DEVELOPMENT AND QUALITY EVALUATION OF RETORT POUCH PROCESSED RAMASSERI IDLI

by,

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DECLARATION

We hereby declare that this thesis entitled "DEVELOPMENT AND QUALITY EVALUATION OF RETORT POUCH PROCESSED RAMASSERI IDLI" is bonafide record of research work done by us during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report entitled "Development and quality evaluation of retort pouch processed Ramasseri idli" is a record of project work done jointly by Krishnaprabha (2013-06-011), Rajani S (2013-06-014), Rohitha P R (2013-06-016), under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to them.

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DEDICATED TO ALL FOOD ENGINEERS

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SYMBOLS AND ABBREVIATIONS

%	Percentage
°C	Degree Celsius
°F	Degree Fahrenheit
&	And
/	Per
<	Less than
=	equal to
>	Greater than
±	Plus or minus
≈	Approximate
ALP	Aluminium laminated polypropylene
ANOVA	Analysis of variance
AO	Antioxidant
CA	Controlled atmospheric
CD	Critical Difference
cfu	colony forming unit
C.	Clostridium
DF	Dilution Factor
Eg	Example
et al.,	and others
etc.	Etcetera
F_0	Thermal death time (sterilisation)
FDA	Food and Drug Administration
Ft	Feet
Fig.	Figure
g^{-1}	per gram
H	Hour
HP	High pressure

Ha	Hectare
HTST	High Temperature Short time
i.e.	That is
IS	Indian Standard
ISO	International Organisation for standardisation
IU	International Units
KCAET	Kelappaji College of Agricultural Engineering and Technology
KAU	Kerala Agricultural University
Kg	Kilogram
kJ	kiloJoules
kW	Kilowatt
L	Litre(s)
L^{-1}	Perlitre
M	Metric
MCPP	Metalized co-extruded polypropylene
mg	Milligram
min	Minute (s)
ml	Millilitre
mt	Million tonnes
mT	Metric tonnes
N	Normality, Newton
No.	Number
NS	Non Significant
P	Probability
PPs	Polyphenols
PFA	Prevention of Food Adulteration
ppm	Parts per million
RH	Relative Humidity
RTU	Ready-to-Use

Sec	Second (s)
S	Significant
SD	Standard Deviation
TPA	Texture Profile Analysis
UV	Ultra Violet
UTM	Universal Testing Machine
viz.,	Namely
via	by way of
V	Volt
Wt.	Weight

Introduction

CHAPTER 1

INTRODUCTION

Food is one of the most essential inputs that human beings require for existence. Human beings are used to many varieties of food from the time immemorial. In course of time, man started to develop a culture and way of life. This resulted in formation of divided and unique life style and food habits.

India is the second largest populated country in the world, which is divided into many states territories. These separations have significantly influenced the food culture of the country. Each territory bears a long diverse and deep rooted tradition in their culinary habits and this tradition distinguishes each from the other.

South India is well known for its epic food culture pattern. As far the tourism sector in India is concerned, south India plays a vital role in its popularity and among the highlights, and the food culture of south India achieves telling position. This specialty in the food habit of south India attracts many tourists to the south Indian states which ultimately contribute significantly to the economic stability of the country.

Among South Indian states, Kerala is known for its traditional tastes. Different varieties of ethnic foods are prepared over many parts of Kerala. One among them is the Ramasseri idli which is exclusively available at Ramasseri village near Palakkad. This breakfast food has not only attracted the attention of the people of south India but also has achieved much popularity among the people from foreign countries.

The Ramasseri idlis are soft, moist and steamed cakes that are made from fermented batter consisting of rice and urad dhal (a type of white beans similar to mung beans). The idli is salty with a hint of sourness. These idlis are steamed in stakes of idli plates. The peculiarity of Ramasseri idli over common idlis available in different parts of south India are its shape, feather light texture and earthy aroma acquired from steam cooking in unglazed clay pots. They are cooked only on wood burning stoves using tamarind woods. The idli can be served together with accompaniments to enhance its taste or with the chutney powder which have its own epic taste.

From the context it is understood Ramasseri idli is a slow food which is prepared by elaborate preparation method that do not suit the food habits of hectic society. Due to increased work pressure and formation of nuclear families, there was an exponential increase in demand of ready to eat processed food in developed country like India. Several issues like obesity, diabetes,

high cholesterol, heart problems etc has been attributed to the increased consumption of fast food and ready to eat fried food items. This caught the attention of people towards traditional RTE foods that could be both nutritious and time saving.

Indian food processing industry is primarily export oriented. With exponential growth rate of around 15%, its share in international market is only 1.7%. In order to meet the requirement of keralite who are residing at different parts of world and foreigners who experiment with new tastes, there is an urgent demand of exporting the ethnic food which can also directly benefit to economic development of country.

Fresh Ramasseri idli has a shelf life of one day due to highly perishable nature which necessitate the need for an adequate technology to convert it as a ready to eat product having increased shelf life that make it suitable for marketing and exporting.

Thermal processing is one of the advanced technologies used for the production of packaged shelf stable food products. Although different processing techniques like high pressure processing, ultra sound treatment, ohmic heating etc have been developed for the preservation of foods, retort processing and canning are the most adapted technologies in food industry. Due to high cost of cans used for thermal processing, there was a need of alternative canning system which should not only be economical but also should ensure longer shelf life. Retort pouch, is a flexible laminate package that can combine the advantages of metal cans and plastic package and is a promising solution for thermal processing. The retort pouches are light in weight easy to pack packages which have proved as an effective method for preservation of perishable products. It is either three or four ply laminate usually consisting of polypropylene, aluminum foil, nylon and polyesters. These hermetically sealed pouches can withstand sterilisation temperatures and are able to provide higher shelf life, easy handling and bulk storage of the product.

The procured fresh Ramasseri idli can be packaged with one or two idli with in a pouch together with chutney powder filled in LDPE pouches. Retort pouch processed Ramasseri idli will provide an ethnic RTE slow food that can be revived into its fresh form by just steaming the product for less than a minute. Owing to immense marketing and exporting potential with in the country, a study on “Development of retort pouch processed Ramasseri idli” will provide a new dimension for food processing and packaging industries over India.

Ultimately this project focuses mainly to prepare a shelf stable slow food thereby creating a high demand for the food in foreign countries and make significant increase in the

export of the product. It can produce a good quality food product with minimum cost to the common people. The current study also aims to expand the food industry by developing similar kinds of traditional foods by retort processing.

With this point of view, the current study on “Development of retort pouched Ramasseri idli” has following specific objectives which include,

- Development of shelf stable Ramasseri idli by retort processing.
- Optimisation of process parameters for the production of thermally processed Ramasseri idli
- Study the shelf life and quality parameters of retort pouch packed Ramasseri idli.

Review of Literature

CHAPTER 2
REVIEW OF LITERATURE

The review of work done by the early researchers and literature collection related to retort pouch processing, its advantages, thermal processing of Ramasseri idli and its storage studies are compiled and presented in this chapter.

Recent consumer trends towards healthier and traditional foods have had significant impact on ready to eat foods. 'Ramasseri idli' is an important ethnic food. In this study deals with a brief account of development and quality evaluation of retort pouch processed Ramasseri idli.

2.1 Ramasseri idli

Ramasseri's claim to fame is a simple breakfast dish, the soft flat breakfast cakes called Ramasseri idli. Idli is a staple breakfast dish all over south India. These soft, moist, steamed cakes are made with fermented batter made from rice and urad dal (a type of white beans similar to mung beans). They taste salty with a hint of sourness. Various accompaniments served with it enhance its taste. Traditionally idlis are steamed in stacks of Idli plates. What makes Ramasseri idli special is its shape, feather light texture and an earthy aroma acquired from steam cooking in unglazed clay pots. The Mudaliars of Ramasseri are the traditional cooks who prepare this idli.

2.2 Retort pouch processing

Retorting is the thermal processing used in retort pouching, and it is otherwise termed as sterilisation. It is the unit operation in which foods are sufficiently heated for sufficient time to destroy microbial and enzyme activity. Thermal processing is the primary process in retort pouching. Heating is a type of preservation technique and mostly it consists of heating holding and cooling of the food product. Thermal processing is based on the lethality of the target microorganism which is attained by heating the food with integrated severity higher than the F value of the microbial strain. The target microbial strain, time and the heat required is determined by the pH, water activity, storage temperature and shelf life. Retort processing includes the aggressive application and penetration of heat but recent advancements in packaging led to this revolution of use of flexible laminate pouches. Retort pouches allow for maximum heat penetration and reduction of nutrient losses compared with canning.

Cluter *et al*. (1994) evaluated the shelf life of cling peaches in retort pouches. Fruit source (fresh and frozen) and syrup pH (3.85 and 3.25) were taken as processing variables and 4, 21 and 38°C were selected as the storage temperature. It was reported that sensory colour, texture, acceptability, instrumental colour and sugar composition were greatly affected by pH. Frozen and fresh source peaches at pH 3.85 met shelf life requirements at 21 and 38°C, respectively.

Sabapathy *et al*. (2000) found that retort pouch processing technology has been widely recognized as one of the alternatives to metal cans for producing thermally processed shelf stable foods.

Nair *et al*. (2003) studied a comparison on the thermal processing in retort pouches and canning. It has been found that among thermal processing retort pouch processing has several advantages over canning. They reported that consumption of canned foods was declining due to high cost of tin for making cans acceptable to the market. They concluded that retort pouch could be imprinted, its size and shape are flexible, and it could be displayed on shelves. Foods could be cooked faster in flexible pouches than in cans and it also helped to reduce the cost of delivery and storage.

Awuah *et al*. (2007) pointed that new processing concepts such as the application of variable retort temperature had received attention from processing experts and promises to improve both the economy and quality of thermally processed foods.

Pritty (2013) optimised the thermal process time temperature combination for safe canned tender 'Varikka' jackfruit in context of increasing shelf life by considering microbiological and quality aspect of product. The thermal processing at temperature 90°C for 19 minutes (F value 10) and at temperature 121°C for 38 minutes (F value one) were chosen as the better time temperature combination for pasteurisation and sterilisation. Based on the combined result of microbiological quality, characteristic variability and sensory perception; pasteurising tender jackfruit at 90°C for 19 minutes was chosen as the optimum thermal process treatment for enhancing the shelf life.

Ramaswamy *et al*. (2014) conducted a study on process optimisation and shelf life study of retort processed rose flavored milk. It was found to be stored at ambient temperature without any appreciable loss in terms of physiochemical, microbiological and sensory attributes and could be used as a potential means of product diversification in the dairy industry.

2.3 Storage studies

Jan and Rab (2012) investigated the influence of storage duration on physico - chemical properties of apple fruits. The per cent weight loss, TSS, pH, total sugar, TSS/Acid ratio, bitter pit incidence and soft rot increased with increase in storage duration while starch score, juice content, titratable acidity, Vitamin C, density and firmness of fruit decreased with increase in storage duration.

Lakshmana *et al*. (2013) conducted a study on retort pouch processed ready to eat tender jack fruit curry. The samples were analysed for changes in moisture, fat, free fatty acids, peroxide value, microbiological and texture, sensory quality attributes during storage period. The hardness of the tender jackfruit reduced from 39 N to 9 N at blanching and in retort processed products due to heat induced softening of tissue. After storage studies it was clear that the product was acceptable and stable up to 12 months under ambient condition with good texture and sensory characteristics.

Mohammedali *et al*. (2013) found that traditional thari kanji payasam in retort pouches remained commercially sterile during the entire storage of 12 months at ambient (27-300°C) and elevated conditions (450°C) and hence the product was safe for consumption.

Shelf life study and quality evaluation of retort pouch packed tender jackfruit curry was done by Nadanasabapathi *et al*. (2013). The curry was acceptable and stable with good texture and sensory qualities up to 12 months of storage.

Nitha *et al*. (2015) conducted a study on development of shelf stable jackfruit varatty by thermal processing in retort pouch. Quality evaluation of the stored thermally processed jackfruit varatty were evaluated based on TSS, total sugars, water activity, moisture content, texture and colour. Based on the physico-chemical analysis, the samples stored at refrigerated condition were found to be better than the ambient storage products for all treatments. Apart from quality evaluation, microbiological load of the stored jackfruit varatty was examined at every 30 days interval for a period of 5 months. The number of colony forming units was found to be nil up to first 30 days of storage in all treatments under refrigerated condition except T1 (Pasteurised at 100ºC for F_1 stored at ambient condition).

2.4 Microbiological quality

Commercial sterility for low acid foods may be defined as that condition in which all *Clostridium botulinum* spores and all other pathogenic bacteria have been destroyed as well as more heat resistant organisms if present, could produce spoilage under normal conditions of storage and distribution (Denny, 1970).

According to Awuah *et al*. (2007) the most problematic microorganism was *C.botulinum*, as it could thrive in the anaerobic conditions inside food containers and produce the very dangerous botulinum toxin. For thermal processing of food with a pH above 4.6, the generally accepted limit below which *C.botulinum* cannot grow, and special attention is given to this bacteria.

Abdulsudi *et al*. (2010) concluded that electrolyzed water can be used as alternative to sodium hypochlorite solution for the microbial control in agricultural produces and food.

Aruna and Poonam (2013) conducted microbiological studies and found out negligible plate count (cfu/g) of mould, bacteria and yeast in processed tomato salsa packed in glass jars, cans and retort pouches during four months of storage analysis.

Pritty *et al*. (2014) reported that tender jackfruit pasteurised at 90°C with F value 10 and sterilisation at 121°C with F_0 value one in canning process were microbiologically safe.

2.5 Texture

Textural properties may serve as an indicator of maturity or process ability to the food processor and that of eating quality to the consumer. It includes those qualities that can be felt with the fingers, tongue, palate or teeth. The textural change of softening of the tissue is caused by enzymatic degradation and solubilisation of pectin materials leading to cell separation and decreased resistance to applied forces. The principle of texture profiling has been applied to instrumental texture measurements with universal testing machine using the classification and definition of textural characteristics as the sensory profiling method. In order to predict consumer response to texture via an objective test, correlation of sensory evaluation results with the results of objective test is necessary.

Texture Profile Analysis (TPA) of raw tender jack fruit, blanched and retort processed was carried out using Universal Testing Machine (UTM) equipped with TPA software by Lakshmana *et al*. (2013) and found that the hardness of the tender jack fruit reduced significantly after retort processing due to the heat induced thermal softening of tissues. Further, the changes

in cohesiveness, springiness, gumminess and chewiness were significant in fresh, blanched and retort processed samples. However, the overall texture of retort processed tender jack fruit curry was acceptable.

Guillermo *et al*. (2014) evaluated the effects of freezing, blanching and frozen storage (five months at 18°C) on the physico-chemical qualities of broad beans at milk maturity stage. In sensory evaluation of cooked beans, a significant increase in texture was found in unblanched beans compared with over blanched beans.

2.6 Colour

Colour characteristic of foods are an important quality attribute resulting from both pigmented and originally non-pigmented compounds. The major causative factor of colour in most foods is the presence of a broad array of natural pigments. There are some notable exceptions, such as caramelisation and browning reaction that occur in the food. Natural pigments in foods are determined not only as an index of economic value but also to control colour during processing and storage. Visual perception of colour can be described by three variables namely, hue, value and chroma. Value (lightness) distinguishes between light colour and dark colour, hue distinguishes among red, yellow, green and blue and chroma (saturation or purity) distinguishes between vivid and dull colours. The visual perception of colour is represented by three axes value (L), hue (a) and chroma (b) of hunter calorimeter (Yeshajahu *et al*., 1996).

Gomez *et al*. (1980) studied the effect of ultraviolet-C light dose on quality of cut- apple, microbiological quality, colour and compression behavior. They reported that the colour and compression parameters were found to be dependent on UV-C dose, storage time and type of pre-treatment. At the end of storage, samples exposed to only UV-C light turned darker (lower 'L' values) and less green (higher 'a' value) when compared to fresh-cut-apple slice.

According to Irwin and Singh (1998) colour was critically important in many dimensions of food choice and influence the perception of other sensory characteristics by the consumer. Colour is actually different wavelengths of white light and is the stimulus that result from the detection of light after it has interacted with an object. A colourimeter quantified colour by measuring three primary colour components of light *viz*., red, green and blue. This was usually done by preparing a sample according to directions and comparing its colour against a reference or series of references.

Segini *et al*. (2004) compared the relationship between instrumental and sensory analysis of texture and colour of potato chips. Parameters like fracture force, deformation and stiffness were measured by a puncture test using an Intron Universal testing machine. The instrumental colour quantification was done by computerised video image analysis technique and the colour was expressed as L*, a*, b* values. Sensory evaluation of texture and colour was performed by a sensory panel specially trained in evaluating potato chips.

Pua *et al*. (2008) conducted an experiment on storage stability of jackfruit powder packaged in Aluminium laminated polyethylene and metalized co- extruded biaxial oriented poly propylene. The total colour difference (ΔE), rates of adsorbed moisture and sensory attributes of drum-dried jackfruit powder packaged in Aluminium laminated polyethylene (ALP) and metalized co-extruded biaxial oriented polypropylene (BOPP/MCPP) pouches stored at accelerated storage (38°C, with 50%, 75°C and 90% relative humidity (RH)) were determined over 12 weeks period. The changes in total colour followed zero order reaction kinetics. The powder packaged in ALP significantly ($P < 0.05$) reduced total colour change, rates of adsorbed moisture, lumpiness intensity of jackfruit powder and was rated higher in terms of overall acceptability over BOPP/MCPP.

Study on retort processed rose flavoured milk was done by Prem *et al*. (2014). The various colour indices L*, a* and b* are found to decrease during the storage and it had been concluded that the degradation of colour was due to Maillard reactions, increasing storage temperature and non-enzymatic spoilages.

Guillermo *et al*. (2014) evaluated the effects of freezing, blanching and frozen storage (five months at 18°C) on the physico - chemical qualities of broad beans at milk maturity stage. Five months frozen storage caused 34% and 31% degradation in total chlorophyll in, over blanched beans and minimally blanched beans, respectively. Maximum colour value variation was observed for fresh beans followed by blanched beans and frozen beans.

2.7 Moisture content

Free water in products was jointly responsible for the growth of undesirable organism such as bacteria or fungi, which produce "toxins" or other harmful substances. But also chemical/biochemical reactions (e.g. the Maillard reaction) increasingly takes place and possibly change the following factors of a product: microbiological stability, chemical stability, content of

proteins and vitamins, colour, taste and nutritional value, stability of the compound and durability, storage and packing, solubility and texture.

Ashaye *et al*. (2006) the moisture content of Roselle jam from dark-red Roselle calyx under cold storage was significantly higher than other Roselle jam samples at 2^{nd}, 4^{th} and 6 weeks of storage. The dry matter content of stored Roselle jams was less than 72% with that processed from light red variety and stored under cold temperature being significantly higher than other jam samples at 2^{nd} and 4^{th} week of storage. There was also no definite pattern in the dry matter content of the jams.

Ashaye *et al*. (2006) concluded that fluctuations in the moisture and dry matter contents were due to the activity of microorganisms and catabolic enzymes produced by them.

2.8 Water activity

In the bound state water is not available to participate in the biological reactions as it is bound by water soluble compounds such as sugar, salt gums, etc (osmotic binding), and by the surface effect of the substrate matrix binding (Gustavo and Canovas, 2007).

2.9 Sensory evaluation

According to ISO (5492) 1992, sensory evaluation is the examination of organoleptic attribute of a product by the sense organ.

Costell and Duran (2012) explained that texture was a primary attribute that, together with taste, visual appearance and aroma comprises the sensory quality of food. The only way to evaluate sensory quality or some of its attributes (i.e., result of sensation experienced by human when consuming food) was to ask the opinion of the consumer, since sensory quality was not an intrinsic food characteristic, but the result of interaction between human kind and food.

Aruna and Poonam (2013) reported sensory score for processed tomato salsa packed in glass jars, cans and retort pouches during four months of storage analysis. The score was in the order of glass jars (refrigeration temperature) > cans > glass jar (room temperature) > retort pouch (refrigeration temperature) > retort pouch (room temperature).

Sensory evaluation of retort processed thari kanchi payasam (by 9 point Hedonic Scale) was done by Mohammedali *et al*. (2013). There was decrease in the colour, flavour, taste, texture and overall acceptance of the product under ambient and elevated temperature. There was greater decrease in the scores for elevated temperature than ambient storage.

Effect of storage on sensory score of badam flavoured milk was studied by Prem *et al*. (2014). There was decrease in colour, flavour and overall acceptance of the product during the course of storage.

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the experimental setup and techniques used for production of retort pouch processed Ramasseri idli. It also describes about the standardised method to carry out quality evaluation and storage studies of retort processed Ramasseri idli.

3.1 Sample collection

Prepared Ramasseri idli were procured from Ramasseri village, near Palakkad. It was brought as fresh and was used for experiments.

3.2 Estimation of Physico-chemical characteristics

3.2.1 Moisture content

Moisture content of raw and processed Ramasseri idli was determined by using hot air oven method. About 5 g of product was weighed and dried at 100°C until a constant weight was obtained. The moisture content was measured in wet basis and expressed as percentage (%).

$$\textbf{Wet Basis\% (wb)} = (Mi - Mf)/Mi$$

$$\textbf{Dry basis \% db} = (Mi - Mf)$$

where, Mi - Initial weight of sample

Mf - Final weight of sample

3.2.2 Water activity

Water activity refers to the unbound water, which can support the growth of microorganism. It is the partial vapour pressure of water in a substance divided by the standard state partial vapour pressure of water. In the field of food science standard state is most often defined as the partial vapour pressure of pure water at the same temperature. The water activity was measured by using water activity meter by placing sample in a small cup which is placed in a sealed chamber and then the knob is closed to read the water activity of the sample. Each sample was replicated three times and its mean value was taken as the water activity of the sample.

3.2.3 pH

pH is the logarithm of the reciprocal of hydrogen ion concentration or measure of active acidity. Change in pH will affect the flavour and overall acceptance of product. By using digital pH meter, pH of raw and processed samples was analysed. The pH meter was standardised with buffer solutions of different pH. Each sample was replicated four times and its mean value was taken as pH of the sample.

3.2.4 Texture profile analysis (TPA)

The texture is an important quality parameter which affects the overall acceptability of consumer. Textural properties of the samples were analysed by using textural analyser (Plate 3.1) which had a microprocessor regulated texture analysis system interfaced to a personal computer. Cylindrical probe of diameter of 5 mm was used. Textural analyser provides a three- dimensional product analysis by measuring force, distance and time. The sample was placed in a flat platform of textual analyser and was subjected to compression by the probe. The test was conducted at the pretest speed of 0.5 m/s, test speed of 1 m/s and post test speed of 10 m/s.

Plate 3.1 Texture Analyser

3.2.5 Colour

Colour is used as an index to the quality of number of foods. Hunter Lab colour flex meter (plate 3.2) was used for the measurement of colour. It works on the principle of collecting the light and measures energy from the sample reflected across the entire visible spectrum. The

system provides reading in terms of L*, a*, b* values. ‘L*’ represents light - dark spectrum with a range from 0 (black) to 100 (white), ‘a*’ is the green-red spectrum with a range from - 60 (green) to + 60 (red) and ‘b*’ represents blue-yellow spectrum with a range from - 60 (blue) to + 60(yellow) dimensions. Each sample was replicated three times and its mean value was taken as result.

Plate 3.2 Hunter lab Colourimeter

3.2.6 Total plate count (TPC)

Microbiological analysis was done to analyse the presence of microbes which may cause the deterioration of the product during storage. It involves the detection of bacteria, yeast and fungi etc. An average of two replications was chosen as the final reading for each sample. Microbiological analysis was performed for the quantification and identification of microorganisms. Nutrient agar was used for bacteria culture.

3.2.7 Sensory analysis

It was done by using 5-point sensory scale. Sensory analysis helps in measuring human responses to the composition of food, comprising colour, flavour, texture and overall acceptability. It is combination of experimental design and statistical analysis to use the human senses for the purpose of evaluation.

3.3 Thermal processing

Thermal processing was done in retort pouch, which is laminates of plastic films and metal foils. It has high strength and can withstand the sterilisation temperature. This three layers

consist of exterior polyester (12.5 μm), middle Aluminium foil (12.5 μm) and interior cast polypropylene (75 μm) layer (plate 3.3). This layer is made up of three or more layers. The outer most layer is polyester, which has good printability and strength. The middle layer is aluminum which act as a barrier for light, odour, gas, the inner most layer is food grade polypropylene which provide high sealability, flexibility and strength to the pouch. Physical properties of retort pouch are listed in Table 3.1

Plate 3.3 Retort pouches

Table 3.1 Physical properties of retort pouch

Properties		**Values**
Thickness (μm)	Total	100
	Polyester	12.5
	Al Foil	12.5
	Cast PP	75
Tensile strength (kg/cm^2)	Machine direction	460
	Cross Direction	430
Tensile strength (kg/cm^2)	Machine direction	45
	Cross Direction	35
Heat seal strength (kg/cm^2)	Machine direction	390
	Cross Direction	380
Bond strength (g /10 mm)		180
Pouch burst strength (psig)		30
OTR (ml/m^2/ 24 h at 1 atm. & at 25°C)		0.35
WVTR (g/m^2/24 h at 37°C & 90% RH)		0.02

Global migration residue (mg/dm^2)(maximum limit value:10 mg/dm^2)	Water extractives at 121°C for 2 hour	0.60
	3% Acetic acid extractives at 121°C for 2 hour	0.25
	n-heptane extractives at 66°C for 2 hour	1.7

3.3.1 Pouch filling, exhausting and sealing

One idli per packet was filled manually in the retort pouch. After filling the retort pouch, the sealing was done using a sealing machine (Plate 3.4) at a pressure of one bar and voltage of 38 V.The sealing time and the cooling time required were 6 s and 15 s respectively.

Plate 3.4 Sealing machine

3.3.2 Positioning of thermocouple in retort pouch

The hermetically sealed retort pouches were loaded into the perforated aluminium trays and placed into retort processing chamber. One of the pouches was fixed with a thermocouple sensor. The sensor tip was inserted into the Ramasseri idli for recording core temperatures.

Plate 3.5 Filling of pouches in retort

3.3.3 Thermal processing

The retort unit consisted of a steam generator at the bottom, retort processing chamber in the middle and water storage tank at the top. All these units along with control panel were mounted on a stainless steel frame. The steam generator or boiler is internally divided into two portions and a pressure gauge is attached to it. One portion is to boil water and produce steam with a capacity is 30 kg and the other one is to store steam for retort processing. A glass tube is attached to one side of the boiler to indicate the water level in the boiler. The retort or processing chamber is made up of 3 mm thick stainless steel plate having a diameter of 350 mm and 400 mm length. The chamber contained four spraying rods: One at the top to spray water, two on either side to spray steam and one at the bottom to release compressed air. Two temperature measuring probes are inserted into the processing chamber through the provision at the top to measure the temperature of processing chamber and the temperature of the product inside the pouch. Removable stainless steel loading tray with thirteen aluminium molds occupies the chamber. The retort is fitted with safety valve, pressure gauge and manually operated air vent

outside the chamber. An overhead stainless steel tank with a capacity of 200 litres of water, used for various processing operations, is provided with the lid to cover the tank.

F value is defined as the time needed to reduce microbiological numbers by a multiple of D value. F_0 value is used to describe process that operates at 121.1°C which are based on the microorganism with Z value of 10°C. Pritty *et al*. (2014) optimised the thermal processing for canned 'Varikka' tender jackfruit for both pasteurisation and sterilisation (Sterilisation was done at $F_0 = 1$ and pasteurisation at $F = 10$). The same F_0 and F values were considered for this research. Retort pouch processing was done in the lab scale retorting machine in the food processing lab of FAPE department. Process times were determined using the cold point method with the help of valsuite software that optimise a suitable combination of time and temperature. The cooling mode cools the product. After thermal processing in retort chamber, the hermetically sealed pouches were surface dried and stored for shelf life studies at ambient temperature as well as refrigerated conditions.

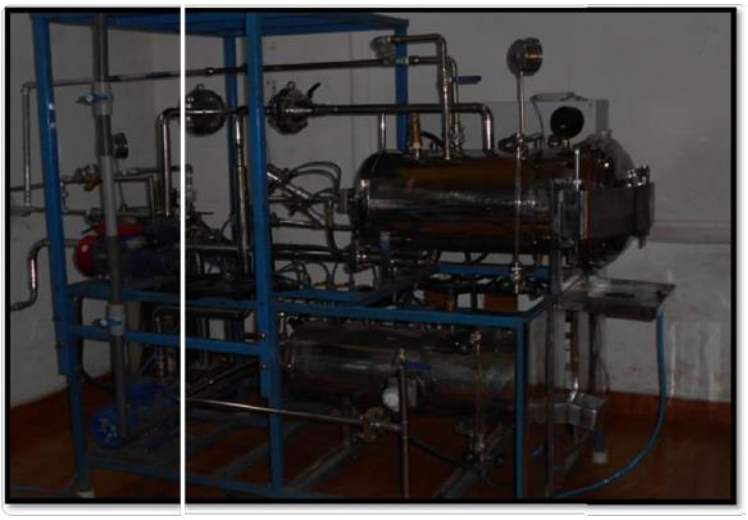


Plate 3.6 Retort machine

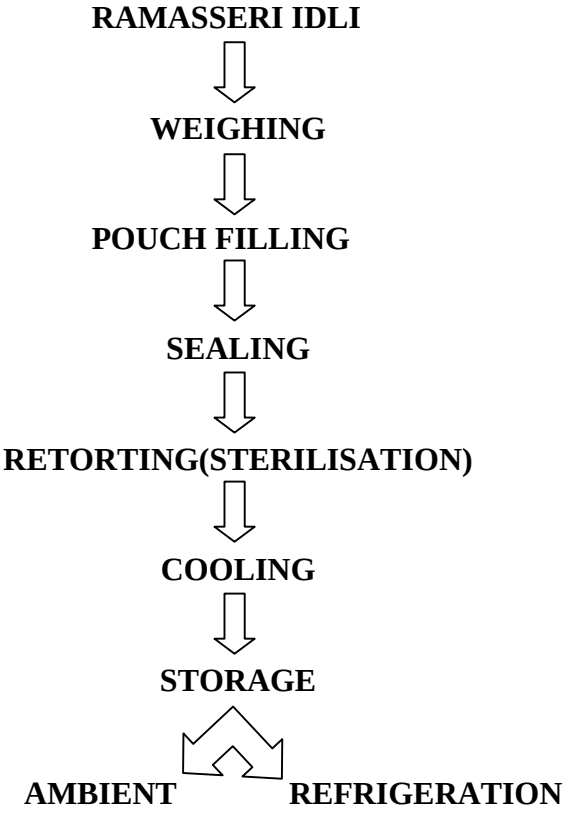
3.4 Stanardisation of time-temperature combinations for thermal processing of Ramasseri idli

The different F value- temperature combinations selected for the standardisation of Ramasseri idli are shown in Table 3.2. These were further tested for Time-Temperature combination and the analysis was done. The current temperature was taken as 100°C and 110°C and the flow chart for the production of thermally processed Ramasseri idli is given in Fig 3.1.

Table 3.2 Standardisation of time-temperature combinations for thermal processing of Ramasseri idli

Sample	Treatment
T1-R	Sterilised at $110^{O}C$ for F_1 stored at refrigerated condition
T1-A	Sterilised at $110^{O}C$ for F_1 stored at ambient condition
T2-R	Sterilised at $110^{O}C$ for F_2 stored at refrigerated condition
T2-A	Sterilised at $110^{O}C$ for F_2 stored at ambient condition
T3-R	Sterilised at $100^{O}C$ for F_1 stored at refrigerated condition
T3-A	Sterilised at $100^{O}C$ for F_1 stored at ambient condition
T4-R	Sterilised at $100^{O}C$ for F_2 stored at refrigerated condition
T4-A	Sterilised at $100^{O}C$ for F_2 stored at ambient condition

Fig 3.1. Flow chart for the production of thermally processed Ramasseri idli.



3.5 Physico-Chemical and microbiological analysis of processed Ramasseri idli.

Physico-chemical characteristics *viz*., moisture content, water activity, pH, colour, textural properties, microbial content etc of Ramasseri idli were estimated according to procedures explained in section 3.1. Microbiological analysis was performed using standard plate count method. Microbiological analysis was performed for the quantification and identification of microorganisms. Detection of bacteria was done using total plate count method. Enumeration of bacteria, yeast and fungus were done by serial dilution and plating method. Nutrient agar was used for bacteria culture.

3.5.1 Standard plate count method

This method allowed the growth of microorganism in nutrient culture Petri plate and the colonies developed were counted. One gram of sample was mixed in 100 ml of distilled water. From the prepared sample, one ml (Ws) was then added to 90 ml of sterile water (10^{-1} dilution) and shaken well for 10 to 15 minutes to assure uniform distribution of microorganisms. Then one ml of this diluted sample was transferred to sterile Petri plate with a sterile micro pipette. Molten and cooled nutrient medium (15 to 20 ml) at 45°C conducive for the growth of the specific organism was added to respective Petri plates. The plates were rotated clockwise and anticlockwise for the thorough mixing of diluent and the medium. Then the Petri plates were incubated at 37°C for one to two days, for the bacterial growth. After the incubation period, the colonies (cfu) were counted and the number of microbiological organisms per gram of sample (Ns) for dilution factor (DF) was calculated as given below

$$\mathbf{Ns = (Ncfu \times DF)/Ws}$$

3.6 Storage Studies

The thermally processed Ramasseri idli in retort pouches were stored for three weeks and shelf life studies were conducted. One Ramasseri idli per packet were stored in ambient condition (temperature at 37°C) and in refrigerated condition (7°C). The following parameters were tested in every one week interval upto three weekends. Final analysis was done after three weeks of storage.

1. Moisture content
2. Water Activity
3. pH
4. Firmness
5. Colour
6. Microbiological analysis
7. Sensory evaluation

3.7 Experimental Design

The independent and dependent variable considered in this study are as follows

Independent variables

- Ambient temperature
- Refrigerated temperature
- Processing temperature
- Processing time

Dependent variables

- Moisture content
- Water activity
- pH
- Firmness
- Colour
- Microbial content
- Sensory evaluation

3.8 Sensory analysis

Sensory analysis is a scientific approach that analyses and measures human responses to the composition of food, comprising colour, taste, texture and overall acceptability. It is combination of experimental design and statistical analysis to use the human senses for the purpose of evaluation. Sensory evaluation of Ramasseri idli was done by 5 point sensory scale. The 5 points in the sensory scale are:

5-Like very much; 4-Like; 3-Neither like nor dislike; 2: Dislike; 1: Dislike very much

3.9 Cost economics

The cost of production of thermally processed Ramasseri idli was estimated by considering the fixed and variable costs. Fixed costs were calculated based on depreciation cost of machines and capital interest of investment. The variable cost of unit was calculated by considering electricity charges, repairs and maintenance, raw materials and cost of labour. Cost analysis is given in Appendix D

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter deals with result and discussion of various experiments conducted to standardise thermally processed Ramasseri idli. Result of shelf life studies of processed Ramasseri idli stored at refrigerated and ambient conditions were presented and critically analysed by comparing with published literature.

4.1 Physico-chemical and microbial characteristics of fresh Ramasseri idli

The estimated composition and quality parameters of fresh unprocessed Ramasseri idli are represented in table 4.1. The initial pH of idli was found to be 5.50. The average value of moisture content and water activity of idli were estimated to be 69.9% (wb) and 0.8725. The Ramasseri idli was white in colour which is indicated by an L* value of 76.183, a* value of 0.077, and b* value of 11.12. The texture profile analysis indicated that the firmness of fresh sample was 1.175 N and the initial microbiological count of the sample was 6 x103 cfu/ml.

Table 4.1 Physico–chemical and Microbiological characteristics of fresh Ramasseri idli

Physico-chemical characteristics		**Result**
Chemical characteristics		
Moisture% (wb)		69.9
pH		5.50
Water activity		0.8725
Physical characteristics		
Colour	L^*	76.183
	a^*	0.077
	b^*	11.12
Texture	Firmness (N)	1.175
Microbiological analysis		
Microbiological load ($x10^3$cfu/ml)		6

4.2 Optimisation of Thermal Processing

The time required to thermally process retort pouched Ramasseri idli to a sterilisation temperature of 100°C and 110°C for F value 1 and 2 was determined. The heating and cooling behavior of product was determined by inserting thermocouple at the centre of retort pouch filled with idli. The purpose of heat penetration study was to determine the heating and cooling behavior of a product or package combinations in a specific retort system for the establishment of safe thermal process. Several factors like product conditions, packaging material and processing conditions can contribute to the variation in the time temperature data gathered.

The heat penetration curve thus obtained comprising of time temperature data were plotted in a semi log paper as shown in Fig 4.1, 4.2, 4.3, and 4.4. The thermal processing time and temperature were standardised based on storage studies.

Based on the Ball's formula and heat penetration curve, the total process time for sterilisation at 100°C to reach F value 1 and F value 2 were 27 min and 33 min, respectively. Similarly, the total process time for sterilisation at 110°C to reach F_1 and F_2 were 35 min and 45 min, respectively.

Mohammedali *et al*. (2013) processed Thari kanchi payasam and reported that the total process time was 35 min with a F_0 value of 3.64. The thermal processing time-temperature combination was optimised based on the storage studies.

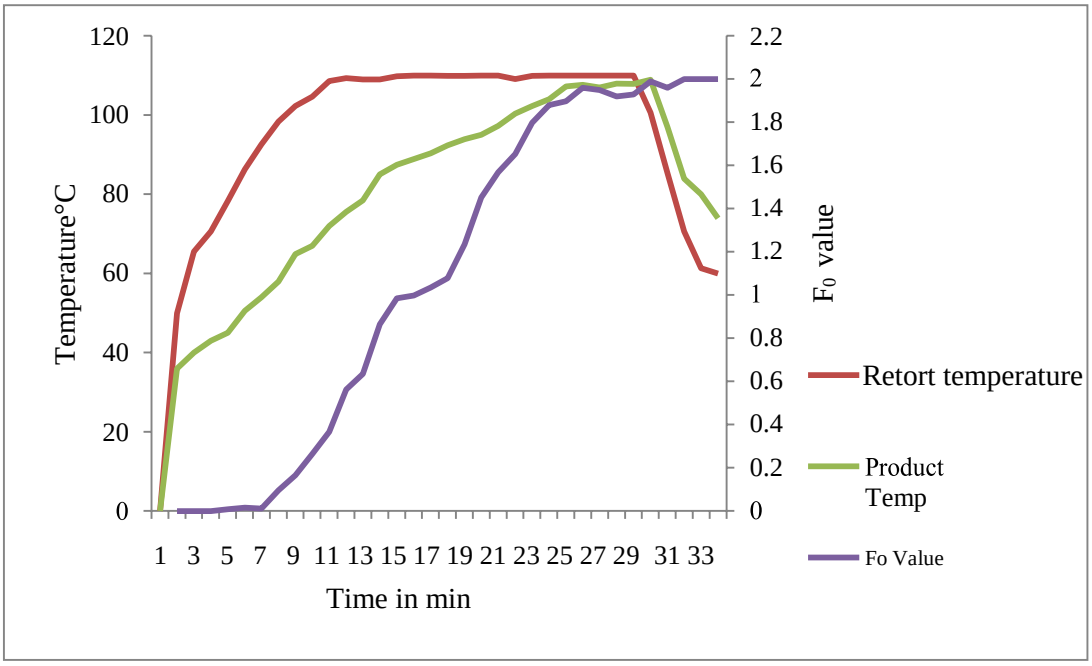


Fig 4.1 Heat penetration characteristics for sterilisation (110°C F_1)

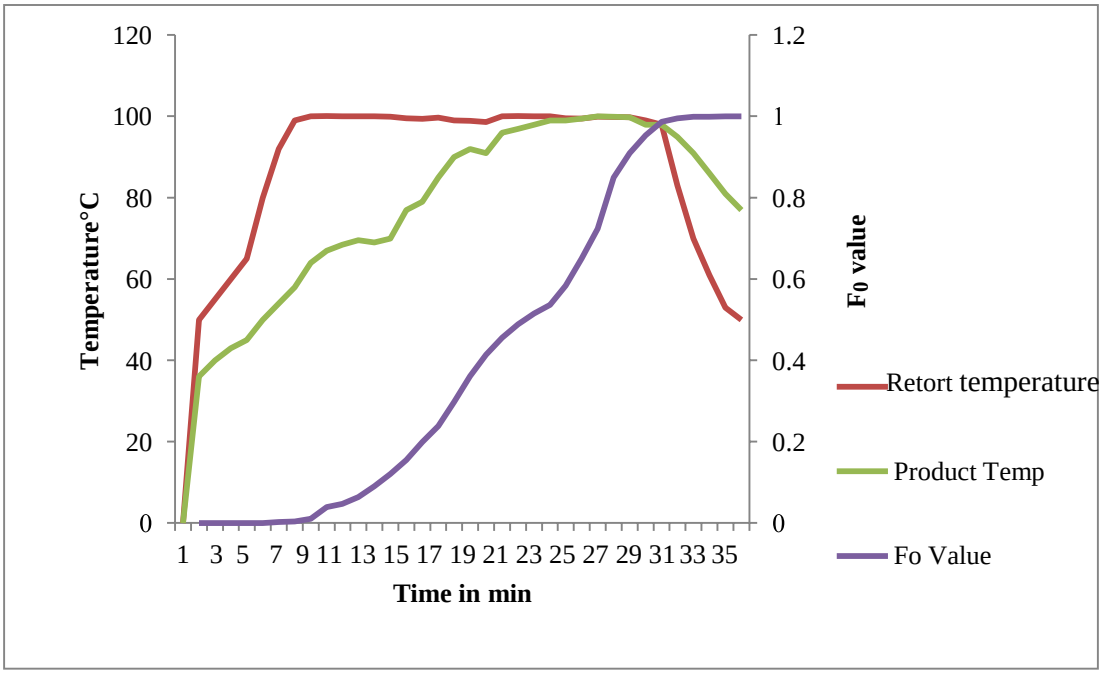


Fig 4.2 Heat penetration characteristics for sterilisation (110°C F_2)

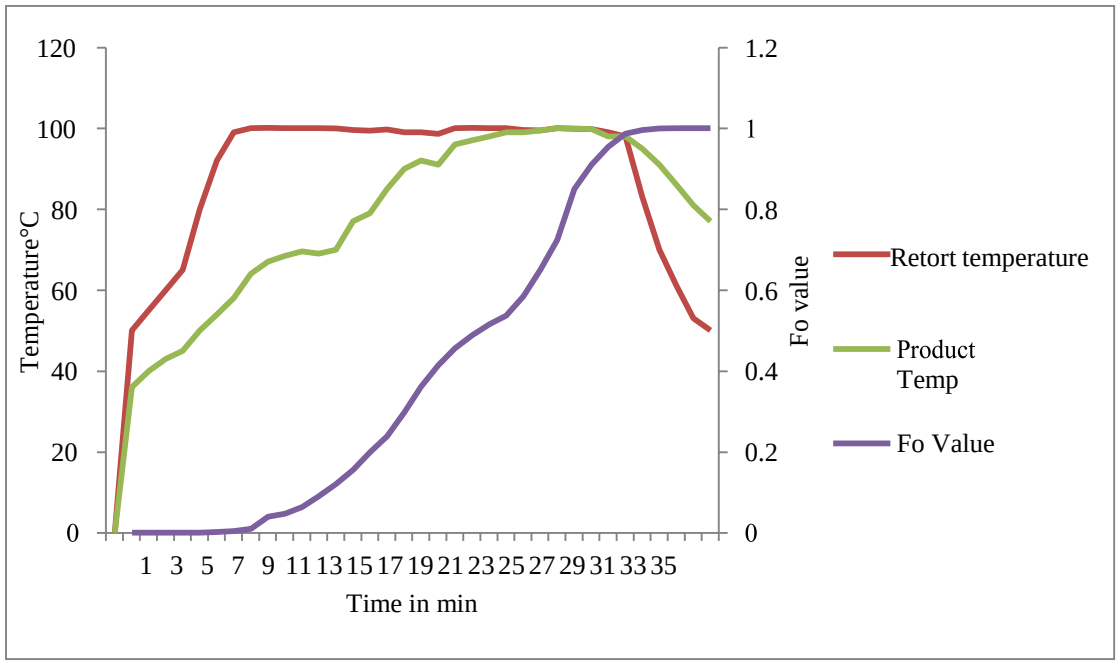


Fig 4.3 Heat penetration characteristics for sterilisation (100°C F_1)

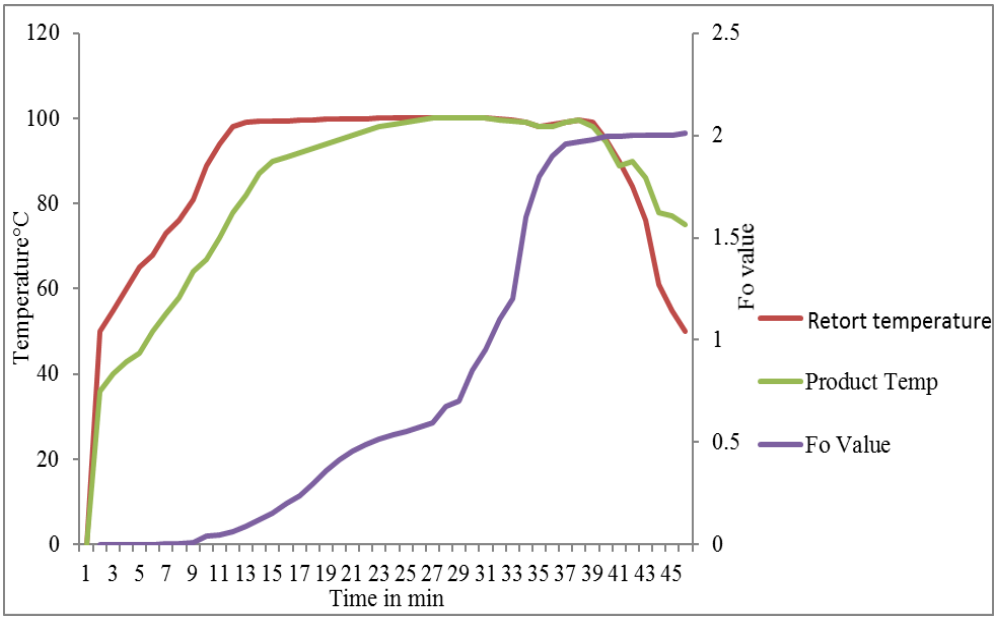


Fig 4.4 Heat penetration characteristics for sterilisation (100°C F_2)

Table 4.2 Physico-chemical and microbiological characteristics of thermally processed Ramasseri idli

Physico-chemical characteristics		**Result**
Chemical characteristics		
Moisture% (wb)		68.9
pH		5.40
Water activity		0.667
Physical characteristics		
Colour	L^*	77.183
	a^*	0.167
	b^*	12.12
Texture	Firmness (N)	1.075
Microbiological analysis		

Microbiological load (x10^3cfu/ml)	Nil

4.4 Quality evaluation of thermally processed Ramasseri idli during storage

4.4.1 Effect of moisture content during storage

A slight increase in moisture content of the retort packaged Ramasseri idli during storage was noted (Fig 4.5, 4.6) which was not significantly varying from initial readings. The moisture content of processed Ramasseri idli at the initial day of packaging for various treatments was 68.4, 69.01, 69.26, and 69.3. The moisture content of processed Ramasseri idli for different treatments T1, T2, T3, and T4 after four weeks of storage stored at refrigerated conditions were 70.25, 70.012, 70.36, and 70.69 respectively. Similarly, moisture content at ambient conditions was 70.86, 71.011, 70.654, and 71.165 respectively.

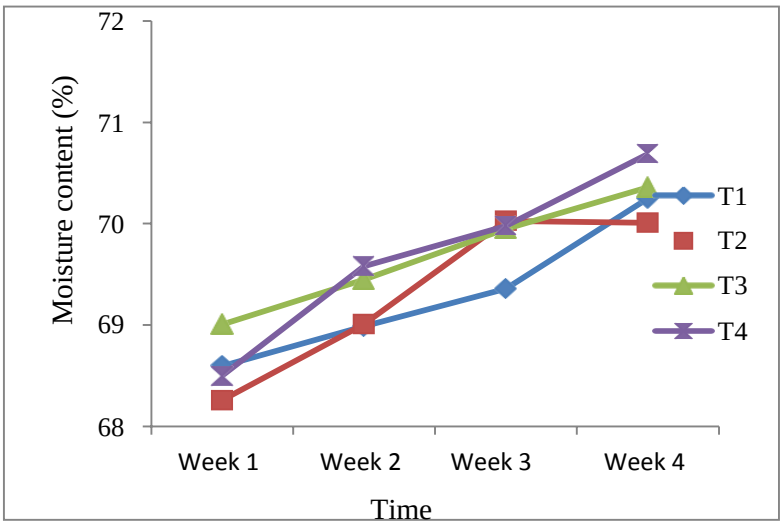


Fig 4.5 Effect of moisture content during storage at refrigerated condition

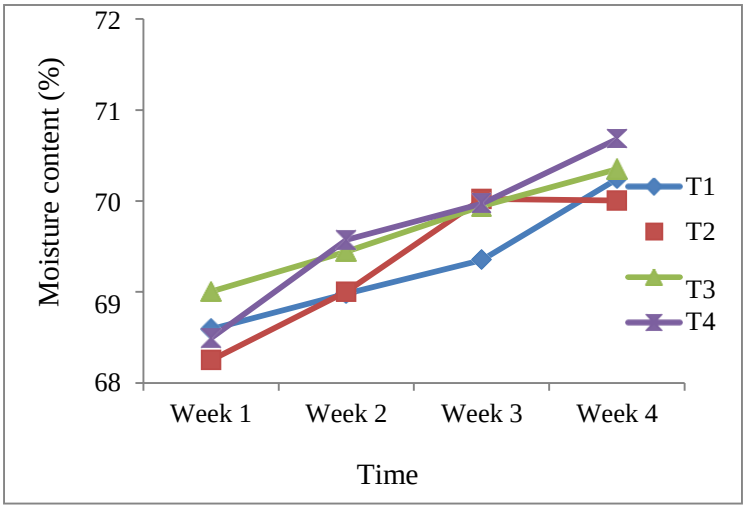


Fig 4.6 Effect of moisture content during storage at ambient condition

4.4.2 Effect of pH during storage

The effect of storage period on firmness value of stored Ramasseri idli under different storage conditions are shown in Fig 4.7 and Fig 4.8.

The pH of Ramasseri idli was found to be decreasing during storage period. The reduction in pH was more pronounced in ambient storage than at refrigerated storage. The values obtained after four weeks of storage at refrigerated conditions for following treatments T1, T2, T3, and T4 were 5.29, 5.32, 5.42, and 5.2 respectively. Similarly, the values obtained at ambient conditions after four weeks of storage were 5.35, 5.3, 5.38, and 5.32 respectively.

It was reported that the influence of temperature decreases pH. Similar trend was also observed during storage by Prince Devadason *et al*. (2010) in retort processed buffalo meat block. This might be due to degradation of proteins and liberation of free amino acids.

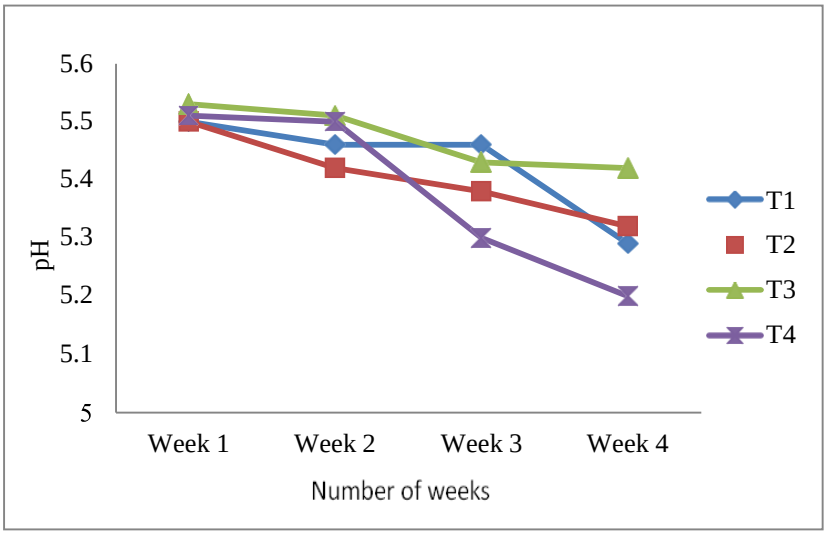


Fig 4.7 Effect of pH during storage at refrigerated condition

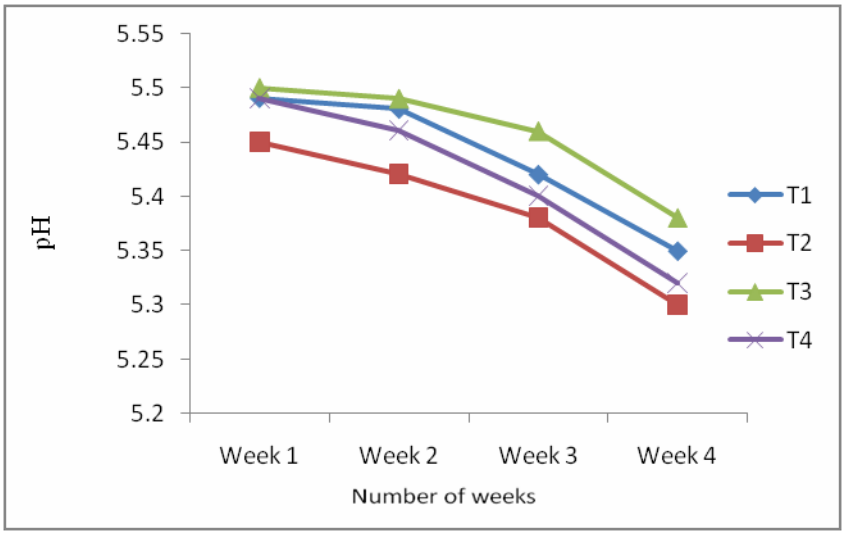


Fig 4.8 Effect of pH during storage at ambient condition

4.4.3 Effect of water activity during storage of thermally processed Ramasseri idli

The effects of storage on water activity of Ramasseri idli under ambient and refrigerated conditions respectively are depicted in Fig 4.9 and 4.10. The water activity of processed Ramasseri idli increased slightly with storage period for both ambient and refrigerated stored product. The increase in water activity was more pronounced in ambient sample than refrigerated sample. After four weeks of storage, the water activity of Ramasseri idli stored at refrigerated conditions was increased to 0.674, 0.675, 0.672, and 0.673 for treatments T1, T2, T3, and T4 respectively. Similarly, the water activity of processed Ramasseri idli stored at ambient conditions was increased to 0.673,

0.676, 0.674, and 0.673 respectively for treatments T1, T2, T3, and T4.

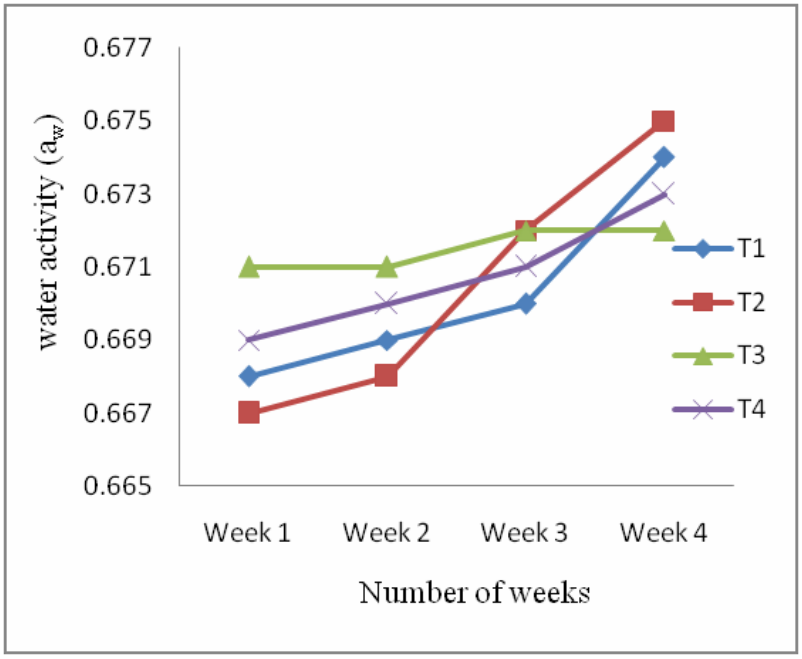


Fig 4.9 Effect of water activity during storage at refrigerated condition

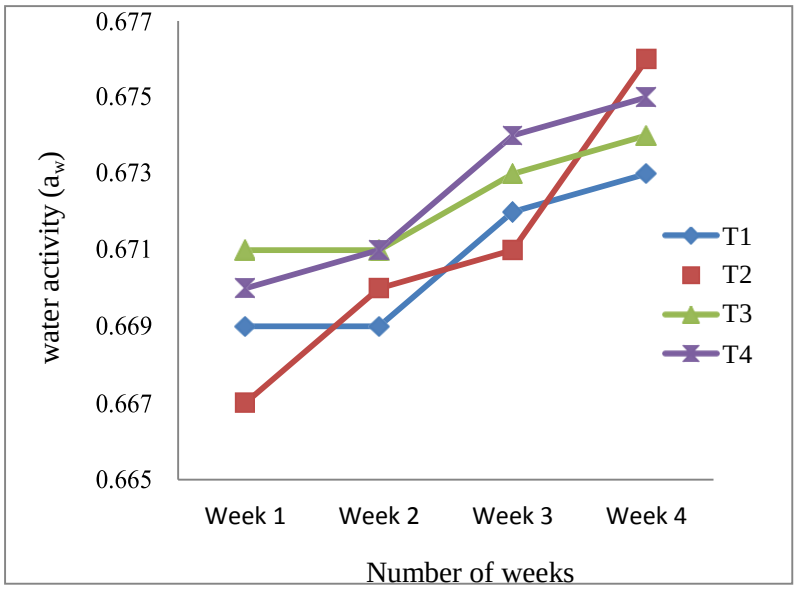


Fig 4.10 Effect of water activity during storage at ambient condition

4.4.4 Effect of colour during storage of thermally processed Ramasseri idli

Change in food colour is associated with heat treatment of the food. Retention of food colour after thermal processing may be used to predict the extent of quality deterioration of food resulting from exposure to heat (Seonggyun *et al*., 1995).

4.4.4.1 Effect of storage on L* value

The effect of storage period on L* value of stored thermally processed Ramasseri idli under ambient and refrigerated conditions are presented in Fig 4.6 and 4.7.

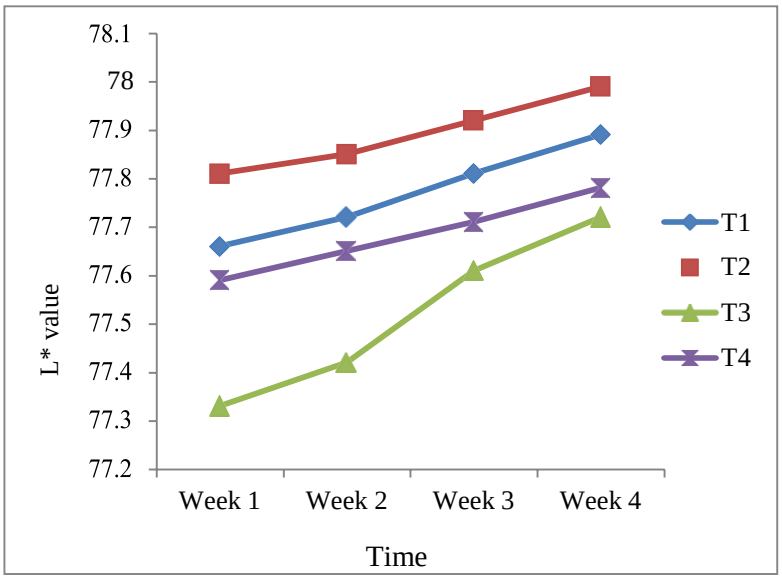


Fig 4.11 Effect of L* value during storage at refrigerated conditions

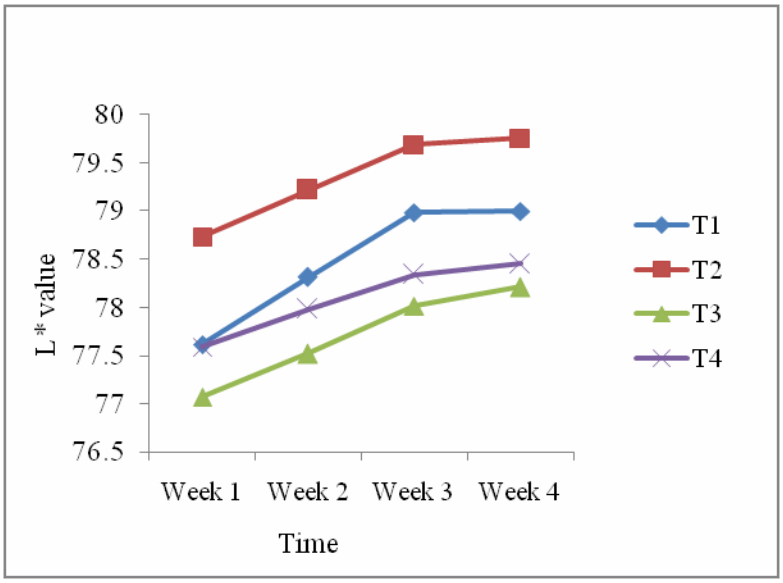


Fig 4.12 Effect of L* value during storage at ambient condition

From the figure it was observed that the L* value of the samples increased with storage period. Also, the sample stored at refrigerated conditions showed less increase in L* values compared to ambient storage. It may be due to less reaction rate at lower temperature.

L* value of the thermally processed Ramasseri idli during the initial day of packaging for treatments T1, T2, T3, and T4 were 78.09, 75.06, 77.49, 78.046 respectively. After 4 weeks of storage, the L*values obtained for Ramasseri idli stored at refrigerated temperature for treatmentsT1, T2, T3, and T4 were increased to 77.63, 77.52, 77.41, and 77.31, respectively. The L*values of processed Ramasseri idli stored at ambient conditions were 77.155, 77.52, 77.43, and 77.32 respectively. It could be seen that with a drop in pH value below 4.5, an increase in the lightness index (Barbut, 2010) could be observed. These changes in colour are due to protein denaturation and coagulation caused by the acid production (NGAPO; Wilkinson; Chong, 1996; Barbut, 2005).

4.4.4.2 Effect of storage on a* value

The effect of storage period on a* value of thermally processed Ramasseri idli under different treatments and storage conditions are presented in Fig 4.13 and Fig 4.14.

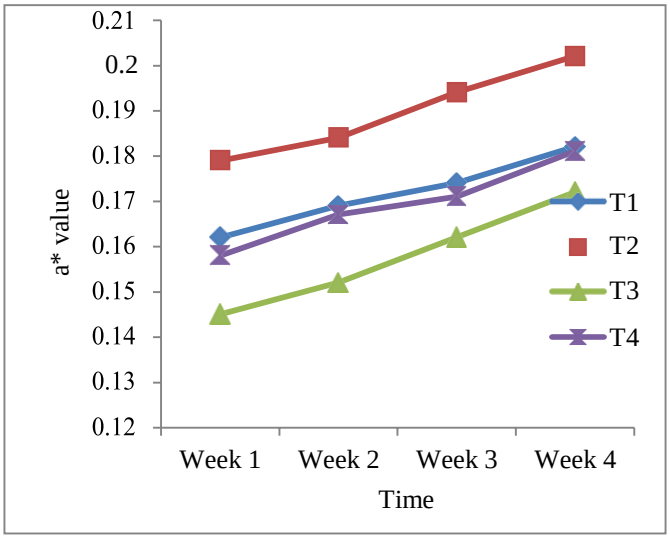


Fig 4.13 Effect of a* value during storage at refrigerated conditions

The red intensity (a*) is the most sensitive parameter for measuring colour, red colour characterisation, and colour stability (Garcia-Esteban *et al*., 2003). It was observed that storage of the samples resulted in slight increase of the redness. The increase in a* value was higher at ambient storage than at refrigerated storage for all treatments. The a* value of processed

Ramasseri idli at the initial day of packaging for various treatments T1, T2, T3 and T4 were 0.116, 0.176, 0.128 and 0.109, respectively. After 4 weeks of storage, the a* values obtained for Ramasseri idli stored at refrigerated temperature for treatments T1, T2, T3, and T4 were 0.182, 0.202, 0.172, and 0.181, respectively. Similarly, a* values of processed Ramasseri idli stored at ambient conditions after four weeks of storage were found to be 0.193, 0215, 0.177, and 0.186, respectively.

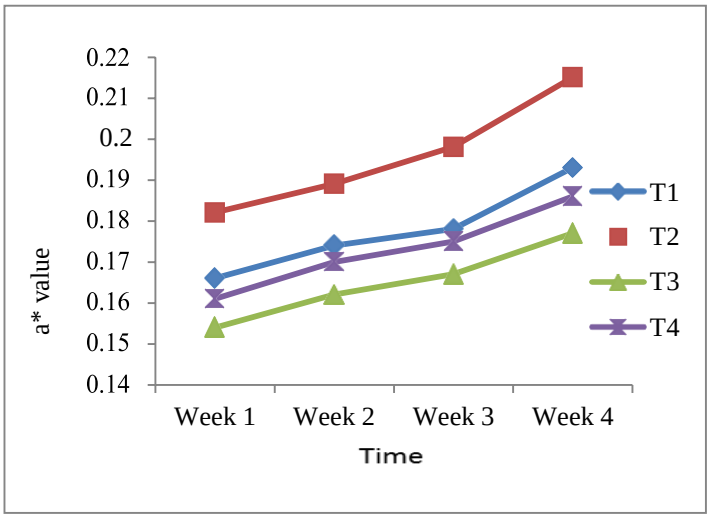


Fig 4.14 Effect of a* value during storage at ambient conditions

4.4.4.3 Effect of storage on b* value

The effect of storage period on b* value of thermally processed Ramasseri idli under different treatments and storage conditions are shown in Fig 4.15 and Fig 4.16.

It was observed that there was an increase in b* value for both ambient and refrigerated stored Ramasseri idli during storage. The b* value of processed Ramasseri idli at the initial day of packaging for various treatments T1, T2, T3, T4 were 11.41, 12.673, 12.47, 12.003 respectively. After four weeks of storage the b* values of Ramasseri idli stored at refrigerated temperature for different treatments stored at refrigerated conditions are T1, T2, T3, T4 were 11.99, 12.247, 11.709, and 11.864 respectively. Similarly, the b* values at ambient storage for different treatments were 12.015, 12.112, 11.847, and 11.875, respectively.

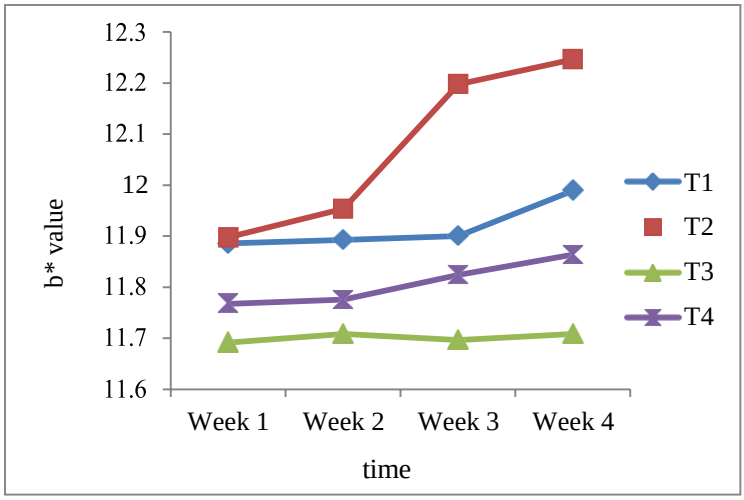


Fig 4.15 Effect of b* value during storage at refrigerated condition

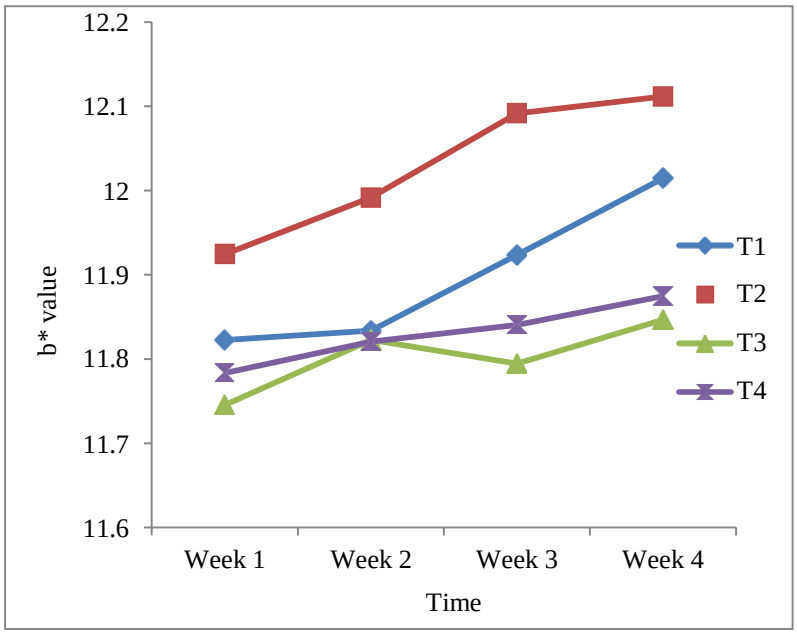


Fig 4.16 Effect of b* value during storage at ambient condition

4.4.5 Effect of firmness during storage

The effect of storage period on firmness value of stored Ramasseri idli under different storage conditions are shown in Fig 4.17 and Fig 4.18.

Refrigerated sample showed more pronounced increase as compared to the ambient sample though there was only negligible increase in firmness. The firmness that is increased can be brought back by steaming the idli for one minute. The firmness value of processed Ramasseri

idli at the first week of packaging for treatments T1, T2, T3, and T4 were 0.8267, 0.5543, 0.8257, and 0.988, respectively. After four weeks of storage, the firmness value of Ramasseri idli stored at refrigerated temperatures was increased to 1.1662 N, 1.1364 N, 1.1562 N, and 1.1669 N for treatments T1, T2, T3 and T4, respectively. Similarly, firmness value of Ramasseri idli stored at ambient conditions was 1.2036 N, 1.1265 N, 1.1456 N, and 1.2001 N, respectively. The increase in the initial firmness as a consequence of the frozen storage, maybe due to the damage of the constituents of the sample produced during frozen storage. It was in accordance with the findings of Fik *et al*. (2002).

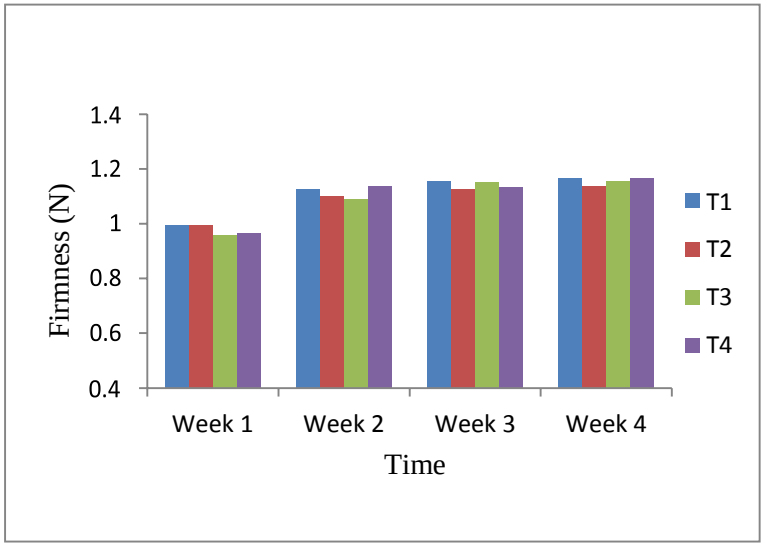


Fig 4.17 Effect of firmness during storage at refrigerated conditions

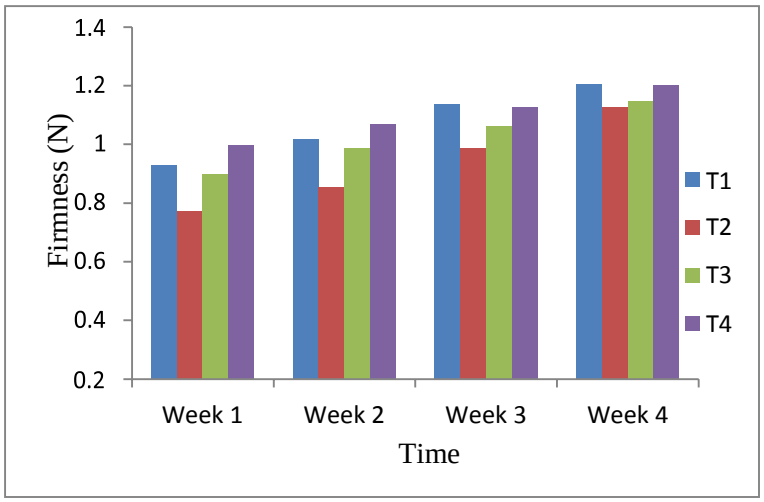


Fig 4.18 Effect of firmness during storage at ambient conditions

4.4.6 Effect of microbiological load during storage

Retort processed Ramasseri idli was examined for its microbiological load at regular intervals of one week and the results are given in Table 4.3 for control sample, the microbiological count was within the permissible limit for one day of storage. It was observed that the number of colony forming units were found to be nil up to first two weeks of storage in all treatments except T2 under refrigerated condition. After four weeks of storage, the observed microbiological counts were within the permissible limit except T2 at ambient condition. The results revealed that all the thermally processed samples under ambient and refrigerated storage were microbiologically safe for three weeks of storage. Effect of storage on microbiological load is illustrated in table 4.3 four weeks of storage studies.

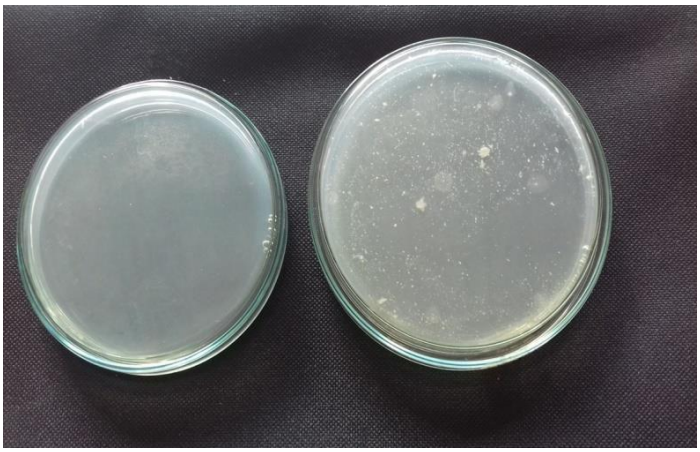


Plate 4.1 Microbiological analysis of stored Ramasseri idli

Table 4.3 Effect of microbiological load during storage of thermally processed Ramasseri idli

Temperature		Microbial growth over Storage period TPC $(10^3$ /ml)				
		Week 0	Week 1	Week 2	Week 3	Week 4
Ambient storage	T 1	0	0	0	2	12

	T 2	0	0	0	12	35
	T 3	0	0	0	0	9
	T 4	0	0	0	1	16
Refrigerated	T 1	0	0	0	2	12
	T 2	0	0	1	4	13
	T 3	**0**	**0**	**0**	**0**	**7**
	T 4	0	0	0	1	8
Control		6	-	-	-	-

4.4.7 Sensory evaluation of the sample:

The retort processed Ramasseri idli was stored for four weeks at ambient and refrigerated conditions and the organoleptic characteristics were evaluated using 5 point sensory scale and the score values were noted. Sensory evaluation of various parameters such as colour, taste, texture and overall acceptability were conducted. From the observations the sensory scores for all the treatments were found to be reducing which make it unacceptable for consumption after four weeks of storage. Fig 4.19 shows the results of sensory evaluation of retort processed Ramasseri idli after three weeks of storage. From the Fig 4.19, it is understood that the treatment T3-R sterilised at 100°C for F_1 stored at refrigerated condition was the best among all treatments followed by T1-A sterilised at 100°C for F_1 stored at ambient condition.

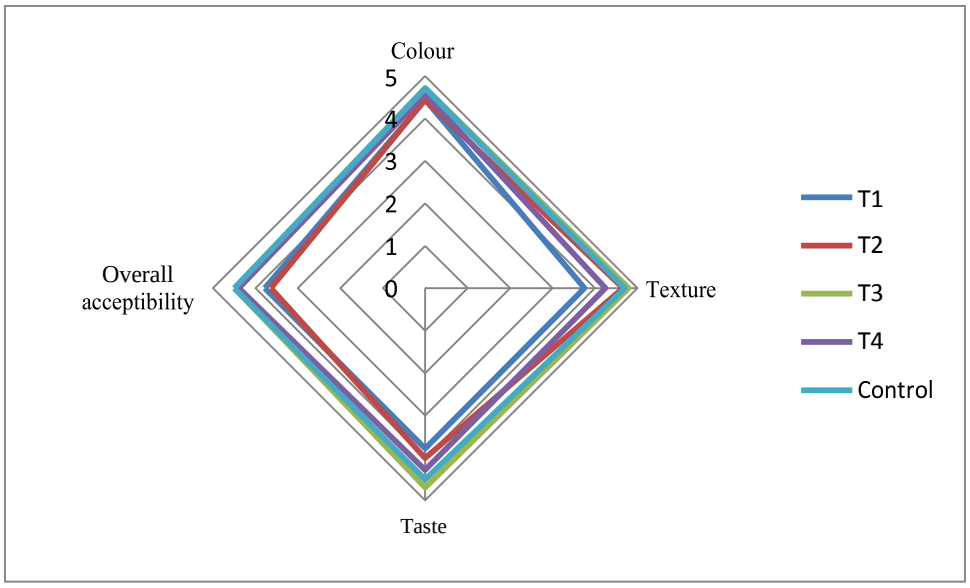


Fig 4.19 Sensory score values of thermally processed Ramasseri idli during refrigerated storage

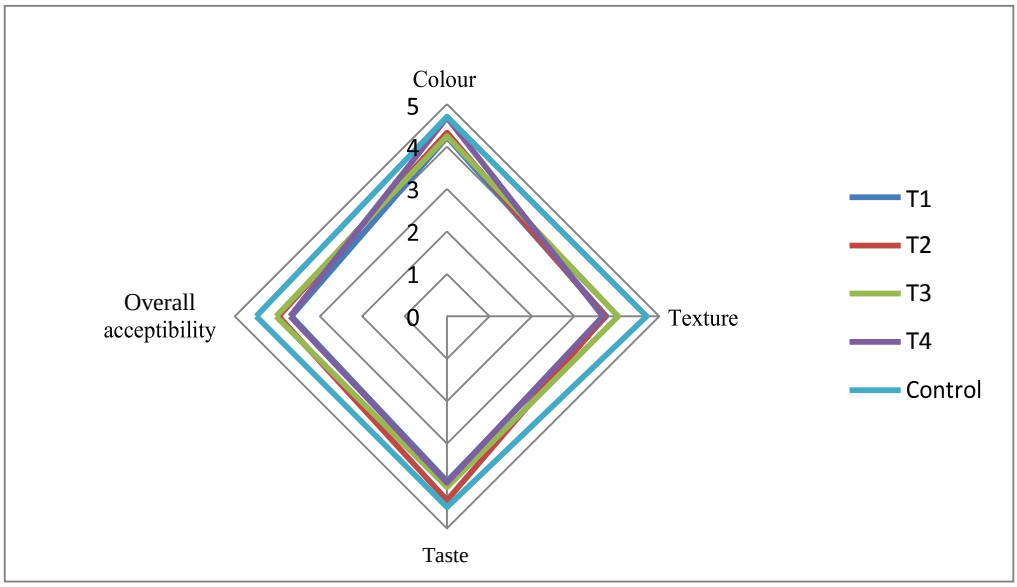


Fig 4.20 Sensory score values of thermally processed Ramasseri idli during ambient storage

Plate 4.2 Sensory evaluation

Cost Economics

Cost economics of the thermally processed Ramasseri idli in retort pouch was calculated and is given in Appendix D. The cost of production of retort pouch containing one idli and chutney powder per pouch was found to be Rs.12/-

Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSIONS

Idli is a staple breakfast dish all over south India. Ramasseri village near Palakkad district of Kerala claims the fame for its traditional breakfast dish called Ramasseri idli. These soft, moist, steamed cakes are made with fermented batter made from rice and urad dal (a type of white beans similar to mung beans). Ramasseri idli is epic in its shape, feather light texture and an earthy aroma acquired from steam cooking in unglazed clay pots. They taste salty with a hint of sourness. Various accompaniments are served with it to enhance its taste. Usually it is served together with chutney powder which could be a better combination with idli.

Ramasseri idli has very less shelf life due to its highly perishable nature. Preservation of these idlis for extending storage period demands cold storage and freezer facilities that are cumbersome and also can affect the texture and appearance of final product. Nowadays, Thermal processing of food commodities in retort pouches has found to be highly successful in extending the shelf life of the product. It is one among the most widely used methods for preservation of perishable products. The present study entitled 'Development and quality evaluation of retort pouch processed Ramasseri idli' focuses on the shelf life study of the retort pouch processed Ramasseri idli and the various parameters affecting it.

Prepared Ramasseri idli were procured from Ramasseri village, near Palakkad. It was brought as fresh and was used for experiments. The physico-chemical and microbiological studies of fresh Ramasseri idli were conducted. Ramasseri idli was white in colour having an L* value of 76.183, a* value of 0.077 and b* value of 11.12. It had a water activity of 0.8725. The moisture content and pH were estimated to be 69.9% and 5.50, respectively. Ramasseri idli had a firmness of 1.175 N. The initial microbiological load of the sample was 6×10^3 cfu/ml.

Thermal processing was done in retort pouches (15 cm × 20 cm). It is a flexible laminated package that can withstand thermal processing temperature. One Ramasseri idli together with 5 g LDPE packaged chutney powder was filled manually in the retort pouch. After filling the retort pouch, the sealing was done using a sealing machine at a pressure of 1 bar and voltage of 38 V. The hermetically sealed retort pouches were loaded into the perforated aluminium trays and placed into retort processing chamber. One of the pouches was fixed with a thermocouple sensor.

The sensor tip was inserted into the retort pouched Ramasseri idli for recording core temperatures. The retort unit consisted of a steam generator at the bottom, retort processing chamber in the middle and water storage tank at the top. All these units along with control panel were mounted on a stainless steel frame. The different F value- temperature combinations selected for standardisation of Ramasseri idli are a) T1-R sterilised at 110°C for F_1 stored at refrigerated condition, T1-A sterilised at 110°C for F_1 stored at ambient condition, T2-R sterilised at 110°C for F_2 stored at refrigerated condition, T2-A sterilised at 110°C for F_2 stored at ambient condition, T3-R sterilised at 100°C for F_1 stored at refrigerated condition, T3-A sterilised at 100°C for F_1 stored at ambient condition, T4-R sterilised at 100°C for F_2 stored at refrigerated condition, T8-A sterilised at 100°C for F_1 stored at ambient condition.

The thermally processed Ramasseri idli in retort pouches were stored for four weeks and shelf life studies were conducted. The Ramasseri idli samples in sterilised pouches were stored in ambient condition (temperature at 37°C) and in refrigerated condition (7°C). The parameters *viz*., moisture content, pH, water activity, colour, texture and microbiological analysis were tested in every one week interval up to three weeks and final analysis was done after four weeks of storage.

There was a slight increase in moisture content of the retort packaged Ramasseri idli during storage which was not significantly varying from initial readings. The moisture content of processed Ramasseri idli at the initial day of packaging for various treatments was 69%. After four weeks of storage, the moisture content of Ramasseri idli stored at refrigerated and ambient conditions were increased to a mean value of 71% for different treatments. The pH of Ramasseri idli was found to be decreasing during storage period. The reduction in pH was more pronounced in ambient storage than at refrigerated storage. It was reported that the influence of temperature decreases pH (Muhammad *et al*., 2010).

Water activity of Ramasseri idli found to be increasing with storage period for all treatments but is not significantly varying from initial analysis. The increase in water activity was more pronounced in ambient sample than refrigerated sample.

During colour analysis, the 'L*' value showed a gradual increase with increase in storage period, for all treatments under ambient and refrigerated conditions. It can be seen that with a drop in pH causes changes in colour which may be due to protein denaturation and coagulation caused by the acid production.

There was increase in a* and b* value for both ambient and refrigerated stored that are not significantly varying from initial readings.

The texture profile analysis of Ramasseri idli just after processing indicated that firmness was reducing for all the four treatments T1, T2, T3 and T4.

Retort processed Ramasseri idli was examined for its microbiological load at regular intervals. It is observed that the number of colony forming units was found to be nil up to first two weeks of storage in all treatments except T2 under refrigerated condition. After four weeks of storage, the observed microbiological counts were within the permissible limit except T2 at ambient condition. The results revealed that all the thermally processed samples under ambient and refrigerated storage were microbiologically safe for three weeks of storage.

Sensory evaluation was done every week. Various parameters such as colour, texture, taste and overall acceptance were evaluated by a 5 point sensory scale. Based on the sensory evaluation, samples processed at 100°C F_1 and stored at refrigerated condition was found to be the best.

Based on the physico-chemical analysis, the samples stored at refrigerated conditions were found to be better than the ambient storage for all treatments. From physico-chemical analysis it can see that minimally thermal processed treatment at a sterilisation temperature of 100°C, F_1 (sterilised at 100°C for F_1 stored at ambient condition) is also giving better result.

Hence, by considering the economy, it is concluded that thermally processed Ramasseri idli at a sterilisation temperature of 100°C, F_1 (sterilised at 100°C for F_1 stored at ambient condition) could be stored safe at ambient temperature for a period of 3 weeks. Cost economics of the thermally processed Ramasseri idli in retort pouch was calculated and the cost of production of retort pouch containing one idli with LDPE packaged chutney powder was found to be Rs.12/-

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Appendices

APPENDIX A

Composition of nutrient agar medium

Peptone	:	5 g
Yeast extract	:	2 g
Beef extract	:	1 g
Sodium chloride	:	5 g
Agar	:	15 g
pH	:	6.5-7.5
Distilled water	:	1000 ml

APPENDIX B

Sensory Evaluation Chart

Treatment	Mean Scores			
	Colour	**Texture**	**Taste**	**Overall**
T1-R				
T1-A				
T2-R				
T2-A				
T3-R				
T3-A				
T4-R				
T4-A				
C				

5– Like very much 4-Like 3-Neither like nor dislike 2-Dislike 1-Dislike very much

Name of examiner: Signature of the examiner:

Date:

Mean sensory scores of the samples after 3 weeks of storage.

Treatment	Mean Scores			
	Colour	**Texture**	**Taste**	**Overall Acceptance**
T1-R	4.444	3.75	3.778	3.778
T1-A	4.223	3.75	3.889	3.667
T2-R	4.445	4.661	4	3.638
T2-A	4.33	3.722	4.33	3.972
T3-R	4.722	4.789	4.692	4.5
T3-A	4.248	4.0277	4.02	4.026
T4-R	4.582	4.25	4.2778	4.3889
T4-A	4.687	3.667	3.916	3.6944

C	4.71	4.699	4.5	4.5

APPENDIX C

Effect of storage on moisture content of Ramasseri idli (w_b).

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	68.6	68.99	69.36	70.25
T1-A	68.65	69.26	70.69	70.86
T2-R	68.26	69.01	70.03	70.012
T2-A	68.99	69.36	70.69	71.011
T3-R	69.01	69.45	69.95	70.36
T3-A	69.26	69.99	70.236	70.654
T4-R	68.5	69.58	69.98	70.69
T4-A	68.99	69.98	70.68	71.165

Effect of pH during storage of thermally processed Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	5.5	5.46	5.46	5.29
T1-A	5.49	5.48	5.42	5.35
T2-R	5.5	5.42	5.38	5.32
T2-A	5.45	5.42	5.38	5.3
T3-R	5.53	5.51	5.43	5.42
T3-A	5.5	5.49	5.46	5.38
T4-R	5.51	5.5	5.3	5.2
T4-A	5.49	5.46	5.4	5.32

Effect of storage on water activity of Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	0.668	0.669	0.67	0.674
T1-A	0.669	0.669	0.672	0.673
T2-R	0.667	0.668	0.672	0.675

T2-A	0.667	0.67	0.671	0.676
T3-R	0.671	0.671	0.672	0.672
T3-A	0.671	0.671	0.673	0.674
T4-R	0.669	0.67	0.671	0.673
T4-A	0.67	0.671	0.674	0.675

Effect of storage on colour of the retort processed Ramasseri idli.

Effect of L^* value during storage of thermally processed Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	77.33	77.15	79.64	77.63
T1-A	77.07	77.12	78.99	77.16
T2-R	77.67	79.21	77.64	77.52
T2-A	77.33	78.21	77.21	77.52
T3-R	77.76	79.87	77.84	77.41
T3-A	78.65	79.33	76.67	77.43
T4-R	77.63	80.03	77.85	77.31
T4-A	78.62	79.73	76.87	77.32

Effect of a^* value during storage of thermally processed Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	0.162	0.169	0.174	0.182
T1-A	0.166	0.174	0.178	0.193
T2-R	0.179	0.184	0.194	0.202
T2-A	0.182	0.189	0.198	0.215
T3-R	0.145	0.152	0.162	0.172
T3-A	0.154	0.162	0.167	0.177
T4-R	0.158	0.167	0.171	0.181
T4-A	0.161	0.17	0.175	0.186

Effect of b^* value during storage of thermally processed Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	11.888	11.893	11.901	11.99
T1-A	11.823	11.834	11.924	12.015

T2-R	11.898	11.957	12.198	12.247
T2-A	11.925	11.992	12.092	12.112
T3-R	11.692	11.709	11.697	11.709
T3-A	11.746	11.823	11.795	11.847
T4-R	11.768	11.776	11.824	11.864
T4-A	11.784	11.821	11.841	11.875

Effect of storage on texture

Effect of storage on firmness of Ramasseri idli.

Treatments	Week 1	Week 2	Week 3	Week 4
T1-R	0.9957	1.1254	1.1538	1.1662
T1-A	0.9267	1.0157	1.1354	1.2036
T2-R	0.9967	1.1006	1.1265	1.1364
T2-A	0.7698	0.8542	0.9856	1.1265
T3-R	0.9565	1.0889	1.1523	1.1562
T3-A	0.8975	0.9865	1.0589	1.1456
T4-R	0.9654	1.1365	1.1325	1.1669
T4-A	0.9956	1.0654	1.1238	1.2001

APPENDIX D

Cost of retort processing

Cost of operation of plant/hr

Cost of machineries	
Retorting autoclave and other accessories	Rs. 9,00,000/-
Initial cost (C)	Rs. 9,00,000/-
Assumptions	
Useful life (L)	15 years
Annual working hours,	1900 hours
Salvage value, S	10% of initial cost
Interest on initial cost, r	12% annually

Repairs and maintenance	5% of initial cost
Insurance and taxes	2% of initial cost
Electricity charge	Rs. 5.2/- unit
Labour wages(8 working hours/ day)	Rs. 300/- day
Cost of a pouch	Rs. 2/-
Fixed cost	
Depreciation: (C-S)/L	Rs. 54000/- year
Interest on average investment	Rs. 59400/- year
Insurance and taxes	Rs. 18000/- year
Total fixed cost	Rs. 131400/- year
Variable cost	
Repair and maintenance	Rs. 45000/-
Electricity cost, Total power consumption	8HP = 6KW
Cost of energy consumption/ year	$\frac{Power x Duration x Cost of one unit}{1000}$ = Rs. 62400/-
Annual labour cost	Rs. 75000/- year

Total variable cost	Rs. 182400/- year
Total cost	Fixed cost + Variable cost = Rs. 313800/- year
Number of batches required for retorting 100pouches	4
Time required for retorting under sterilisation temperature (ts)	30 min
Total cost of packing operation(Cpouch)	$(C_{oper} \times n \times t_s)/60$ = Rs. 436.5
Labour cost	Rs. 420/-
Total expenditure for retorting 100 pouches of Ramasseri idli	$C_L + C_P + C_{RAMASSERI\ IDLI} + C_{POUCH}$ = 420+400+80+436.5 = 1336.5/-
Total expenditure for a retort pouched Ramasseri idli	Rs. 12/-

Abstract

ABSTRACT

Ramasseri is claim to fame for its simple breakfast dish called Ramasseri idli. These soft, moist, steamed cakes are made with fermented batter made from rice and urad dal. They taste salty with a hint of sourness. Various accompaniments served with it enhance its taste. Development and quality evaluation of retort pouch packaged Ramasseri idli was undertaken with specific objectives of standardisation of thermal process in retort pouch package, shelf life study and quality evaluation. Retort pouch packaging system is a flexible, laminated package that can withstand thermal processing temperatures and combines the advantages of both metal cans and plastic packages. Shelf life study and quality evaluation in terms of microbial analysis (total plate count), pH, water activity, texture and colour were done. Microbial analysis also showed that the product was safe up to three weeks of storage.

The Ramasseri idli was procured and packaged in retort pouches with one idli and 5 g chutney powder packaged in LDPE in a single pouch. Four Different combinations of temperature and F_0 values (110°C-1D; 110°C-2D; 100°C-1D; 100°C-2D) was given to pouches and found out the time required for processing. After thermal processing the packets are stored for shelf life studies under ambient storage (A) and refrigerated storage (R) at 7°C. The processed product was analysed for microbial and physico-chemical qualities *viz*; moisture content, pH, water activity, colour and texture using standard procedure at regular intervals.

From the storage studies the pH of the processed Ramasseri idli after four weeks of storage was found to show a reducing trend for most of the samples. It may be due to increase in acidity during storage. There was a slight increase in moisture content of the retort packaged Ramasseri idli during storage which was not significantly varying from initial readings. There were no significant changes in water activity when compared to control for processed ones. The effect of storage period on colour, signifies that L* value of stored thermally processed idli increases whereas a* values and b* values shows an increasing trend which does not vary significantly from in initial colour value of sample. The texture analysis indicated that the firmness of the processed samples tends to decrease just after thermal processing. During storage period there was an inconsiderable increase in firmness. Refrigerated sample showed more pronounced increase as compared to the ambient sample though there was only negligible increase in firmness. The increased firmness can be brought back by steaming the idli for one minute.

The microbial load of samples just after processing was nil whereas the observed bacterial counts for most of the samples after three weeks shows best results i.e., not more than 50/ml prescribed by Prevention of Food Adulteration Rules, 1956 (PFA, 2000). During sensory evaluation various parameters such as colour, texture, taste and overall acceptance were evaluated by a 5 point sensory scale. Based on the sensory evaluation, the thermal processed Ramasseri idli by four treatments showed best results up to three week of storage of which samples processed at 100°C F_1 and stored at refrigerated condition was found to be the best.

Cost economics of the thermally processed Ramasseri idli in retort pouch was calculated and the cost of retort pouch contains one idli and LDPE packaged chutney powder was found to be Rs. 12/-

Based on above results it could be concluded that the retort pouch processing is an ideal method of preserving Ramasseri idli for long period of storage. It was found from the experiment that the product could be stored for three weeks without contamination and deterioration in product quality. The best thermal processing method for retort pouched product was found to be 100°C-1D refrigerated storage (T3-R), since the values obtained from physico-chemical and microbiological analysis of the above sample were not significantly varying from the control sample.