STUDIES ON THE PACKAGING OF PROCESSED CHEESE

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1987

STUDIES ON THE PACKAGING OF PROCESSED CHEESE

A DISSERTATION

SUBMITTED TO THE KURUKSHETRA UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF SCIENCE

IN

DAIRYING (DAIRY TECHNOLOGY)

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I certify that the work reported in the thesis entitled, "Studies on the Packaging of Processed Cheese" is a bonafide piece of work carried out under my guidance by Mr. Kolli Eswara Babu, B.Sc. in Dairying (Dairy Technology), as the partial requirement for the award of the degree of M.Sc. in Dairying (Dairy Technology) in the Faculty of Dairying, Animal Husbandry & Agriculture of the Kurukshetra University, Kurukshetra.

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ACKNOWLEDGEMENT

The author wishes to express his deep sense of gratitude and indebtedness to Dr. G.K. Goyal, Scientist (Dairy Technology), National Dairy Research Institute, Karnal, for his valuable guidance and unstinted encouragement during the course of this investigation and preparation of this manuscript.

He wishes to express his appreciation to Dr. S.K.Gupta Head, Division of Dairy Technology, Dr. S. Singh, Scientist (S-3) and Dr. R. Balachandran, Scientist (S-3) for their interest in this work. He also wishes to thank all the members of the staff of the Dairy Technology Division.

In addition, the author is grateful to Mr.Surinder Singh, Scientist (S-2) for his suggestions during the statistical analysis of the data.

Thanks are also due to Dr. R. Nagarcenkar, Director, National Dairy Research Institute, Karnal for providing the necessary facilities for the investigation.

Finally he wishes to express his gratefulness to his beloved parents, colleagues and undergraduate friends for giving necessary encouragement during the course of this project.

(KOLLI ESWARA BABU)

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ABBREVIATIONS USED IN THIS THESIS

Al	-	Aluminium
ASF	-	Anaerobic spore formers
CC	-	Cubic centimeter
FDM	-	Fat in Dry Matter
FFA	-	Free Fatty acids
g	-	Gram
h	-	hour
ISI	-	Indian Standards Institution
log	-	logarithum
LDPE	-	Low Density Polyethylene
m	-	metre
min	-	minute
mg	-	milligram
ml	-	millilitre
µm	-	millimicron
OTR	-	Oxygen transmission rate
PFA	-	Prevention of Food Adulteration act
PP	-	Polypropylene
PS	-	Polystyrene
PVC	-	Polyvinyl chloride
PVDC	-	Polyvinylidene chloride
RU	-	Reading Units
RH	-	Relative Humidity
SNF	-	Solids Not Fat
SPC	-	Standard Plate Count
WVTR	-	Water vapour transmission rate
Y&M	-	Yeasts & moulds

CHAPTER – I

INTRODUCTION

1.0.0.0 INTRODUCTION

Cheese is one of the oldest foods of the mankind. At times, cheese has enabled people to survive periods of famine, and also during wars dating back 5th century A.D., when the invading Asiatic hordes fighted the legions of the Po valley on the Italian Lombardy plains. First time, the cheese was made few thousand years ago. The oldest of writings from Egypt, Greece, and Italy contain the detailed reports about cheese. Even numerous quotations regarding cheese have been mentioned in the Bible, songs of Holmer, Virgil and Ovid's poetry, and in the works of Columella, Paladin, Varro, Pliny the elder and Martial.

1.1.0.0 Cheese is the product made from the curd obtained from milk by coagulating the casein with the help of rennet or similar enzyme in the presence of lactic acid, produced by added or adventitious microorganisms, from which part of the moisture has been removed by cutting, cooking and/or pressing, which has been shaped in a mould, and then ripened by holding it for some time at suitable temperatures and humidities (Davis, 1976).

1.2.0.0 At present there are about 20 types of cheese in the world, and are known by over a thousand different names (De, 1980). Cheeses are classified in different ways like geographical considerations, e.g. country, town or region where the cheese was first manufactured; method of manufacture,

e.g. temperature of cooking etc., physical and rheological properties, e.g. very hard, i.e. containing low moisture (13-34%) like Romano and Parmesan varieties of cheese; medium moisture (34-45%) like Edam, Brick, Swiss and Cheddar; high moisture (45-55%) like Mozzarella, Camembert and Blue cheese; and very high moisture (55-80%) like cottage, Ricotta, and Cream cheeses. With the exception of certain high and very high moisture cheeses, all the varieties of cheese are consumed after ripening at specific temperatures in order to obtain desired optimum flavour. However, many times the ripening process continues even after the desired flavour is reached and protein is decomposed, thus resulting in low quality cheese. With a view to improve the various types of cheese, and to enhance their keeping quality, and to develop a protein food of high nutritive value from the milk protein, the Swiss, Walter Gerber and Fritz Stettler. Than succeeded in finding a solution to referred objectives, and invented processed cheese in the year 1911.

1.3.0.0 Processed cheese is the food prepared by comminuting and mixing into a homogenous plastic mass with the aid of heat with one or more types of cheese, with one or more of the permissible emulsifiers, namely the sodium or potassium salts of citric acid, phosphoric acid, tartaric acid, lactic acid etc. in such quantity that the weight of such emulsifying agents is not more than 4 per cent of the weight of the processed cheese. It may contain edible common salt, annatto or carotene or permitted flavourings

as specified under the PFA rules, 1955. The processed cheese is quite high in its nutritive value. It contains milk proteins, calcium and phosphorous, fat soluble vitamins, viz. A,D,E and K, and provides energy. The processed cheese offers numerous advantages over natural cheeses, viz. it can be stored for months or even years; surface infection is avoided; can be stored without refrigeration; no loss in weight and aroma due to drying; loss due to find formation is eliminated; has no smeary surface; and has extremely good digestibility, thus becoming a highlyssuitable food.

1.4.0.0 In the manufacture of processed cheese, the relatively coarsely dispersed para casein calcium of the raw cheese is changed into a homogenous flowing condition, i.e. a sol, which after cooling forms a homogenous gel (processed cheese). This is achieved by means of heat and using sodium citrate as a peptising agent.

1.5.0.0 In India, the estimated total cheese production was about 2,000 tonnes in 1982. This figure includes the Cheddar, Gouda and processed cheeses only (Singh, 1985).

1.6.0.0 Packaging of any food product is a very essential step in the manufacturing line. This is because the product has to be saved from many adversaries such as insects, rodents and microorganisms; light and oxygen in case of fatty products. At times, the microorganismsspoil the product to such an extent that the product becomes unfit for human consumption, and if consumed, results in food poisoning. Therefore, it becomes all necessary that the

food product available to the consumers is of the same high quality, he used to get in freshly manufactured product. This holds true for processed cheese as well. While selecting a package for processed cheese, due considerations must be given that the package ensures the predetermined shelf life of the product; the pack is of right shape and size, and its design attracts the customer. The tincan fulfils most of the requirements of a perfect package, but it is quite expensive and involves the expenditure of valuable foreign exchange.

1.7.0.0 Presently, the processed cheese in foreign countries is generally being wrapped in sliced form in PP film or co-extruded PP, and the wrapped portions placed in a PVDC film. In India, the processed cheese is being packed in small portions in Aluminium foil, which in turn are placed in a carton. Few organizations are also packaging processed cheese in lacquered tincans. The wrapping of portions of processed cheese in PP requires high speed machine; whereas the use of Al. foil plus cartons, and tincans is expensive. Recently, the plastic industry in this country has made available in the market low cost, beautify, hygienic and convenient plastic containers.

1.8.0.0 Since not much published information is available on the studies on shelf life of processed cheese packed in plastic containers, the studies reported in this dissertation were undertaken to generate scientific information on the packaged product, and the interaction of product and package during storage at selected temperature and humidity conditions.

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The processed cheese was also packed in metal containers to see how they compared with plastics containers and whether the high cost of metal cans was commensurate with the increased shelf life of the product.

1.9.0.0 The studies on the packaging of processed cheese in plastics containers and metal cans are reported in the following pages of the thesis as classified below.

1.9.1.0 Section 1 of the thesis provides the background information on the need for the present studies. Section 2 contains a critical review of published scientific information on the related aspects of the packaging of processed cheese. Section 3 depicts the scope of the present studies and the plan of work. The experimental procedures adopted in the present investigations are described in section 4. In section 5, the results obtained on sensory attributes, chemical and microbiological changes in respect of packaged processed cheese during and after storage at different conditions, are presented and discussed. A consolidated summary of the study carried out and the observations made are delieneated in section 6. A comprehensive bibliography of the references cited in the dissertation follows the summary. Wherever necessary, the results are depicted graphically in respect of changes in sensory characteristics, chemical and microbiological quality.

CHAPTER – II

REVIEW OF LITERATURE

2.0.0.0 REVIEW OF LITERATURE

Packaging is a coordinated system which prepares goods for transport, distribution, storage, retailing and end-use. It is also a means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost. Packaging also performs a techno-economic function aimed at minimizing costs of delivery while maximizing sales, and hence profits. Therefore, packaging is a complex, dynamic, scientific, artistic, and controversial segment of business. In general, packaging contains, protects, and preserves the contents. It also informs the consumers about the facts of the product. In addition to convenience, packaging also helps in selling of the product.

The packaging has undergone a fast change in last decades. The packaging of dairy products in the past to the general public meant only the use of leaf cups, reclaimed sugar bags, wrapping paper, newsprint, used tin containers, or in special cases, parchment wrappers for products like butter. The packaging of dairy products in under-developed countries had been of minor importance. According to one report (De, 1980), the estimated per capita expenditure on packaging in 1972 was: USA - Rs. 460; UK - Rs. 280; Japan - Rs. 217; and India - only Rs. 6.

The selection of packaging materials mainly depends on the composition and nature of the product to be packaged, desired shelf life of the product and sales appeal.

Extensive research work has been done in many of the Western and European countries on the packaging of various types of dairy products, including processed cheese. The technology developed for the packaging of processed cheese in the foreign countries, which is most specific to their requirements, has been adopted in this country without any scientific backing, and also without considering the exact packaging requirements under our climatic and marketing conditions. However, the review of work done abroad and little work done in this country on the packaging of processed cheese has been included in this chapter.

2.1.0.0 PACKAGING OF PROCESSED CHEESE

In order to retain the desired qualities of the processed cheese for a longer period, the following work has been published concerning the packaging of processed cheese.

2.1.1.0 Portioning and packaging:

During the last 60 years, tremendous improvements have been made in the methods of filling of processed cheese. In early days, the processed cheese was being filled by small, semi-automatic machines into hand-made moulds of tin foil, top of which were covered with Al. foil, and were then manually closed (Meyer, 1961). In past decades, the processed cheese was made in small blocks of rectangular, triangular or round shapes. But, presently all operations such as forming of the moulds, portioning out of the cheese, closing

and sealing, labelling and discharging of the finished pack are carried out with automatic filling and sealing machines. This has been possible due to the advancements made in the packaging machinery (Meyer, 1964). The processed cheese has been packaged in the following different manners.

2.1.1.1 Processed cheese in portions

A French company M/s. Framageries GrossJean SA (1969) recommended a pull-tab for opening portions of processed cheese. In this system, the pull-tab, preferably made of plastics or heat sealable aluminium material was sealed by means of a heated plate onto the inside of the sheeting, which formed the pack for the cheese segment. The tab, in the form of a ribbon lay parallel to the longitudinal axis of the cheese portion and about 1 cm was left at the end ofor gripping.

The portions of processed cheese in different shapes such as triangular, square, rectangular, round or half moon-shaped had been wrapped in foil by using Kustner cheese packaging machine (Meyer, 1973). The size of the portion varied from 5-250 g depending upon the size of the portion. The machine could pack about 50-250 portions per minute.

A report (Anon, 1974) described the various aspects of cheese in individual portion packs, covering cheese types (fresh, soft, pressed, blue veined, goat's milk and processed), advantages, consumer attitude etc.

A Swiss company suggested a new laminate for portion packaging of cheese (Anon, 1978). The construction of the laminate included a 15 μm polyamide, 12 μm partially metallized polyster film and 40 μm Surlyn ionomer film (Du Pont de Nemours). It was claimed that the polyster gave excellent impermeability, while the ionomer (because it could be reliably heat-sealed even when the surface was soiled with fat) reduced the risk of leakage.

Guyonnet (1980) fabricated a portion-packaging machine, particularly suitable for processed cheese. The machine had work positions in-line, each having the same number of identical working tools, which in relation to the work positions as a whole, constituted a plurality of parallel work lines. Both work positions and working tools could be readily removed from the common frame.

2.1.1.2 Processed cheese in blocks

The size of the blocks of the processed cheese generally ranges between 500 g to 2.5 kg. In this case the machine discharges the required quantities automatically, in one or more thrusts from a broad nozzle into the box placed underneath (of wood, plastics or metal lined with foil). An improvement in the method of moulding and wrapping of block processed cheese was put forward by Burgess (1944), according to which a flexible sheet was prefolded in a form suitable for packaging processed cheese. The sheet was coated on one side with a thermoplastic, self-sealing coating, which enabled the packages to be hermetically sealed.

Vonk (1970) packed blocks of processed chees in moulds itself, which also served as packages. In this system, the plastic bags were placed into the compartments of a mould of light insulating synthetic material, e.g. foamed plastics. After sealing the plastic bags, the mould was closed by a suitable lid, or two similar moulds were combined, preferably with an interlayer of foil or cardboard by means of adhesive tape.

2.1.1.3 Processed cheese in cans

Tincans are the most secure packages for processed cheese. A typical processed cheese tincan is round in shape and ranges in capacity from 100 g to 1000 g. The can as well as the lid are lacquered on the inside with a double layer of gold lacquer as a protection against corrosion.

As a result of development in the field of canned processed cheese, the Alpac cans were introduced. The typical can was made from aluminium. It was smooth walled and lacquered on the inside (of can and lid) with physiologically unquestionable plastics material. This new type of can could be made air and gas tight by welding together, and could be opened by means of a projecting tearstrip on the lid. Different filling and sealing machines for processed cheese in cans were also put in use (Meyer, 1973).

2.1.1.4 Processed cheese in cups and plastic containers

For the main reasons of convenience and economy, a Danish firm M/s. Andersen and Bruun developed pleated cone shaped aluminium cups (Alucup) which were widely used for the packaging of processed cheese about 25 years back. The cups were attractive and had a capacity of 50-100 g. There was a protective lacquer inside. The cup after filling could be closed in an airtight manner with an aluminium lid. In this case, the cups were sealed by using a small sealing machine (Meyer, 1973).

More recently, plastic cups/tubs in different shapes such as cylindrical, conical etc. made of polystyrene, hard PVC or other plastics materials (250-600 micron thickness) appeared in the overseas market, and were wholeheartedly welcomed by the consumers (Meyer, 1973). The filling and sealing of the cups/tubs was achieved by a machine having an output of 30 packs/min. However, the processed cheese having a temperature of more than $70^{o}C$ could not be filled for the reasons of containers becoming soft and getting deformed as the thermal resistance of the material of the plastic cups/tubs was between 70^{o}-$75^{o}C$. To overcome this problem, Kalle AG in Wiesbaden-Biebrich developed a new package made from hard PVC, which remained stable upto a temperature of $88^{o}C$, thus rated quite suitable for processed cheese.

2.1.1.5 Processed cheese in tubes

The processed cheese has also been packed in tubes made of metal or plastics, with holding capacity of 75-150 g. The filling and closing of tubes required special tube filling units.

Volkov, Astakhova and Kuleshova (1969) presented a detailed information on the UPT-14 ultrasonic sealer and its application to packaging of processed cheese in LDPE tubes, and aluminium tubes.

A report (Anon, 1978) described the technique of flattening of processed cheese in package. In this system, the hot processed cheese in liquid form was fed into a tube of polyester Mylar 50 CS, the tube was flattened and pressure-sealed transversely which formed the individual portions. After cooling in chilled water, the individual portions were separated and arranged in stacks of 2-12 before over-lapping. The thickness of the portion (and consequently their weights) was adjustable, which produced packs of 18-28 g as per the market requirements.

2.1.1.6 Processed cheese in slices

The processed cheese in sliced form was first made in America by Kraft Cheese Company in the year 1950 (Kraft Kasewerke, 1950). In this technique, the cheese emulsion was run over a cooling cylinder on which it hardened, and was then removed as a band of cooled cheese. The broad band was then cut by knives into slices, laid above each

other in layers of eight, divided, cut and automatically wrapped. There had been very good response from the consumers in favour of this type of packaging system.

According to Carne (1979), the annual consumption of processed cheese in slices form in the USA was over 600 million kg, which corresponded to approximately 70 per cent of the total processed cheese consumption.

Due to very favourable acceptance of this new packaging technology, the scientists and the companies involved in the manufacture of processed cheese have been continuously researching the newer packaging materials, techniques of manufacture and wrapping (Swift & Co. Ltd., 1963; Fromageries Bet-La Vache Qui Rit, 1965; Fievet, 1968; Bush & Hannon, 1970; Miller, Borgardt and Olson, 1970; Hansen, 1973; Boef, 1974; Gorshe, 1981; Heitz, 1982).

Though many types of flexible wrapping materials and laminates, substantially impervious to gas and moisture have been used for the packaging of sliced processed cheese, but by and large, polypropylene or co-extruded PP as inner wraps, and PVDC coated cellophane or PP for outer wraps have been in use in USA (Goyal, 1986).

2.1.2.0 Packaging materials and their requirements for processed cheese:

The processed cheese undergoes sterilization process during manufacture, and hence is more stable. It has been successfully packaged in Saran film (Anon, 1967)

and Aluminium foil having a heat sealable coating (Wearmouth, 1956). The packaging of processed cheese in wax coated cellophane treated with a mould-preventive agent to retard bacterial growth has also been recommended (Sachrow and Griffin, 1970).

Heiss and Eichner (1970) suggested that the packaging materials for processed cheese should be light-proof, pliable and adhering but not sticky, heat resistant (filling temperatures between 70° and 80°C), and resistant to weak acids and soluble salts.

Sachrow (1971) studied the suitability of foil laminates, cellophane, Al.foil, cast PP etc. for the packaging of processed cheese (sliced or in pieces).

Moll (1974) reviewed the basic requirements of suitable materials for packaging of cheese with reference to permeability to water vapour and gases, transmission of light and heat, external appearance and shelf life required.

Walter (1977) recommended a drawn container of metal plastics laminate for the packaging of processed cheese. The container consisted of a metal layer having a thickness of 0.04-0.30 mm, preferably 0.05-0.20 mm, and a biaxially oriented plastics layer having a thickness of 0.008-0.025 mm, preferably 0.012-0.020 mm.

2.2.0.0 STORAGE STUDIES OF PROCESSED CHEESE

2.2.1.0 Keeping quality:

Toma, Moldovan and Istudor (1962/63) were

successful in improving the keeping quality of processed cheese by efficient thermal treatment and the addition of preservatives. Heating the melt at 85°C for 6 min or 88°C for 4 min gave products which kept for over 3 months at 37°C, whilst those treated at 80°C for 4 min were blown within 30 days. The incorporation of sorbic acid or potassium sorbate into the melt at the rate of 0.1 per cent also reported to be effective and the product had a shelf life of over 3 months at 20°C.

Fluckiger (1964) suggested that the main cause of blowing of processed cheese was the corrosion of Al.foil, which was due to the absence of a lacquer coating or due to the pores present in the lacquer coating. He also listed the factors which favoured corrosion, and described a test for examining the lacquer coating on Al.foil.

From a study, Komissarova (1965) found that the processed cheese could be kept best at -2 to -3°C and 85-90 percent RH or at 4-5°C at the same RH. He observed that the shelf life of the processed cheese decreased as the storage temperature increased.

Olotex, Ferrer and Gardener (1971) packed processed cheese in various types of packaging materials having different water vapour permeabilities and subjected the packed product to different climatic conditions (20, 30 and 37°C; 45, 53, 75 and 100% RH) and evaluated the product organoleptically on a Hedonic scale.

Hartmann (1972) observed that only films of very low oxygen permeability, e.g. Hostaphan-PEX (PVDC-coated) (permeability 15 cc/m^2/24 h) gave adequate protection to the quality of Emmental processed cheese over reasonably long storage periods.

With the aim of extending the shelf life of tinned processed cheese from 30 to 90 days at 30°C, Kalra, Laxminarayana and Dudani (1973) added nisin (100 Reading Units/g) to melted cheese. The increase in shelf life was mainly due to inhibition of the growth of anaerobic spore formers. However, nisin failed to check the growth of yeasts and moulds.

Pulay and Zukal (1974) studied the shelf life of processed cheese when heated to 92°-95°C during manufacture, and stored at either 22°C or 37°C. The experiments showed that many samples deteriorated within 30 days at both the temperatures.

The laboratory trials of Snegireva, Popkova, Kuleshova and Kazakevich (1976) revealed that for the packaging of processed cheese, polystyrene cups were better than foil, which corroded and showed mould growth. The optimum storage temperature and RH for processed cheese were observed by them to be $-4^{\circ} \pm 1^{\circ}$C and 85-90 per cent, respectively. The cheese in PS cups was found to be of satisfactory quality for 3 months. As expected, the shelf life of the processed cheese declined with increase in storage temperature.

The sausage-shaped smoked processed cheese of 280-290 mm length and 60 mm diameter, weighing 0.8-1.0 kg, when packaged in a 2-ply casing consisting of an inner layer of Poviden film of USSR manufacture (impervious to gas, moisture and vapour) and an outer layer of spirally applied cellophane film, did not dry during storage for one year, either at 4^{o}-6^{o}C or at -2^{o}C. The observations also showed that the cheese samples could be stored without loss of quality for 4-5 months at 4^{o}-6^{o}C, or for 7-9 months at -2^{o}C (Bednykh, Zakharova and Dudnik, 1980).

Tewari and Chakraborty (1986) packed the processed Cheddar cheese in tincans and stored at 5 ± 1^{o}C. From the study, they observed that slight differences in the quality of natural Cheddar cheese were not of much practical significance after processing.

Singh and Kanawjia (1987) recommended that the cheese should become a part of regular diet of our explorers in Antarctica and to our soldiers in Siachin.

2.2.2.0 Chemical Quality:

Csiszar and Tomka (1949) compared the uncoated Al. foil with lacquer coated Sl foil for the packaging of processed cheese. They observed that the periphery of processed cheese developed hydrogen 24 hrs after wrapping in uncoated foil, whereas the cheese packed in lacquer coated foil did not show this defect.

Storck (1953) examined the cases of water "weeping" followed by proteolysis in processed cheese, and

concluded that the weeping defect was not connected with the proteolysis, but was due to insufficiently ripe cheese, too low a pH at melting and use of too high temperature during processing.

Arnott, Morris and Combs (1957) studied the effects of certain chemical factors and noted that the pH, fat and moisture content did not affect the melting quality of processed cheese.

Ellickson and Hasenzahl (1958) observed that the incorporation of Uvinul-490 (a light screening substance based on substituted benzophenones) in the wax coating for dellophane wrappers used for wrapping processed cheese retarded oxidation from 12 hrs (control wraps) to 64 hrs during exposure of the wrapped cheese in a dairy display case under fluorescent lighting at $45^{o}F$.

Morris, Manning and Jenness (1969) suggested that a white powdery deposit of Ca-citrate on the surface of processed cheese slices (which appeared on the areas subjected to pressure) could be prevented by avoiding the use of citrates in the manufacture of processed cheese.

Thomas (1969) investigated the effects of many variables such as age of cheese, duration of heating period and temperature, final moisture content, pH etc on the flavour, and development of browning in processed cheese.

Ozer (1970) analysed many samples of Turkish processed cheese and reported the average chemical composition:

pH - 5.46; Moisture - 46.77 per cent; SNF - 32.89 per cent; FDM - 38.23 per cent; Salt - 5.32 per cent; Protein - 21.75 per cent.

After analysing a large number of processed cheese samples (409), the upper and lower limits for moisture and fat contents of good quality processed cheese were established (Maver, Belameric, Kovacevic and Milosevic, 1975).

Puhan and Renz (1975) recommended that the tear-off strips made of plastics and not that of Al should be used in case of processed cheese, in order to avoid corrosion and other defects in the product.

The experiments of Csok (1978) showed that the browning rate of processed cheese, heat-treated at 95°C was affected little by storage temperature; but after heat treatment at 108 or 115°C, the browning rate increased with increasing storage temperature (6, 16, 30°C). The higher the temperature of heat treatment and longer the holding time (10 vs 5 or 0 min), the more intensive was the browning. The temperatures below 10°C were found to be excellent for the storage of processed cheese.

Wagner and Wagner-Hering (1981) discussed the various aspects of production and composition of processed cheese which affected the quality characteristics of the product. The aspects included: the colloidal nature of casein and its structure; effect of polyphosphates used as stabilizers; microflora of processed cheese; milk products used in the manufacture (casein, whey concentrates, buttermilk); and nutritive value of processed cheese.

Chandan (1982) discussed gas and moisture vapour permeabilities of the packaging materials for processed cheese.

Bley, Johnson and Olson (1985) suggested that the browning in processed cheese could be controlled by regulating the salt contents in the cheese, by using strains of Streptococcus thermophillus or by cooling the processed cheese very rapidly, regardless of sugar and salt contents.

Goyal and Gupta (1987) recommended that in order to preserve the textural qualities, and to avoid weight loss and oxidation in the processed cheese, the packaging materials should have excellent water vapour and gas barrier properties.

2.2.3.0 Microbiological quality:

2.2.3.1 Different bacterial counts including yeasts & moulds

Ledabyl (1953) investigated the sources of re-infection and changes in the bacterial flora of processed cheese during processing and subsequent storage. According to him, cooking at 80°C for 10 min caused the complete destruction of acid and alkali producing bacteria and moulds, but temperatures exceeding 95°C for 10 min were needed for destruction of the spore formers. He recommended a 3 per cent solution of H_2O_2 for disinfecting the hands and the equipments.

For assessing the quality of processed cheese, the accelerated keeping quality tests at 30°C and

37°C for 14 and 7 days respectively as well as microbiological tests were found to be suitable (Mergl, 1968).

Lebert, Brat, Hurmier, Pien and Thomas (1969) discussed in detail the bacteriological analysis of processed cheese, including the tests for processed cheese packaged in air-tight containers (analysis of gas present, checking of air-tightness, examination of inner surfaces of containers).

Marenzi and Salvadori (1969) studied the microflora of stored Italian processed cheese (with added nisin).

Petrica, Pambucol, Rosu and Ionescu (1969) analysed bacteriologically 56 samples of processed cheese representing 21 varieties. The total bacterial counts ranged from 300,000 to 2 million per g. Bacillus cereus var. mycoides was detected in 39 (69.6%) of the samples. Bacillus subtilis was detected in 43 (76.8%), Staphylococci (coagulase -ve) in 25 (44.6%), diplococci in 3 (5.4%) and Cl.putrefaciens in 5 (8.9%). However, no pathogenic organisms were found in the samples.

Ozer (1970) examined 175 samples of 31 samples of 31 processed cheese types for bacteriological quality. The total bacterial count, yeasts and moulds, mesophilic aerobic spores and anaerobic spores were reported to be 2×10^7/g, 53/g, 1300/g and 420/g respectively.

Mittic, Otenhajmer and Borota (1972) conducted a detailed study of microbiological quality of processed cheese packed in tincans (sterilized at 117-119°C).

Jantea, Oprisescu, Stancescu, Molnar and Sepetenav (1972) collected 109 samples of cheeses from a point of sale and analysed them for the presence of fungi. Eight samples of processed cheese contained 650 fungi per g. The workers also opined that cheese was one of the most dangerous of animal foods as far as fungal toxins were concerned.

A study on the microbiological analysis of Bulgarian processed cheese showed that the total bacterial counts in processed cheese stored at 20-25°C increased progressively from 900/g on 1st day to 6,800/g on the 30th day, while proteolytic microorganisms counts remained constant at approximately 500/g. During storage at 4-6°C, total and proteolytic microorganisms counts respectively decreased from 900 and 600/g to 400 and 300/g on the 30th day (Mladenov, Madzharova, and Draganova, 1972).

Sozzi (1974) tried 3 types of processed cheese for evaluating 3 methods for quick assessment of the bacteriological stability of processed cheese, and compared them with traditional method, in which the samples were examined daily for physical changes during incubation for upto 30 days at 37°C.

Al-Ashmay, Mohomed and Moursy (1977) experimentally tested 40 samples of processed cheese purchased from retail shops in Cairo and Giza. The mean total bacterial count was observed to be 287×10^3/g and mould count 52 ± 7/g. The anaerobic bacteria were reported

to be present in all the samples, while the coliform bacteria in 12.5 per cent of the samples.

Kumar and Brave (1978) studied the effect of different levels of nisin on microbiological quality of processed cheese. They observed that the addition of 100 RU nisin/g to processed cheese was sufficient to check any significant increase in bacterial counts during storage.

Aleksieva, Duparinova, Kostova and Mladenova (1984) isolated organisms from processed cheese which showed blowing 5 days after production, and identified them to be Candida utilis.

2.2.3.2 Spore formers

Guht (1954) noted that processing did not destroy all the spore formers in cheese, and also the spoilage of processed cheese did not depend entirely on the spore formers present.

Demeter (1958) suggested measures for controlling anaerobic spore formers in natural and processed cheese, and outlined methods for the detection of butyric acid bacteria in cheese.

Babad and Boros (1961) observed that the aerobic spore forming bacilli counts of 200-300/g did not cause sufficient spoilage in processed cheese.

Grecz, Wagenaar and Pack (1965) studied the storage stability of Clostridium botulinum toxin and spores in processed cheese.

Edward, Brave and Prasad (1972) detected anaerobic bacilli resembling Cl.butyricum in swollen cans of processed cheese.

Atwal, Reddy, Chand and Srinivasan (1974) analysed the processed cheese samples collected from NDRI, Karnal and observed that the mesophilic spore forming bacteria in the range of 264-568/g were present.

Pulay (1974) described the factors which affect the viability of butyric acid bacteria and keeping quality of processed cheese.

Hobrecht (1975) recommended that in efficiently sterilized processed cheese, the toxinogenic and proteolytic clostridia should not be detectable in 1 g and the counts of aerobic bacteria should not exceed 100/g.

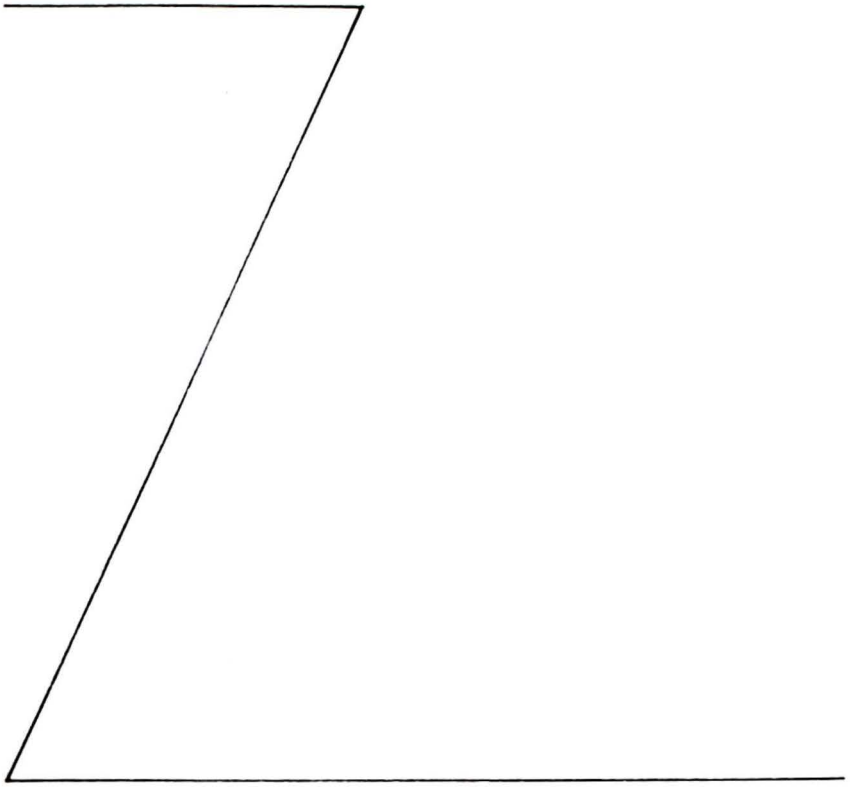
Appuswamy and Ranganathan (1981) analysed 140 samples of processed cheese procured from various markets and dairies of India, and found that Clostridia were present in 66.4 per cent of the samples. The blown cans of the processed cheese had average clostridial counts of 1000/g while the normal cans 500/g.

Gioni, Valdez, Pesca De Ruiz and Oliver (1982) isolated and identified several types of anaerobic contaminants from the processed cheese manufacturing machine.

From a study carried out by Aleksieva, Kostova and Mladenova (1985) on the microbiological quality of processed cheese, it was observed that there existed no relationship between microflora and season.

Taylor (1986) studied the effect of antibotulinal agents on inhibiting the outgrowth of Cl.botulinium spores and subsequent toxin formation in high moisture, pasteurized processed cheese spreads.

CHAPTER - III



SCOPE AND PLAN OF WORK

3.0.0.0

SCOPE AND PLAN OF WORK

The detailed review of literature on the packaging of different varieties of processed cheese in general, and processed Cheddar cheese in particular in the preceding chapter indicates that the presently available information on the technology for packaging of processed cheese, with special reference to the availability of packaging materials in this country, is almost negligible. Having better keeping quality, the packaging requirements of processed cheese in comparison to other dairy products are much more tedious. Though, the processed cheese can be safely packaged in lacquered tinplate can, the major drawback is its high cost. Recently, many types of convenient flexible plastic containers have appeared in Indian market for the packaging of various food/dairy products. They are being used indiscriminately for the packaging of many dairy products without any backing of scientific information. These plastic containers can be advantageously used for the packaging of processed cheese provided the packaging techniques, keeping quality, and the interaction of the product and package under different conditions of handling are studied and standardized. It is in this context, the present investigations have been taken up.

3.1.0.0 SCOPE

The present investigation on the use of flexible plastic containers vis-a-vis tinplate cans for the packaging of processed cheese has the scope of:

3.1.1.0 Studies on the keeping quality of processed cheese when packed in different packages.

3.1.2.0 The interaction of the product and package during various stages of storage under preset conditions of temperature and humidity.

3.2.0.0 PLAN OF WORK

The plan of work was set as follows.

3.2.1.0 On the basis of currently available flexible containers, and keeping in view the convenience to the consumers and packager, the processed cheese was planned to be packed in the following presterilized packages and also in tincans to serve as comparison in the storage studies as indicated below:

3.2.1.1 Tin cans - P_1 (Cap: 240 g)

3.2.1.2 Polystyrene (PS) cup - P_2 (Cap: 150 g)

3.2.1.3 Low density polyethylene (PDPE) tub - P_3 (Cap: 150 g)

The PS cups and LDPE tubs used in the study were certified to be as food grade by the suppliers of the containers.

3.2.2.0 The samples of processed cheese packed as mentioned under section 3.2.1.0 were stored under the following conditions of temperature and humidity.

3.2.2.1 Accelerated conditions of storage: 30°C and 60 per cent relative humidity (RH).

3.2.2.2 Refrigeration conditions of storage: 7-8°C and 80 per cent RH.

3.2.3.0 The samples of processed cheese stored as under section 3.2.2.0 were evaluated at regular intervals of 0, 10, 20 and 30 days in case of samples kept at 30°C & 60 per cent RH, and after 0, 30, 60 and 90 days for samples maintained under refrigeration conditions (7-8°C & 80% RH).

3.2.4.0 The fresh samples of processed cheese were examined for the following characteristics.

3.2.4.1 Sensory attributes

Acceptability of the production the basis of appearance, body & texture, and aroma & flavour.

3.2.4.2 Chemical quality

Percentage of moisture, fat, protein, salt ash and soluble nitrogen. Also, the determination of free fatty acids in terms of oleic acid and pH were included in the study.

3.2.4.3 Microbiological quality

Standard plate count (SPC), yeast & moulds (Y&M) count. Anaerobic spore formers (ASF) count, as Most Probable Number (MPN), was also estimated.

3.2.5.0 In order to assess the quality of the product and the extent of deterioration, the stored samples were sought to be examined for the following characteristics:

3.2.5.1 Sensory attributes

As given under section 3.2.4.1.

3.2.5.2 Chemical quality

Percentage of moisture, and soluble nitrogen, pH, and free fatty acids (% oleic acid).

3.2.5.3 Microbiological quality

As described under section 3.2.4.3.

3.2.6.0 With a view to study the interaction between the package and the product with respect to various attributes, which affect the quality of the product, the data obtained from this experimental work was proposed to be analysed statistically.

CHAPTER – IV

EXPERIMENTAL

4.0.0.0 EXPERIMENTAL

The experimental procedures followed to study the various aspects as mentioned in the Scope under section 3.1.0.0 are described in this chapter. The first section deals with the selection of packaging materials. The methods used for the preparation of processed cheese and its packaging have been detailed in the second section. The third section is concerned with the procedures used for sensory evaluation, chemical analyses of cheese and microbiological analyses of processed cheese. In the last section, the methods and techniques followed for statistical analyses of the data have been given.

4.1.0.0 SELECTION OF PACKAGING MATERIALS

4.1.1.0 Tinplate cans (P_1):

Tinplate cans used in the package studies were obtained from reputed Indian firms. The cans were lacquered. The capacity of each can was 240 gm. The height and dia of the tincan were respectively 7.80 cm and 5.90 cm.

4.1.2.0 Polystyrene cups (P_2):

The polystyrene cups and their lids were procured from the leading manufacturers of plastics of the country. The cups were opaque and white in colour. The height and top dia of the cups were 7.10 cm and 6.20 cm respectively. The thickness of the cup sheet was 0.20 mm.

4.1.3.0 Low density polyethylene tubs (P_3):

The low density polyethylene tubs and their lids were collected from manufacturers of plastic containers of the country. The tubs and lids were transluscent. The capacity of each tub was 150 gm, and the height and top dia of the tub were 3.40 cm and 7.90 cm respectively. The thickness of the tub sheet was 0.60 mm.

4.1.4.0 Sterilization of the packaging materials:

The sterilization of the packages was done as per the standard procedure (Gyanendra Kumar and Srinivasan, 1982).

4.1.4.1 Cans and their lids

Sterilization of tin cans and their lids was done by first cleaning with hot detergent solution and sterilizing in a hot air oven at 165-170^{o}C for 2 hrs, immediately before use.

4.1.4.2 Plastic containers

The plastic containers were first cleaned by using 'teepol' and they were then chemically sterilized by keeping them in chlorine solution (200 ppm) for 3 min. Then the packages were air dried. This sterilization of the packages was done immediately before use as far as possible under aseptic conditions.

4.2.0.0 TECHNIQUES FOLLOWED IN THE PREPARATION OF PROCESSED CHEESE

PLATE : 1

Packages Used In this Study

P_1 – TINCAN

P_2 – PS CUP

P_3 – LDPE TUB

4.2.1.0 Preparation of processed cheese:

Processed cheese was prepared by using medium ripened (upto 6 months old) Cheddar cheese collected from the Experimental Dairy of the National Dairy Research Institute, Karnal. The raw Cheddar cheese was from crossbred cow's milk. The paraffin wax coatings from cheese blocks were removed by using a knife. Representative samples of raw cheese used in the preparation of each lot of processed cheese were examined for physical quality and chemical quality by following standard experimental procedures.

4.2.2.0 Equipments:

4.2.2.1 Double jacketted stainless steel kettle

The double jacketted kettle used for the preparation of processed cheese was made of stainless steel. It was open, shallow and round-bottomed, and was fitted to iron bars. The specifications of the kettle were:

Top diameter	65 cm
Depth at center	45 cm
Total product handling capacity	50 kg

The kettle was connected with steam inlet and outlet and was designed to withstand steam pressures upto 2.0 kg/cm^2.

4.2.2.2 Ladle:

It was a wooden ladle with flattened end: weight - 0.80 kg, length - 85 cm, and width of the flattened end - 17 cm.

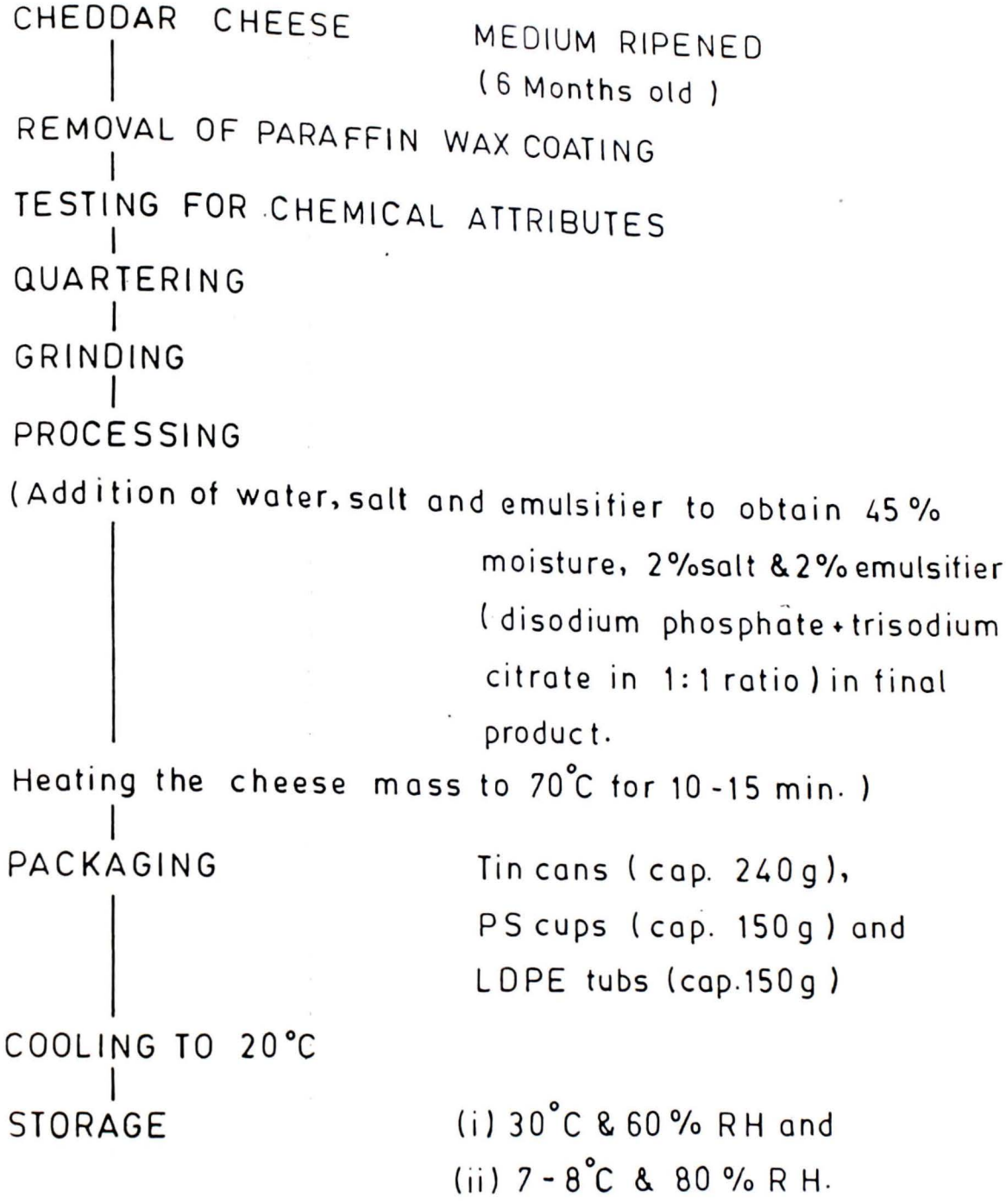


FIG.1: FLOW OF PROCESSED CHEESE INGREDIENTS FROM RECEIVING THROUGH PACKAGING AND STORAGE

4.2.3.0 Techniques of manufacturing processed cheese and its packaging:

In the present study, the methods suggested by Kosikowski (1982) were followed for the preparation of processed cheese. Medium ripened Cheddar cheese blocks as described under section 4.2.1.0 were taken. The cheese blocks were analysed for fat, moisture and salt contents for computing the amount of salt, water and emulsifier to be added to obtain the finished processed cheese of required composition. The cleaned cheese blocks were precut with the help of a clean knife. Then the small pieces of Cheddar cheese were ground by introducing them into a grinder which was manually operated.

Immediately before processing, the jacketted kettle and wooden ladle were first thoroughly cleaned by using 'Teepol'. Then, approximately 10 kg of ground Cheddar cheese were transferred to the kettle. The calculated amounts of salt (to get 2% salt in the final product) and 2 per cent emulsifier (disodium phosphate and trisodium citrate in 1:1 ratio) were dissolved in the computed amount of cold, clean water. This solution was added to the ground cheese in the kettle. Steam was turned on to the jacket at a pressure of 1.5 kg/cm^2. The mass was stirred continuously at a speed of about 50-60 kg circular motions per minute by the flattened end of the ladle in order to get a smooth product. When the cheese mass became velvety, smooth and attained the temperature of $70^{o}C$, the processed cheese was directly transferred (filled) in 3 types of

pre-sterilized packages, namely tincans, PS cups and LDPE tubs. Immediately after filling, the plastic containers were covered with their respective lids, which in turn were further sealed by using cellotape (width 2.5 cm). The metal cans were sealed by using electrically operated can seamer. The sealed packages after about one hour were then stored under two different conditions, viz. 30°C & 60 per cent RH, and 7-8°C & 80 per cent RH.

4.3.0.0 MATERIALS AND METHODS USED IN THE EVALUATION OF PROCESSED CHEESE, ANALYSIS OF CHEDDAR CHEESE, CHEMICAL AND MICROBIOLOGICAL ANALYSES OF PROCESSED CHEESE

4.3.1.0 Sensory evaluation of processed cheese:

The samples of processed cheese stored (as given under section 3.2.2.1 and 3.2.2.2) in the 3 different types of packages were evaluated organoleptically by a panel of 5 judges for appearance, body & texture, and aroma and flavour.

The packaged samples of processed cheese stored at 30°C & 60 per cent RH were examined for sensory attributes after an interval of 0, 10, 20 and 30 days, while the samples stored at 7-8°C & 80 per cent RH were evaluated after an interval of 0, 30, 60 and 90 days.

The stored test samples were tempered at 10°C - 15.5°C (50°F-60°F) for 3 hrs before they were presented under code numbers to each judge. The product was evaluated by the judges by using Numerical Score Card (Appendix XXI).

4.3.2.0 Chemical analyses of Cheddar and processed cheese:

In the present investigations, all the chemicals used were of analytical grade. Glass double distilled water was used throughout the analysis. This section includes the sampling procedures adopted, and the determination of moisture, fat and salt in case of Cheddar cheese; and moisture, fat, protein, salt, ash, fat degradation in terms of free fatty acids, protein breakdown, i.e. soluble nitrogen, and pH in respect of processed cheese.

4.3.2.1 Techniques of sampling:

The sampling of the test samples was done in accordance with the procedures recommended by ISI: IS: 2785 (1964). The samples were prepared for chemical analysis by passing them quickly through a stainless steel grater. The grated cheese sample was then grinded in a mortar and the same was then transferred to a sterilized sample bottle. The analysis was performed without delay.

4.3.2.2 Determination of moisture

The moisture content in Cheddar/processed cheese was estimated gravimetrically by following the procedure described for hard cheese and processed cheese in ISI standard, IS: 2785 (1964).

4.3.2.3 Determination of fat

Milk fat in Cheddar/processed cheese was determined by adapting the procedure as described by Indian Standard Institution (IS: 2785-1964).

Accurately 1.0 to 1.5 g of the prepared sample was weighed into the Mojonnier extraction tube. 10 ml of hydrochloric acid (Sp.gr. 1.125) was added and boiled gently (with shaking) in a boiling water bath, until all solid particles dissolved. Then the tube was cooled in running tap water. 10 ml of ethyl alcohol (95 to 96% by volume) was added and thoroughly mixed. 25 ml of ether (density - 0.720, peroxide free) was added and the tube was closed with cork and vigorously shaken for one minute. Then, 25 ml of light petroleum (boiling range 40-60°C) was added and shaken vigorously for 30 seconds and centrifuged at about 1000 rpm for 30 seconds and the supernatent layer was transferred to a Mojonnier fat dish. The extraction of the residue was repeated by using 5 ml of ethyl alcohol, 15 ml of ether and 15 ml of light petroleum. The final extraction was done with 15 ml each of ether and light petroleum and the fat layer was transferred to the fat dish. The solvents from the Mojonnier fat dish were evaporated by keeping the dish on hot plate at 135°C (275°F) for one hour. Precautions were taken to remove all traces of the volatile solvent. The dish was then cooled in a dessicator charged with an efficient dessicant (silica gel). The fat dish was then weighed accurately. The heating was repeated for periods of 30 min, until the weight no longer decreased. The fat was determined by using the following formula:

$$\text{Per cent fat} = \frac{\text{weight of fat extracted}}{\text{weight of sample}} \times 100$$

4.3.2.4 Salt

Salt content in Cheddar/processed cheese was determined as per the following method recommended by ISI IS: 2785 (1964).

About 2 g sample of the Cheddar/processed cheese was accurately weighed in a 300 ml flask. 10 ml of distilled water and 25 ml of 0.05 N standard silver nitrate solution were added to the sample. The contents of the flask were heated to 75° to 80°C to facilitate the dispersion of the cheese with vigorous swirling. Then 10 ml of concentrated nitric acid were added and the contents of the flask were boiled gently until the curd digested. The finishing stage was detected when the silver chloride became granular, the liquid turned to clear brown yellow colour, and the fat layer became free from solid material. Then, to the contents of the flask 2 ml of iron alum solution and approximately 50 ml of distilled water were added. The excess silver nitrate was determined by titration with 0.05 N potassium thiocyanate solution until the first appearance of an orange tint which persisted for 15 seconds. The equivalent of 25 ml of silver nitrate solutions as thiocyanate was determined in the same manner, using the same volumes of reagents and water.

The salt content of the Cheddar/processed cheese samples was calculated by employing the following formula:

$$\text{Salt (percent by weight)} = \frac{29.2\ (V_1 - V_2)}{W}$$

where,

V_1 = volume in ml of standard potassium thiocyanate equivalent to 25 ml of silver nitrate

V_2 = volume in ml of potassium thiocyanate used in the titration of excess silver nitrate, and

W = weight in g of cheese taken for test

4.3.2.5 Determination of total protein

Nitrogen in processed cheese was estimated by Kjeldahl method as described in AOAC (1975) and the percentage protein was calculated by using following formula:

Per cent protein = per cent Nitrogen x 6.38

4.3.2.6 Determination of total ash

Total ash content in processed cheese was determined as per the method prescribed by ISI SP:18 (Part I-1980).

Accurately about 3 g of the processed cheese sample was taken in a dried and weighed silica dish. The dish was first gently heated over a flame and then heated strongly in a muffle furnace at 550 $\pm$ 20°C, till grey ash resulted. The dish was cooled in a dessicator and then weighed. The dish was again heated at 550 $\pm$ 20°C for 30 min. It was then cooled in a dessicator and weighed. The process of heating for 30 min, cooling and weighing was repeated many times until the difference between two successive weighings was less than one milligram.

$$\text{Total ash, per cent by weight} = \frac{10\,(W_2 - W)}{W_1 - W}$$

where,

W_2 = weight in g of the dish with the ash

W = weight in g of the empty dish

W_1 = weight in g of the dish with the material taken for the test

4.3.2.7 Fat breakdown

The fat breakdown in processed cheese was determined by estimating free fatty acids (FFA) (% oleic acid) according to the procedure evolved by Thomas, Harper and Gould (1954).

Two grams of cheese were weighed accurately, ground and transferred (using hot distilled water) into Mojonnier extraction flask. Then 10 ml of ethyl alcohol (95%) were added to the extraction flask. The contents were cooled and shaken vigorously for 2 min. Subsequently, 20 ml of ethyl ether and 30 ml of petroleum ether (40^{o}-60^{o}C B.P) were added and the flask was shaken vigorously after addition of each solvent. The contents were then centrifuged for 5 minutes and ether extract was transferred into a clean 250 ml conical flask. To this was added one gm of anhydrous sodium sulphate followed by thorough shaking. The extract was decanted into another clean and dry 250 ml conical flask and was titrated with standard N/100 alcoholic sodium hydroxide solution using phenolphthalein (0.5%) as indicator. The FFA value was calculated as percentage oleic acid in cheese.

$$\text{FFA (\% oleic acid)} = \frac{V \times 0.282}{W}$$

where,

V = ml of 0.01 N alc. NaOH used

W = weight of the sample

4.3.2.8 Soluble nitrogen

The soluble nitrogen in processed cheese was found out by the standard method (Kosikowski, 1982). About 3 g of cheese sample was accurately weighed and transferred to a mortar and a small amount of Sharp's extraction solution (57.5 ml glacial acetic acid, 131.6 g sodium acetate, 47.0 g sodium chloride, 1 lit distilled water) (tempered at 50°C) was added. The contents were ground into a paste. Additional solution was added to make a dilute suspension and the contents were quantitatively transferred to a 100 ml volumetric flask and the volume was made up to the mark. The suspension was incubated at 50°C in a thermostatically controlled water bath for 1 hr with occasional shaking and filtered through Whatman No. 42 filter paper. Twenty five ml portion of filtrate was transferred to a 300 ml kjeldahl flask for digestion. The digested material was distilled and the distillate was collected in 25 ml boric acid solution. A blank was carried out simultaneously. The sample and blank distillates were titrated against 0.02 N HCl using 0.5 ml of mixed indicator. The soluble N in cheese sample was computed by using the following formula:

Per cent soluble N = 0.0373 (V - B)

V = ml of 0.02 N HCl used for sample

B = ml of 0.02 N HCl used for blank

4.3.2.9 pH

The pH of processed cheese was determined as per the following procedure:

10 gm of shredded processed cheese was taken and 10 ml of distilled water was added to it to make a paste in a small beaker, and the pH was directly noted by using a glass electrode pH meter (Toshniwal-Moller).

4.3.3.0 Microbiological examination of processed cheese:

For the microbiological analysis of processed cheese, the sampling and the preparation of dilution blanks were carried out as per the methods described in Laboratory Manual (1959).

4.3.3.1 Preparation of dilution blank

The dilution blank consisted of 2 per cent sodium citrate solution in 99 ml and 9 ml portions in screw capped dilution bottles and culture tubes respectively. They were autoclaved at 121°C for 20 min. The dilution blanks were warmed to 45°C before use for preparation of samples.

4.3.3.2 Sampling of cheese

With sterile cheese trier, 2 to 3 plugs of 2 inch size were removed from the processed cheese samples and 1/2 inch portion from the surface was discarded by cutting with a sterile knife. The remaining part of the plug was cut into small pieces and 11 g of cheese was aseptically weighed and transferred to a mortar. To this,

about 5 g of sterile sand was added and the sample was thoroughly mixed. This was then transferred to a bottle containing 99 ml of dilution blank. Further dilutions were made with 9 ml dilution blanks in culture tubes.

4.3.3.3 Standard plate count (SPC)

SPC in processed cheese was determined by using tryptone dextrose yeast extract agar (TDYA) medium of the following composition (Laboratory Manual, 1959).

Tryptone	-	0.50%
Yeast extract	-	0.25%
Dextrose	-	1.10%
Agar-agar	-	1.50%
pH	-	7.0

The tryptone and yeast extract were dissolved in warm distilled water. The mixture was boiled for 10 min. It was then filtered through ordinary filter paper. To this, required quantity of agar powder was added and the mixture boiled, filtered through muslin cloth, which was lined with absorbent cotton soaked in water. Subsequently, the dextrose was added and the volume was made up by using warm distilled water and the pH was checked. The medium (150 ml each) was filled in each of the 250 ml capacity conical flask. The flasks were fitted tightly with cotton plugs and sterilized by autoclaving at 15 psi ($121^{o}C$) for 15-20 min. Appropriate dilutions of the samples were plated using TDYA medium and the plates were incubated at $37 \pm 1^{o}C$ for 48 hrs.

The colonies were counted according to the standard procedures as suggested by American Public Health Association (APHA, 1967).

4.3.3.4 Yeasts and Moulds (Y&M) counts

The yeasts and moulds count in processed cheese was determined by using potato-dextrose agar (PDA) medium as per the procedure detailed in IS: 5403 (1969).

a) Composition of PDA:

200 g of potato infusion	1 litre of water
Dextrose	20 g
Agar	15 g
Distilled water	1 litre
pH	3.5

b) The medium was sterilized by autoclaving at a pressure of 15 psi for 15 minutes. The pH of the medium was then adjusted to 3.5 at the time of pouring the plates, by using 10 per cent sterile tartaric acid.

c) The further dilutions, when required were made from 1:10 dilution of the suspension of the sample and the plates were prepared in duplicates, and incubated at 22°C for 3 to 5 days. The colonies of yeasts and moulds were counted as per the standard method (APHA, 1967).

4.3.3.5 Anaerobic spore formers

Anaerobic spore formers count in processed cheese was determined by using Differential Reinforced Clostridial Medium (DRCM) as recommended by Freams and Fitzpatrich (1956).

a) Composition and preparation of DRCM

The basal medium contained peptone -10g; lab lemco - 10g; hydrated sodium acetate -5 g; yeast extract - 1.5 g; soluble starch - 1 g; glucose - 1 g; L-cysteine HCl - 0.5 g; distilled water - 1000 ml; pH 7.1-7.2. To prepare the basal medium, peptone, lab lemco, sodium acetate, and yeast extract were added to 800 ml distilled water. A starch solution was prepared in the other 200 ml of water by making a cold paste in a little water boiling the rest and then stirring it into the paste. The solutions were mixed and steamed for 30 min to dissolve the ingredients. After steaming, the glucose and cysteine HCl were added and the pH was adjusted to 7.1-7.2 with 10N NaOH. The medium was then filtered, while still hot into screw capped tubes which were then sterilized by autoclaving (121°C/15 min). Immediately before use, sodium sulphite and ferric citrate were added to give final concentrations of 0.04 per cent and 0.07 per cent (W/V) (anhydrous salts) respectively. The sodium sulphite (anhydrous) was prepared as a 4 per cent (W/V) solution and the ferric citrate (scales) as a 7 per cent (W/V) solution. The ferric citrate was heated for about 5 min, so that it dissolved completely. Both solutions were sterilized and stored at 3-5°C. On the day of DRCM requirement, the basal medium was steamed and cooled; equal volumes of sodium sulphite and ferric citrate were mixed together and 0.5 ml of the mixture added aseptically to each 25 ml of DRCM.

b) Enumeration of clostridia from processed cheese

Ten g of processed cheese was macerated in sufficient 0.1 per cent peptone water to give a 0.2 or 0.1 (W/V) dilution of the food. Decimal dilutions of the macerate were prepared in the same diluent and 1 ml of the original macerate and the next two decimal dilutions were transferred to the tubes containing DRCM. Three tubes with each dilution (Taylor, 1962) were inoculated. The tubes were observed for blackening of the medium, after incubation of the tubes at 37°C for 48-72 hours, and the results were reported in most probable number (MPN) counts.

4.4.0.0 PROCEDURES FOLLOWED FOR THE STATISTICAL ANALYSES OF THE DATA

The data obtained during present investigations were subjected to statistical analyses by following the methods and techniques as suggested by Snedecor and Cochran (1967).

CHAPTER - V

RESULTS AND DISCUSSION

5.0.0.0 RESULTS AND DISCUSSION

The results obtained during the present investigations on the quality of processed cheese, changes in sensory, chemical and microbiological qualities of the packaged product when fresh and after different intervals of storage, and the possible interactions between package and product during storage are presented in Tables 1 to 12 and Appendices I to XX. In the body of the text, the Figures (graphs) for such changes in the values at the begining and at the end of the storage periods are included and discussed. To facilitate the discussion, the Tables concerning the statistical analyses of the data are also included in the body of the text.

5.1.0.0 CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF FRESHLY MANUFACTURED PROCESSED CHEESE USED FOR THE PACKAGE AND STORAGE STUDIES

5.1.1.0 The methods of preparation of processed cheese used in the experiments have been delineated in section 4.2.0.0.

The data on the moisture, fat, protein, salt, ash, emulsifier, free fatty acids, soluble nitrogen and pH of fresh processed cheese manufactured in the laboratory are presented in Table 1. The containers used for the package and storage studies are shown in Plate 1. The microbiological quality of the fresh processed cheese in terms of standard

Table 1: Chemical quality of processed cheese before packaging.

S.No.	Constituent	Maximum	Minimum	Average*
1.	Moisture (%)	43.54	42.78	43.15
2.	Fat (%, on dry matter basis)	52.08	51.86	51.97
3.	Protein (%)	20.12	18.63	19.37
4.	Salt (%)	2.16	2.04	2.10
5.	Ash (%)	3.60	3.46	3.57
6.	Emulsifier (%)	2.00	2.00	2.00
7.	Free fatty acids (% oleic acid)	0.084	0.082	0.083
8.	Soluble nitrogen (%)	1.693	1.489	1.583
9.	pH	5.62	5.56	5.59

* Mean of three trials

plate count, yeasts & moulds, and anaerobic spore formers is given in Table 2.

Table 2: Microbiological quality of processed cheese before packaging.

S.No.	Type of microorganisms	Counts/g		
		Maximum	Minimum	Average*
1.	Standard plate count	720	580	650
2.	Yeasts and moulds	13	6	9
3.	Anaerobic spore formers (MPN/100 g)	9.1	3.6	6.63

* Mean of three trials

5.1.1.1 Table 1 on the chemical quality of freshly manufactured processed cheese indicates that the moisture content (%) varied from 43.54 to 42.78 with an average of 43.15. This slight difference in the moisture content may be due to the difference in the extent of heating (which is practically unavoidable) during manufacture of processed cheese.

The average figure for moisture content in Turkish processed cheese was reported to be 46.77 per cent (Ozer, 1970), while the mean values for processed Cheddar cheese were observed to be 42.40, 42.80 and 42.90 per cent by Tewari and Chakraborty (1986).

5.1.1.2 The fat content (on dry matter basis) in fresh processed cheese samples ranged from 52.08 to 51.86 per cent with an average of 51.97 per cent. All these values were much above the legal minimum requirement of 40 per cent for the fat content in processed cheese, prescribed by the PFA (1959).

5.1.1.3 The values for protein content (%) of freshly manufactured processed cheese used in the packaging studies varied from 20.10 to 18.63, averaging 19.37.

In Turkish processed cheese, the average protein content was reported to be as 21.75 per cent (Ozer, 1970).

5.1.1.4 The maximum and minimum figures for salt content were 2.16 and 2.04 per cent respectively in the fresh processed cheese samples, with an average of 2.10 per cent (Table 1).

5.1.1.5 The values for ash content (%) in the samples of processed cheese used in the package studies averaged 3.57, with a maximum of 3.60 and a minimum of 3.46.

5.1.1.6 Except to indicate that the emulsifier content in the processed cheese samples was 2 per cent, there is nothing specific to mention here.

5.1.1.7 The initial maximum and minimum values for the fatty acids (FFA), in terms of % oleic acid, in processed cheese samples were very nearly the same, being 0.084 and 0.082 respectively with an average of 0.083.

5.1.1.8 The soluble nitrogen contents (%) in the freshly prepared processed cheese used in the present studies on packaging averaged 1.583. The maximum and minimum values for soluble nitrogen were observed to be 1.693 and 1.489 per cent, respectively.

5.1.1.9 The pH of the freshly manufactured processed cheese samples varied from 5.62 to 5.56 with an average of 5.59.

5.1.1.10 The above values indicate that the samples of processed cheese used for the packaging studies conformed to the standards laid down by the ISI (1964) and PFA (1976). However, among the trials, there were little differences in the values and this is inherent in the method of preparation of the product.

5.1.2.0 <u>Discussion of results on the microbiological quality of processed cheese</u>:

The data pertaining to the microbiological quality of fresh samples of processed cheese in terms of

standard plate count (SPC), yeast and moulds (Y&M), and anaerobic spore formers (ASF) are presented in Table 2.

5.1.2.1 The standard plate counts of freshly prepared processed cheese were observed to range from 580 to 720 with an average of 650 per g; while the yeasts & moulds counts varied from 6 to 13 per g (average 9/g). The maximum value for anaerobic spore formers (MPN/100 g) stood at 9.1, while the minimum at 3.6 with an average value of 6.6. The results confirm the observations of Guht (1954) that the processing of cheese did not destroy all the spore formers in cheese.

The above values in general are in harmony with the findings of earlier workers (Kalra et al., 1973; Appuswamy and Ranganathan, 1981). The total counts in the fresh samples of Bulgarian processed cheese have been reported to be as 900/g (Mladenov et al., 1972).

5.2.0.0 CHANGES IN QUALITY OF PROCESSED CHEESE STORED IN DIFFERENT PACKAGES UNDER DIFFERENT TEMPERATURE AND HUMIDITY CONDITIONS

The samples of freshly prepared processed cheese in the laboratory were examined for their degree of deterioration during storage, when packed in the selected packages, viz. tincan (P_1), Polystyrene cup (P_2), and Low density polyethylene tub (P_3) and stored under the preset conditions of temperature and humidity. The various parameters studied in the evaluations of the degree of deterioration in different samples packed in different packages stored under different conditions are

discussed in this section under the following heads: sensory characteristics, chemical changes, and microbiological changes.

5.2.1.0 Sensory characteristics:

The data on the appearance, body & texture, and aroma & flavour of the processed cheese samples as determined by the procedures described in section 4.3.1.0 are discussed under this head.

The acceptance of data for appearance, body & texture, and aroma & flavour as mean sensory scores based on numerical scoring test of the processed cheese samples stored in the 3 different types of packages for different periods at 30°C & 60 per cent RH, and 7-8°C & 80 per cent RH are depicted in Figures 2 and 3, and Appendices I to VI. The statistical analysis of the data is presented in Tables 3 to 5.

5.2.1.1 Appearance

The Figure 2 shows that the product packaged in P_1, i.e. tincan scored highest for appearance, body & texture and aroma & flavour, followed by the sample packaged in P_3 and P_2 respectively under both the conditions of storage. The initial score of 17.5 for appearance decreased to 16.1, 15.5 and 14.5 respectively in case of P_1, P_3 and P_2 after 30 days of storage at higher temperature conditions (Appendix I); whereas the values for appearance were found to be slightly higher, being 16.3, 15.6, and 15.0 respectively in respect of the 3 types of packages after 90 days of storage at

KEY TO THE CURVES

P_1 – TIN CAN (CAPACITY 240 g)

P_2 – POLYSTYRENE CUP (CAPACITY 150g)

P_3 – LOW DENSITY POLYETHYLENE TUB (CAPACITY 150g)

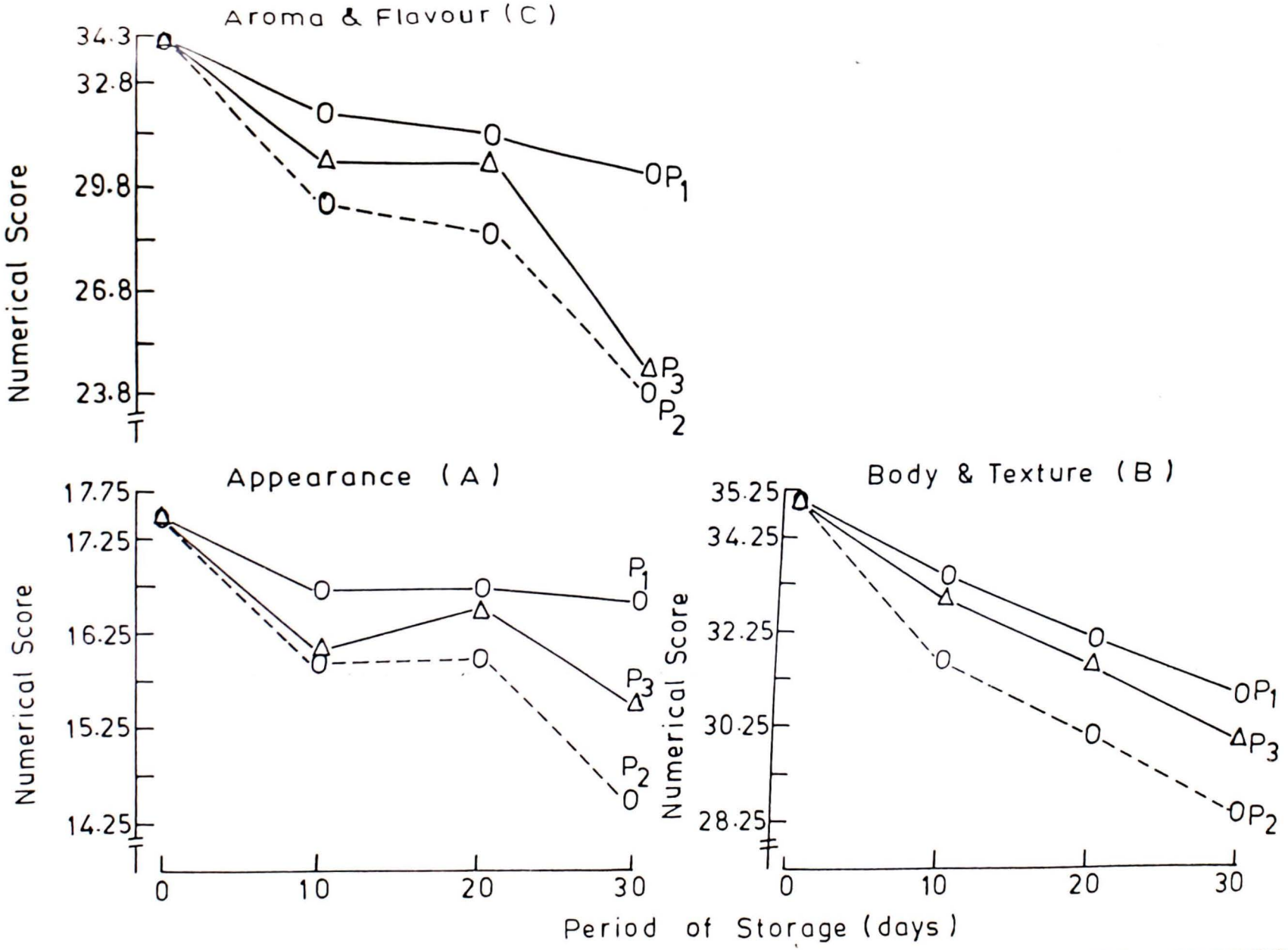


FIG.2: EFFECT OF DIFFERENT PACKAGES ON THE NUMERICAL SENSORY SCORES OF PROCESSED CHEESE STORED AT 30°C AND 60% RH

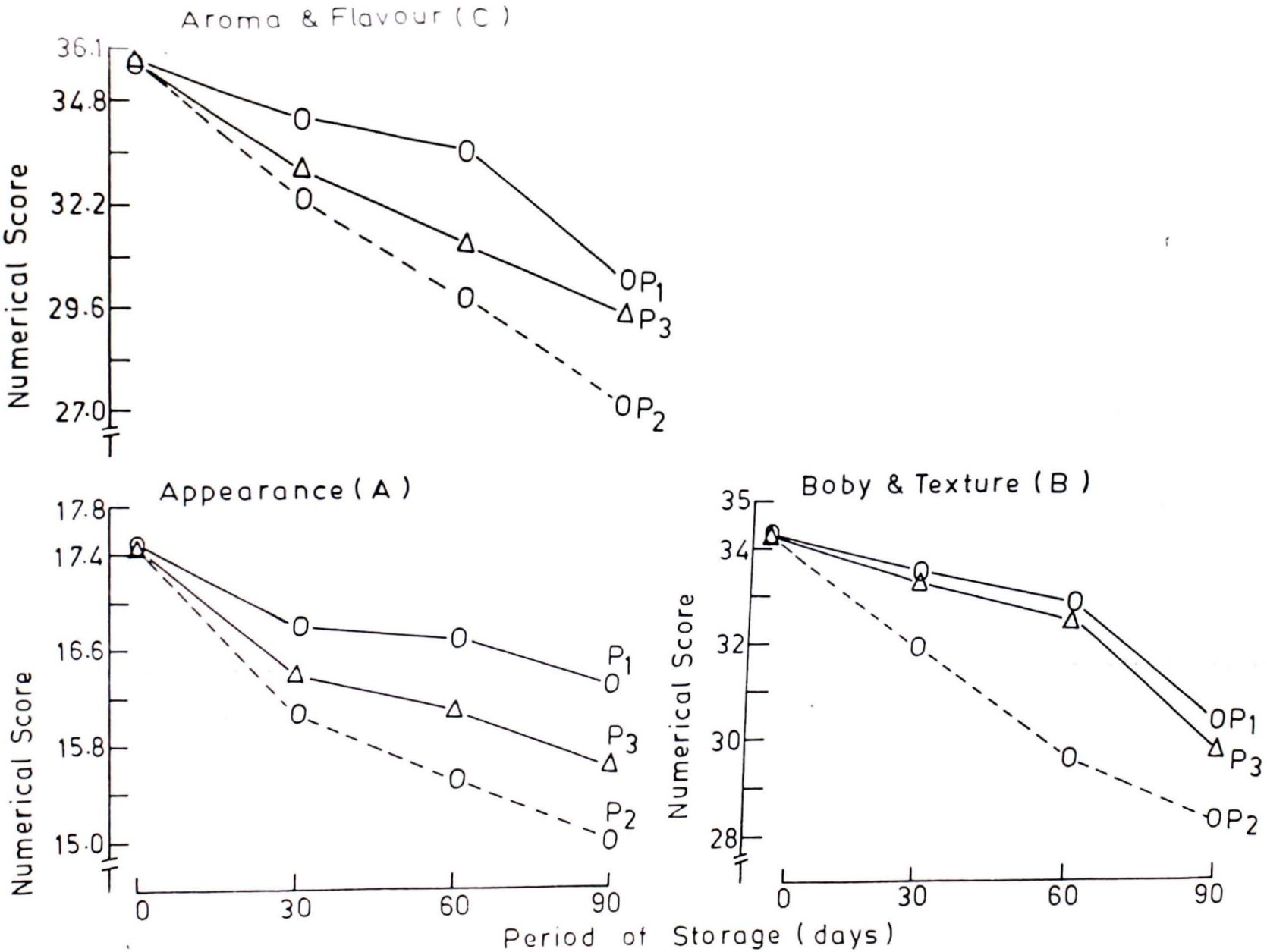


FIG.3: EFFECT OF DIFFERENT PACKAGES ON THE NUMERICAL SENSORY SCORES OF PROCESSED CHEESE STORED AT 7-8°C AND 80% RH

7-8°C & 80 per cent RH. The experiments showed that the figures for appearance in case of all the samples stored under the two conditions ranged from good to fair (Appendices I and II), revealing that the processed cheese samples with regard to appearance were acceptable in all the 3 types of packages upto 30 and 90 days respectively at 30°C & 60 per cent RH, and 7-8°C & 80 per cent RH.

The statistical analysis of the data (Table 3) showed that the variations in the scores for appearance due to different trials were significant ($P < 0.01$) only in the case of lower temperature storage conditions. The differences due to the intervals of storage, the types of packages, and the various judges, each individually, contributed significantly ($P < 0.01$) towards the changes in appearance under both the conditions of storage. Also, the interaction intervals x packages was significant ($P < 0.05$). However, the interactions judges x intervals; judges x packages; and intervals x packages x judges were found to be not significant under any of the two studied storage conditions.

5.2.1.2 Body & texture

The numerical scores assigned for body & texture to the processed cheese samples stored in different packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH are presented in Appendices III and IV, and Figures 2 and 3. Analysis of variance of the data is recorded in Table 4.

Figure 2 and Appendix III show that the scores were maximum (mean 30.9) for theproduct packed in P_1, followed

Table 3: Analysis of variance of sensory scores for appearance of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7.8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	1.1722222	1.29286526	11.8222221	15.5540134**
Among intervals of storage	3	35.2666666	38.8962504**	26.7018517	35.1305327**
Among packages	2	10.4222222	11.4948591**	10.8388888	14.2602821**
Among judges	4	6.98611105	7.70510941**	3.3555555	4.41476694**
Interaction intervals x packages	6	1.97777773	2.18132716*	1.35740745	1.78588539*
Interaction intervals x judges	12	1.99351846	2.19868791	1.15555554	1.52031710
Interaction packages x judges	8	0.1861111	0.205265329	0.443055537	0.582910025
Interaction intervals x packages x judges	24	0.732407429	0.807785524	0.13749991	0.180903107
Error	108	0.906685508		0.760075342	

** Significant at 1% level of significance.

* Significant at 5% level of significance.

Table 4: Analysis of variance of sensory scores for body & texture of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	46.422222	7.64536927**	38.4848888	10.7532852**
Among intervals of storage	3	236.133332	38.8892743**	211.029680	58.9586670**
Among packages	2	52.405555	8.63077643**	65.622222	18.3338940**
Among judges	4	156.991666	25.8552738**	49.963888	13.9591830**
Interaction intervals x packages	6	7.7611111	1.27819300	8.49629678	2.37374152
Interaction intervals x judges	12	32.2953702	5.31878959**	10.163888	4.51595580**
Interaction packages x judges	8	2.57916687	0.424768189	1.2472228	0.348455818
Interaction intervals x packages x judges	24	0.77731475	0.128017532	0.713888788	0.199450117
Error	118	6.07193980		3.57928440	

** Significant at 1% level of significance.

by P_3 (mean 30.0), and P_2 (mean 28.3), after 30 days of storage at 30°C & 60 per cent RH. It is evident from Figure 3 that the tincan (P_1) scored highest (mean 30.3) and the P_2 lowest (mean 28.3), while the P_3 obtained an intermediary mean score of 29.7 after 90 days of storage under the refrigeration conditions. This trend of the 3 types of packages towards the changes in sensory scores for body & texture was most likely due to different water vapour permeabilities of the plastic containers. P_2 being made of PS in all the possibilities might have permitted the escape of more moisture as compared to P_3 (Appendices VII and VIII), which was made of LDPE (Kumar et al., 1976; Kumar and Srinivasan, 1983b). This most likely resulted in minimum scores for body & texture in case of the product packed in P_2, followed by P_3 and P_1 (tincan being impermeable to moisture vapour) in descending order. The results are in agreement with the findings of Olotex et al. (1971) who also reported lower scores for the samples of processed cheese packed in plastic containers having more water vapour permeabilities.

The analysis of variance of the data (Table 4) revealed that the changes in the sensory scores for body & texture of the processed cheese samples due to the durations of storage, the 3 types of packages, and the judges were highly significant ($P < 0.01$) under both the conditions. Interaction judges x intervals was also significant ($P < 0.01$), while the other studied interactions were observed to be not significant under any of the conditions.

5.2.1.3 Aroma & Flavour

Data on the sensory scores for aroma and flavour of the processed cheese samples stored in the different packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH are given in Appendices V and VI and illustrated in Figures 2 and 3. The F values of the data on aroma & flavour are indicated in Table 5.

From Figure 2, it can be seen that the mean initial score of 34.1 decreased to 30.2, 24.6 and 23.8 in P_1, P_3 and P_2 respectively after 30 days of storage at 30°C & 60 per cent RH. The maximum decrease in aroma & flavour scores was noticed in case of P_2 under both the conditions of storage. As expected, the tincan being impermeable to odours and oxygen had highest scores for aroma & flavour (Appendices V and VI). Since the oxygen transmission rate (OTR) of PS is more to that of LDPE (Kumar et al., 1976; Kumar and Srinivasan, 1983b), this might have resulted in lower scoring for aroma & flavour for the samples packed in P_2.

Table 5 indicates that the periods of storage and the types of packages had highly significant ($P < 0.01$) effect on aroma & flavour scoresof processed cheese samples at both the conditions. The differences in the scores due to different judges were less significant ($P < 0.05$) in case of the samples stored at 7-8°C & 80 per cent RH. The interaction between intervals and packages was also highly significant ($P < 0.01$) under both the conditions; whereas

Table 5: Analysis of variance of sensory scores for aroma & flavour of processed cheese in different types of packages stored at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	18.429166	3.60951334*	103.716666	18.9872778**
Among intervals of storage	3	488.370369	95.6516083**	239.79999	43.8998802**
Among packages	2	143.116666	28.0306507**	47.816666	8.75373611**
Among judges	4	102.977777	20.1690983**	17.508325	3.20522811*
Interaction intervals x packages	6	34.7759261	6.81116930**	8.28333366	1.51641933**
Interaction intervals x judges	12	14.148148	2.77103853**	3.48981483	0.638875954
Interaction packages x judges	8	3.227778	0.632188552	2.004167	0.366900298
Interaction intervals x packages x judges	24	2.41481466	0.472962573	2.646775904	0.484538804
Error	118	5.10572041		5.46242945	

** Significant at 1% level of significance.

* Significant at 5% level of significance.

the interaction judges x intervals was observed to be significant ($P < 0.01$) only at higher temperature storage (Table 5). However, the interactions judges x packages, and intervals x packages x judges were found to be not significant under any of the two storage conditions.

At 30°C & 60 per cent RH, processed cheese samples packaged in tincans (P_1) were acceptable upto 30 days, while the product packed in PS cups (P_2) and LDPE tubs (P_3) was acceptable to the panelists upto 20 days only. The processed cheese samples stored at 7-8°C & 80 per cent RH were found to be of acceptable quality in all the three types of packages (P_1, P_2 and P_3) for 90 days. Interestingly, in the evaluation of the packages, Tables 1 to 6 show that consistently $P_1 > P_3 > P_2$ for storage of the processed cheese at both the conditions.

The above results confirm the earlier findings of Komissarora (1965) and Snegireva et al. (1976) that the shelf life of processed cheese declined with the increase in storage temperature. Snegireva et al. (1976) also observed that the shelf life of processed cheese in polysterene cups was 3 months at -4 ± 1°C & 85-90 per cent RH.

5.2.2.0 Chemical changes:

5.2.2.1 Moisture content

The values for moisture content of processed cheese samples stored in the 3 different packaging materials under the 2 conditions of temperature and humidity are given in Appendices VII and VIII, and graphically plotted in

Figures 4 and 5. The statistical analysis of the data on moisture content is shown in Table 6.

From Figure 4 and Appendix VII, it can be observed that the mean initial moisture content of 43.15 per cent in processed cheese samples decreased to 42.73, 42.03 and 42.26 per cent in P_1, P_2 and P_3 respectively, after 30 days of storage at 30°C & 60 per cent RH. The minimum decrease in moisture content of processed cheese samples was noted in P_1, and maximum decrease in P_2. This is obviously because P_1 being tincan was completely impermeable to moisture vapour, while the P_2 and P_3 being plastic containers, permitted the egress of the moisture vapours. Between the 2 plastic containers, P_2 which was made of PS showed more moisture loss in the product during storage compared to P_3 which was made of LDPE. Obviously, this was due to more moisture permeability of the PS than the LDPE containers (Kumar *et al.* 1976; Kumar and Srinivasan, 1983b).

Moisture loss from the processed cheese samples stored at 7-8°C & 80 per cent RH from the packages was maximum in case of P_2 followed by P_3 and P_1 (Figure 5). The results in general, agree with the experiments conducted by Olotex *et al.* (1971), who also reported more moisture loss from the samples packed in plastic containers having higher WVTR.

Analysis of variance established significant ($p < 0.01$) differences towards the moisture content due to the intervals of storage, and the types of packages, only

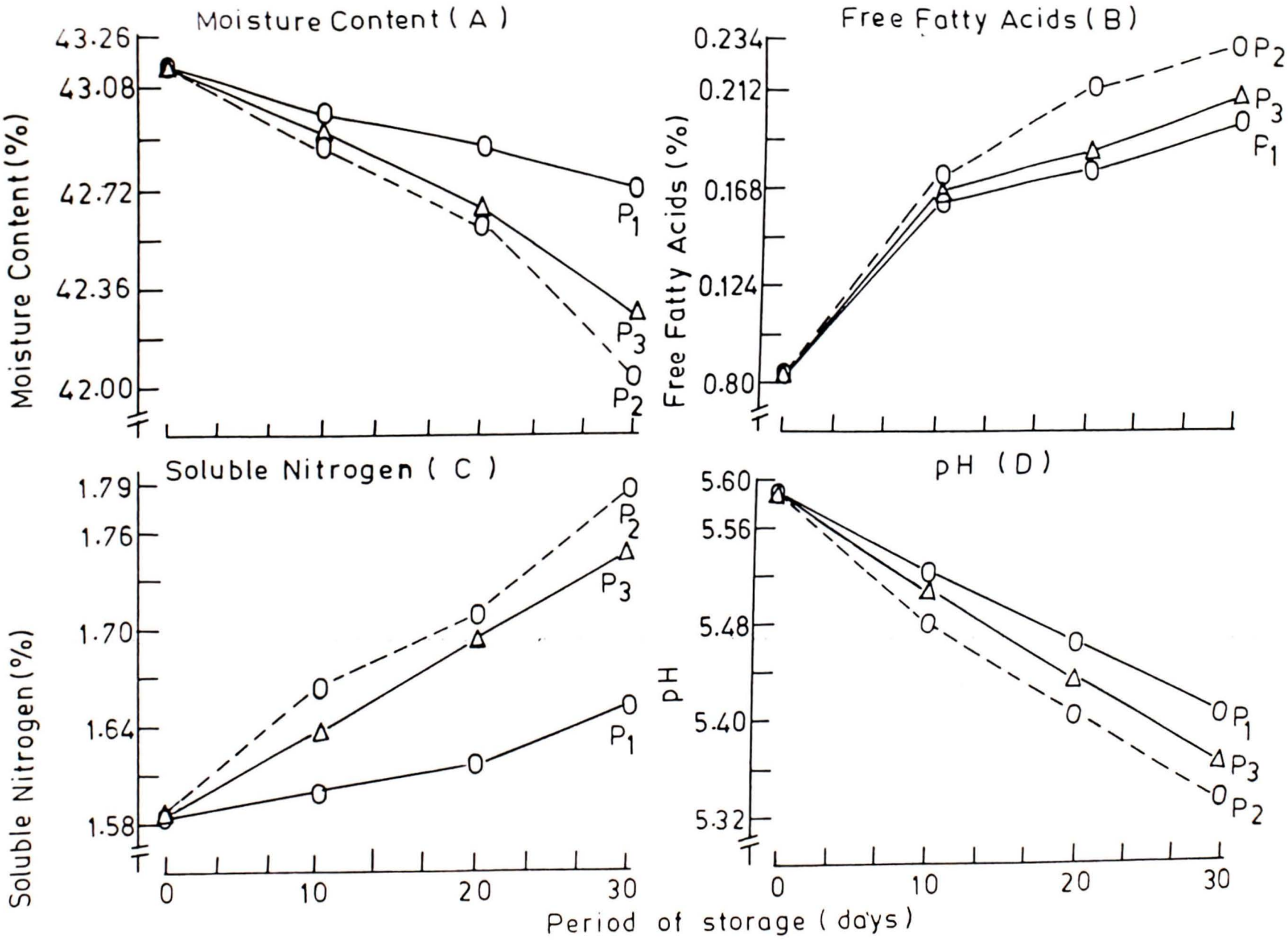


FIG.4: EFFECT OF DIFFERENT PACKAGES ON THE CHEMICAL QUALITY OF PROCESSED CHEESE STORED AT 30 °C AND 60 % R H

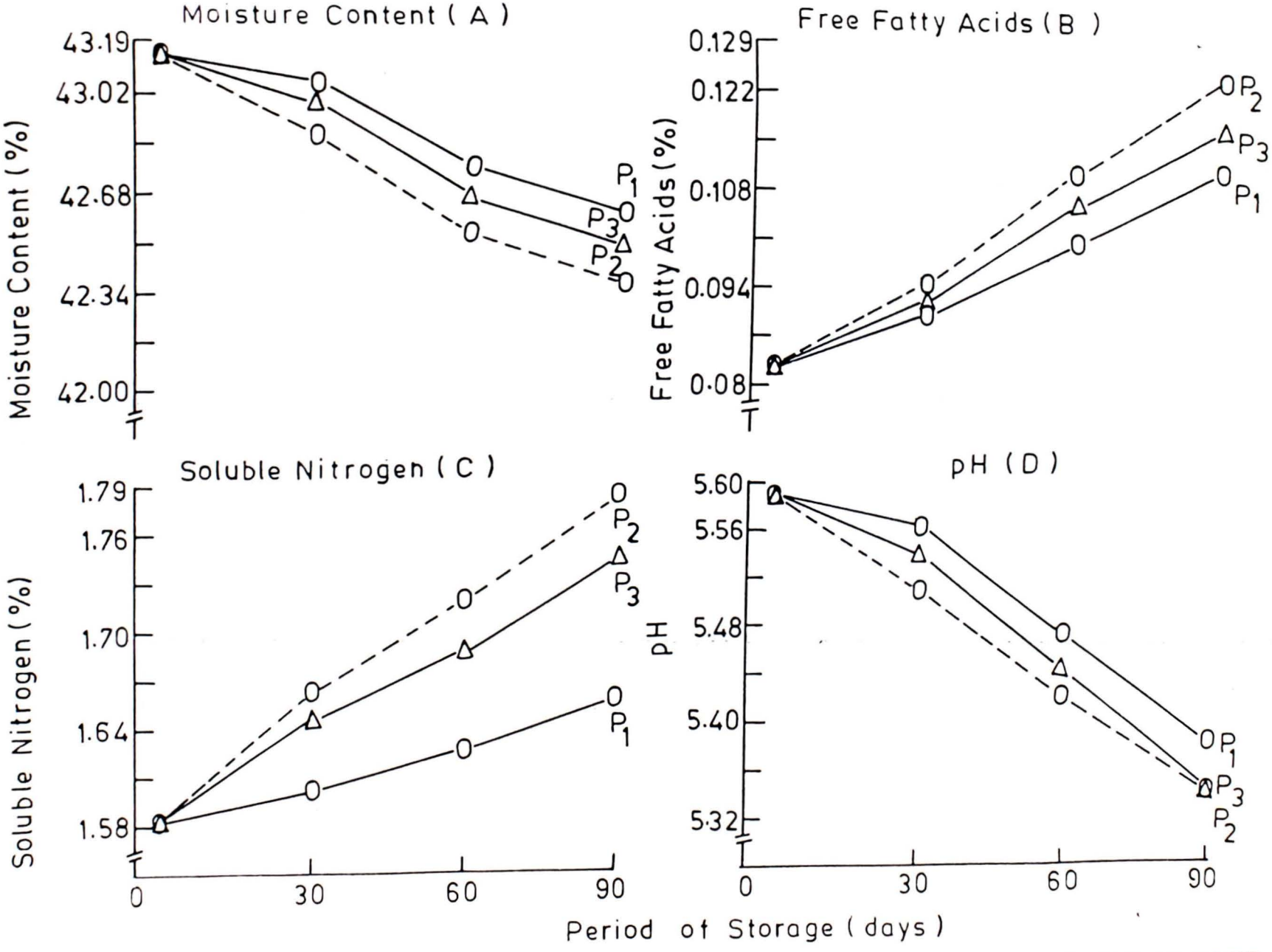


FIG.5: EFFECT OF DIFFERENT PACKAGES ON THE CHEMICAL QUALITY OF PROCESSED CHEESE STORED AT 7-8 °C AND 80% RH

Table 6: Analysis of variance for moisture content of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	1.3313443	95.9962040**	28.5746527	1.12979443
Among intervals of storage	3	1.0766027	77.6281330**	20.7463804	0.820277515
Among packages	2	0.2437861	17.5781277**	26.5534526	1.04987953
Interaction x intervals x packages	6	0.07473055	5.38842516**	24.6243528	0.973606120
Error	22	0.0138687181		25.2919043	

** Significant at 1% level of significance.

at 30°C & 60 per cent RH. Interaction packages x intervals was also found to be significant ($P < 0.01$) for higher temperature conditions only (Table 6).

5.2.2.2 Free fatty acids (FFA)

Figures 4 and 5 and Appendices IX and X give the values for FFA of the processed cheese samples stored in the 3 different typesof packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH. Analysis of variance is presented in Table 7.

The mean initial value for FFA (% oleic) increased from 0.083 to 0.199, 0.231 and 0.209 in P_1, P_2 and P_3 respectively after 30 days of storage at 30°C & 60 per cent RH. The FFA contents increased in respect of the 3 packages to 0.110, 0.123, and 0.116 after 90 days of storage at 7-8°C & 80 per cent RH. The degradation of fat is considered to be primarily affected by the growth of yeasts & moulds. This tendency can be observed from Appendices IX and X (FFA values) vis-a-vis Appendices XVII and XVIII (Y&M counts). From the consideration of least fat cleavage, it can be concluded that P_1 proved to be the best package, followed by P_3 and P_2 for storage of processed cheese under the two studied conditions (Figures 4 and 5).

Analysis of variance of the data on FFA (Table 7) revealed that the durations of storage, and the types of packages, each individually,contributed significantly ($P < 0.01$) towards the changes in the values of FFA under both the conditions of storage. However, the interaction

Table 7: Analysis of variance for free fatty acids of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	0.0005775	13.6892836**	0.00005 01944445	4.29772962**
Among intervals of storage	3	0.0293299629	694.947957**	0.00181255555	155.193941**
Among packages	2	0.00137158333	32.4984738**	0.000110111110	9.42789159**
Interaction intervals x packages	6	0.000235657408	5.58369727**	0.00024333328	2.08345936
Error	22	0.0000422045450		0.0000116792932	

** Significant at 1% level of significance.

intervals x packages was significant ($P < 0.01$) only in case of storage at 30°C & 60 per cent RH.

5.2.2.3 Soluble nitrogen

The values for soluble nitrogen, which is an index of proteolysis, of the processed cheese samples stored in the 3 different packages for the different periods under the 2 storage conditions are illustrated in Figures 4 and 5, and Appendices XI and XII. Their analysis of variance is shown in Table 8.

The results indicate that the extent of protein breakdown in the processed cheese samples packed in tincans (P_1) was minimum followed by P_3 and P_2 under the two conditions of storage. This difference in the soluble nitrogen contents of the cheese samples packed in the 3 types of packages can be mainly attributed to the corresponding growth of microorganisms (Appendices XV and XVI) particularly proteolytic types. These results compare favourably with those of Kumar et al. (1975) and Kumar and Srinivasan (1982), who also observed significant differences in the protein breakdown in the samples of khoa when packed in different packages.

Table 8 shows that the intervals of storage, the 3 types of packages, and the interaction intervals x packages had very significant ($P < 0.01$) effect on the soluble nitrogen content of the processed cheese samples during storage at both the conditions.

Table 8: Analysis of variance for soluble nitrogen of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	0.123027083	12736.8616**	0.135176027	1056.83368**
Among intervals of storage	3	0.0329936664	3415.79880**	0.0348944072	272.811575**
Among packages	2	0.01649 27495	1707.47661**	0.0155733608	121.755703**
Interaction intervals x packages	6	0.0024656391	255.264964**	0.002252443526	17.6099971**
Error	22	0.00000965913636		0.00012790662	

** Significant at 1% level of significance.

5.2.2.4 pH

Appendices XIII and XIV, and Figures 4 and 5 depict the values for pH of the processed cheese samples stored in the 3 different packaging materials under the 2 conditions of storage. Statistical analysis of the data is presented in Table 9.

At 30°C & 60 per cent RH, the initial value for pH of processed cheese decreased from 5.59 to 5.40, 5.33 and 5.36 in packages P_1, P_2 and P_3 respectively after 30 days of storage. Almost the same trend was observed for the processed cheese samples stored under refrigeration conditions in the 3 types of containers. The differences in the values for pH of the processed cheese samples packed in different packages may be due to the varied growth of microorganisms (acid producing).

Statistically, the durations of storage, the types of packages, and interaction intervals x packages, each individually, were observed to be highly significant ($P < 0.01$) for changes in the values of pH under both the conditions of storage.

From the results on chemical changes it can be concluded that the P_1 was the best packaging material followed by P_3 and P_2 respectively for storing processed cheese at any of the two studied conditions.

5.2.3.0 Microbiological changes:

5.2.3.1 Standard plate count (SPC)

The standard plate counts(in $\log_{10}$) of the processed cheese samples stored in the 3 different types of

Table 9: Analysis of variance for pH of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	0.00608611	27.7341019**	0.01121111	64.1559702**
Among intervals of storage	3	0.08964722	408.517942**	0.099060233	566.885961**
Among packages	2	0.004411111	20.1012098**	0.00393611	22.5245275**
Interaction packages x intervals	6	0.0008	3.64556039**	0.000506483333	2.89836864**
Error	22	0.000219445		0.000174747727	

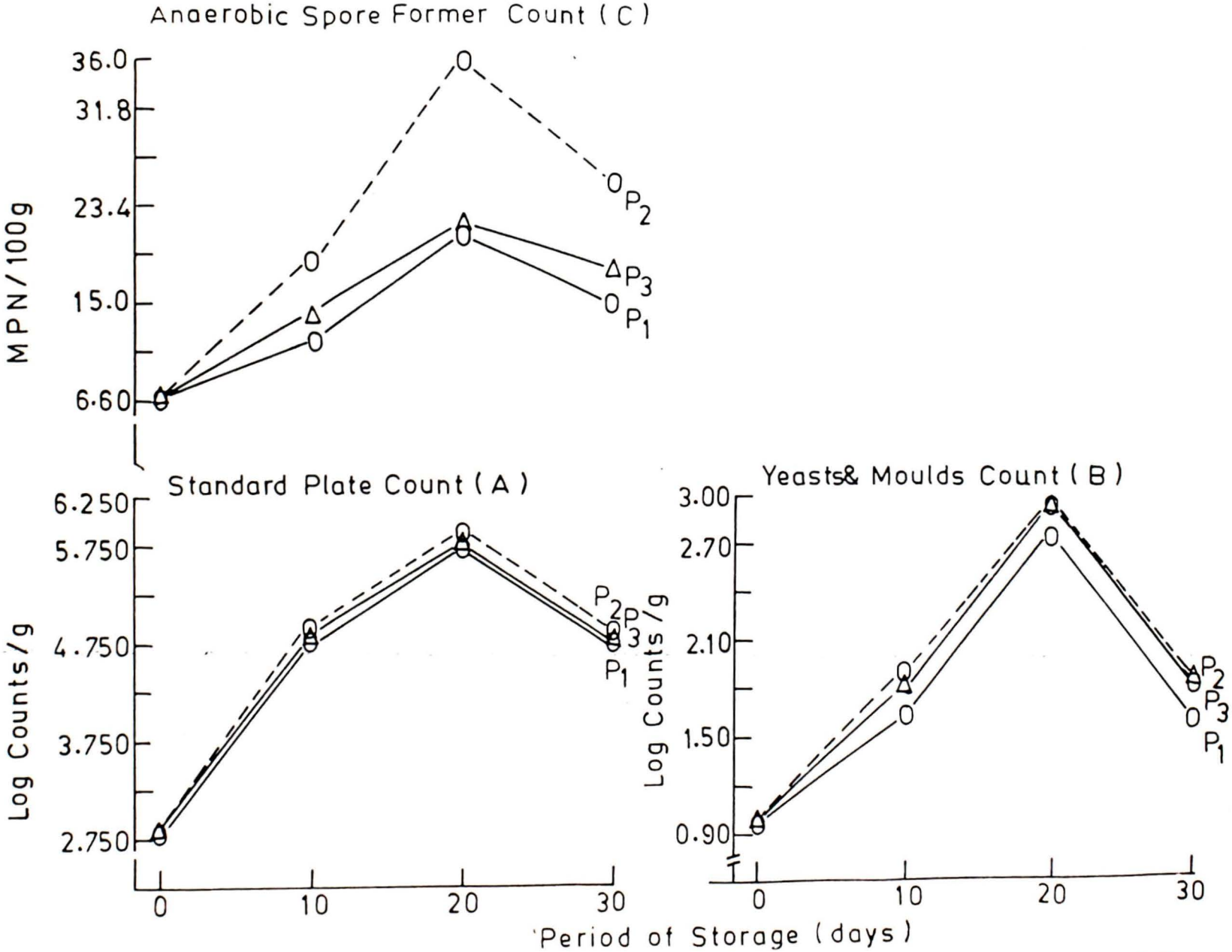
** Significant at 1% level of significance.

packages under the 2 storage conditions for specified periods are shown in Figures 6 and 7, and Appendices XV and XVI. Analysis of variance is given in Table 10.

On storage at 30°C & 60 per cent RH for 10 days, the processed cheese samples in all the 3 types of packages showed rapid growth of microorganisms, while subsequent storage indicated gradual increase in SPC, and the counts decreased slightly at the end of the 30 days of storage (Appendix XV). The decrease in counts after 20 days was mainly due to setting in of lag phase of the microbial growth.

Storage of processed cheese at 7-8°C & 80 per cent RH resulted in minimum counts for the samples packaged in P_1, followed by P_3 and P_2 respectively in the ascending order. This trend was observed for both the conditions of the storage (Figures 6 and 7). These observations in general, coincide with the results of other workers (Kumar et al., 1975; Kumar and Srinivasan, 1983a), who also noted changes in total counts due to different types of packages.

There were found to be highly significant ($P < 0.01$) differences in the total counts due to the 3 types of packages, and the intervals of storage under both the conditions. Interaction between intervals and packages was significant ($P < 0.01$) for the lower temperature storage only.



FIG·6 EFFECT OF DIFFERENT PACKAGES ON THE MICROBIOLOGICAL QUALITY OF PROCESSED CHEESE STORED AT 30°C AND 60 % RH

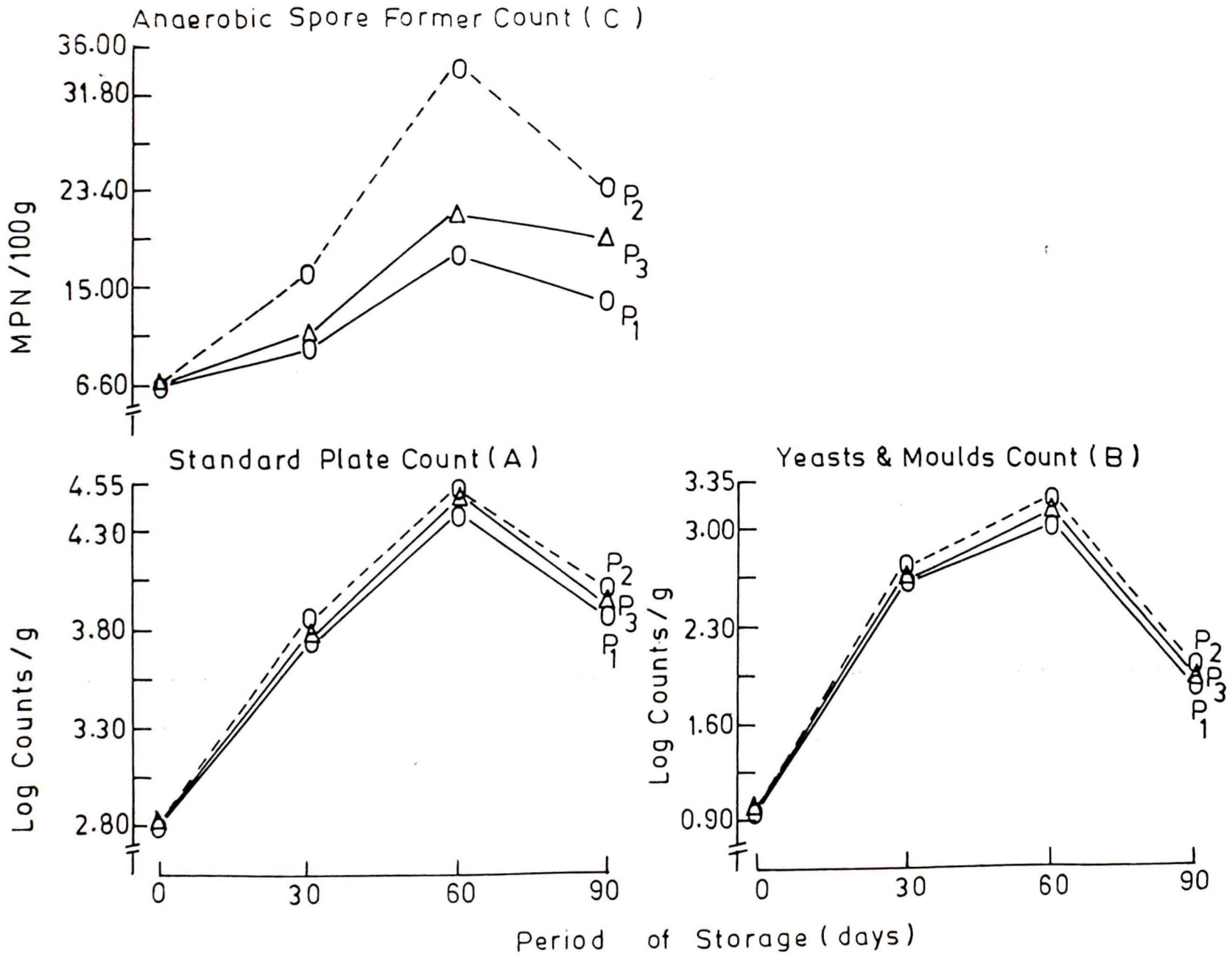


FIG. 7: EFFECT OF DIFFERENT PACKAGES ON THE MICROBIOLOGICAL QUALITY OF PROCESSED CHEESESTORED AT 7-8 °C AND 80 % RH

Table 10: Analysis of variance for standard plate count of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	0.016043693	21.1236619**	0.02929836	5.79550256**
Among intervals of storage	3	14.3045855	18833.8050**	4.35266498	860.999756**
Among packages	2	0.12305361	16.2016492**	0.0266226945	5.26622972**
Interaction intervals x packages	6	0.0017352875	2.28473747	0.003191213	0.631253186**
Error	22	0.000759512863		0.005 05536140	

** Significant at 1% level of significance.

5.2.3.2 Yeasts & moulds counts (Y&M)

The yeasts & moulds counts of the processed cheese samples stored in the 3 types of packaging materials for different time intervals under the two conditions are given in Appendices XVII and XVIII, and Figures 6 and 7. Analysis of variance is shown in Table 11.

On storage at 30°C & 60 per cent RH, the average Y&M count (in $\log_{10}$) increased from 0.949 to 2.757, 2.936 and 2.928 respectively in P_1, P_2 and P_3 after 20 days of storage. The counts, however, decreased in all the packages to 1.608, 1.810 and 1.788 in respect of P_1, P_2 and P_3 after 30 days of storage (Figure 6). This decrease in Y&M counts was obviously due to setting in of lag phase.

The initial average Y&M count (in $\log_{10}$) of 0.949 showed maximum increase in case of samples packed in P_2, followed by P_3 and P_1 in descending order (the mean values being 3.234, 3.217 and 3.086 respectively) after 60 days of storage at 7-8°C & 80 per cent RH. Similar to the total counts, the YIM counts also showed a decreased trend at the end of 90 days of storage. These results are in harmony with the observations of Kumar et al. (1975) and Kumar and Srinivasan (1983a), who concluded that the types of package affected the growth of Y&M in khoa samples when stored at refrigeration conditions.

It can be seen from Table 11 that the durations of storage significantly ($P < 0.01$) affected the growth of Y&M under both the conditions, while the types of packages influenced ($P < 0.01$) the Y&M counts in case of higher

Table 11: Analysis of variance for yeasts & moulds count of processed cheese stored in different types ofpackages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	0.607213083	103.159738**	1.09340286	52.4159079**
Among intervals of storage	3	5.63066618	956.596736**	8.43085848	404.161281**
Among packages	2	0.091648083	15.5701393**	0.0365874435	1.75394096
Interaction intervals x packages	6	0.0109388243	1.85840241	0.007642482	0.366367829
Error	22	0.00588614404		0.0208601339	

** Significant at 1% level of significance.

temperature storage conditions only. The interaction intervals x packages towards the changes in Y&M counts was observed to be not significant under any of the studied conditions (Table 11).

5.2.3.3 Anaerobic spore formers (ASF)

Appendices IXX and XX and Figures 6 and 7 show the effect of 3 types of containers used for the packaging and storage of processed cheese under the two conditions on the anaerobic spore formers (MPN/100 g) count. The statistical analysis of the data obtained during the experiments is reported in Table 12.

The studies revealed that on storage at 30°C & 60 per cent RH, the initial ASF count (MPN/100 g) (mean of three trials) in processed cheese samples increased from 6.6 to 21, 36 and 21.6 respectively in P_1, P_2 and P_3 after 20 days of storage. These counts however, decreased (due to lag phase) on prolonged storage of 30 days.

On storage at 7-8°C & 80 per cent RH, the average ASF counts in processed cheese samples were found to be 14.3, 24 and 19.3 in respect of P_1, P_2 and P_3 after 90 days of storage indicating that the minimum multiplication of anaerobic spore formers had been in case of the product packed in P_1 (tincan) followed by P_3 (LDPE tub) and P_2 (PS cup). Thus P_1 proved to be the best package followed by P_3 and P_2 respectively from the consideration of minimum multiplication of ASF.

From Table 12, which deals with the statistical analysis of the data pertaining to ASF counts, it is evident that the durations of storage, the 3 types of packages, and

Table 12: Analysis of variance for anaerobic spore formers count of processed cheese stored in different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH.

Sources of variation	d.f.	30°C & 60% RH		7-8°C & 80% RH	
		MSS	F.value	MSS	F.value
Among trials	2	68.7519444	15.7355291**	91.3211111	15.8621482**
Among intervals of storage	3	609.521851	139.503674**	534.308425	92.8074498**
Among packages	2	215.041944	49.2174995**	204.163611	35.4624841**
Interaction intervals x packages	6	39.5493518	9.05181643**	37.0673148	6.43845912**
Error	22	4.36921717		5.75717172	

** Significant at 1% level of significance.

interaction package x intervals, each individually, significantly ($P < 0.01$) contributed in the growth of anaerobic spore formers (Table 12).

The results obtained during this investigation on the microbiological quality of processed cheese packed in different packages, in general, are in accordance with the work reported by earlier workers (Babad and Boros, 1961; Oxer, 1970; Mladenov et al., 1972; Al-Ashmay et al., 1977; and Appuswamy and Ranganathan, 1981), who studied the different types of microorganisms in fresh and stored processed cheese and noted the changes in microbiological counts as influenced by different factors. The results are also in agreement with those of Dallyn and Everton (1973), Kumar et al. (1975) and Kumar and Srinivasan (1983a), who concluded that the microbial growth was a major factor in the selection of the most suitable packaging material for a particular product.

5.3.0.0 SOME IMPORTANT OBSERVATIONS

During the entire storage periods (i.e. 30 days at 30°C & 60% RH and 90 days at 7-8°C & 80% RH) of processed cheese, not even a single sample packed in plastic containers or tincans showed the defects of water "weeping" (Storck, 1953) or blowing of lid. However, bloating was observed in some of the tincans (P_1) containing processed cheese samples after 50 days of storage at 30°C & 60 per cent RH (Plate 2). This defect was obviously due to anaerobic spore formers present in cheese. But, no bloating was observed in tin containers, when stored under refrigeration conditions upto 120 days. Some of the plastic containers (approximately 15%) showed

mould growth on the surface of processed cheese after 30 days of storage at 30°C & 60 per cent RH. A very good growth of moulds in different colours can be seen in Plate 2, which was observed in plastic containers after 50 days of storage at 30°C & 60 per cent RH.

PLATE : 2

Defects Observed In -
Processed Cheese.

P_1 — BLOATING.

P_2 & P_3 — MOULD GROWTH

CHAPTER - VI

GENERAL SUMMARY

6.0.0.0 GENERAL SUMMARY

The material presented in the foregoing pages of this thesis pertains to the studies on the packaging of processed cheese.

6.1.0.0 In the introduction, the importance of processed cheese and also the present status of its packaging have been pointed out. The necessity to develop low cost and convenient packaging materials for the processed cheese is stressed.

6.2.0.0 A comprehensive review of the available literature on the packaging of processed cheese in different manners, use of different packaging materials for processed cheese, and storage studies of processed cheese, which included keeping quality, chemical and microbiological changes, is presented.

6.3.0.0 Since no approach to investigate the packaging of processed cheese in flexible materials with special reference to indigenously available plastic containers has so far been made, the scope and plan of the work of the present studies were drawn up to include observations on the storage studies at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH. The experimental methods adopted during the present investigations have also been described.

6.4.0.0 Evaluation of the processed cheese stored in the 3 different packaging materials under the two conditions

for different time intervals for various sensory attributes by a panel of judges also formed a part of the present study. The observations relating to chemical and microbiological changes in processed cheese during the course of storage are recorded.

6.5.0.0 The data collected during the entire investigations are discussed with the help of their actual values (except sensory scores, where average values are given) presented in XX tables of details (Appendices), 12 Tables of consolidated data, 6 Figures and 2 Plates.

From the results obtained, the following conclusions are indicated:

6.5.1.0 Sensory evaluation for the appearance, body & texture, and aroma & flavour characteristics of the processed cheese samples stored in the 3 different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH for various time intervals revealed that the product packed in P_1 (tincans) was liked most, followed by P_3 (LDPE tub) and P_2 (PS cup) respectively under both the conditions.

6.5.2.0 Analysis of variance showed that the 3 types of packages, and the durations of storage, each individually, had highly significant ($P < 0.01$) effect on the sensory characteristics of the processed cheese under both the conditions.

6.5.3.0 At 30°C & 60 per cent RH, the processed cheese samples were found to be acceptable upto 20 days in plastic containers, i.e. P_2 (PS cup) and P_3 (LDPE tub) and 30 days

for different time intervals for various sensory attributes by a panel of judges also formed a part of the present study. The observations relating to chemical and microbiological changes in processed cheese during the course of storage are recorded.

6.5.0.0 The data collected during the entire investigations are discussed with the help of their actual values (except sensory scores, where average values are given) presented in XX tables of details (Appendices), 12 Tables of consolidated data, 6 Figures and 2 Plates.

From the results obtained, the following conclusions are indicated:

6.5.1.0 Sensory evaluation for the appearance, body & texture, and aroma & flavour characteristics of the processed cheese samples stored in the 3 different types of packages at 30°C & 60 per cent RH and 7-8°C & 80 per cent RH for various time intervals revealed that the product packed in P_1 (tincans) was liked most, followed by P_3 (LDPE tub) and P_2 (PS cup) respectively under both the conditions.

6.5.2.0 Analysis of variance showed that the 3 types of packages, and the durations of storage, each individually, had highly significant ($P < 0.01$) effect on the sensory characteristics of the processed cheese under both the conditions.

6.5.3.0 At 30°C & 60 per cent RH, the processed cheese samples were found to be acceptable upto 20 days in plastic containers, i.e. P_2 (PS cup) and P_3 (LDPE tub) and 30 days

in P_1 (tincan), while the processed cheese was observed to be of acceptable quality in all the 3 types of packages upto 90 days at 7-8°C & 80 per cent RH.

6.6.0.0 The 3 types of packages, the durations of storage and interaction packages x intervals each individually were observed to have significant effect ($P < 0.01$) on the moisture content of processed cheese samples, only in case of higher temperature storage.

6.7.0.0 Statistical analysis also revealed that the 3 types of packages and the intervals of storage had highly significant ($P < 0.01$) influence on the free fatty acid contents of the processed cheese under both the storage conditions. Interaction between intervals and types of packages was significant ($P < 0.01$) only at 30°C & 60 per cent RH.

6.8.0.0 The 3 typesof packages, the durations of storage, and the interaction intervals x packages were observed to be highly significant ($P < 0.01$) towards the changes in soluble nitrogen contents of the processed cheese sample under both the storage conditions.

6.9.0.0 The values for pH of the processed cheese samples were significantly ($P < 0.01$) affected by the 3 types of packages, durations of storage, and the interaction between intervals and packages underboth the conditions.

6.10.0.0 The 3 types of packages and the intervals of storage periods were found to significantly influence ($P < 0.01$) the standard plate counts (SPC) of the processed cheese samples under the two studied conditions of storage. Interaction

between intervals and packages was significant ($P < 0.01$) only at 7-8°C & 80 per cent RH.

6.11.0.0 The experiments also revealed highly significant ($P < 0.01$) differences in the yeasts & moulds counts of the processed cheese samples due to various intervals of storage under both the conditions, while the types of packages affected ($P < 0.01$) the yeasts & moulds counts only at 30°C & 60 per cent RH. However, the interaction intervals x packages played no significant role in the multiplication of yeasts & moulds under any of the studied conditions of storage.

6.12.0.0 It was observed that the 3 types of packages, different intervals of storage, and interaction between intervals and packages had highly significant ($P < 0.01$) effect on the anaerobic spore formers count of processed cheese samples stored under the two conditions.

6.13.0.0 From the present investigations, it can be concluded that the studied flexibleplastic containers, the package P_3 consisting of low density polyethylene (tub: capacity - 150 g) and the package P_2, made of polystyrene (cup: capacity - 150 g) may be used for storing processed cheese at 30°C & 60 per cent RH (keeping quality: 20 days) and 7-8°C & 80 per cent RH (keeping quality: 90 days). The tincans (P_1) proved better than the plastic containers for storage of processed cheese under both the conditions (keeping quality at 30°C & 60% RH: 30 days; at 7-8°C & 80% RH: 90 days). Thus for storing the processed cheese under the two conditions, package-wise, P_1 was observed to be the best followed by P_3 and P_2 respectively.

6.14.0.0 An exhaustive bibliography of the references indicated in the review, and elsewhere is also separately attached, immediately following this summary of results.

6.15.0.0 Appendices.

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APPENDIX - I

Mean sensory scores (based on numerical scoring test) for appearance of processed cheese stored in different packages at 30°C & 60 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	16.8	16.8	16.8	16.8	14.8	16	17.4	15.8	16.8	16.8	14.8	16
T_2	17.4	17.4	17.4	16.6	16.4	15.4	17.4	15.8	16.8	15.8	14.2	15.2
T_3	18.2	18.2	18.2	16.8	16.4	17	15.8	16.4	15.8	15.8	14.4	15.2
Mean	17.5	17.5	17.5	16.7	15.9	16.1	16.8	16	16.5	16.1	14.5	15.5

APPENDIX - II

Mean sensory scores (based on numerical scoring test) for different packages at 7-8°C & 80 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	17.0	17.0	17.0	16.8	16.0	16.6	17.2	15.4	16.2	17.2	15.6	16.2
T_2	17.2	17.2	17.2	16.2	16.0	16.2	16.0	15.0	15.6	15.4	14.2	14.8
T_3	18.2	18.2	18.2	17.4	16.2	16.4	17.0	16.2	16.6	16.4	15.2	15.8
Mean	17.5	17.5	17.5	16.8	16.1	16.4	16.7	15.5	16.1	16.3	15.0	15.6

APPENDIX - III

Mean sensory scores (based on numerical scoring test) for body & texture of processed cheese stored in different packages at 30°C & 60 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	33.2	33.2	33.2	34.2	31.8	33	32.6	30	31	30.8	28.2	29.8
T_2	34.4	34.4	34.4	31.8	31.2	32.6	31.4	30	32	30.8	28.4	29.6
T_3	37.6	37.6	37.6	34.2	32	33.2	32.4	29.8	31.8	31.2	28.4	30.6
Mean	35.1	35.1	35.1	33.4	31.7	32.9	32.1	29.9	31.6	30.9	28.3	30.0

APPENDIX - IV

Mean sensory scores (based on numerical scoring test) for body & texture of processed cheese stored in different packages at 7-8°C ' 80 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	35.2	35.2	35.2	34.0	32.0	34.2	32.4	29.4	32.0	30.2	28.2	28.8
T_2	34.2	34.2	34.2	33.4	34.4	36.0	33.2	30.2	33.8	30.6	28.6	30.0
T_3	33.4	33.4	33.4	33.0	29.4	31.6	32.8	29.4	31.8	30.2	28.2	30.2
Mean	34.3	34.3	34.3	33.5	31.9	33.9	32.8	29.6	32.5	30.3	28.3	29.7

APPENDIX - V

Mean sensory scores (based on numerical scoring test) for aroma & flavour of processed cheese stored in different packages at 30°C & 60 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	32.4	32.4	32.4	32.4	30.2	31.4	32.2	29.4	32.2	31	24.4	24.7
T_2	33.2	33.2	33.2	31.4	27.6	30.2	30.8	28	29.2	30	23.7	24.8
T_3	36.8	36.8	36.8	32	30	29.8	31	28	31	29.6	23.3	24.3
Mean	34.1	34.1	34.1	31.9	29.3	30.5	31.3	28.5	30.8	30.2	23.8	24.6

APPENDIX - VI

Mean sensory scores (based on numerical scoring test) for aroma & flavour characteristics of processed cheese stored in different packages at 7-8°C & 80 per cent RH (mean of 5 judges)

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	32.8	32.8	32.8	32.6	30.8	31.4	32.4	28.4	30.2	29.8	26.4	28.4
T_2	37.2	37.2	37.2	36.6	33.8	35.8	34.4	29.2	31.6	30.8	27.8	29.8
T_3	37.2	37.2	37.2	33.8	32.2	32.2	33.6	31.8	32.0	30.4	26.8	29.6
Mean	35.7	35.7	35.7	34.3	32.3	33.1	33.5	29.8	31.3	30.3	27.0	29.3

APPENDIX - VII

Moisture (percent) of processed cheese stored in different types of packages at 30°C & 60 per cent RH.

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	43.54	43.54	43.54	43.36	43.28	43.30	43.30	42.78	42.84	43.21	42.04	42.52
T_2	43.14	43.14	43.14	43.02	42.87	42.93	42.85	42.67	42.74	42.63	42.17	42.37
T_3	42.78	42.78	42.78	42.59	42.48	42.54	42.50	42.31	42.37	42.36	41.88	41.90
Mean	43.15	43.15	43.15	42.99	42.88	42.92	42.88	42.59	42.65	42.73	42.03	42.26

APPENDIX - VIII

Moisture (percent) of processed cheese stored in different types of packages at 7-8°C & 80 per cent RH.

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	43.54	43.54	43.54	43.42	43.19	43.36	43.18	42.95	43.09	43.02	42.78	42.93
T_2	43.14	43.14	43.14	43.09	42.96	43.01	42.92	42.67	42.82	42.76	42.48	42.66
T_3	42.78	42.78	42.78	42.63	42.48	42.56	42.18	42.00	42.08	42.04	41.82	41.91
Mean	43.15	43.15	43.15	43.05	42.88	42.98	42.76	42.54	42.66	42.61	42.36	42.50

APPENDIX - IX

Free fatty acids (percent oleic) of processed cheese stored in different types of packages at 30°C & 60 per cent RH.

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	0.083	0.083	0.083	0.154	0.163	0.157	0.173	0.194	0.180	0.197	0.218	0.205
T_2	0.082	0.082	0.082	0.162	0.180	0.167	0.173	0.211	0.183	0.193	0.229	0.209
T_3	0.084	0.084	0.084	0.167	0.182	0.173	0.185	0.236	0.191	0.208	0.247	0.214
Mean	0.083	0.083	0.083	0.161	0.175	0.166	0.177	0.214	0.185	0.199	0.231	0.209

APPENDIX - X

Free fatty acids (percent oleic) of processed cheese stored in different types of packages at 7-8°C & 80 per cent RH

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	0.083	0.083	0.083	0.090	0.096	0.093	0.097	0.106	0.103	0.107	0.118	0.112
T_2	0.082	0.082	0.082	0.088	0.092	0.090	0.098	0.108	0.103	0.109	0.121	0.115
T_3	0.084	0.084	0.084	0.091	0.093	0.092	0.105	0.117	0.110	0.114	0.129	0.121
Mean	0.083	0.083	0.083	0.090	0.094	0.092	0.100	0.110	0.105	0.110	0.123	0.116

APPENDIX - XI

Soluble nitrogen (percent) of processed cheese stored in different types of packages at 30°C & 60 per cent RH.

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	1.693	1.693	1.693	1.708	1.771	1.734	1.727	1.818	1.802	1.758	1.885	1.859
T_2	1.567	1.567	1.567	1.582	1.649	1.626	1.601	1.696	1.681	1.636	1.763	1.731
T_3	1.489	1.489	1.489	1.505	1.571	1.548	1.524	1.619	1.601	1.559	1.686	1.651
Mean	1.583	1.583	1.583	1.598	1.664	1.636	1.617	1.711	1.695	1.651	1.778	1.747

APPENDIX - XII

Soluble nitrogen (percent) of processed cheese stored in different types of packages at 7-8°C & 80 per cent RH.

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	1.693	1.693	1.693	1.712	1.766	1.750	1.751	1.839	1.803	1.771	1.912	1.885
T_2	1.567	1.567	1.567	1.586	1.653	1.632	1.607	1.702	1.663	1.641	1.768	1.698
T_3	1.489	1.489	1.489	1.509	1.576	1.556	1.527	1.625	1.605	1.563	1.671	1.656
Mean	1.583	1.583	1.583	1.602	1.665	1.646	1.628	1.722	1.690	1.658	1.784	1.746

APPENDIX - XIII

pH of processed cheese stored in different types of packages at 30°C & 60 per cent RH.

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	5.62	5.62	5.62	5.53	5.52	5.53	5.48	5.41	5.44	5.41	5.33	5.37
T_2	5.60	5.60	5.60	5.53	5.50	5.52	5.47	5.40	5.44	5.40	5.33	5.36
T_3	5.56	5.56	5.56	5.49	5.43	5.47	5.44	5.40	5.42	5.38	5.32	5.34
Mean	5.59	5.59	5.59	5.52	5.48	5.51	5.46	5.40	5.43	5.40	5.33	5.36

APPENDIX - XIV

pH of processed cheese stored in different packages at 7-8^{0}C & 80 per cent RH.

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	5.62	5.62	5.62	5.60	5.56	5.59	5.51	5.46	5.48	5.41	5.37	5.37
T_2	5.60	5.60	5.60	5.54	5.50	5.52	5.46	5.40	5.42	5.39	5.31	5.33
T_3	5.56	5.56	5.56	5.54	5.48	5.51	5.45	5.41	5.43	5.35	5.33	5.33
Mean	5.59	5.59	5.59	5.56	5.51	5.54	5.47	5.42	5.44	5.38	5.34	5.34

APPENDIX - XV

Standard plate count (in $\log_{10}$) per g of processed cheese stored in different types of packages at 30°C & 60 per cent RH

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	2.763	2.763	2.763	4.756	4.869	4.832	5.707	5.792	5.756	4.732	4.857	4.819
T_2	2.813	2.813	2.813	4.793	4.845	4.813	5.770	5.903	5.785	4.778	4.813	4.785
T_3	2.857	2.857	2.857	4.851	4.892	4.875	5.813	5.924	5.875	4.778	4.851	4.845
Mean	2.811	2.811	2.811	4.800	4.869	4.840	5.763	5.873	5.805	4.763	4.840	4.816

APPENDIX-XVI

Standard plate count (in $\log_{10}$) per g of processed cheese stored in different types of packages at 7-8°C & 80 per cent RH

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	2.763	2.763	2.763	3.653	3.716	3.819	4.431	4.498	4.544	3.875	4.008	3.977
T_2	2.813	2.813	2.813	3.681	3.832	3.724	4.414	4.476	4.446	3.857	3.991	3.954
T_3	2.857	2.857	2.857	3.919	4.041	4.002	4.342	4.579	4.556	3.903	3.982	3.944
Mean	2.811	2.811	2.811	3.751	3.863	3.848	4.397	4.518	4.515	3.878	3.994	3.958

APPENDIX - XVII

Yeasts and moulds count (in $\log_{10}$) per g of processed cheese stored in different types of packages at 30°C & 60 per cent RH

Trials	Period of storage (days)											
	10			20			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	0.778	0.778	0.778	1.380	1.518	1.602	2.602	2.748	2.699	1.342	1.477	1.544
T_2	0.954	0.954	0.954	1.602	1.914	1.813	2.857	2.964	2.954	1.602	1.875	1.778
T_3	1.114	1.114	1.114	1.903	2.204	2.146	2.813	3.097	3.130	1.880	2.079	2.041
Mean	0.949	0.949	0.949	1.628	1.879	1.854	2.757	2.936	2.928	1.608	1.810	1.788

APPENDIX - XVIII

Yeasts and moulds count (in $\log_{10}$) per g of processed cheese stored in different types of packages at 7-8 °C & 80 per cent RH

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	0.778	0.778	0.778	2.380	2.415	2.477	2.819	2.903	2.963	1.301	1.544	1.477
T_2	0.954	0.954	0.954	2.740	2.819	2.785	3.041	3.193	3.158	2.041	2.204	2.079
T_3	1.114	1.114	1.114	2.845	2.914	2.875	3.398	3.602	3.531	2.301	2.556	2.447
Mean	0.949	0.949	0.949	2.655	2.716	2.712	3.086	3.234	3.217	1.881	2.100	2.001

APPENDIX - XIX

Anaerobic spore formers count (MPN/100 g) in processed cheese stored in different types of packages at 30°C & 60 per cent RH

Trials	Period of storage (days)											
	0			10			20			30		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	3.6	3.6	3.6	9.1	15	15	21	29	21	15	21	15
T_2	9.1	9.1	9.1	15	21	15	21	43	23	15	29	20
T_3	7.2	7.2	7.2	11	19	13	21	36	21	15	26	19
Mean	6.63	6.63	6.63	11.7	18.33	14.34	21	36	21.67	15	25.34	18

APPENDIX - XX

Anaerobic spore formers count (MPN/100 g) in processed cheese stored in different types of packages at 7-8°C & 80 per cent RH

Trials	Period of storage (days)											
	0			30			60			90		
	Type of package											
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T_1	3.6	3.6	3.6	7.2	14	7.3	16	23	19	14	21	19
T_2	9.1	9.1	9.1	12	19	14	19	39	23	15	28	20
T_3	7.2	7.2	7.2	9.1	16	13	19	39	21	14	23	19
Mean	6.6	6.6	6.6	9.43	16.34	11.43	18	33.67	21	14.34	24	19.34

APPENDIX - XXI

Evaluation card for numerical scoring test for quality attributes

Product: Processed cheese Made on _____

Stored at _____ Tested on _____

Please rate the samples for quality attributes according to the following grade descriptions and scoring.

Quality Grade Description	Score		
	Appearance	Body and texture	Aroma and flavour
Excellent	19-20	38-40	38-40
Good	17-18	32-37	32-37
Fair	14-16	27-31	27-31
Poor	13 or below	26 or below	26 or below

Sample Nos.

(1) (2) (3)

1. Appearance
2. Body & texture
3. Aroma & flavour

Remarks, if any

Signature :

Date :