c 3.10±0.17 ^A
Psychrophilic (cfu/g)	Control	^a 1.86 ±0.10 ^A	^b 2.08±0.03 ^A	^b 2.24±0.08 ^A	^c 2.53±0.06 ^A
	Pork with <i>Anishi</i>	^a 1.76 ±0.10 ^A	^a 1.95±0.08 ^A	^b 2.30±0.04 ^A	^c 2.56±0.04 ^A
	Pork with <i>Silam</i>	^a 1.78±0.11 ^A	^b 2.08±0.03 ^A	^c 2.32±0.02 ^A	^d 2.56±0.03 ^A
	Pork with FDS	^a 1.76±0.09 ^A	^a 1.92±0.07 ^A	^b 2.27±0.05 ^A	^c 2.53±0.06 ^A
Coliform (MPN/g)	Control	<3	<3	<3	<3
	Pork with <i>Anishi</i>	<3	<3	<3	<3
	Pork with <i>Silam</i>	<3	<3	<3	<3
	Pork with FDS	<3	<3	<3	<3
Yeast and mould(cfu/g)	Control	ND	ND	ND	ND
	Pork with <i>Anishi</i>	ND	ND	ND	ND
	Pork with <i>Silam</i>	ND	ND	ND	ND
	Pork with FDS	ND	ND	ND	ND

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, ND= Not Detected, n=5

TABLE 4.28. ANALYSIS OF VARIANCE OF MICROBIOLOGICAL QUALITIES OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE			
		TPC	Psychrophilic	Coliform	Yeast & moulds
Products	3	0.2148 ^{NS}	0.0513 ^{NS}	--	--
Days	3	19.2312 ^{**}	6.4515 ^{**}	--	--
Error	73	5.3621	1.5920	--	--

df= degree of freedom, NS=Non-significant, **= Significant at 1 percent level

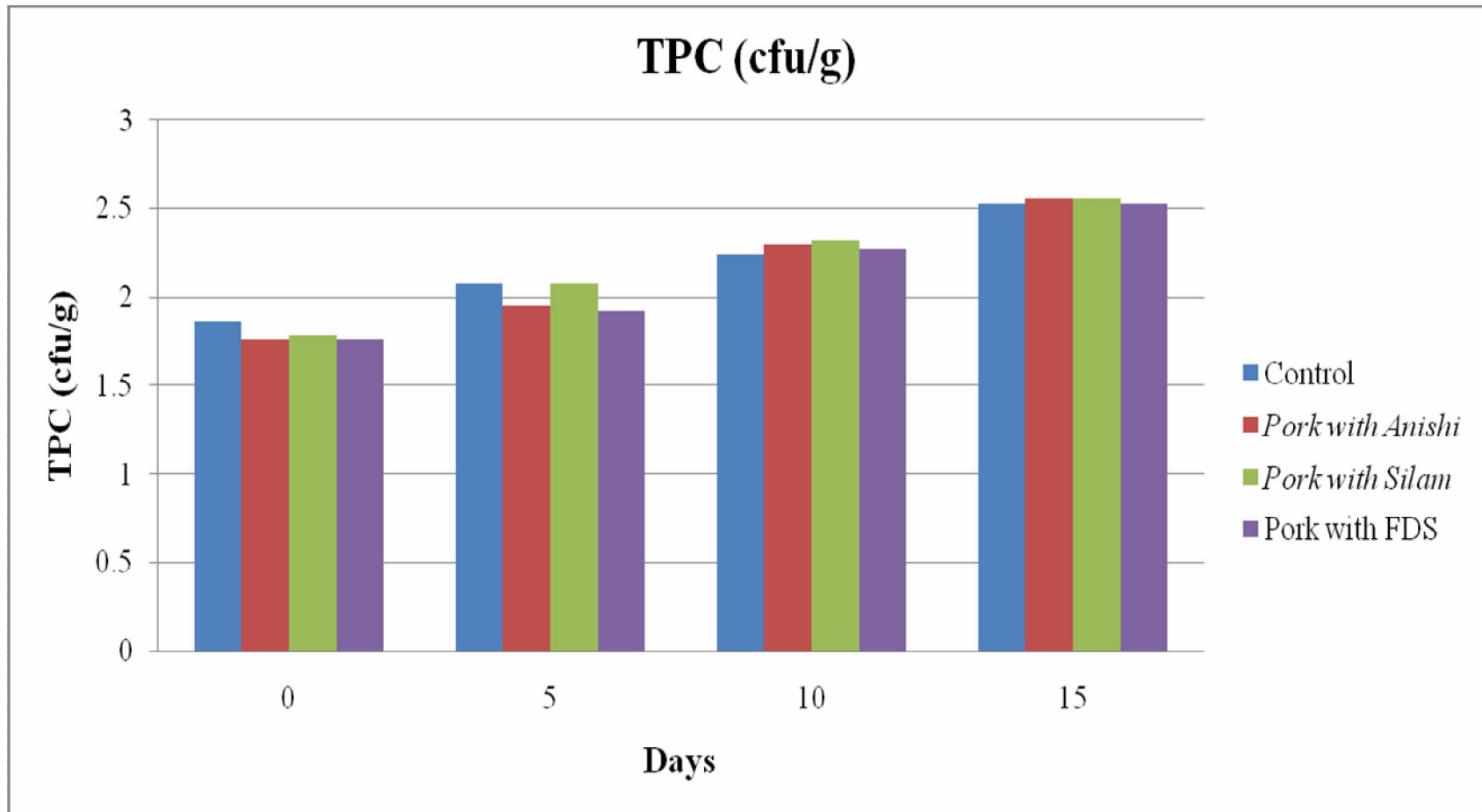


FIG 4.24. GRAPHICAL REPRESENTATION OF EFFECT OF TPC (cfu/g) OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

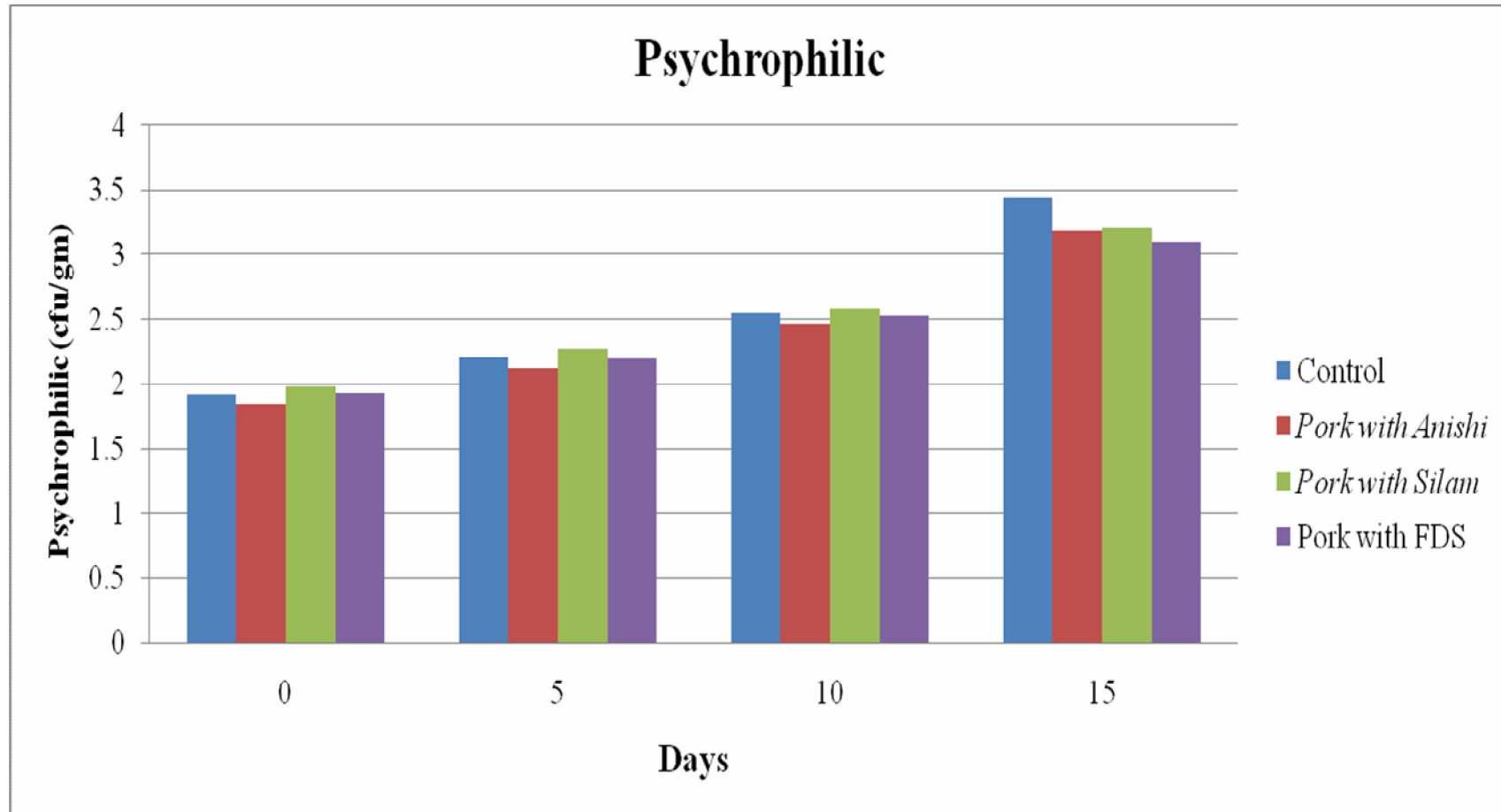


FIG 4.25. GRAPHICAL REPRESENTATION OF EFFECT OF PSYCHROPHILIC (cfu/g) OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.12. AMINO ACID CONTENT OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

The results pertaining to changes in amino acid contents in control and treated products under vacuum packaging at refrigeration storage periods on 0 and 15 day are showed in Table 4.29

The results of amino acid content in control and the treated products on 0 day indicated that control sample and pork with FDS had higher amino acid contents. However, on 15 day it was recorded decrease in amino acid content in control and pork with FDS. The decrease in amino acid content might be due to quantitative reduction of total crude protein under vacuum packaging. Among the traditional pork products incorporated with FDS recorded highest content of amino acid as compared to pork with *Anishi* and *Silam*. Lowest amino acid content was recorded in pork with *Anishi* followed by pork with *Silam*.

In a study conducted by Hęs *et al.* (2007) found that during storage of meatballs from ground pork without the addition of antioxidants, a significant decrease has been found in the availability of lysine and methionine and also protein digestibility in vitro.

Control sample and pork with FDS products were recorded high content of lysine and methionine compared with pork with *Anishi* and *Silam*. However, there was decreased in amino acid contents in control and all the treated pork products during storage periods of 15 day.

TABLE 4.29. TREND OF CHANGES IN AMINO ACID (mg/100g) CONTENT OF VACUUM PACKAGING ON 0 AND 15 DAYS OF REFRIGERATED STORAGE OF TRADITIONAL PORK PRODUCTS

Amino acid	Traditional pork products of Nagaland (Vacuum packaging)							
	Control		Pork with <i>Anishi</i>		Pork with <i>Silam</i>		Pork with FDS	
	0 Day	15 Day	0 Day	15 Day	0 Day	15 Day	0 Day	15 Day
L-Alanine	0.53	0.52	0.43	0.39	0.44	0.44	0.52	0.51
L-Arginine	2.09	2.17	2.21	2.13	2.00	1.95	2.04	2.04
L-Aspartic Acid	1.38	1.41	1.43	1.38	1.31	1.27	1.37	1.35
L-Cystine	0.19	0.2	0.21	0.20	0.19	0.18	0.19	0.19
L-Glutamic Acid	2.74	2.74	2.34	2.17	2.41	2.4	2.76	2.68
L-Glycine	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
L-Histidine	1.88	1.88	1.81	1.71	1.74	1.69	1.90	1.89
L-Isoleucine	0.53	0.53	0.51	0.48	0.48	0.47	0.53	0.53
L-Leucine	1.08	1.10	1.13	1.08	1.02	0.98	1.07	1.06
L-Lysine	1.17	1.19	1.21	1.16	1.09	1.05	1.16	1.14
L-Methionine	0.37	0.38	0.37	0.34	0.35	0.33	0.38	0.37
L-Phenylalanine	0.57	0.59	0.6	0.58	0.54	0.53	0.57	0.57
L-Proline	1.17	1.17	0.99	0.91	1.02	1.01	1.18	1.14
L-Serine	0.72	0.72	0.6	0.55	0.63	0.62	0.73	0.71
L-Threonine	0.71	0.71	0.66	0.63	0.63	0.62	0.72	0.7
L-Tyrosine	0.6	0.59	0.47	0.42	0.49	0.49	0.6	0.57
L-Valine	0.67	0.67	0.55	0.50	0.57	0.57	0.68	0.65
L-Tryptophan	0.31	0.32	0.28	0.27	0.30	0.29	0.31	0.30

4.13. EFFECT OF TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

The texture profile parameters of control and traditional pork products under vacuum packaging were studied on 0, 5, 10 and 15 day and the results obtained are analyzed and discussed below.

4.13.1. Hardness

The mean hardness (N/cm²) of control and traditional pork products under vacuum packaging are presented in Table 4.30. The analysis of variance is presented in Table 4.31. The graphical representation is presented in Fig. 4.26.

The mean hardness recorded for control product under vacuum packaging on 0 day was 16344.51±11.10 and in case of the treated products were 13917.27±15.09, 13764.74±100.05 and 15996.77±3532.83 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean hardness recorded for control product were 13984.49±2.52, 11713.31±60.08 and 5927.51±56.51, respectively. These mean hardness in pork with *Anishi* were 11982.37±0.56, 11940.50±11.77 and 5631.54±155.71, for pork with *Silam* were 12229.15±73.53, 8300.10±85.64 and 5941.01±107.19 and for pork with FDS were 11281.37±2484.70, 5753.37±192.76 and 4041.44±346.29, respectively.

The analysis of variance revealed no significant differences in control and treated formulations during storage periods. However, significant ($p < 0.05$) differences was observed in control and treated products. The results exhibited decreasing trend on the storage periods from 0 to 15 day. On 0 day highest hardness was recorded in control compared to pork with *Anishi*, *Silam* and FDS. Significant decrease of hardness was observed on 10 day of storage in pork with FDS. This might be due to moisture intake by the products during the storage periods and products became softer as storage periods increased. Hardness is affected by moisture content (Yang *et al.*, 2012). Due to proteolysis, hardness of the products lowers down (Ruiz-Ramirez *et al.*, 2006) and from

the protein content of the products, it is observed that protein content was reducing with storage period.

4.13.2. Springiness

The mean springiness (cm) of control and traditional pork products under vacuum packaging are presented in Table 4.30. The analysis of variance is presented in Table 4.31. The graphical representation is presented in Fig.4.27.

The mean springiness recorded for control product under vacuum packaging on 0 day was 0.38 ± 0.00 and in case of the treated products were 0.44 ± 0.00 , 0.35 ± 0.00 and 0.47 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean springiness recorded for control product were 0.48 ± 0.03 , 0.48 ± 0.00 and 0.55 ± 0.00 , respectively. These mean springiness in pork with *Anishi* were 0.46 ± 0.01 , 0.49 ± 0.00 and 0.50 ± 0.00 , for pork with *Silam* were, 0.40 ± 0.02 , 0.46 ± 0.00 and 0.54 ± 0.00 , and for pork with FDS were 0.51 ± 0.00 , 0.55 ± 0.01 and 0.57 ± 0.00 , respectively.

The analysis of variance revealed no significant differences in control and all the treated formulations under vacuum packaging during storage periods. Highly significant ($p < 0.01$) differences was also observed in control and treated formulations. The results exhibited increasing trend of springiness in control and treated products as the day of storage period increases. On 0 to 15 day the springiness was recorded highest in pork with FDS compared to control, pork with *Anishi* and *Silam*. Springiness behavior varies significantly with the processing techniques and it could be correlated with the influence of moisture in the product of low fat emulsified meatball as reported by Hsu and Yu (1999). Similar results were also observed by Kim *et al.* (2014a) where there was increased springiness in beef jerky.

4.13.3. Cohesiveness

The mean cohesiveness (ratio) of control and traditional pork products under vacuum packaging are presented in Table 4.30. The analysis of variance is presented in Table 4.31. The graphical representation is presented in Fig.4.28.

The mean cohesiveness recorded for control product under vacuum packaging on 0 day was 0.60 ± 0.00 and in case of the treated products were 0.43 ± 0.00 , 0.47 ± 0.00 and 0.49 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean cohesiveness recorded for control product were 0.54 ± 0.00 , 0.44 ± 0.00 and 0.43 ± 0.00 , respectively. These mean cohesiveness in pork with *Anishi* were 0.42 ± 0.00 , 0.39 ± 0.00 and 0.37 ± 0.00 , for pork with *Silam* were 0.47 ± 0.00 , 0.36 ± 0.00 and 0.34 ± 0.00 , and for pork with FDS were 0.46 ± 0.00 , 0.42 ± 0.01 and 0.38 ± 0.00 , respectively.

The analysis of variance revealed no significant differences in control and all the treated formulations under vacuum packaging during storage periods. Highly significant ($p < 0.01$) differences was observed in control and treated formulations. On 0 day the cohesiveness value was highest in control sample compared to treated samples incorporated with *Anish*, *Silam* and FDS. The significant decrease in cohesiveness during the storage periods in control and treated products might be due to increase in moisture content in the samples during storage periods. The decreasing trend of cohesiveness was also reported in *Sous vide* cooked turkey stored at 4°C under vacuum packed (Akollu *et al.*, 2018). Pulgar *et al.* (2012) reported similar decrease in textural parameters in sample cooked at core temperature of 90°C , 100°C and 120°C in *Sous-vide* cooked pork cheeks under vacuum ascribed to the solubilization of collagen.

4.13.4. Chewiness

The mean chewiness (N/cm) of control and traditional pork products under vacuum packaging are presented in Table 4.30. The analysis of variance is presented in Table 4.31. The graphical representation is presented in Fig. 4.29.

The mean chewiness recorded for control product under vacuum packaging on 0 day was 4678.57 ± 7.28 and in case of the treated products were 3160.73 ± 2.62 , 2024.04 ± 0.26 and 4675.67 ± 0.37 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean chewiness recorded for control product were 3058.55 ± 0.37 , 2440.23 ± 0.37 and 1558.96 ± 0.37 , respectively. These

mean chewiness in pork with *Anishi* were 2780.12 ± 4.74 , 1498.22 ± 0.37 and 1173.05 ± 0.37 , for pork with *Silam* were 1936.22 ± 0.37 , 1358.74 ± 1.15 and 1278.22 ± 0.60 , and for pork with FDS were 3708.35 ± 0.38 , 952.63 ± 6.69 and 892.44 ± 24.65 , respectively.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations under vacuum packaging. However, no significant difference was observed in the storage periods. The results exhibited decreasing trend of chewiness during storage period in control and treated products. On 0 day the chewiness was highest in control compared to pork with *Anishi*, *Silam* and FDS. Significant decrease of chewiness were recorded on 10 and 15 day in pork with FDS. The chewiness of the products is affected by water binding ability and swelling properties of the products (Fernandez *et al.*, 2004). Protein degradation due to chemical and enzymatic activity may be the reason for the samples to become softer in the storage, although heating inactivates part of the muscle proteases, residual protease activity continues in the refrigerated product (Diaz *et al.*, 2008).

TABLE 4.30. EFFECT OF TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean± SE on different days			
		0	5	10	15
Hardness (N/cm ²)	Control	^a 16344.51±11.10 ^A	^b 13984.49±2.52 ^A	^c 11713.31±60.08 ^A	^d 5927.51±56.51 ^A
	Pork with <i>Anishi</i>	^a 13917.27±15.09 ^A	^b 11982.37±0.56 ^A	^b 11940.50±11.77 ^A	^c 5631.54±155.71 ^A
	Pork with <i>Silam</i>	^a 13764.74±100.05 ^A	^b 12229.15±73.53 ^A	^c 8300.10±85.64 ^A	^d 5941.01±107.19 ^A
	Pork with FDS	^a 15996.77±3532.83 ^A	^{ab} 11281.37±2484.70 ^A	^{bc} 5753.37±192.76 ^A	^c 4041.44±346.29 ^A
Springiness (cm)	Control	^c 0.38±0.00 ^B	^b 0.48±0.03 ^B	^b 0.48±0.00 ^B	^d 0.55±0.00 ^B
	Pork with <i>Anishi</i>	^a 0.44±0.00 ^B	^c 0.46±0.01 ^B	^b 0.49±0.00 ^B	^d 0.50±0.00 ^B
	Pork with <i>Silam</i>	^a 0.35±0.00 ^B	^c 0.40±0.02 ^B	^b 0.46±0.00 ^B	^d 0.54±0.00 ^B
	Pork with FDS	^a 0.47±0.00 ^B	^c 0.51±0.00 ^B	^b 0.55±0.01 ^B	^d 0.57±0.00 ^B
Cohesiveness (Ratio)	Control	^c 0.60±0.00 ^B	^b 0.54±0.00 ^B	^c 0.44±0.00 ^B	^d 0.43±0.00 ^B
	Pork with <i>Anishi</i>	^a 0.43±0.00 ^B	^c 0.42±0.00 ^B	^b 0.39±0.00 ^B	^d 0.37±0.00 ^B
	Pork with <i>Silam</i>	^c 0.47±0.00 ^B	^d 0.47±0.00 ^B	^b 0.36±0.00 ^B	^d 0.34±0.00 ^B
	Pork with FDS	^c 0.49±0.00 ^B	^b 0.46±0.00 ^B	^c 0.42±0.00 ^B	^c 0.38±0.00 ^B
Chewiness (N/cm)	Control	^a 4678.57±7.28 ^C	^b 3058.55±0.37 ^C	^c 2440.23±0.37 ^C	^d 1558.96±0.37 ^C
	Pork with <i>Anishi</i>	^a 3160.73±2.62 ^C	^b 2780.12±4.74 ^C	^c 1498.22±0.37 ^C	^d 1173.05±0.37 ^C
	Pork with <i>Silam</i>	^d 2024.04±0.26 ^C	^b 1936.22±0.37 ^C	^c 1358.74±1.15 ^C	^d 1278.22±0.60 ^C
	Pork with FDS	^a 4675.67±0.37 ^C	^b 3708.35±0.38 ^C	^c 952.63±6.69 ^C	^d 892.44±24.65 ^C

Mean having different superscript in column (capital letter) differ significantly (p<0.01) for different products on different days

Mean having different superscript in row (small letter) differ significantly (p<0.01) between days of different products

SE= Standard Error, n=5

TABLE 4.31. ANALYSIS OF VARIANCE OF TEXTURE PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE			
		Hardness	Springiness	Cohesiveness	Chewiness
Products	3	27106341.8*	0.0272**	0.0409**	6073722.79**
Days	3	326777016.9**	0.0616**	0.0631**	1937864.21 ^{NS}
Error	73	7247795	0.0007	0.0004	1262715.0

df= degree of freedom, NS=Non-significant, **= Significant at 1 percent level, *= Significant at 5 percent level

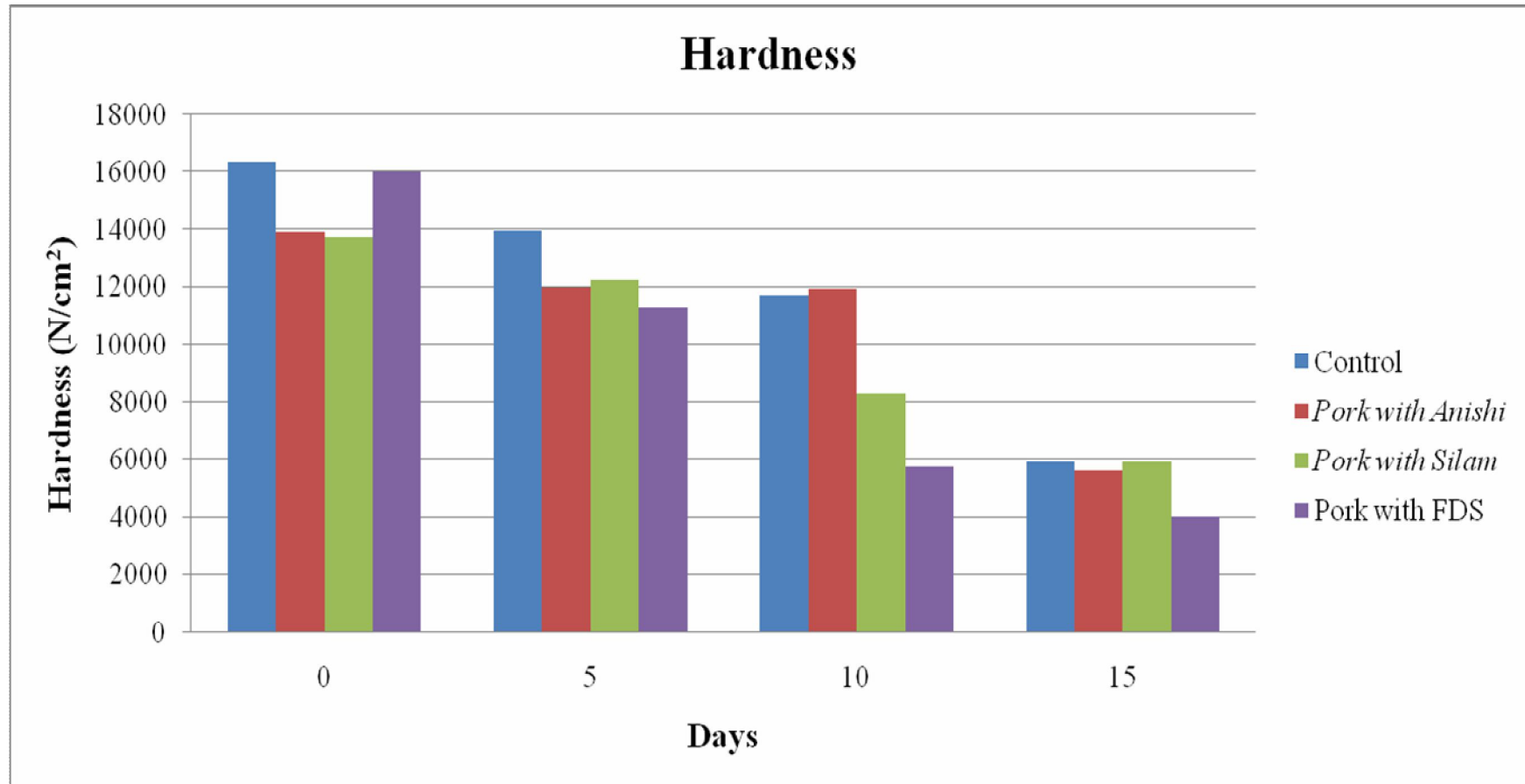


FIG 4.26. GRAPHICAL REPRESENTATION OF EFFECT OF HARDNESS OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

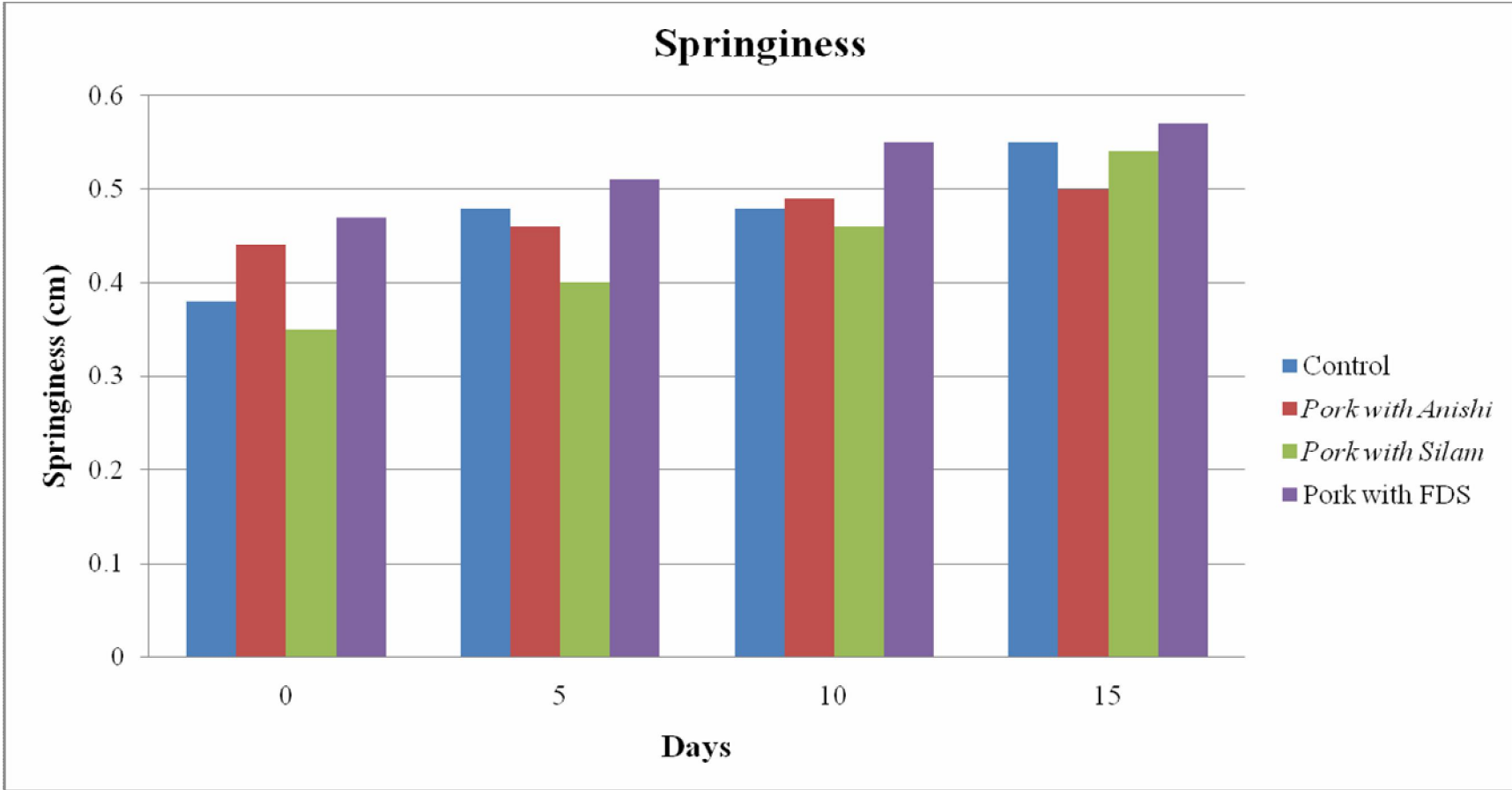


FIG 4.27. GRAPHICAL REPRESENTATION OF EFFECT OF SPRINGINESS OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

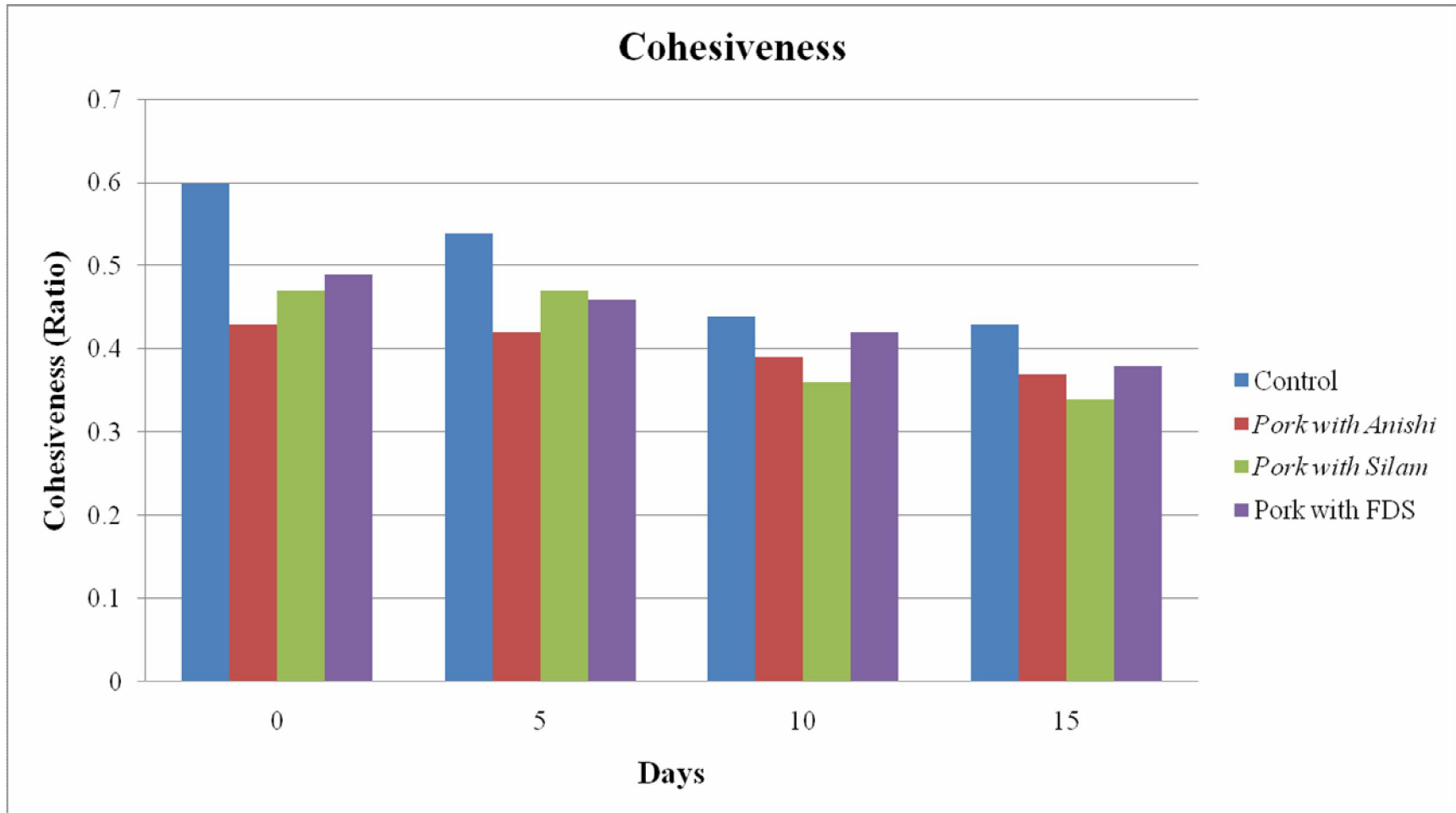


FIG 4.28. GRAPHICAL REPRESENTATION OF EFFECT OF COHESIVENESS OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

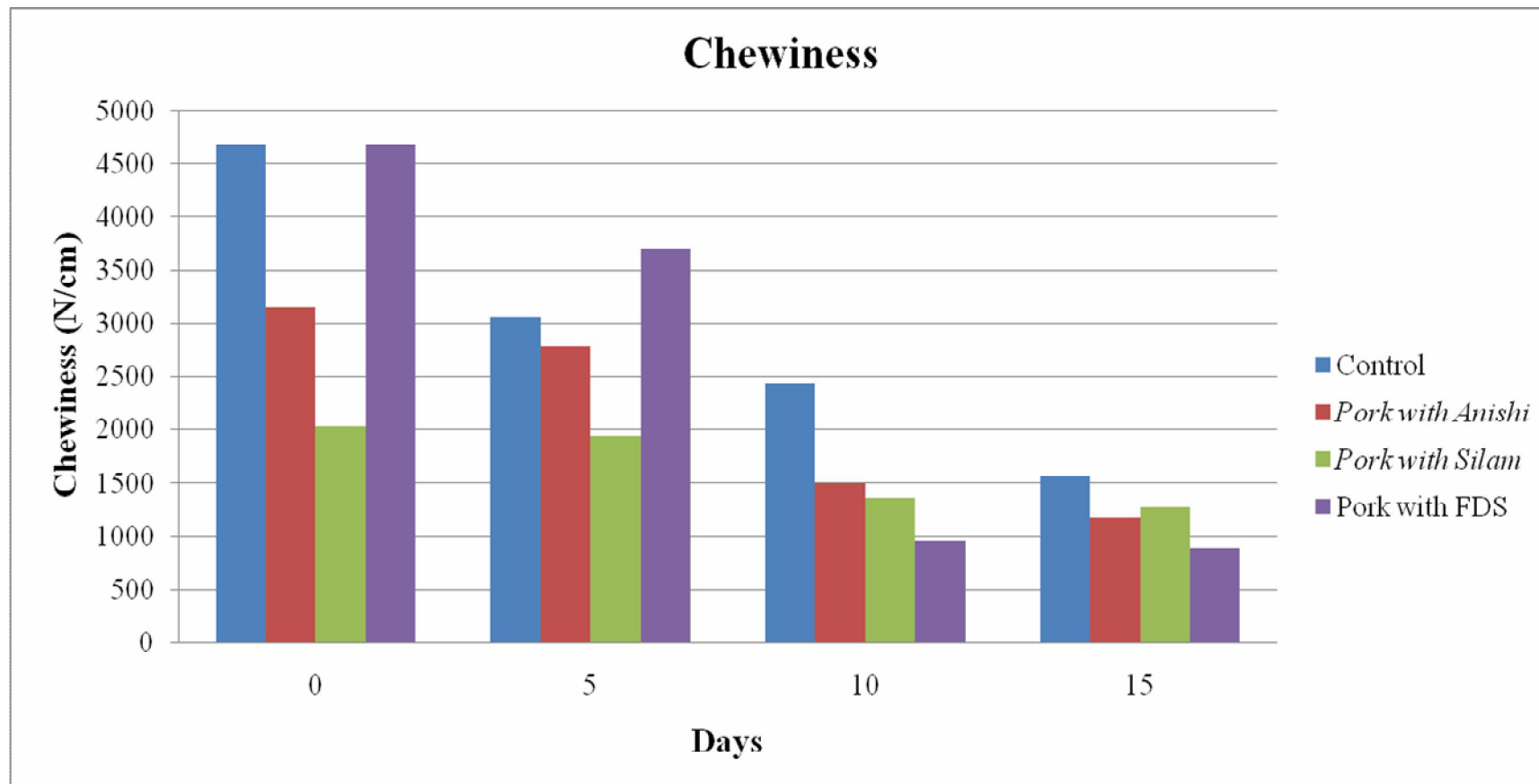


FIG 4.29. GRAPHICAL REPRESENTATION OF EFFECT OF CHEWINESS OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.14. EFFECT OF COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.14.1. Lightness (L*)

The mean lightness (L*) of control and traditional pork products under vacuum packaging are presented in Table 4.32. The analysis of variance is presented in Table 4.33. The graphical representation is presented in Fig. 4.30.

The mean L* recorded for control product under vacuum packaging on 0 day was 52.52 ± 0.06 and in case of the treated products were 30.58 ± 0.19 , 55.13 ± 0.05 and 53.13 ± 0.11 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean L* recorded for control product were 51.59 ± 0.20 , 49.75 ± 0.03 and 46.29 ± 0.01 , respectively. These mean L* in pork with *Anishi* were 29.33 ± 0.18 , 27.85 ± 0.04 and 24.55 ± 0.09 for pork with *Silam* were 49.47 ± 5.24 , 44.98 ± 0.02 and 41.68 ± 0.04 and for pork with FDS were 51.24 ± 0.55 , 46.76 ± 0.02 and 40.27 ± 0.00 respectively. Changes in the colour value (L*) were observed to decrease with increase in storage time in control and pork with *Anishi*, *Silam* and FDS. However, higher L* were recorded in control products in all the storage periods of vacuum packaged refrigeration storage. Pork with *Anishi* was recorded lowest L* in all the storage periods.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations and during storage periods under vacuum packaging. The higher values of L* in the products may be related to the greater amount of exuded water, which remains impregnating the surface of the water. This occurrence has been pointed out as a cause of higher L* values (Rees *et al.*, 2003 a,b). Higher values of L* was also recorded by Bingol *et al.* (2013) in vacuum packaging of frozen cooked doner kebab.

4.14.2. Redness (a*)

The mean redness (a*) of control and traditional pork products under vacuum packaging are presented in Table 4.32. The analysis of variance is presented in Table 4.33. The graphical representation is presented in Fig. 4.31.

The mean a* recorded for control product under vacuum packaging on 0 day was 11.63 ± 0.07 and in case of the treated products were 12.91 ± 0.02 , 10.75 ± 0.15 and 12.10 ± 0.04 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean a* recorded for control product were 11.18 ± 0.05 , 5.77 ± 0.01 and 4.60 ± 0.01 , respectively. These mean a* in pork with *Anishi* were 5.56 ± 0.04 , 5.49 ± 0.01 and 5.17 ± 0.05 , for pork with *Silam* were, 8.56 ± 0.05 , 4.22 ± 0.01 and 4.05 ± 0.01 and for pork with FDS were 7.90 ± 0.01 , 7.75 ± 0.01 and 5.73 ± 0.04 , respectively. Redness (a*) in control and pork with *Anishi*, *Silam* and FDS showed decreasing trends upto 15 day of storage.

The analysis of variance revealed highly significant ($p < 0.01$) differences in control and all the treated formulations and storage periods under vacuum packaging. Redness (a*) intensity in cooked meat is inversely related to the degree of denatured myoglobin, denaturing process starting at 60°C (Geileskey *et al.*, 1998). Redness (a*) which is used as an indicator of colour stability in meat and meat products (Garcia-Esteban *et al.*, 2004) showed pronounced fading with increasing storage periods in vacuum packaging systems.

4.14.3. Yellowness (b*)

The mean yellowness (b*) of control and traditional pork products under vacuum packaging are presented in Table 4.32. The analysis of variance is presented in Table 4.33. The graphical representation is presented in Fig. 4.32.

The mean b* recorded for control product under vacuum packaging on 0 day was 11.14 ± 0.07 and in case of the treated products were 4.12 ± 0.56 , 8.33 ± 0.09 and 7.58 ± 0.55 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean b* recorded for control product were 11.37 ± 0.06 , 17.36 ± 0.03

and 19.01 ± 0.08 , respectively. These mean b^* in pork with *Anishi* were 12.75 ± 0.09 , 15.04 ± 0.09 and 20.01 ± 0.30 , for pork with *Silam* were 11.10 ± 0.05 , 16.04 ± 0.01 and 20.18 ± 0.11 , and for pork with FDS were 12.26 ± 0.07 , 23.31 ± 0.05 and 24.91 ± 0.11 , respectively. The b^* values recorded increase trends during storage periods in all product formulations.

The analysis of variance revealed highly significant ($p < 0.01$) difference in control and treated formulations during storage periods under vacuum packaging. Cilla *et al.* (2006) reported that the increase in yellowness colour in MAP samples is related to increased pigment oxidation during storage. Martinez *et al.* (2005) demonstrated that myoglobin oxidation is favored as the concentrations of CO_2 increased. Difference in b^* along the storage periods can be related to the intensity of the oxidation process that causes an increase of the yellowness values as a consequence of rancidity (Garcia-Esteban *et al.*, 2004).

TABLE 4.32. EFFECT OF COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean±SE of different days			
		0	5	10	15
L*	Control	^a 52.52±0.06 ^A	^b 51.59±0.20 ^A	^c 49.75±0.03 ^A	^d 46.29±0.01 ^A
	Pork with <i>Anishi</i>	^a 30.58±0.19 ^B	^b 29.33±0.18 ^B	^c 27.85±0.04 ^B	^d 24.55±0.09 ^B
	Pork with <i>Silam</i>	^a 55.13±0.05 ^C	^{ab} 49.47±5.24 ^A	^b 44.98±0.02 ^C	^b 41.68±0.04 ^C
	Pork with FDS	^a 53.13±0.11 ^D	^b 51.24±0.55 ^A	^c 46.76±0.02 ^D	^d 40.27±0.00 ^D
a*	Control	^a 11.63±0.07 ^A	^b 11.18±0.05 ^A	^c 5.77±0.01 ^A	^d 4.60±0.01 ^A
	Pork with <i>Anishi</i>	^a 12.91±0.02 ^B	^b 5.56±0.04 ^B	^b 5.49±0.01 ^B	^c 5.17±0.05 ^B
	Pork with <i>Silam</i>	^a 10.75±0.15 ^C	^b 8.56±0.05 ^C	^c 4.22±0.01 ^C	^c 4.05±0.01 ^C
	Pork with FDS	^a 12.10±0.04 ^D	^b 7.90±0.01 ^D	^c 7.75±0.01 ^D	^d 5.73±0.04 ^D
b*	Control	^a 11.14±0.07 ^A	^b 11.37±0.06 ^A	^c 17.36±0.03 ^A	^d 19.01±0.08 ^A
	Pork with <i>Anishi</i>	^a 4.12±0.56 ^B	^b 12.75±0.09 ^B	^c 15.04±0.09 ^B	^d 20.01±0.30 ^B
	Pork with <i>Silam</i>	^a 8.33±0.09 ^C	^b 11.10±0.05 ^C	^c 16.04±0.0 ^C	^d 20.18±0.11 ^B
	Pork with FDS	^a 7.58±0.55 ^C	^b 12.26±0.07 ^D	^c 23.31±0.05 ^D	^d 24.91±0.11 ^C

Mean having different superscript in column (capital letter) differ significantly ($p < 0.01$) for different products on different days

Mean having different superscript in row (small letter) differ significantly ($p < 0.01$) between days of different products

SE= Standard Error, n=5

TABLE 4.33. ANALYSIS OF VARIANCE OF COLOUR PROFILE OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE		
		L*	a*	b*
Products	3	2120.2863**	10.8474**	59.5159**
Days	3	308.5513**	170.0067**	708.2178**
Error	73	11.6048	2.3511	3.8609

df= degree of freedom, **= Significant at 1 percent level

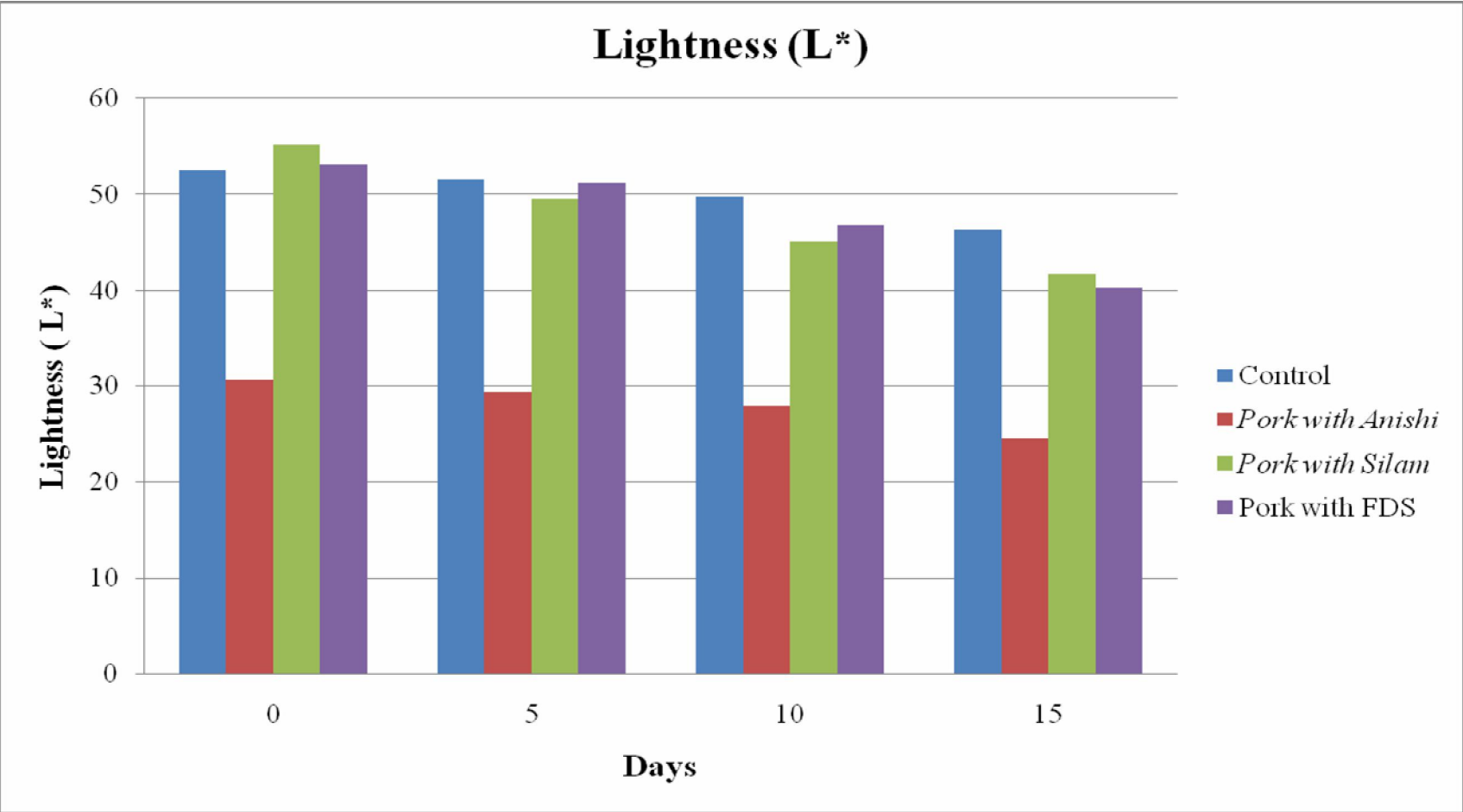


FIG 4.30. GRAPHICAL REPRESENTATION OF LIGHTNESS (L*) OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

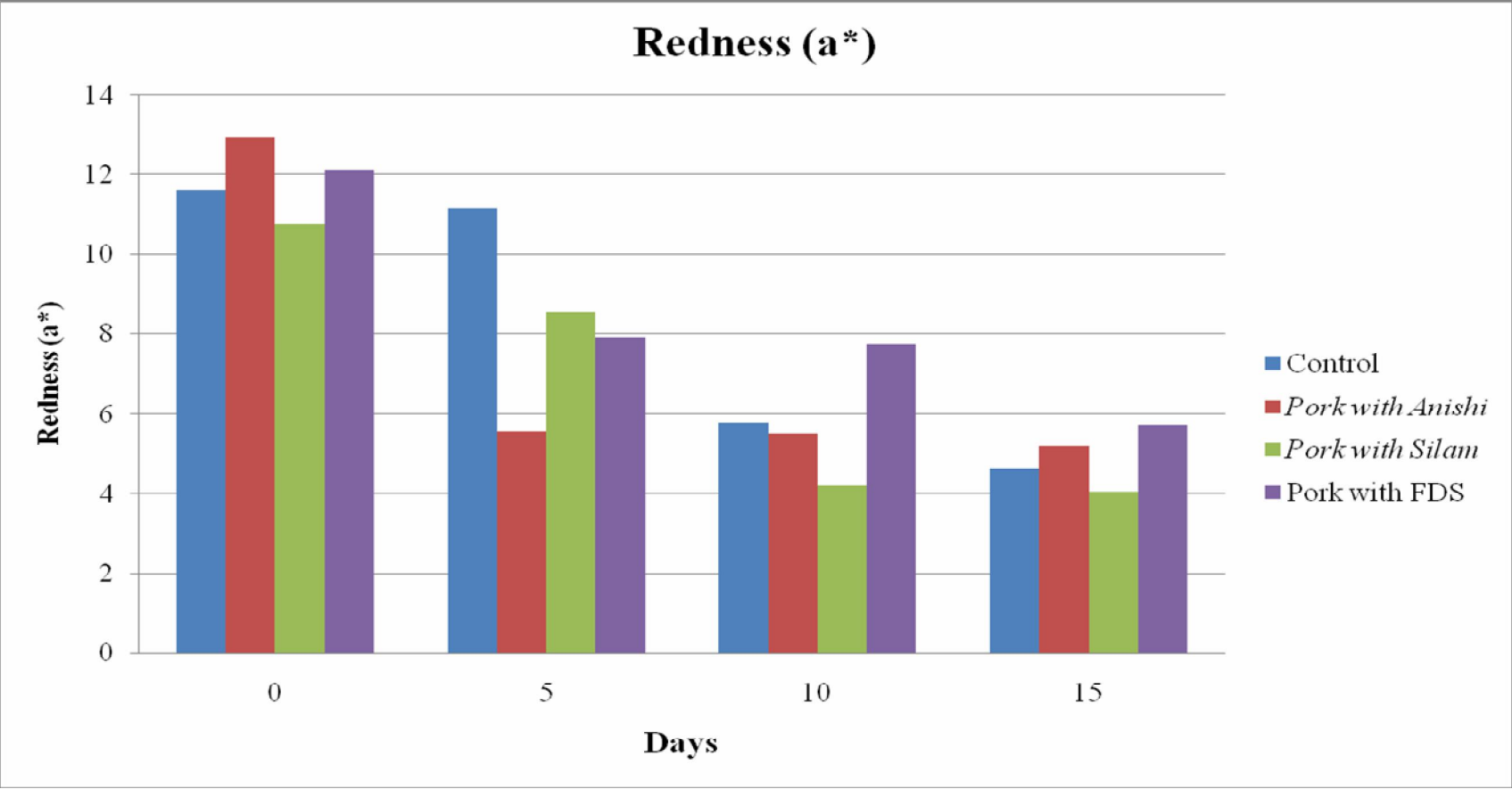


FIG 4.31. GRAPHICAL REPRESENTATION OF REDNESS (a*) OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

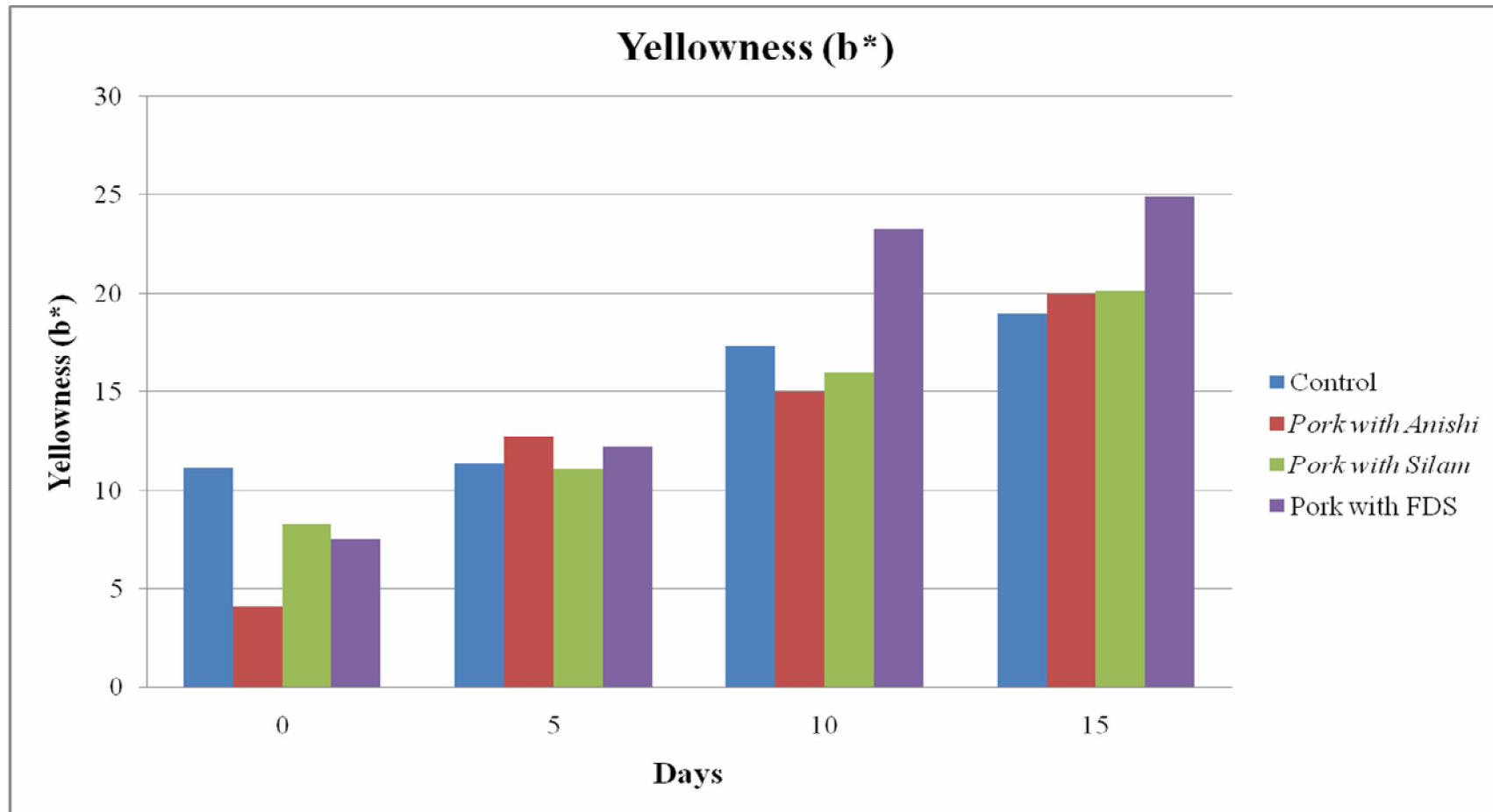


FIG 4.32. GRAPHICAL REPRESENTATION OF YELLOWNESS (b*) OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.15. SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

The mean sensory scores of vacuum packaging in control and traditional pork products are presented in Table 4.34. The analysis of variance is presented in Table 4.35. The graphical representation is presented in Fig. 4.33.

4.15.1. Appearance

The mean appearance recorded for the control product under vacuum packaging on 0 day was 6.49 ± 0.09 and in the treated products were 6.34 ± 0.08 , 6.60 ± 0.08 and 6.77 ± 0.07 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean appearance recorded for control product were 6.26 ± 0.07 , 5.91 ± 0.11 and 5.60 ± 0.08 , respectively. These mean values for appearance in pork with *Anishi* were 6.20 ± 0.07 , 6.51 ± 0.09 and 5.31 ± 0.08 , for pork with *Silam* were 6.11 ± 0.05 , 6.17 ± 0.06 and 6.00 ± 0.00 and for pork with FDS were 6.63 ± 0.08 , 6.51 ± 0.09 and 6.00 ± 0.00 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in appearance among control and treated formulations during storage periods under vacuum packaging. There was also highly significant ($p < 0.01$) differences in appearance in control and treated formulations. Highest appearance score was recorded in pork with FDS on 0 day compared to control, pork with *Anishi* and *Silam*. The appearance score decreases on increase in days of storage in control and the treated products. However, the appearance scores were rated as desirable upto 15 day of storage periods. The results were in agreement with the finding of Devi and Singh (2018) who also observed that appearance and colour decreases as the storage advanced in guinea fowl meat sausage (Deuri *et al.*, 2016) in ready-to eat *Vawksa rep* during refrigeration storage.

4.15.2. Flavour

The mean flavour recorded for the control product under vacuum packaging on 0 day was 6.06 ± 0.04 and in the treated products were 6.63 ± 0.08 , 6.74 ± 0.07 and 6.26 ± 0.07 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and

15 day of storage the mean flavour recorded for control product were 6.00 ± 0.00 , 5.86 ± 0.06 and 5.60 ± 0.08 , respectively. These mean values for flavour in pork with *Anishi* were 6.37 ± 0.08 , 6.29 ± 0.08 and 5.29 ± 0.10 , for pork with *Silam* were 6.34 ± 0.08 , 6.23 ± 0.07 and 6.11 ± 0.05 and for pork with FDS were 6.29 ± 0.08 , 6.11 ± 0.05 and 5.37 ± 0.10 , respectively.

Analysis of variance revealed highly significant ($p<0.01$) differences in flavour among control and treated formulations during storage periods under vacuum packaging. There was also highly significant ($p<0.01$) differences in flavour in control and treated formulations. The highest flavour score was recorded in pork with *Silam* compared to control and pork with *Anishi* and FDS on 0 day. Decreasing trend of flavour scores were observed in control and the treated pork products as the storage day advanced. On 15 day of storage the pork with *Silam* recorded the highest flavour score compare to control and pork with *Anishi* and FDS. Devatkal *et al.* (2003) reported that deterioration of flavour might be due to microbial growth and oxidative rancidity in restructured pork rolls. As the storage period advanced, the decline in flavour scores might be due to oxidation of fat. Devi and Singh (2018) also reported a significant ($p<0.01$) decline in flavour score in guinea fowl meat sausage under vacuum packaging with the advancement of storage period.

4.15.3. Juiciness

The mean juiciness recorded for the control product under vacuum packaging on 0 day was 6.09 ± 0.05 and in the treated products were 6.86 ± 0.06 , 6.94 ± 0.04 and 6.86 ± 0.06 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean juiciness recorded for control product were 6.00 ± 0.0 , 5.80 ± 0.07 and 5.17 ± 0.06 , respectively. These mean values for juiciness in pork with *Anishi* were 6.43 ± 0.08 , 6.31 ± 0.08 and 5.23 ± 0.11 , for pork with *Silam* were 6.20 ± 0.07 , 6.11 ± 0.05 and 6.43 ± 0.08 and for pork with FDS were 6.80 ± 0.07 , 6.17 ± 0.06 and 5.49 ± 0.09 , respectively.

Analysis of variance revealed highly significant ($p<0.01$) differences in juiciness among control and treated formulations during storage periods under vacuum packaging. There was also highly significant ($p<0.01$) difference in juiciness in control and treated

formulations. Highest juiciness score was recorded in pork with *Silam* on 0 and 15 day of storage periods compared to control, pork with *Anishi* and FDS. Decreasing trend of juiciness scores were observed in control and the treated pork products as the storage day advanced. Devi and Singh (2018) reported a significant ($p<0.01$) reduction in the juiciness score was observed with the advancement of storage periods for aerobic packaging and vacuum packaging in guinea fowl meat sausages.

Dehydration and moisture reduction of the product with advancement of refrigerated storage could be the reason for lower juiciness scores. Deuri (2016) also reported that overall, juiciness scores declined progressively from 1 to 15 day of storage in ready-to-eat vacuum packaging of *Vawksa rep* (smoked pork product) during refrigerated storage.

4.15.4. Tenderness

The mean tenderness recorded for the control product under vacuum packaging on 0 day was 6.11 ± 0.05 and in the treated products were 6.86 ± 0.06 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean tenderness recorded for control product were 6.00 ± 0.0 , 5.80 ± 0.12 and 5.40 ± 0.08 , respectively. These mean values for tenderness in pork with *Anishi* were 6.31 ± 0.08 , 6.37 ± 0.08 and 5.43 ± 0.09 , for pork with *Silam* were 6.29 ± 0.08 , 6.17 ± 0.06 and 6.11 ± 0.05 and for pork with FDS were 6.89 ± 0.05 , 6.57 ± 0.08 and 5.29 ± 0.08 , respectively.

Analysis of variance revealed highly significant ($p<0.01$) differences in tenderness among control and treated formulations during storage periods under vacuum packaging. There was also highly significant ($p<0.01$) difference in tenderness in control and treated formulations. Tenderness scores were higher in pork with *Silam* and FDS on 0 day compared to control and pork with *Anishi*. On 15 day of storage the tenderness score was recorded highest in pork with *Silam*. Decreasing trend of tenderness was observed in control and the treated pork products as the storage day advanced. The decrease in tenderness might be due to loss of moisture during the storage periods. Similar finding of decrease in tenderness were also reported by Devi and Singh (2018) in guinea fowl meat sausages under vacuum packaging.

4.15.5. Overall acceptability

The mean overall acceptability recorded for the control product under vacuum packaging on 0 day was 6.26 ± 0.07 and in the treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS, respectively. On 5, 10 and 15 day of storage the mean overall acceptability recorded for control product were 6.00 ± 0.0 , 5.94 ± 0.04 and 5.60 ± 0.08 , respectively. These mean values for overall acceptability in pork with *Anishi* were 6.60 ± 0.08 , 6.49 ± 0.09 and 5.37 ± 0.08 , for pork with *Silam* were 6.14 ± 0.06 , 6.06 ± 0.04 and 6.00 ± 0.00 and for pork with FDS were 6.97 ± 0.03 , 6.26 ± 0.07 and 5.49 ± 0.09 , respectively.

Analysis of variance revealed highly significant ($p < 0.01$) differences in overall acceptability among control and treated formulations during storage periods under vacuum packaging. There was also highly significant ($p < 0.01$) difference in overall acceptability in control and treated formulations. On 0 day the overall acceptability were recorded highest in all the treated products compared to control. Decreasing trend of overall acceptability were recorded on 5, 10 and 15 day of storage. The decrease in overall acceptability scores with increasing storage periods might be due to decrease in appearance, flavour, juiciness and tenderness scores. Pork with *Silam* recorded highest sensory scores for all the sensory attributes viz. appearance, flavour, juiciness, tenderness and overall acceptability during the entire periods of refrigeration storage. Similar observation of decreased in overall acceptability with increasing storage periods was also reported by Devatkal and Mendiratta (2001) in pork rolls. Deuri (2016) also reported decreased in overall acceptability as the storage periods advanced in ready-to-eat vacuum packaging of *Vawksa rep* (smoked pork product) during refrigerated storage

These findings are in agreement with the findings of Singh *et al.* (2002) who also observed that the product packed under vacuum or nitrogen gas remained organoleptically acceptable for 10 and 15 days under refrigerated and frozen storage. However, Pandey and Yadav (2005) found that overall acceptability scores declined with storage time irrespective of packaging and storage condition. Sharma *et al.* (2017) also reported that vacuum packaging was effective to preserve the sensory attributes of the chevon *tikki* upto 14 days of storage at refrigeration temperature ($4 \pm 1^\circ\text{C}$).

TABLE 4.34. SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Parameters	Products	Mean±SE of different days			
		0	5	10	15
Appearance	Control	^a 6.49±0.09 ^{AB}	^a 6.26±0.07 ^A	^b 5.91±0.11 ^A	^c 5.60±0.08 ^A
	Pork with <i>Anishi</i>	^{ab} 6.34±0.08 ^A	^b 6.20±0.07 ^A	^a 6.51±0.09 ^B	^c 5.31±0.08 ^B
	Pork with <i>Silam</i>	^a 6.60±0.08 ^{BC}	^b 6.11±0.05 ^A	^b 6.17±0.06 ^C	^b 6.00±0.00 ^C
	Pork with FDS	^a 6.77±0.07 ^C	^{ab} 6.63±0.08 ^B	^b 6.51±0.09 ^B	^c 6.00±0.00 ^C
Flavour	Control	^a 6.06±0.04 ^A	^{ab} 6.00±0.00 ^A	^b 5.86±0.06 ^A	^c 5.60±0.08 ^A
	Pork with <i>Anishi</i>	^a 6.63±0.08 ^B	^b 6.37±0.08 ^B	^b 6.29±0.08 ^B	^c 5.29±0.10 ^B
	Pork with <i>Silam</i>	^a 6.74±0.07 ^B	^b 6.34±0.08 ^B	^{bc} 6.23±0.07 ^B	^c 6.11±0.05 ^C
	Pork with FDS	^a 6.26±0.07 ^C	^a 6.29±0.08 ^B	^a 6.11±0.05 ^B	^b 5.37±0.10 ^{AB}
Juiciness	Control	^a 6.09±0.05 ^A	^a 6.00±0.00 ^A	^b 5.80±0.07 ^A	^c 5.17±0.06 ^A
	Pork with <i>Anishi</i>	^a 6.86±0.06 ^B	^b 6.43±0.08 ^B	^b 6.31±0.08 ^B	^c 5.23±0.11 ^A
	Pork with <i>Silam</i>	^a 6.94±0.04 ^B	^c 6.20±0.07 ^C	^c 6.11±0.05 ^C	^b 6.43±0.08 ^B
	Pork with FDS	^a 6.86±0.06 ^B	^a 6.80±0.07 ^D	^b 6.17±0.06 ^{BC}	^c 5.49±0.09 ^C
Tenderness	Control	^a 6.11±0.05 ^A	^{ab} 6.00±0.00 ^A	^b 5.80±0.12 ^A	^c 5.40±0.08 ^A
	Pork with <i>Anishi</i>	^a 6.86±0.06 ^B	^b 6.31±0.08 ^B	^b 6.37±0.08 ^{BC}	^c 5.43±0.09 ^A
	Pork with <i>Silam</i>	^a 7.00±0.00 ^C	^b 6.29±0.08 ^B	^{bc} 6.17±0.06 ^C	^c 6.11±0.05 ^B
	Pork with FDS	^a 7.00±0.00 ^C	^a 6.89±0.05 ^C	^b 6.57±0.08 ^B	^c 5.29±0.08 ^A
Overall acceptability	Control	^a 6.26±0.07 ^A	^b 6.00±0.00 ^A	^b 5.94±0.04 ^A	^c 5.60±0.08 ^A
	Pork with <i>Anishi</i>	^a 7.00±0.00 ^B	^b 6.60±0.08 ^B	^b 6.49±0.09 ^B	^c 5.37±0.08 ^B
	Pork with <i>Silam</i>	^a 7.00±0.00 ^B	^b 6.14±0.06 ^A	^{bc} 6.06±0.04 ^A	^c 6.00±0.00 ^C
	Pork with FDS	^a 7.00±0.00 ^B	^a 6.97±0.03 ^C	^b 6.26±0.07 ^C	^c 5.49±0.09 ^{AB}

Mean having different superscript in column (capital letter) differ significantly ($p < 0.01$) for different products on different days

Mean having different superscript in row (small letter) differ significantly ($p < 0.01$) between days of different products

SE= Standard Error, n=5

TABLE 4.35. ANALYSIS OF VARIANCE OF SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

Source	df	Mean±SE				
		Appearance	Flavour	Juiciness	Tenderness	Overall acceptability
Products	3	5.0000**	5.8595**	11.8494**	10.7357**	6.3928**
Days	3	16.8047**	17.8928**	30.5779**	34.3309**	35.3785**
Error	553	0.2221	0.2125	0.2269		0.1711

df= degree of freedom, NS=Non-significant, **= Significant at 1 percent level

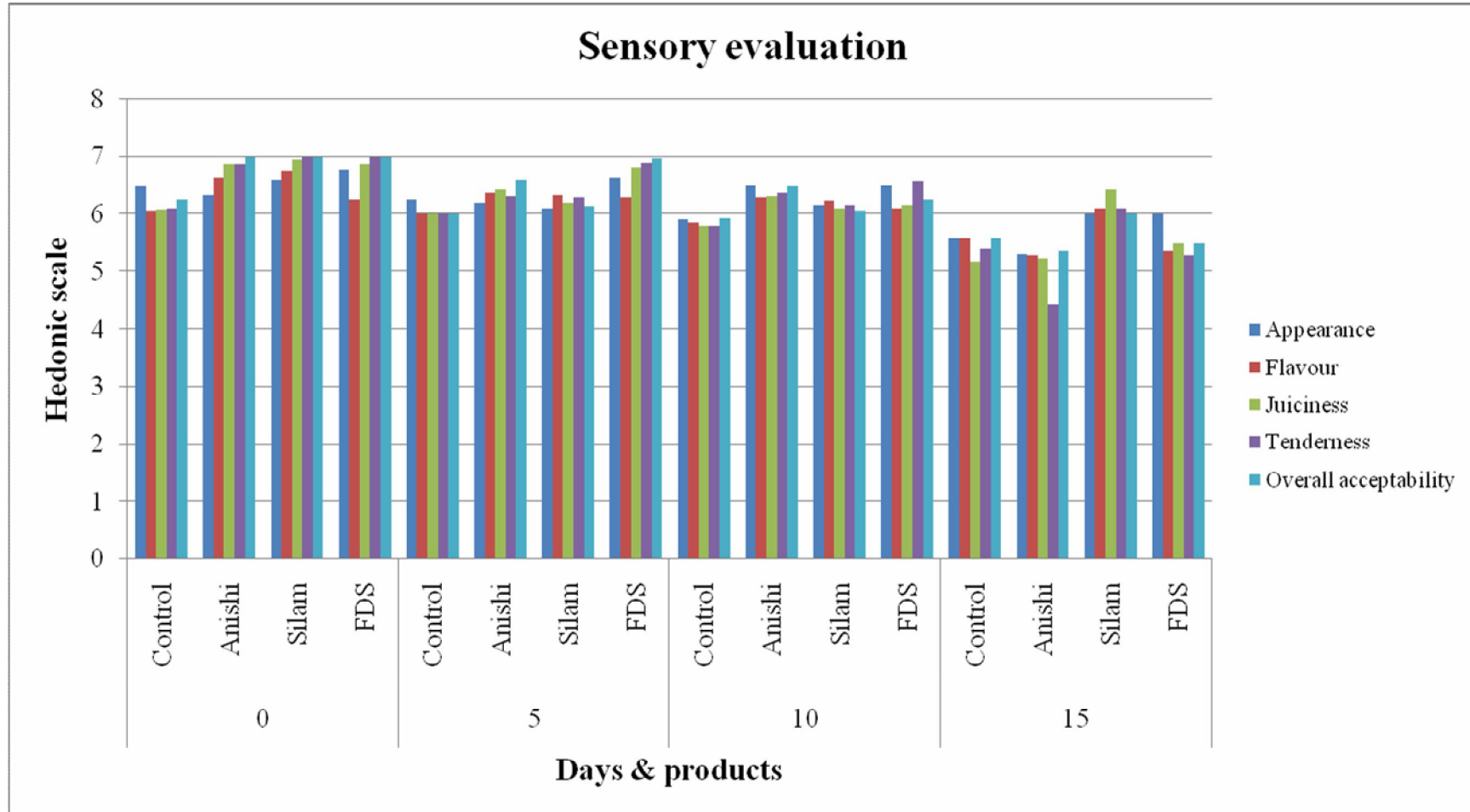


FIG 4.33. GRAPHICAL REPRESENTATION OF SENSORY EVALUATION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

4.16. COST OF PRODUCTION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING

The cost of production in control and traditional pork products under vacuum processing is presented in Table 4.36.

Considering all aspects like cost of raw materials, production, processing, labour, transportation, electricity, the cost of production for vacuum packaging of traditional pork products per kilogram were found to be Rs. 419.00 for control, Rs. 418.00 for pork with *Anishi*, Rs. 417.00 for pork with *Silam* and Rs. 418.00 for pork with FDS. The result indicates that the costs of final products were lower for pork with *Anishi*, *Silam* and FDS incorporated pork products. Among the pork products, the cost of pork with *Silam* was lower than pork with *Anishi* and FDS. Whereas, the cost of control was higher compared to all the pork products incorporated with *Anishi*, *Silam* and FDS. The study indicates that incorporation of ingredients viz. *Anishi*, *Silam* and FDS in pork products could be produced with economic benefit for production of traditional pork products under vacuum packaging.

(* The cost of machineries were not included in calculating cost of production).

TABLE 4.36. COST OF PRODUCTION OF TRADITIONAL PORK PRODUCTS UNDER VACUUM PACKAGING: COST FOR 2 KGS

Ingredients	Control	Pork with <i>Anishi</i>	Pork with <i>Silam</i>	Pork with FDS
Pork 2 kg @ Rs. 260/kg	520.00	520.00	520.00	520.00
Additives (Salt, condiments, tomato, green chillies) LS	50.00	50.00	50.00	50.00
<i>Anishi</i> (5%) @ Rs. 400/kg	-	40.00	-	-
<i>Silam</i> (10%) @ Rs. 400/kg	-	-	80.00	-
FDS (5%) @ Rs. 400/kg	-	-	-	40.00
Processing cost (Labour, water etc.)	50.00	50.00	50.00	50.00
Electricity cost (Rs.) LS	50.00	50.00	50.00	50.00
Total cost (Rs)	670.00	710.00	750.00	710.00
Final product (Kg)	1.60	1.70	1.80	1.70
Cost of production (Rs/Kg)	419.00	418.00	417.00	418.00

Chapter-V

SUMMARY AND CONCLUSION

A study was conducted to develop certain ready-to eat traditional pork products of Nagaland under retort pouch and vacuum packaging by incorporating different levels of plant based, non-meat ingredients viz. *Anishi*, *Silam* and Fermented Dried Soya (FDS) which could be stored for considerable period at room temperature and refrigeration temperature without affecting the physico-chemical, microbial, organoleptic and keeping qualities. *Anishi* is prepared from edible species of *Colocassia* leaf. The dried *Anishi* cakes are cooked with dry meat, especially pork. The *Silam* seed (*Perilla frutescens*), which is slightly bigger than a mustard seed, extensively used as roasted and ground paste in curries and other ready- to-eat foods. Fermented Dried Soya (FDS), which is locally termed as *Axone* (*Akhuni*) is a traditional Nagamese fermented, sticky paste like product of soyabean.

On the basis of result of the pilot study, three different formulations were prepared i.e., pork with *Anishi* (5%), pork with *Silam* (10%), and pork with FDS (5%) along with a control (without addition of any of the above ingredients). The products thus prepared were evaluated for various important meat products quality traits including the production cost to find out the most desired and economic formulation.

A purposive survey was also conducted in 6 (six) different villages of Dimapur district of Nagaland representing three different tribes (Ao, Sema and Angami). A questionnaire was developed for the survey and 30 numbers of household were involved for the survey. Informations were collected on existing traditional methods of preparation of pork product with *Anishi*, *Silam* and FDS and the level of the ingredients used, mode of consumption, as well as culinary and ethnic values using questionnaires and direct observation.

Five batches of traditional pork products for each formulation were prepared and subjected to retort pouch and vacuum packaging and studied for 6 months with one month interval for retort packaging under ambient temperature (25-32°C) and for vacuum packaging under refrigeration temperature (4±1°C) on 0, 5, 10 and 15 days.

The parameters thus studied for retort pouch packaging and vacuum packaging were - Physico-chemical properties, sensory evaluation, microbiological study, storage life and cost economics.

PURPOSIVE SURVEY

A total of thirty numbers of households were surveyed, ten each for each product. All the respondents were females. It was observed that, most of the time the preparations of traditional products in the household are done by the female members only. Non meat ingredients and vegetables used for the products were onion, garlic, ginger, tomato, green chillies and local peppers and were mostly procured from the local market. These ingredients were used for the preparation of pork with *Anishi*, *Silam* and FDS.

The cost of production for traditional pork products at field level per kilogram were found to be Rs. 350.00 for pork with *Anishi*, Rs. 375.00 for pork with *Silam* and Rs. 375.00 for pork with FDS. The costs of final products were lower for pork with *Anishi*, compared to pork with *Silam* and FDS incorporated pork products.

STANDARDIZATION OF LEVEL OF INGREDIENTS IN TRADITIONAL PORK PRODUCTS

The standardization was done with incorporation of different levels of ingredients. For both *Anishi* and FDS the percent levels were 1, 2, 3, 4, 5, and 6. The percent levels for *Silam* were 2, 4, 6, 8, 10, and 12. The higher sensory scores were observed in 5 percent levels of incorporation in *Anishi* and FDS, while higher score was observed in *Silam* at 10 percent level of incorporation. Accordingly, 5 percent levels each of incorporation were selected in the products containing *Anishi* and FDS and 10 percent level in *Silam* for further processing. The results revealed highly significant ($P < 0.01$) difference in all the levels in the products with the ingredients *Anishi*, *Silam* and FDS.

RETORT POUCH PROCESSING OF TRADITIONAL PORK PRODUCT

The retort temperature and the product core temperature before processing was 32°C and 30°C. The product core temperature reached its first lethality rate of 0.001, when

the product core temperature was 90°C and the retort temperature was 121.1°C in the treatment.

The total heating time for control, pork with *Anishi*, *Silam* and FDS were recorded 23, 22, 20 and 24 minutes based on the time taken for the products core temperature to reach 121.1°C. Cooling time for control, pork with *Anishi*, *Silam* and FDS were 8, 7, 8 and 10 minutes after attaining necessary core temperature of 121°C. After cooling, the retort temperature was 45°C and the product core temperature was 60°C.

Total lethality (F_0) received for the traditional pork products for control, pork with *Anishi*, *Silam* and FDS were 10.88, 11.24, 10.63 and 10.27 minutes. The processing time for control, pork with *Anishi*, *Silam* and FDS were 34, 32, 32 and 34 minutes. Total processing time was recorded highest for control and pork with FDS.

Proximate composition of traditional pork products

The mean percent moisture content on recorded 0 day for the control product under retort pouch packaging was 69.52 ± 0.31 and in treated products were 68.55 ± 0.43 , 69.77 ± 0.11 and 68.65 ± 0.10 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean moisture content showed highest in control and lowest in pork with *Anishi*. Significant ($p < 0.01$) differences in control and treated products during storage days and significant ($p < 0.01$) differences in control and treated products were observed. The decreasing trend in moisture content in control and treated products were also observed during the entire storage periods.

The mean percent ether extract content recorded on 0 day for the control product under retort pouch packaging was 9.37 ± 0.14 and in treated products were 9.31 ± 0.43 , 8.03 ± 0.10 and 8.99 ± 0.08 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean ether extract content recorded highest in pork with *Anishi* and lowest was in pork with *Silam*. Increasing trend of ether extract contents were observed in control and treated products on advancement of storage period. Significant ($p < 0.01$) differences was also observed in control and treated products during storage periods. However, no significant difference was observed in control and treated products.

The mean percent total ash content recorded for the control product under retort pouch packaging on 0 day was 4.20 ± 0.08 and in treated products were 5.32 ± 0.20 , 5.26 ± 0.17 and 4.34 ± 0.07 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean total ash content recorded highest in pork with FDS and lowest in control as compared to treated products. Significant ($p < 0.01$) differences in different days of storage periods was observed in control and treated products. However, no significant difference was observed in control and treated products. The increase in total ash content was observed in all the products during storage periods.

The mean percent crude protein content recorded for the control product under retort pouch packaging on 0 day was 16.35 ± 0.19 and in treated products were 15.18 ± 0.22 , 16.57 ± 0.13 and 17.08 ± 0.04 for pork with *Anishi*, *Silam* and FDS. The crude protein contents were recorded highest in pork with FDS compared to control, pork with *Anishi* and *Silam* from 0 to 180 days and lowest in pork with *Anishi*. Significant ($p < 0.01$) differences in control and the treated products and also during different storage days were observed. There was decreasing in crude protein contents as the storage period increases.

Physico-chemical composition of traditional pork products

The mean pH values recorded for the control product under retort pouch packaging on 0 day was 5.88 ± 0.08 and in treated products were 5.62 ± 0.12 , 5.86 ± 0.08 and 5.87 ± 0.10 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean pH values revealed significant ($p < 0.01$) differences in control and treated products and during the storage period. There was decreasing trend in pH values in the storage period in control and treated products.

The mean TBARS values recorded for control product under retort pouch packaging on 0 day was 0.12 ± 0.01 and in treated products were 0.14 ± 0.01 , 0.13 ± 0.01 and 0.14 ± 0.01 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean TBARS values showed increasing trend with the advancement of storage period. Highest TBARS values was observed on 180 day of storage in pork with FDS and lowest was recorded in control. Significant ($p < 0.01$) differences in control and treated products and during entire storage period were observed.

The mean tyrosine values recorded for control product under retort pouch packaging on 0 day was 64.62 ± 0.18 and in treated products were 81.82 ± 1.77 , 75.51 ± 1.73 and 82.72 ± 1.10 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean tyrosine values recorded highest in pork with *Anishi* and lowest in control. Significant ($p < 0.01$) differences in control and treated products during the storage periods were observed. Increasing trend of tyrosine values were also observed on advancement of storage period.

Amino acid content of traditional pork products

The results of amino acid content in control product and traditional pork products on 0 day revealed that control sample; pork with *Anishi* and FDS had higher amino acid content. However, on 180 day of storage the decrease in amino acid contents in control and traditional pork products were observed. Among the traditional pork products incorporated with FDS was recorded highest content of amino acid as compared to pork incorporated with *Anishi* and *Silam*.

Texture profile of traditional pork products

The mean hardness recorded for control product under retort pouch packaging on 0 day was 2606.92 ± 178.59 and in treated products were 2652.78 ± 161.70 , 2962.68 ± 55.40 and 4025.90 ± 69.71 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean hardness recorded highest in pork with FDS and lowest in control product. The hardness revealed significant ($p < 0.01$) differences in control and treated products under retort packaging and storage period. Increase in hardness was observed during storage periods.

The mean springiness recorded for control product under retort pouch packaging on 0 day was 0.39 ± 0.00 and treated products were 0.31 ± 0.02 , 0.33 ± 0.01 and 0.35 ± 0.03 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean springiness recorded highest in pork with FDS and lowest in pork with *Anishi*. Significant ($p < 0.01$) differences in control and treated products under retort packaging was observed during storage period. Increase in springiness was observed during the storage period.

The mean cohesiveness recorded for control product under retort pouch packaging on 0 day was 0.21 ± 0.00 and in treated products were 0.21 ± 0.00 , 0.26 ± 0.00 and 0.28 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS. On 90 and 180 day of storage the mean cohesiveness recorded highest in pork with FDS and lower values were observed in control and pork with *Anishi*. Significant ($p<0.01$) differences in control and the treated products were observed during storage period. There was increased trend of cohesiveness during storage periods.

The mean chewiness recorded for control product under retort pouch packaging on 0 day was 248.73 ± 10.85 and in treated products were 239.20 ± 21.86 , 261.36 ± 14.07 and 379.88 ± 17.55 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean chewiness recorded highest in pork with FDS and lowest in pork with *Anishi*. The chewiness showed significant differences ($p<0.01$) in control and treated products and during storage period. Increasing trend of chewiness were observed during the storage periods.

Colour profile of traditional pork products

The mean values for lightness recorded for control product under retort pouch packaging on 0 day was 59.71 ± 0.02 and in treated products were 38.26 ± 0.41 , 54.80 ± 0.01 and 56.73 ± 0.02 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean values for lightness recorded highest in control and lowest in pork with *Anishi*. The lightness revealed significant ($p<0.01$) differences in control and treated products and during storage period. The L^* value was decreased significantly from 0 to 180 day.

The mean values for redness recorded for control product under retort pouch packaging on 0 day was 6.71 ± 0.07 and in treated products were 6.65 ± 0.06 , 5.54 ± 0.13 and 7.67 ± 0.09 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean redness recorded highest in pork with FDS and lowest in pork with *Silam*. The a^* showed significant ($p<0.01$) differences in control and treated products and during storage period. Redness of the products were found to decrease with storage periods.

The mean values for yellowness recorded for control product under retort pouch packaging on 0 day was 19.88 ± 0.54 and in treated products were 22.32 ± 0.44 , 18.52 ± 1.31

and 23.39 ± 0.51 for pork with *Anishi*, *Silam* and FDS. On 90 and 180 day of storage the mean b^* values recorded highest in pork with FDS and lowest in pork with *Silam*. The b^* revealed significant ($p < 0.01$) differences in control and treated products and during storage period. Decreasing trend of b^* was observed in control and treated products.

Microbiological qualities of traditional pork products

The microbiological revealed absences of total plate count, coliform count and yeast and mould counts in control and the treated products during the entire storage period upto 180 days. The retort processing involves thermal processing to bring the food as rapidly as possible to temperatures at which unwanted microorganisms are killed which render the food commercially sterile. On this basis, the control product and the treated products were rendered as “commercially sterile” upto 6 months of storage.

Sensory evaluation of traditional pork products

The mean appearance recorded for the control product under retort pouch packaging on 0 day was 6.57 ± 0.08 and in treated products were 6.40 ± 0.10 , 6.43 ± 0.08 and 6.40 ± 0.08 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean appearance recorded highest score in pork with FDS and lower score was recorded in control during storage periods. Significant ($p < 0.01$) differences in control and treated products were observed during storage period. However, significant ($p < 0.05$) differences were also observed in control and the treated products. The appearance scores revealed a decreasing trend with increase in storage periods.

The mean flavour recorded for the control product under retort pouch packaging on 0 day was 6.77 ± 0.07 and in treated products were 6.69 ± 0.08 , 6.77 ± 0.07 and 6.77 ± 0.07 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean flavour recorded higher score in pork with *Silam* and lower score in pork with FDS. The flavour scores showed significant ($p < 0.01$) differences in flavour in control and treated products during storage periods.

The mean juiciness recorded for the control product under retort pouch packaging on 0 day was 6.80 ± 0.07 and in treated products were 6.89 ± 0.05 , 6.97 ± 0.03 and 7.00 ± 0.00

for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean juiciness recorded highest score in pork with *Silam* and lowest score in pork with FDS. The juiciness scores revealed significant ($p<0.01$) differences in control and treated products and during storage period. The juiciness scores gradually decreases on increase in days of storage in control and treated products.

The mean tenderness recorded for the control product under retort pouch packaging on 0 day was 6.94 ± 0.04 and in treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean tenderness recorded highest in pork with *Silam* and lower score in pork with *Anishi*. The tenderness scores revealed significant ($p<0.01$) differences in control and treated products and during storage periods.

The mean overall acceptability recorded for the control product under retort pouch packaging on 0 day was 7.00 ± 0.00 and in treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, *Silam* and FDS. During 180 days of storage the mean overall acceptability recorded highest in pork with *Silam* and lowest score in control. Significant ($p<0.01$) differences in control and treated products and during storage period were observed. There was a decreasing trend in overall acceptability scores on increase in days of storage. However, overall acceptability scores in pork with *Anishi*, *Silam* and FDS were rated moderately desirable upto 6 months of storage.

Cost of production of traditional pork products

The costs of production were found to be Rs. 519.00 for control, Rs. 512.00 for pork with *Anishi*, Rs. 506.00 for pork with *Silam* and Rs. 512.00 for pork with FDS per kilogram of products. The costs of final products were lower for pork with *Anishi*, *Silam* and FDS incorporated pork products. Among the pork products, the cost of pork with *Silam* was lower than pork with *Anishi* and FDS. Whereas, the cost of control was higher compared to all the pork products incorporated with *Anishi*, *Silam* and FDS.

VACUUM PACKAGE PROCESSING OF TRADITIONAL PORK PRODUCTS

Under vacuum packaging the traditional pork products along with control were evaluated with different parameters on 0, 5, 10 and 15 day of refrigeration storage.

Proximate composition of traditional pork products

The mean percent moisture content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 71.34 ± 0.48 and in treated products were 70.90 ± 0.81 , 68.97 ± 0.86 and 69.59 ± 0.23 for pork with *Anishi*, *Silam* and for pork with FDS. During 15 days of storage the mean moisture content recorded highest in pork with *Anishi* and lowest in pork with FDS. Significant ($p < 0.01$) differences was observed in control and treated products and during storage periods. Decreasing trend of moisture contents was observed in control and the treated products.

The mean percent ether extract content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 5.92 ± 0.44 and in treated products were 6.45 ± 0.18 , 8.03 ± 0.79 and 6.68 ± 0.05 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean ether extract content recorded highest in pork with *Silam* and lowest in pork with *Anishi*. Significant ($p < 0.01$) differences in control and treated products were observed and also during storage periods. Ether extract values were found to increase with the advancement of storage.

The mean percent values of total ash content recorded for the control product under vacuum packaging at refrigeration storage on 0 day was 6.57 ± 0.29 and in treated products were 6.40 ± 0.18 , 6.29 ± 0.18 and 6.18 ± 0.305 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean total ash content recorded highest in control and lowest in pork with FDS. Significant ($p < 0.01$) differences in control and treated products were observed and during different storage periods. Decreasing trend of total ash content was observed during storage periods.

The mean percent values of crude protein content recorded for control product under vacuum packaging at refrigeration storage on 0 day was 16.77 ± 0.49 and in treated products were 15.56 ± 0.43 , 16.01 ± 0.16 and 17.55 ± 0.28 for pork with *Anishi*, *Silam* and

FDS. During 15 days of storage the mean crude protein content recorded highest in pork with FDS and lowest in pork with *Anishi*. Significant ($p<0.01$) differences in products and during storage period was observed in control and treated products.

Physico-chemical properties of traditional pork products

The mean values of pH recorded for control product under vacuum packaging at refrigeration storage on 0 day was 5.86 ± 0.01 and in treated products were 5.81 ± 0.02 , 5.89 ± 0.01 and 5.98 ± 0.03 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean pH values were recorded higher values in pork with FDS and lower values in pork with *Anishi*. The pH values revealed significant ($p<0.01$) differences in control and all the treated products. The decline in pH values were observed with an increase in storage period.

The mean TBARS values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 0.86 ± 0.02 and in treated products were 0.78 ± 0.04 , 0.65 ± 0.03 and 0.74 ± 0.03 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the TBARS values recorded highest in pork with *Anishi* and lowest in control. Significant ($p<0.01$) differences were observed in control and all the treated products and during entire storage period. Increasing trend of TBARS values were recorded in control and treated products on storage periods.

The mean tyrosine values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 60.00 ± 0.14 and in treated products were 60.07 ± 0.24 , 58.00 ± 0.25 and 55.44 ± 0.28 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the tyrosine values recorded highest in control and lowest in pork with *Silam*. Significant ($p<0.01$) differences were observed in control and all the treated products and during storage periods. The increasing trends of tyrosine values was observed in control and all the treated products with increase in storage periods.

Microbiological qualities of traditional pork products

The mean TPC values recorded for control product under vacuum packaging at refrigeration storage on 0 day was 1.92 ± 0.06 and in treated products were 1.84 ± 0.09 ,

1.98±0.05 and 1.93±0.06 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the TPC values recorded highest in control and lowest in pork with FDS. Significant ($p<0.01$) differences were observed in control and all the treated products during storage period. However, no significant differences was observed in control and the treated products. The increasing trends of TPC were recorded in control and all the treated products with the advancement of storage time.

The mean psychrophilic counts recorded for control product under vacuum packaging at refrigeration storage on 0 day was 1.86±0.10 and in treated products were 1.76±0.10, 1.78±0.11 and 1.76±0.09 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the psychrophilic counts were recorded highest in pork with *Silam* and lowest in pork with FDS. Significant ($p<0.01$) differences were observed in control and all the treated products during storage period. However, no significant differences was observed in control and the treated products. The increasing trends of psychrophilic counts were observed in control and all the treated products during different storage periods.

Coliform counts were recorded <3 in control and all the treated products during the entire refrigeration storage conditions. Whereas, the yeast and mould were not detected in control and all the treated products during the entire storage periods of study under refrigerate condition ($4\pm 1^{\circ}\text{C}$).

Amino acid content of traditional pork products

The amino acid content in control and the treated products on 0 day showed that control sample and pork with FDS had higher amino acid contents. However, on 15 day it was recorded decrease in amino acid content in control and pork with FDS. Among the traditional pork products incorporated with FDS recorded highest content of amino acid as compared to pork with *Anishi* and *Silam*. Lowest amino acid content was recorded in pork with *Anishi* followed by pork with *Silam*.

Texture profile of traditional pork products

The mean hardness recorded for control product under vacuum packaging on 0 day was 16344.51±11.10 and in treated products were 11982.37±0.56, 13764.74±100.05 and

15996.77±3532.83 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean hardness recorded highest in control and lowest in pork with FDS. Significant ($p<0.01$) differences were observed in control and treated products during storage period. However, significant ($p<0.05$) differences were observed in control and treated products. Decreasing trend on hardness was observed during the storage period from 0 to 15 day.

The mean springiness recorded for control product under vacuum packaging on 0 day was 0.38 ± 0.00 and in treated products were 0.44 ± 0.00 , 0.35 ± 0.00 and 0.47 ± 0.00 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean springiness recorded highest in pork with FDS and lowest in pork with *Anishi*. Significant ($p<0.01$) differences were observed in control and all the treated products and during storage periods. Increasing trend of springiness in control and treated products was observed with an advancement of storage period.

The mean cohesiveness recorded for control product under vacuum packaging on 0 day was 0.60 ± 0.00 and in treated products were 0.43 ± 0.00 , 0.47 ± 0.00 and 0.49 ± 0.00 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean cohesiveness was recorded highest in control and lowest in pork with *Anishi*. Significant ($p<0.01$) differences were observed in control and all the treated products and during different storage periods.

The mean chewiness recorded for control product under vacuum packaging on 0 day was 4678.57 ± 7.28 and in treated products were 3160.73 ± 2.62 , 2024.04 ± 0.26 and 4675.67 ± 0.37 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean chewiness was recorded highest in control and lowest in pork with FDS. Significant ($p<0.01$) differences were observed in control and all the treated products. However, no significant difference was observed in the storage periods. Decreasing trend of chewiness during storage period in control and treated products was observed.

Colour profile of traditional pork products

The mean L^* recorded for control product under vacuum packaging on 0 day was 52.52 ± 0.06 and in treated products were 30.58 ± 0.19 , 55.13 ± 0.05 and 53.13 ± 0.11 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean L^* recorded highest in

control and lowest in pork with *Anishi*. Significant ($p < 0.01$) differences were observed in control and all the treated pork products and during storage period. The lightness was observed to decrease with an increase in storage time in control and treated products.

The mean a^* recorded for control product under vacuum packaging on 0 day was 11.63 ± 0.07 and in treated products were 12.91 ± 0.02 , 10.75 ± 0.15 and 12.10 ± 0.04 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean a^* recorded highest in control and lower values in pork with *Silam*. Significant ($p < 0.01$) differences were observed in control and all the treated products and storage period. Redness in control and pork with *Anishi*, *Silam* and FDS showed decreasing trends upto 15 day of storage.

The mean b^* recorded for control product under vacuum packaging on 0 day was 11.14 ± 0.07 and in treated products were 4.12 ± 0.56 , 8.33 ± 0.09 and 7.58 ± 0.55 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean b^* recorded highest in pork with FDS and lowest in control. Significant ($p < 0.01$) difference were observed in control and all the treated products and during storage period. The yellowness values were recorded and showed an increasing trends during storage period in all product formulations.

Sensory evaluation of traditional pork products

The mean appearance recorded for the control product under vacuum packaging on 0 day was 6.49 ± 0.09 and in treated products were 6.34 ± 0.08 , 6.60 ± 0.08 and 6.77 ± 0.07 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean appearance score recorded was higher in pork with FDS and lower scores in control. Significant differences in appearance was observed among control and treated products and during storage period. The appearance score decreases with an increase in storage period.

The mean flavour recorded for the control product under vacuum packaging on 0 day was 6.06 ± 0.04 and in treated products were 6.63 ± 0.08 , 6.74 ± 0.07 and 6.26 ± 0.07 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean flavour recorded higher scores in pork with *Silam* and lower scores in control. Significant ($p < 0.01$) differences in flavour among control and treated products and during storage period were

observed. Decreasing trend of flavour scores was observed in control and the treated pork products as the storage period advanced.

The mean juiciness recorded for the control product under vacuum packaging on 0 day was 6.09 ± 0.05 and in treated products were 6.86 ± 0.06 , 6.94 ± 0.04 and 6.86 ± 0.06 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean juiciness recorded higher scores in pork with *Silam* and lower scores in control. Significant ($p < 0.01$) differences in juiciness among control and treated products and during storage period were observed. Decreasing trend of juiciness scores was observed with the advancement of storage period in control and the treated products. .

The mean tenderness recorded for the control product under vacuum packaging on 0 day was 6.11 ± 0.05 and in the treated products were 6.86 ± 0.06 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, pork with *Silam* and for pork with FDS. On 5, 10 and 15 day of storage the mean tenderness recorded higher scores in pork with *Silam* and lower scores in control. Significant ($p < 0.01$) differences in tenderness among control and treated products and during storage period was observed decreasing trend of tenderness was observed in control and the treated pork products as the storage day advanced.

The mean overall acceptability recorded for the control product under vacuum packaging on 0 day was 6.26 ± 0.07 and in treated products were 7.00 ± 0.00 , 7.00 ± 0.00 and 7.00 ± 0.00 for pork with *Anishi*, *Silam* and FDS. During 15 days of storage the mean overall acceptability recorded higher scores in pork with *Silam* and lower scores in control. Significant ($p < 0.01$) differences in overall acceptability among control and treated products and during storage period were observed. Decreasing trend of overall acceptability was recorded with the advancement of storage periods.

Cost of production of traditional pork products

The cost of production for vacuum packaging of traditional pork products per kilogram were found to be Rs. 419.00 for control, Rs. 418.00 for pork with *Anishi*, Rs. 417.00 for pork with *Silam* and Rs. 418.00 for pork with FDS. The costs of final products were lower for pork with *Anishi*, *Silam* and FDS incorporated pork products. Among the pork products, the cost of pork with *Silam* was lower than pork with *Anishi* and FDS.

Whereas, the cost of control was higher compared to all the pork products incorporated with *Anishi*, *Silam* and FDS.

CONCLUSION

Based on the results obtained on studying various parameters included in the present investigation, it may be concluded that traditional pork products could be prepared satisfactorily by incorporation of 5 percent *Anishi*, 10 percent *Silam* and 5 percent FDS without adversely effecting the various meat quality traits and thereby relatively cheaper traditional pork products could be obtained. However, further studies involving similar ingredients at different levels and for longer duration might be of immense value to draw a concrete conclusion and to recommend the best suited formulations for commercialization and entrepreneurship development.

APPENDICES

APPENDIX – I

PURPOSIVE SURVEY FOR THREE TRADITIONAL PORK PRODUCTS OF NAGALAND

Product name: Pork with *Anishi/Silam*/FDS

Respondent No. _____ Mobile No. _____ Date: _____

Name & Address: _____

Gender: _____ (M/F) Education qualification: _____ Community: _____

Family size:

Men: _____, Women: _____, Children: _____, Total: _____

Please tick [] in the relevant questions given below:

1. How often do you prepare *anishi/silam*/FDS with pork in a week?- 2 (1)/3 (2)/ 4(3) /5(4).
 2. Where do you get *anishi/silam*/FDS?- (Home preparation (1) /buy from local market (2) /buy form village (3).
 3. *Anishi/silam*/FDS with pork is prepared for – (lunch (1) /dinner (2) / both (3).
 4. How much dried *anishi/silam*/FDS cake is added per kg of pork (approx.)? – (1/2/3/4)
 5. What is the approximate weight of one dried cake? -gm
 6. How do you add the *anishi/silam*/FDS in pork product? – before cooking (1)/during cooking (2)/ after cooking (3).
 7. Where do you buy pork?- (local market (1)/meat shop (2)/slaughter house (3).
 8. What type of pork is used for cooking with *anishi/silam*/FDS? - fresh (1)/smoked (2).
 9. Which portion of the pork is used for cooking with *anishi/silam*/FDS?- lean meat (1)/fatty (2)/both (3)
 10. How much quantity of pork meat is used for once cooking with *anishi/silam*/FDS for your family?- ½kg (1)/1kg (2) /2kg(3) /3 kg(4).
-

11. What are the ingredients used while cooking pork with *anishi/silam*/FDS? Please list them below.

SN	Ingredients
1	Tomato, Garlic, Green chillies, Ginger and salt.
2	Tomato, Garlic, Green chillies, Ginger, Local pepper and salt.
3	Tomato, Garlic, Green chillies, Ginger, potato and salt.
4	Tomato, Garlic, Green chillies, Ginger, onion and salt.

12. How much quantity of different ingredients are used, say approximately for 1 kg of pork with *anishi/silam*/FDS? -

SN	Ingredients /Quantity (gm)
1	Ginger 10g, green chillies 10 nos., tomato 2 nos., garlic 10g, onion 2 nos., salt 1 ½ tsf
2	Ginger 15g, green chillies 15 nos., tomato 3 nos., garlic 15g, onion 2 nos., salt 2 tsf
3	Ginger 20g, green chillies 20 nos., tomato 4 nos., garlic 20g, onion 3 nos., salt 2 ½ tsf

13. In what form the ingredients are use for cooking pork with *anishi/silam*/FDS? – Powder (1)/paste (2)/both (3).
14. Where do you get the ingredients? (Purchased from local market (1)/from garden (2)/other (3).
15. What is the cost of *anishi/silam*/FDS per kg if you purchased from local market? Rs...../-
16. Presently, what is the cost of pork per kg in the market? Rs.....
17. Do you sell the pork products with *anishi/silam*/FDS in the local market? Yes (1)/No (2). if yes then, what is the price? (Rs.)
18. Do you have any knowledge of the *anishi/silam*/FDS compositions? Yes (1) /No (2).
19. Why do you like to consume *anishi/silam*/FDS cooked with pork? (flavour (1)/ taste (2)/ colour (3)/ other (4).
20. Generally, how much time it takes for you to cook *anishi/silam*/FDS with pork? (15 min (1)/20 min (2)/more (3).

- 21. Who cooked mostly the pork with *anishi/silam*/FDS at home? (Father (1)/mother (2)/children (3).
- 22. Do you cooked pork with *anishi/silam*/FDS during important occasions like marriages /festivals? Y (1) /N (2)
- 23. Where did you learn the cooking method of *anishi/silam*/FDS with pork? (from family members (1) / friends (2)/ self (3).
- 24. How do you cook the *anishi/silam*/FDS with pork? (pressure cooking (1)/steam cooking (2).
- 25. How do you consume the *anishi/silam*/FDS with pork product? (hot cooked (1)/ after cooling (2).
- 26. What is their comment on the nutritive value / food value / belief /etc.....
- 27. Flow chart of the product cooking/processing:

Signature

APPENDIX – II
SCORE CARD FOR TASTE PANEL

Name : _____

Address : _____

Date & Time : _____

Scores under Hedonic Scale

Very Desirable	:	7
Desirable	:	6
Moderately Desirable	:	5
Slightly Desirable	:	4
Slightly Undesirable	:	3
Moderately Undesirable	:	2
Undesirable	:	1

Name of the Product: “ _____ ”

Products	Appearance	Flavour	Juiciness	Tenderness	Overall acceptability
A					
B					
C					
D					

Special comments / suggestions if any:

Signature

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