EFFECT OF ADDITION OF COCONUT MILK ON THE PREPARATION OF PANEER

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Approval Letter

This dissertation **entitled** ***Effect of Addition of Coconut Milk on the Preparation of Paneer*** **by Sumitra Shrestha has been accepted as a partial fulfilment of the requirement for the B.Tech. Degree in Food Technology.**

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Abstract

Coconut paneer is a dairy product prepared by using coconut milk as a principle ingredient. The aim of this research was to develop the formulation of coconut milk paneer and to study the physio-chemical properties of plain and coconut milk paneer. Design expert was employed for formulating the recipe of paneer. The obtained 9 formulations of coconut paneer were prepared in lab. The panner were coded as A, B, C, D, E, F, G and H with varying level of coconut milk and fresh milk where the ratio of coconut milk: fresh milk were in 75:25, 62.52:37.48, 50:50, 87.71:12.29, 100:0, 68.69:31:31, 51.43:18.57, 56.28:43.72. The samples were subjected to sensory evaluation for consumer acceptability and chemical analysis were carried out.

From sensory evaluation, 12% coconut milk and 87% fresh milk were found to be significantly best ($p<0.05$). In most of the formulations, taste, color, body and overall acceptability were significantly affected ($p<0.05$) by variation in coconut milk and fresh milk. Coconut paneer analyzed for moisture, fat, protein, total solids, ash content, pH and carbohydrate were found out to be 83.02, 7.50, 3.20, 16.98, 0.71, 6.4 and 5.57% respectively while that of control sample was found to be 84.5, 4.8, 2.99, 15.5, 0.6, 6.5 and 7.11% respectively.

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List of abbreviations

Abbreviations	Full forms
ANOVA	Analysis of variance
AOAC	Association of Analytical Communities
CCT	Central Campus of Technology
DDC	Dairy Development Corporation
DOA	Department of Agriculture
DOE	Design of Experiments
EVA	Ethylene vinyl acetate
FAO	Food and Agricultural Organization
FSSAI	The Food Safety and Standard Authority of India
LCFA	Long chain fatty acids
MCFA	Medium chain fatty acids
MCT	Medium chain triglycerides
NDDB	Nepal Dairy Development Board
PVDC	Poly-Vinylidene Chloride

SNF	Solid Not Fat
TS	Total solid

Part I

Introduction

1.1 General introduction

Paneer, a popular indigenous product of South Asia, is similar to an unripen variety of soft cheese. It is obtained by heat and acid coagulation entrapping all of fat, casein complexed with denatured whey protein and a portion of salt and lactose. Paneer is marble white in appearance, having firm, cohesive and spongy body with a close-knit structure and a sweetish-acidic-nutty flavor. It has a simple, fresh, versatile flavor which makes it highly useful in an assortment of recipe (Singh and Kanawjia, 1992).

Paneer is a rich source of high-quality proteins, fat, minerals and vitamins (Shrivastava and Goyal, 2007). The unique feature of paneer is that it not only includes casein but also contains most of whey proteins which gets recovered during its manufacture, while they are mostly lost in the case of other types of cheese. It forms base for variety of culinary dishes, stuffing material for various vegetable dishes, snacks and sweetmeats (Aneja, 2007). Different types of coagulants at different concentrations including natural coagulants are used for its preparation, which have profound effect on the compositional, functional, physio-chemical and sensory characteristics of paneer (Kumar *et al.*, 2008).

Coconut *(Cocus nucifera* L.) is one of the oldest fruits in the world and is confined to seacoast in the humid tropics. It has been estimated that 25% of the world's output of coconut is consumed as coconut milk (Gwee, 1988). Coconut milk is being used by confectionaries, bakeries, biscuit, and ice cream industries worldwide to enhance flavor and taste of various product (Persley, 1992).

Coconut milk was found to be rich in calcium. The milk was reported to be high in minerals and in vitamin content (Nieuwentus and Nieuwelink, 2002).

Contrary to widely held opinion, the coconut provides nutritious source of meat, juice, milk and oil. It is classified as a "functional food" because it provides many health benefits beyond its nutritional content, due to its fiber and oil content (Sanful, 2009). The oil is known as to contribute to improved insulin secretion and the utilization of blood glucose; reduce symptoms associated with malabsorption syndrome and cystic fibrosis; help to relieve symptoms associated with crohn's disease; ulcerative colitis and stomach ulcers; improve the utilization of essential fatty acids and protect them from oxidation (Seow and Gwee, 1997).

1.2 Statement of the problem

Paneer, traditionally prepared from full fat buffalo milk is characterized by marble white color nutty flavor, and closely-knit smooth texture. Paneer is highly nutritious and has the wholesomeness of milk. The main drawbacks of paneer are its high fat content. Higher dietary fat is known to increase the chances for arterial hypertension, coronary heart disease and obesity. The high fat content in paneer not only contributes to it but also makes it less acceptable to health-conscious consumers. To meet the ever-growing demand of paneer by the health-conscious consumers, researchers are developing new varieties of paneer Suvarna (2014).

The physiological effects of MCFA in coconut oil are distinctly different from those of LCFA more commonly found in our foods. The saturated fatty acids in coconut oil are predominately medium-chain fatty acids. Both the saturated and unsaturated fat found in meat, milk, eggs, and plants (including almost all vegetable oils) are composed of LCFA. MCFA are very different from LCFA. They do not have a negative effect on cholesterol and help to protect against heart disease. The best sources of MCFA are coconut and palm kernel oils (Pamplona-Roger, 2007).

The potential for a paneer like product from coconut and cow milk blend is always an alternative as coconut milk is rich in emulsifiers and it is a natural oil-in-water emulsion just like cow milk, hence both can mix readily.

Some published reports have indicated that coconut fat could be used to prepare highly acceptable and relatively inexpensive new types of dairy-like foods. Such as custard-like products, various types of cheeses, yoghurt and drinks (Davide *et al.*, 1988) developed a fresh soft cheese spiced with garlic (Queso de Ajo) starter and blue type cheese, from a blend of milk and coconut milk.

1.3 Objectives

1.3.1 General objective

The general objective of this work is to prepare paneer from coconut milk blended with cow milk and to conduct its quality evaluation in terms of color, body, texture, flavor, and overall acceptability.

1.3.2 Specific objectives

The specific objectives were:

- To study the physio-chemical properties of plain and coconut milk paneer.
- To carry physio-chemical analysis of best product.
- To carry the physio- chemical properties of fresh milk and coconut milk.
- To compare the best product physical and chemical parameters (control and sample).

1.4 Significance of the study

Paneer is a milk product prepared by the combined action of acid coagulation and heat treatment of cow or buffalo milk (Rao and Patil, 1999). The high cost of paneer has prohibited its consumption by many sections of the society. Therefore, to reduce the cost of paneer, it is necessary to replace the milk by cheap and nutritious and non-conventional ingredients (Sutar *et al.*, 2010).

Coconut is highly nutritious and rich in fiber, vitamins and minerals. The saturated fat content in coconut milk has been shown to be a good saturated fat, easily metabolized to give the body quick energy. The principal fatty acid in coconut milk is lauric acid, which is the same fatty acid found in abundance in mother's milk and is known to promote normal brain development and contribute to healthy bones. Coconut also has important anti-carcinogenic and anti-pathogenic properties (Ishiaq and Odeyemi, 2012). It is classified as a functional food because of its health benefits and nutritional content.

In the rapidly changing socio-economic scenario, novel ways of value addition are essential. Incorporation of functional ingredients like fibers, proteins, hydrocolloids, herbs and vegetable oils will help to increase the yield and decrease the calorific value of paneer making it attractive to consumers. It also leads to formation of innovative varieties, which further will increase its marketability. Technologies involving incorporation of native food ingredients will help to diversify processing operations and to achieve value addition in a different dimension. In this context, a study on coconut milk incorporated paneer is proposed.

1.5 Limitations of the work

- Only one variety of coconut will be studied for preparation of coconut milk.
- Shelf life of the product will not be studied due to time constraints.
- Rheological parameters (hardness, cohesiveness, chewiness) of paneer could not be estimated due to unavailability of texturometer in the laboratory.

Part II

Literature review

2.1 History of dairy development

Organized dairy development activities in Nepal began in1952 with the establishment of Yak cheese factory in Langtang of Rasuwa district under Food and Agriculture Organization FAO assistance in 1953. In 1954, a Dairy Development Section was established under the Department of Agriculture (DoA) and also a small-scale milk processing plant was started in Tusal a village of Kavre district. In 1955, a Dairy Development Commission was formed (Khan and Pal, 2011).

The First Five Year Plan (1956-61) stressed on the need to develop a modern dairy industry. Accordingly, in1956, a Central Dairy Plant, with an average milk processing capacity of 500 L/h was established in Lainchaur, with the financial assistance from New Zealand and technical assistance from FAO. Around the same time, a second mini milk processing plant was established in kharipati, in Bhaktapur district. The plant started processing of milk and marketing activities from 1958. History of dairy co-operatives dates back to First Five Year Plan (1956-61) when the dairy cooperatives were formed in Tusal Village of Kavre district (Mathur, 1991).

In earlier days when there were no organized dairies, demand for milk was fulfilled by raising cows/buffaloes by the people themselves or through the direct supply from the professional milk producers. These producers used to go house by house and deliver the required quantity of milk to the household (FAO, 2010).

2.2 Paneer

Paneer represents a South Asian variety of soft cheese obtained by acid and heat coagulation of milk. It is non-fermentative, non-rennet, non-melting and unripen type of cheese. The unique feature of paneer is that it not only includes casein but also most of whey proteins, which gets recovered during its manufacture while they are mostly lost in whey in case of other types of cheeses (Khan *et al.*, 2011).

It must have a characteristic blend of the flavor of heated milk and acid, i.e., pleasant, mild, acidic and sweet (nutty). Its body and texture must be sufficiently firm to hold its shape during cutting/slicing, yet it must be tender enough not to resist crushing during mastication, i.e., the texture must be compact and smooth; Its color and appearance must be uniform, pleasing white, with a greenish tinge in the case of buffalo milk paneer and light yellow in the case of cow milk paneer. It is used in culinary dishes, snacks, and an excellent substitute of meat (Kumar *et al.*, 2014).

2.2.1 History and development of paneer

People during the *Kusana* and Saka *Satavahana* periods (Khan and Pal, 2011) used to consume a solid mass, whose description seems to be the earliest reference to the present-day paneer. The solid mass was obtained by the admixture of heated milk and curd. The nomads of South West Asia developed distinct heat/acid varieties of cheese. Cheese manufactured using high heat and precipitation without resorting to use of starter culture was practiced in many countries of South Asia and Central South and Latin America. First several distinctive cheese varieties were developed by Nomads of South West Asia. One of the unique Iranian nomadic cheese was called ‘Paneer-khiki’. It was originally developed by the well-known ‘Bhakhtiari’ tribe that resided in *Isfahan* in summer and *Shraz* in winter. The literal meaning of ‘paneer’ is container and ‘khiki’ is skin (Khan and Pal, 2011) .

White paneer is a staple food of Nomads in Afghanistan. It is referred to as ‘Paneer-e-khom’ and ‘Paneer-e-pokhta’ when made from raw and boiled milk respectively. A product similar to this is also found in Mexico and Caribbean islands. Paneer is indigenous to South Asia and was first introduced in India by Afghan and Iranian travelers (Mathur, 1991).

A product similar to paneer is white unripen cheese made from milk coagulated by rennet or acid referred to as Kareish in Egypt, Armavir in Western Caucasus, Zsirpi in Himalayas, Feta in Balkans and *Queso Criollo, Queso del Pais, Queso* Lianero etc. in Latin America (Torres and Chandan, 1981) .

2.2.2 Composition of paneer

The chemical composition of milk depends mainly on the type of milk, composition of milk, the condition of coagulation. The technique of straining/pressing and the losses of milk solids in whey. An average chemical composition of paneer is given in Table 2.1.

Table 2.1 Approximate composition (%) of paneer

Product	Moisture (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
Buffalo milk paneer	52.3	27	15.8	2.3	1.9
Cow milk paneer	52.5	25	17.3	2.2	2.0

Source: Chawla *et al.* (1985)

2.2.3 Defects in paneer

Low quality milk, faulty method of production, unhygienic condition, lack of refrigeration facility and proper storage conditions are mainly responsible for defects in paneer (Kumar *et al.*, 2014).

- ❖ Flavor defects: It arises from poor quality coagulating agent, improper heating and temperature. It includes:
- Sour flavor due to use of milk having high titratable acidity and addition of excess amount of coagulating agent.
- Smoky flavor due to use of smoky fire for heating of milk.
- Rancid flavor is the result of hydrolysis of fat by lipase enzyme or oxidation during storage at room temperature.
- Stale flavor is caused by the storage of paneer at low temperature for longer duration.
- ❖ Body and texture defects: Body refers to firmness while texture refers to fine structure of paneer.
- Hard body is caused by low fat: SNF ratio in milk and high coagulation temperature.
- Coarse texture is due to use of high acidic milk and inadequate of fat content in milk. Too low Ph of coagulation also affects texture of paneer.
- ❖ Color and appearance defects:
- Dry surface in paneer is due to high percentage of fat in the milk used.
- Surface hardening is caused when paneer is exposed to atmospheric air for longer duration.

- Moldy surface is due to storage of paneer in humid condition and excessive moisture content in paneer.
- Foreign matters are seen due to improper straining of the milk and transport of paneer in unhygienic manner (Kumar *et al.*, 2014).

2.2.4 Standards of paneer

Today, there are many choices in paneer to cater a wide variety of consumer tastes and standards of identity as well as specification are set so that consumers will get a consistent product, no matter what brand or type they buy. The Dairy Development Corporation (DDC), Nepal specification for paneer is shown in Table 2.2.

Table 2.2 DDC specification of paneer

Characteristics	Requirement (g)
Moisture (%)	47.5
Protein (%)	19.7
Fat (%)	26
Carbohydrate (%)	0.6
Minerals (%)	1.9

2.2.5 Shelf life of paneer

The major hurdle in the production of paneer commercially is its low shelf life. Paneer could be stored for only 6 days at 10ºC without much deterioration in its quality, though the freshness is lost after 3 days. It is noticed that growth of micro-organisms on the surface of paneer leads to its spoilage. Formation of a greenish yellow slime on the surface is accompanied with discoloration and off flavor. Therefore, efforts have been made to increase the shelf life of paneer by checking the surface growth of micro-organisms. Dipping of paneer in brine solution may increase the shelf life from 7 days to 20 days at 6-8ºC (Kanawjia and Khurana, 2006).

2.2.6 Packaging of paneer

Use of packaging materials significantly increased the shelf life of paneer. Packaging provides protection against different physiochemical and microbiological changes maintaining its quality, sales appeal, freshness and consumer convenience. Use of saran coated packaging films helped in enhancing the shelf life of paneer to a greater extent (Sachdeva and Singh, 1990). Packaging of chemical preservative treated paneer with or without vacuum extended its shelf life up to 35 and 50 days, respectively at 8ºC. Vacuum packaging of cow milk paneer is reported to have enhanced its shelf life from 1 week to 30 days at 6ºC (Sachdeva and Prokopek, 1992).

Paneer packaged in high barrier film (EVA/EVA/PVDC/EVA) under vacuum and heat treated at 90ºC for 1 min had a shelf life of 90 days under refrigeration. Heat sterilization led to considerable extension in shelf life of paneer. Paneer packed in tins along with water/brine and sterilized in autoclave at 1 kg/cm² for 15 min could stay well for 4 months at room temperature (Kanawjia and Singh, 2000).

2.3 Factors affecting the quality of paneer

2.3.1 Type of milk

Acidic milk having titrable acidity of 0.20 to 0.23% yields a product with inferior quality. Homogenization of cow milk is recommended to bring about improvement in the yield and organoleptic score of paneer. For making good quality paneer, buffalo milk is considered more suitable than cow milk (Sachdeva *et al.*, 1985).

Animal udder infection (mastitis) results in higher pH values for fresh milk whereas lower values show bacterial action. The bacterial action disturbs salt balance i.e., causes progressive removal of calcium and phosphates from caseinate phosphate micelle due to which coagulation is faster simply on heating or on addition of small amount of coagulant which directly affects the quality of the final product (Acharya and Katwal, 2002).

2.3.2 Heat treatment of milk

The yield and total solids recovery increases with the increase in heating temperature while solids in whey decreases. This is due to complex formation between whey proteins and casein. At higher temperatures casein acts as a scavenger for serum proteins, which are otherwise lost in whey (Aneja, 2007).

Temperatures beyond 90ºC, however, cause deposition of milk solids on the heating surface resulting in an overall solids loss. Milk heated at 90ºC without any holding, results in paneer with a total solids recovery of about 66%. The recovery does not increase appreciably on holding the milk at 90ºC and is, therefore, not required (Masud, 2002; Muller *et al.*, 1967).

2.3.3 Temperature of coagulation

Coagulation temperature influences the moisture content, fat and TS recovery and thereby the yield of paneer; it also influences its body and texture characteristics. The moisture and yield of paneer decreases consistently with the increase in coagulation temperature. The recovery of total solids increases directly with the coagulation temperature while the solids loss in whey decreases. Paneer obtained by coagulating milk at 70ºC had the best organoleptic quality and had desired frying quality namely integrity/shape retention and softness (Chandan, 2007).

2.3.4 Concentration of coagulant

The concentration of coagulant has a profound effect on the body and texture of paneer. Low acid strength results in soft body and smooth texture, while high acid strength results in hard body. The amount of coagulant required for coagulation of milk depends upon the type of milk, buffering capacity of milk, type of coagulant and the coagulation temperature employed. The total solid loss in whey increases as there is an increase in concentration of coagulant (Khan and Pal, 2011). Sachdeva and Singh (1988) reported that loss of total solid in whey was 5.8%, 6.4% and 6.8% on coagulating milk with 1%, 2% and 3% citric acid respectively.

The sensory score were maximum for paneer made with each coagulant of 1% solution and decreased with increase in concentration; stronger solutions resulted in paneer with slightly acidic taste and harder body. Solutions lower than 1% concentration would increase the bulk of the contents posing problems in handling (Sachdeva and Singh, 1988). The yield of paneer obtained from 1% citric acid was highest (14.2%) than other coagulant concentrations. The sensory evaluation results indicated that the product prepared from citric, tartaric and lactic acids at 1% each could be considered the best product (Karadbhajne and Bhoyarkar, 2010). The percent yield obtained from 1% citric acid was 14.2%, which is higher than 2% and 3% solution whereas in case of tartaric acid and lactic acid, 2% solution was optimized (Acharya and Katwal, 2002).

2.3.5 Acidity of milk

Milk having acidity within the range of 0.14-0.16% should be accepted for paneer manufacture. As a result of bacterial action on milk lactose there is increase in acidity in milk (Acharya and Katwal, 2002).

2.3.6 pH of milk

Variation in the pH of coagulation has a significant effect on the body and texture, flavor, quality and yield of paneer. According to (Sachdeva and Singh, 1988), with the fall in pH (5.5-5.0), the moisture retention and yield of paneer decreased. However, at coagulation pH of 5.0; the moisture, TS recovery and yield were lower. The moisture content and yield of paneer increased from 50 to 58.6% and from 20.8 to 24.8% respectively, when coagulation pH increased from 5.1 to 5.4. Sensory quality was best at pH 5.3–5.35 which is recommended for paneer making from buffalo milk.

2.4 Deep oil frying of paneer

Frying is considered to be one of the oldest methods of food preparation due to high cooking rates and desirable product characteristics. It is a unit operation which is mainly used to alter the eating quality of a food. Deep-fat frying involves immersion of food in hot edible oil at a temperature above the boiling point of water for a given period of time. Vegetable oil is must suitable for deep frying since it contains health friendly unsaturated fat and have a higher value of smoke point (Farkas *et al.*, 1996; Simmons, 2017). The process involves both mass transfers, mainly represented by water loss and oil uptake, and heat transfer. Deep-fried foods are now popular for their distinct flavor and texture, as evidenced by the multi-billion-dollar market products. The attainment to a high and constant quality of fried products with appropriate oil content is of considerable interest to food industry and consumers (Ziaiifar, 2008).

The moisture removal from food material must be sufficient to ensure the optimum fat uptake (Farkas *et al.*, 1996; Ziaiifar, 2008). During frying, water escapes from the food while oil migrates into the food providing nutrients and flavors. Frying oils thus have the original property of being both a heat transfer medium and an ingredient of the final product representing up to 40% of the total mass in products like chips. During deep-oil frying, water in the crust will evaporate and move out of the food. In order for the flow of vapor to continue, sufficient water has to be able to migrate from the core of the food to the crust and the crust has to remain permeable. The fact that the vapor leaves void for the oil to enter later is the reason why oil uptake is largely determined by the moisture content of the food. Similarly, sections of the food with more moisture loss also show more oil-uptake (Mehta and Swinburn, 2001).

Oil uptake is considered the major nutritional critical point of deep-fat frying because of the obesity and the negative effects of excess oil consumption on human health. This point has caught the attention of researchers. In recent years, there has been a strong encouragement to reduce oil content of fried foods, prompting many researches on the development of food products that have reduced fat and cholesterol levels. The quality of frying oils as well as fatty acids composition and degree of degradation of fat, frying medium, oil content and frying temperature affects the oil uptake and texture of fried food products (Mirzaei *et al.*, 2015). The capillary effect (primary) and the vacuum effect (secondary) are the main mechanisms in oil absorption. The product porosity can be the place of oil absorption so it determines the capacity of oil absorption. During the frying period, the absorbed oil content is not enough to fill the pores, which are continuously forming. While during cooling period, the pores are mostly filled by oil (Ziaiifar, 2008).

Choe and Min (2007) observed the oil uptake in different food products. They found the oil uptake in potato chips, corn chips, tortilla chips, dough nuts, French fries and fried noodles to be in between 33-38%, 30-38%, 23-30%, 20-25%, 10-15% and 14% (Choe *et al.*, 1993) respectively. Similarly, according to a study by Mirzaei *et al.* (2015) the oil uptake of potato French fries was 23% to 28% at 160ºC and180ºC respectively. It was observed that the oil uptake was higher at around 180ºC than 160ºC (Mirzaei *et al.*, 2015).

2.5 Coconut

2.5.1 Description and origin

The coconut *(Cocos nucifera* L.*)* is a member of the family Arecaceae (palm family). It is the only accepted species in the genus Cocos, and is a large palm, growing up to 30 m tall, with pinnate leaves 4–6 m long and pinnae 60–90 cm long which old leaves break away cleanly, leaving the trunk smooth. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which is not a botanical nut (Afodunrinbi and Onyeukwu, 2000; Akoma *et al.*, 2000). The coconut palm is found throughout the tropics, where it is interwoven into the lives of the local people. It is particularly important in the low islands of the Pacific where, in the absence of land-based natural resources, it provides almost all the necessities of life-food, drink, oil, medicine, fiber, timber, thatch, mats, fuel, and domestic utensils. For good reason, it has been called the “tree of heaven” and “tree of life”. Today it remains an important economic and subsistence crop in many small Pacific island states (Banzon, 1990).

The coconut's name is a bit of a misnomer, since it is botanically classified as a drupe and not a nut. It is the largest seed known (Banzon, 1990).

2.5.2 Varieties

Varieties and characteristics of coconut shown in the Table 2.3

Table 2.3 Varieties and characteristics of coconut

Variety	Characteristics
Tall	Thick stem with swollen base (bole). Later flowering (5–6 year from out planting). Little or no overlapping of male and female phases of an inflorescence encouraging out- crossing.
Dwarf	Slender stem with short internodes. Bole slight or absent. Early flowering (3 year from out planting). Considerable overlapping of male and female phases of an inflorescence resulting in self-pollination

Source: Romney (1997)

2.5.3 Coconut meat

Coconut meat is the edible white meat of a coconut; often shredded for use in cakes and curries. It contains essential mineral salts particularly magnesium, calcium and phosphorus which are of great importance to the musculoskeletal system. Though present in small amounts (32 mg/100 g of magnesium) in coconut meat, the Magnesium content surpasses that of all animal-based foods including meat, fish, milk and eggs (Pamplona-Roger, 2007).

2.5.4 Coconut fat

Coconut oil is composed predominately of medium-chain fatty acids (MCFA), also known as medium-chain triglycerides (MCT). The size of the fatty acid is important because the human body responds to and metabolizes each fatty acid differently depending on its size. So, the physiological effects of MCFA in coconut oil are distinctly different from those of LCFA more commonly found in our foods. The saturated fatty acids in coconut oil are predominately medium-chain fatty acids. Both the saturated and unsaturated fat found in meat, milk, eggs, and plants (including almost all vegetable oils) are composed of LCFA. MCFA are very different from LCFA. They do not have a negative effect on cholesterol and help to protect against heart disease. MCFA help to lower the risk of both atherosclerosis and heart disease. It is primarily due to the MCFA in coconut oil that makes it so special and so beneficial. There are only a very few good dietary sources of MCFA. The best sources of MCFA are coconut and palm kernel oils (Pamplona-Roger, 2007).

2.5.5 Coconut protein

Coconut proteins are generally classified according to their solubility and amino acid composition. The predominant proteins in coconut endosperm or kernel are classified as globulin (salt-soluble) and albumin (water-soluble), which account for 40% and 21% of total protein, respectively. Globulin fraction of coconut has a high level of charged amino acids. Those are aspartic acid, glutamic acid, arginine, and lysine (Patil and Benjakul, 2017; Simmons, 2017). The albumin fraction has higher proportions of amino acids with polar side chains. The relative proportion of each protein fraction affects the functional properties and the nutritional quality. The differences in maturation stage, fertilizer, climate, starting material, and so on, also result in varying proportion of various proteins in coconut meat (Patil and Benjakul, 2017). Distribution of proteins in defatted coconut meal, classified based on solubility, is shown in Table 2.4.

Table2.4 Distribution of protein in defatted coconut meal

Protein	Extraction solvents	Proportion (%)
Albumin	Water	19
Globulin	Nacl (1-0.5M)	36
Prolamin	Isopropyl alcohol (70%)	2
Glutelin-1	Glacial acetic acid (50%)	10
Glutelin-2	NaOH (0.1M)	4
Unextractable protein	Residue	-

Source: Patil and Benjakul (2017)

2.5.6 Coconut milk

Coconut milk is the term used to designate the liquid obtained by the manual or mechanical extraction of grated coconut meat with or without added water. The term coconut milk and coconut cream are used interchangeably. But coconut milk refers to the milky fluid, freshly extracted from the coconut kernel with or without added water, and coconut cream refer to the high fat cream like material obtained from the coconut milk by either gravity separation or centrifugation (Banzon, 1990).

Maturity of the coconut greatly affects the yield of coconut milk. Mature brown husked coconuts with no protruding sprouts produce higher yields of milk. Coconut milk is generally produced from mature nuts of 12 months in age. At this stage, the meat is hard and thick, with a typical composition of as follows: 50% moisture, 34% oil, 3.5% protein, 3% fiber, 2.2% ash and 7.3% carbohydrates (Banzon, 1990).

Composition of coconut milk is shown in the Table 2.5

Table 2.5 composition of coconut milk

Components	Quantity (%)
Moisture	72.88
Ash	1.7
Protein	2.02
Fat	5
Acidity (as % citric acid)	0.13
Carbohydrate	2.81

Source: USDA (2012)

2.5.7 Nutritional and medicinal importance of coconut milk

Some of the most important benefits of coconut milk are:

- Coconut milk can give about 22% of the recommended daily allowance of iron, it can help to treat anemia caused by iron deficiency.
- Coconut is a dairy free alternative to those who are lactose intolerant and are also allergic to animal milk. This milk is also nut free, soy free and gluten free.
- It is known to relieve the symptoms of sore throat.

- The saturated fat content in coconut is made up of short and medium chain fatty acids. These fatty acids are quickly converted in to energy instead of storing as fat in the body.
- Coconut milk is an excellent source of Vitamin E. It helps in the nourishment of the skin.
- Coconut milk is a reservoir of antioxidants. Antioxidants help the body fight aging, low vision and low bone density.
- Apply coconut milk to the scalp to have dandruff free hair and condition your hair naturally.
- It also aids in digestion and is also used as a laxative. It can also be a remedy for urinary and kidney problems.
- A major part of the fats found in coconut milk is lauric acid, which has been found to exhibit antibacterial, antifungal and antiviral properties. This fatty acid can boost the immune system and its disease fighting ability.
- A major part of the fats found in coconut milk is lauric acid, which has been found to exhibit antibacterial, antifungal and antiviral properties. This fatty acid can boost the immune system and its disease fighting ability (Banzon, 1990).

2.5.8 Coconut products

2.5.8.1 Coconut flour

Coconut flour is a unique product from coconut residue as a byproduct in the processing of coconut milk. It has off white color and is comparable with other cereal flour in terms of energy, carbohydrates and fat contents. Coconut flour can be used as bulking agent fillers and substitute for wheat flour, rice flour and potato flour at certain level. It can combine well with chocolate and cinnamon flavored baked products as well as cheese flavored and barbecue flavored snacks (Arancon, 1999).

Coconut flour provides a number of health benefits especially in relation to coronary heart diseases, cancer, diabetes and mineral absorption in the human body system. The dietary fiber of coconut flour can bind of bile acids of large intestines colon or rectum (Arancon, 1999).

2.5.8.2 Coconut water

The liquid endosperm contained in the cavity of coconut kernel is called coconut water. It varies in the volume and nutrition depending on the maturity of the fruits. It is ready and handy boon to combat the dehydration of patient suffering from diarrhea and vomiting and is a cheap substitute to glucose, saline or plasma. It contains not only glucose but also other ingredients such as low fat, amino acids, vitamins and minerals (phosphorous, sulphur, iron, calcium, sodium and potassium and they are in proportion depending on the maturity of coconut. Coconut water can be used for the preparation of carbonated coconut water (Silva, 2008).

Part III

Materials and method

3.1 Raw materials

The materials collected for the paneer preparation were as follows:

3.1.1 Milk

Fresh milk (kamadhenu) (fat = 5% and SNF =8%) was collected from market of Dharan.

3.1.2 Coconut

Coconut was collected from the local market of Dharan.

3.1.3 Chemicals and Equipment

The chemicals and equipment used were provided by CCT lab. The chemicals used are listed below and the list of equipment is shown in Table 3.1.

- Citric acid
- Catalyst mixture (Mixture of 2.5 g of powdered SeO_2, 100 g K_2SO_4 and 20 g $CuSO_4.5H_2O$)
- Mixed indicator Solution (Mixture of 10 ml of 0.1% bromocresol green and 2 ml of 0.1% methyl red solution which was prepared separately in 95%ethanol)
- Sodium bicarbonate ($NaHCO_3$)
- Sodium Hydroxide (NaOH)
- Conc. Sulphuric acid (H_2SO_4)
- Oxalic acid
- Amyl Alcohol
- Gerber sulphuric acid
- Neutral boric acid
- Phenolphthalein
- Conc Hydrochloric acid (HCl)
- Conc. Nitric acid (HNO_3)
- Petroleum benzene

Table 3.1 List of the equipment used

Physical apparatus	Physical apparatus
Heating arrangements	Grinding apparatus
Electric balance	Stainless steel vessel
Thermometer	Dessicator
Centrifuge	Kjeldahl digestion and distillation set
Muslin cloth	Refrigerator
Titration apparatus	Daily routine glassware
Soxhlet apparatus	Stirrer
Hot air oven	Muffle furnace
Gerber butyrometer	Pressing arrangements

3.2 Methods

3.2.1 Extraction of coconut milk from coconut

Coconut was cracked into halves manually and removed with knives. The brown part of the coconut milk was scraped off gently to enhance color of milk and cut into small pieces. to enhance grinding. Coconut milk was prepared by mixing the grinded meat with equal amount of water in a blender, filtered manually with muslin cloth, and manually squeezed with twisting motion. The flow diagram is shown in Fig 3.1.

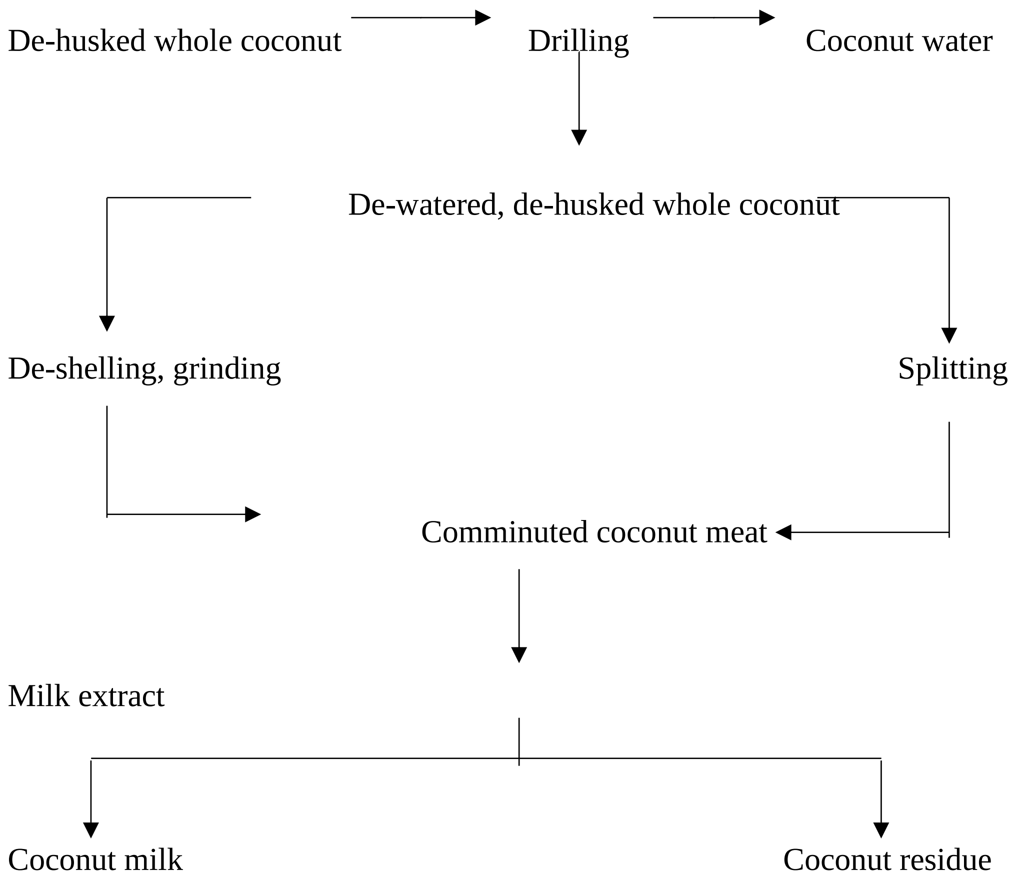

Fig. 3.1 Flow chart for the preparation of coconut milk.

3.2.2 Experimental plan

Eight samples were prepared as A, B, C, D, E, F, G and H as shown in Table 3.2. Each sample had different formulations based on results shown by Design Expert.

Table 3.2 Experimental plan

Samples	Milk (%)	Coconut milk (%)
A	75	25
B	62.52	37.48
C	50	50
D	87.71	12.29
E	100	0
F	68.69	31.31
G	51.43	18.57
H	56.28	43.72

3.2.3 Methods of paneer preparation

The method of preparation of coconut paneer is shown in Fig. 3.2

Fresh milk → Milk in different proportions ← Coconut milk

↓

Heating (80-85ºC) for 5 min

↓

Cooling (70ºC)

↓

Addition of coagulum (2% citric acid)

↓

Continuous stirring till clear whey separates out

↓

Settling (for 10 min)

↓

Draining of (whey)

↓

Pressing the coagulum after filling in muslin cloth (2 kg for 25 min)

↓

Removal of blocks and cutting into desired shapes

↓

Immersion of paneer blocks in chilled water (4ºC) for 2-3 h

↓

Draining of water and whey and wiping surface

↓

Storage at 4ºC

Fig. 3.2 Flow diagram for preparation of coconut paneer.

3.3 Details of preparation

3.3.1 Heat treatment

The milk with different formulations (fresh milk: coconut milk= 100:0, 88:12, 88:18, 75:25,69:31, 57:43, 50:50) was heated at 80-85ºC for 5 min and cooled to 70ºC.

3.3.2 Coagulation

The milk was coagulated with 2% citric acid solution, which was added slowly with continuous stirring.

3.3.3 Whey drainage

After coagulation of milk, curd is formed and clear whey is separated out which was allowed to settle for 10 min. The whey was then drained out through a muslin cloth.

3.3.4 Pressing

Pressing was done in a wooden mould of dimension 4"×4"×4" with a pressure of 2 kg as per Vishweshwaraiah and Anantakrishnan (1986) and. It was done for 25 min. Pressing was done for complete whey expulsion and to get the final desired shape of the product.

3.3.5 Dipping in chilled water

The pressed block was removed from the hoop and immersed in chilled water (4ºC) for 2-3 h. The chilled pieces of paneer were removed and placed on wooden plank to remove occluded water and wiped with blotting paper. The paneer pieces were vacuum packed and placed in refrigeration temperature (4±1ºC).

3.4 Physio -chemical analysis of raw material and final product

3.4.1 Chemical analysis of raw material

The raw material was analyzed for fat content by Gerber method protein content by formal titration method as described in AOAC (2005). Acidity by titration method and pH by pH meter.

3.4.2 Analysis of final product

3.4.2.1 Moisture content

Moisture content of the control and best sample was determined by hot air oven method as per AOAC (2005).

3.4.2.2 Protein content

Protein content of the product was determined by Micro-Kjeldahl method as stated by Ranganna (1986).

3.4.2.3 Total ash

Total ash was determined by dry ashing method as mentioned in AOAC (2005).

3.4.2.4 Fat content

The fat content was determined by Soxhlet apparatus (AOAC, 2005).

3.4.2.5 Acidity and pH

Acidity was determined by titration method and pH by pH meter (NDDB, 2001).

3.4.2.6 Carbohydrate content

Carbohydrate content was determined by difference as described per Nepal Dairy Development Board NDDB (2001).

3.5 Sensory evaluation

A panel consisting of 10 members was selected for sensory evaluation. Blended coconut paneer samples were presented to the panelists drawn from the faculty members and students of CCT, Hattisar. The panelists were asked to judge the sample for color, texture, flavor, body and overall acceptability using a 9-point hedonic scale rating. The results of the sensory evaluation were studied statistically using the software GenStat Release 12.1 (Appendix A).

3.6 Statistical analysis

The data obtained were analyzed statistically by using analysis of variance technique (ANOVA) to find if the differences were significant or not at 5% level of significance.

Part IV

Results and discussion

The experimental finding from the preparation of whole milk and coconut milk blended paneer are presented and discussed in this part. Blends of coconut milk and whole milk were heated and coagulated to prepare paneer. The results that show the effect of blending coconut milk on chemical and sensory characteristics of fresh milk and its paneer are presented.

4.1 Chemical composition of raw material

Proximate analysis provides inexpensive yet very informative, particularly from the nutritional and biochemical points of views. The results normally expressed in percentage and because of the fairly general nature of test employed for the determination, the term crude is usually used as a modifier; for instant, crude protein, crude fat etc. therefore proximate constituent represent only a category of compounds present in biological material. The proximate analysis of coconut milk and milk is given in Table 4.1.

Table 4.1 Physico-chemical analysis of coconut milk and milk.

Attribute	Coconut milk	whole Milk
Moisture (%)	83.02±0.05	84.5±0.02
Crude fat (%)	7.50±0. 58	4.8±0.54
Crude protein (%)	3.20±0.09	2.99±0.07
Ash (%)	0.71±0.62	0.6±0.2
Carbohydrate (%)	5.57±0.21	7.11±0.11
Total solid (%)	16.98±0.05	15.5±0.08
pH	6.4	6.5

***Values are the means of three determinations± standard deviations. Figures in parentheses are the standard deviations.

4.2 Sensory analysis of paneer

Sensory analysis of the coconut milk incorporated paneer was done by 10 semi-trained panelists evaluating color, flavor, shape, texture and overall acceptability. Statistical method was used to find out the best sample. Analysis of variance (ANOVA) was carried out using least significant difference LSD at (5%) level of significance.

4.2.1 Effect of formulation on color

The mean sensory scores± standard deviation for color of samples A, B, C, D, E, F, G and H were found to be 6.4±0.52, 6.77±0.44, 6.22±0.44, 8.33±0.5, 8.33±0.5, 6.44±0.52, 6.33±0.5, 6.55±0.52 respectively as shown in Fig.4.1. The mean score was found highest for sample D which was equal to control E. Samples D and B, D and C were found to be significantly different from each other in color but samples A, F, G and H had the same mean score.

Fig. 4.1 represents the mean sensory scores for color of coconut milk incorporated paneer. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D, E, F, G and H represent sample formulations as given in Table 3.2

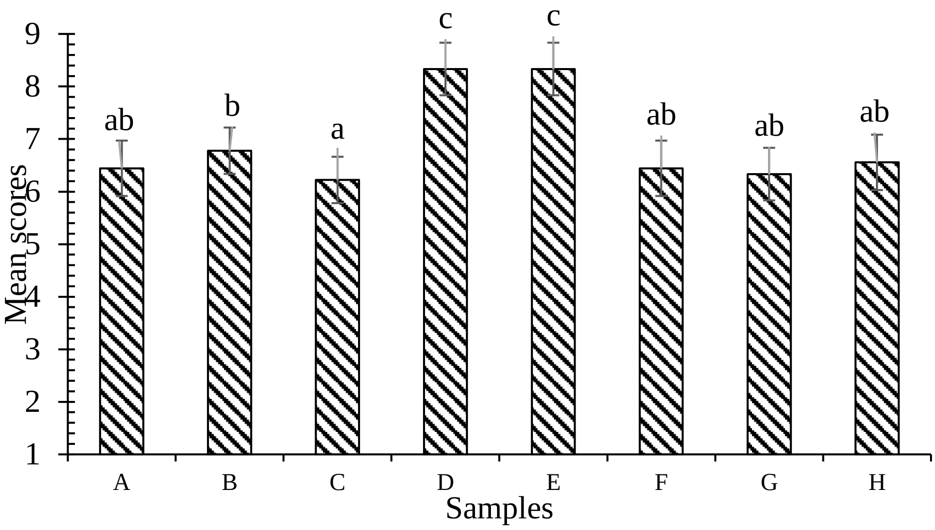

Fig. 4.1 Mean sensory score for color of coconut paneer

4.2.2 Effect of formulation on flavor

The mean sensory scores± standard deviation for flavor of samples A, B, C, D, E, F, G and H were found to be 6.44±0.52, 6.55±0.52, 6.0±0, 8.22±0.44, 8.66±0.5, 6.55±0.52, 6.77±0.44, 6.55±0.52 respectively. The mean sensory score flavor was found to be highest for sample D after sample E which was the control sample. Sample D was significantly different from control E, A, B, F, G, H but not from sample C with highest proportion of coconut milk as shown in Fig. 4.2.

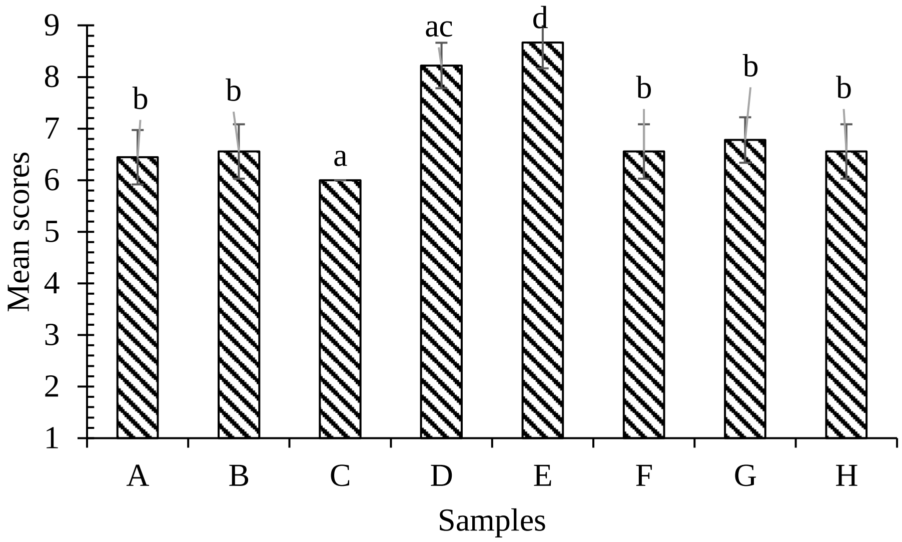

Fig. 4.2 Mean sensory score for flavor of coconut paneer

It was found that the incorporation of coconut milk at 12% had flavor difference significantly (p ≤0.05). The scores seemed to decrease with increasing coconut milk except for 12 % of coconut milk concentration. This can be attributed to the fact that the nutty flavor was offensive to most of the people as dominated the overall flavor of paneer.

Fig. 4.2 represents the mean sensory scores for flavor of coconut milk incorporated paneer. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D, E, F, G and H represent sample formulations as given in Table 3.2

4.2.3 Effect of formulation on body

The mean sensory scores± standard deviation for body of samples A, B, C, D, E, F, G and H were found to be 6.66±0.5, 6.66±0.5, 6.22±0.44, 8.33±0.5, 8.55±0.52, 6.55±0.52, 6.88±0.33, 6.55±0.52 respectively. The mean sensory score was found to be highest for sample D after control sample E as shown in Fig. 4.3.

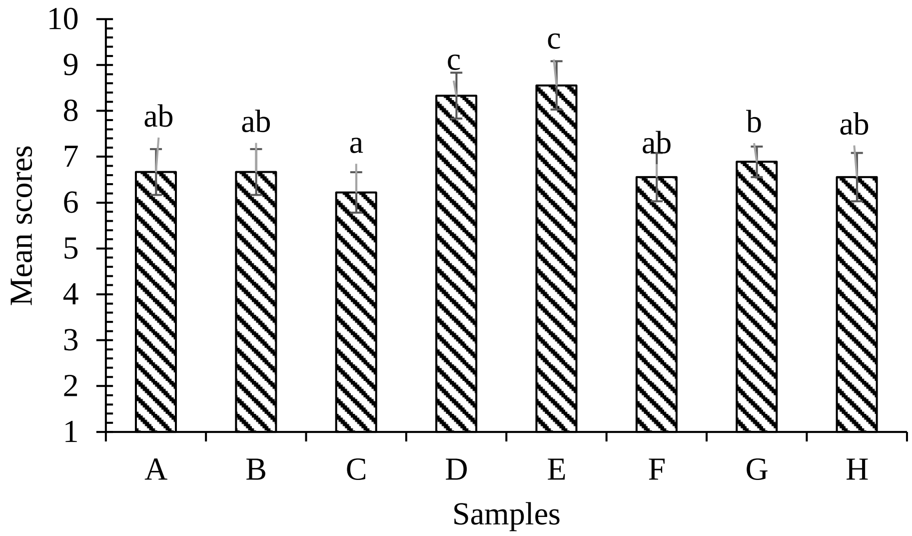

Fig. 4.3 Mean sensory score for body of coconut paneer

Fig. 4.3 represents the mean sensory scores for body of coconut milk incorporated paneer. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D, E, F, G and H represent sample formulations as given in Table 3.2

4.2.4 Effect of formulation on texture

The mean sensory scores± standard deviation for texture of samples A, B, C, D, E, F, G and H were found to be 6.44±0.52, 6.33±0.5, 6.22±0.44, 8.33±0.5, 8.22±0.44, 6.66±0.5, 6.77±0.44, 6.44±0.52 respectively. The mean sensory scores for texture were found to be highest for sample D and lowest for sample C. Sample D and control E obtained similar sensory scores.

Samples D and E, A and B, F and H had no significant difference between them at 5% level of significance. It was indicated that too high coconut milk proportion was not preferred by the panelists for texture. Suvarna (2014) also reported that increase in coconut milk affected the texture of paneer.

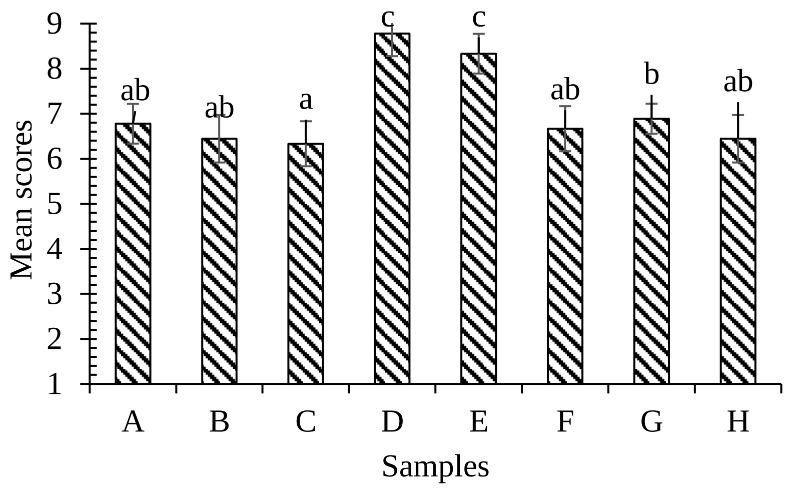

Fig. 4.4 Mean sensory score for texture of coconut paneer

Fig. 4.4 represents the mean sensory scores for texture of coconut milk incorporated paneer. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D, E, F, G and H represent sample formulations as given in Table 3.2.

4.2.5 Effect of formulation on overall acceptability

The mean sensory scores± standard deviation for overall acceptability of samples A, B, C, D, E, F, G and H were found to be 6.77±0.44, 6.44±0.52, 6.33±0.5, 8.77±0.44, 8.33±0.5, 6.77±0.5, 6.88±0.33, 6.44±0.52 respectively. The mean sensory score was found to be highest for D which was completely different from A, B, C, F, G and H as shown in Fig. 4.5

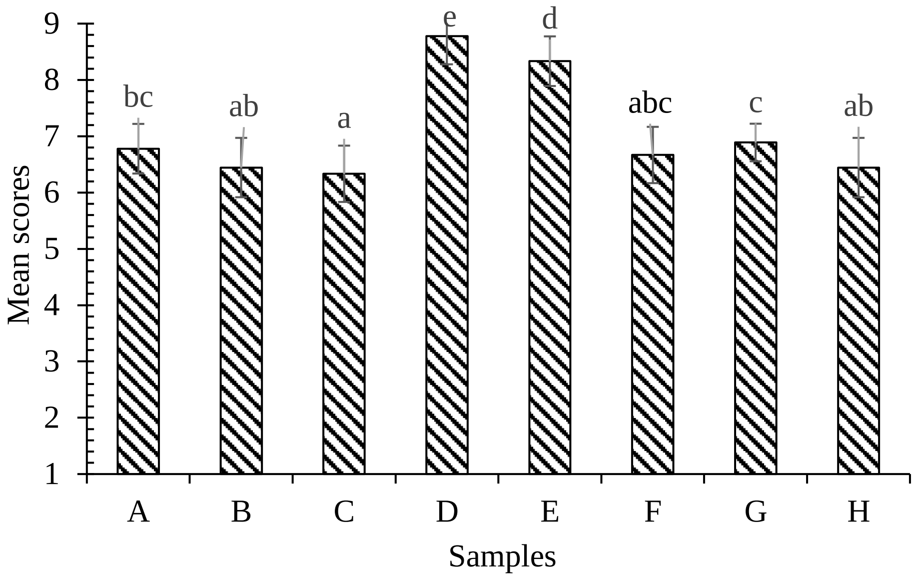

Fig. 4.5 Mean sensory score for overall acceptability of coconut paneer

Fig. 4.5 represents the mean sensory scores for overall acceptance of coconut milk incorporated paneer. Values on top of the bars bearing similar superscript are not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D, E, F, G and H represent sample formulations as given in Table 3.2.

Mean score of sample D was highest which indicates that sample d represents the same overall acceptance as control E. Sample C had least score indicating that higher proportion of blending of coconut milk and milk were not preferred by the panelists. Suvarna (2014) also observed lower scores for samples with higher proportion of coconut milk content in terms of acceptability of paneer and higher scores for samples with lower proportion of coconut milk. The preference was in decreasing order with increasing proportion of coconut milk.

Therefore, sample D was found to be the best in most of the parameters and overall acceptability as well. The formulation with 88% milk and 12% coconut milk was chosen to be the best product by sensory evaluation and obtained data interpretation. This conclusion was derived based on sensory analysis of limited number of panelists and so the experimental results should be taken with some reservations as it may differ when subjected to other populations.

4.3 Chemical analysis of coconut paneer and product

Sensory optimized paneer sample D and control sample was subjected to chemical analysis and the data obtained are as shown in Table 4.2.

Table 4.2 Proximate analysis of the best coconut paneer sample D and control E.

Parameter	Sample D	Control (wet basis)
Moisture content (%)	52.63±0.31	54.30±0.23
Fat (%)	23.24±0.25	23.01±1.02
Protein (%)	19.12±0.11	18.81±0.03
Fiber (%)	0.92±0.21	0.3±0.05
Ash (%)	2.51±0.35	1.5±0.05
Acidity as lactic acid (%)	0.29±0.02	0.31±0.6
Carbohydrate (%)	1.58±0.05	2.71±0.08
Total solid (%)	47.37±0.31	49.7±0.23
pH	6.5	6.4

The paneer prepared from 100% whole milk was taken as the control. The control paneer was marble white in color. Prince *et al.* (2007) has also reported that good quality milk paneer is marble white in appearance, having a slight spongy body, loose knit texture and possessing a sweetish acidic nutty flavor.

The moisture content in filled paneer prepared by coagulating with citric acid was 52.63%. According to FSSAI (2011) paneer should not contain more than 70.0% moisture. In both sample D and sample E the moisture was far below the specified level. Fat content of coconut milk incorporated Paneer was higher in comparison to control paneer. Suvarna (2014) reported a fat content of 24.12% and Masud *et al.* (2007) indicated 23.0% fat in paneer prepared from buffalo milk. Shashikumar and Puranik (2011) reported a fat content of 24.85% in paneer prepared from cow milk. Davide *et al.* (1988) also reported higher fat content of 26.78% in coconut milk incorporated paneer (90:10). The fat content noticed in the present study was found to be in line with the above-mentioned observations.

The protein content of coconut milk blend paneer prepared using citric acid was19.12% and that of control paneer was 18.81%. The protein content observed in the present study in milk paneer (18.81%) is found to be in line with the protein content reported by Chawla *et al.* (1987) in buffalo milk paneer 18.43%, Syed *et al.* (1992) in cow milk paneer and Agnihotri and Pal (1996) in goat milk paneer 19.99%. The protein content of 18.06% reported by David (2012) in coconut milk based functional paneer prepared out of buffalo milk and coconut milk was found to be similar to the protein content noticed in whole milk and coconut milk paneer. Fiber content of coconut milk incorporated paneer was higher compare to control paneer which has no fiber content. Suvarna (2014) reported fiber content of 0.57% to 1.422% in fiber enriched paneer. Ash content of coconut milk incorporated paneer was slightly higher in comparison to control paneer which somewhat does not collides with the value given by Suvarna (2014). The composition of raw ingredients greatly influences the ash of paneer.

The value of acidity percent for control milk paneer and blend milk paneer were 0.31 and 0.29, respectively in the present investigation. The acidity decreases slightly with an increase in the amount of coconut milk in the blend (David, 2012; Suvarna, 2014).

The pH of coconut milk blend paneer noticed in the present study is almost similar to the pH reported by Biradar *et al.* (2012) in paneer prepared by blending soy milk and buffalo milk at different levels. Kumar *et al.* (2008),Rai *et al.* (2008) and David (2012) reported a decrease in pH with increase in acidity.

4.4 Oil uptake

Vegetable (sunflower) oil was used for deep frying of paneer. Vegetable oil was used since it contains health friendly unsaturated fat and have higher value of smoke point (Farkas *et al.*, 1996; Simmons, 2017) . The frying and temperature was set to 160ºC because Mirzaei *et al.* (2015) recommended it since frying at 160ºC gave the product with best texture and suitable crust thickness but higher temperature than this offered very thick crust. Fig. 4.6 shows the results of the oil uptake by paneer samples.

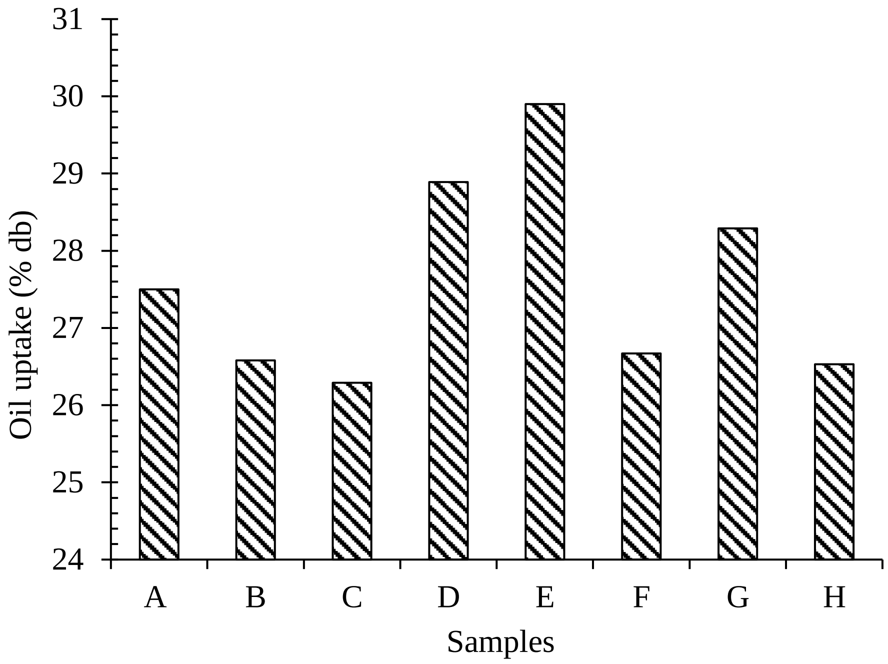

Fig. 4.6 Results of the oil uptake by the paneer samples

The samples were diced into cubes of approximately 2cm × 2cm × 2cm (±0.5cm). Deep oil frying was done at a temperature of 160ºC for 2 min. The oil uptake by paneer samples after deep oil frying was calculated in dry basis. 10 g deep oil fried sample was taken for the oil uptake determination. Sample C yielded the maximum 6.3 g oil than all other samples. During frying, water escapes from the food while oil migrates into the food providing nutrients and flavors. Deep oil frying process involves both mass transfers, mainly represented by water loss and oil uptake, and heat transfer. The moisture removal from food material must be sufficient to ensure the optimum fat uptake (Farkas *et al.*, 1996; Ziaiifar, 2008). The results of oil uptake supported the review done by Ziaiifar (2008).

The paneer samples D and E were found to have higher values for oil uptake i.e. 28.89% and 29.90% respectively. The samples A, B, C, D, E, G, and H had the oil uptake 27.50%, 26.58%, 26.29%, 28.89%, 29.90%, 26.67%, 28.59% and 26.53% respectively. Oil uptake is dependent in the initial fat and moisture content of the product. Higher value of fat means lower will be the moisture content. During frying, oil fills the voids created in the product by rapid loss of water vapor. The less moisture content means less oil uptake since the amount of moisture leaving the frying material becomes minimum allowing less space for oil to penetrate and fill the void spaces and vice-versa. The samples D and E had less initial fat content and higher values for moisture content than other which resulted greater value of oil uptake. During frying, porosity increases due to forceful water evaporation and pore formation which makes way for oil penetration to the interior of food being fried. During cooling, surface oil temperature tends to decrease while adhered oil interfacial tension and viscosity increases resulting in more oil absorption. The quality of frying oils as well as fatty acids composition and degree of degradation of fat, frying medium, oil content and frying temperature affects the oil uptake and texture of fried food products (Mirzaei *et al.*, 2015). Choe and Min (2007) observed the oil uptake in different food products. They found the oil uptake in potato chips, corn chips, tortilla chips, dough nuts, French fries and fried noodles to be in between 33 -38%, 30-38%, 23-30%, 20-25%, 10-15% and 14% (Choe *et al.*, 1993) respectively. Similarly, according to a study by Mirzaei *et al.* (2015) the oil uptake of potato French fries was 23% to 28% at 160ºC and 180ºC respectively. It was observed that the oil uptake was higher at around 180ºC than 160ºC (Mirzaei *et al.*, 2015).

4.5 Yield of paneer

The yield of paneer samples A, B, C, D, E, F, G, and H. were found to be 12.91%, 12.48%, 12.03%, 15.98%, 15.276%, 12.61%, 14.69% and 12.39% respectively. These values were slightly less than the findings of Smitha *et al.* (2014). Fig. 4.7 shows the yield of prepared paneer samples.

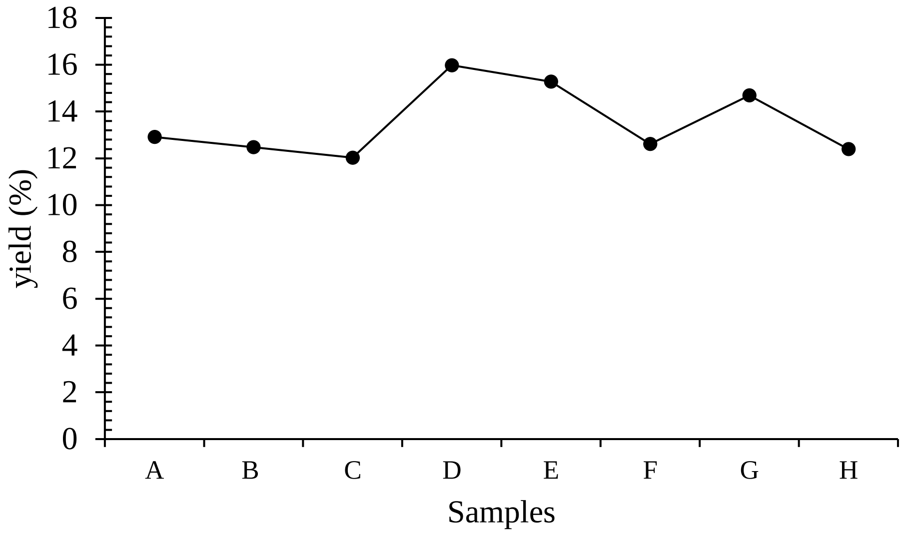

Fig. 4.7 yield of the prepared paneer samples

Higher fat in milk results in lower moisture retention in paneer and, therefore, a loss in terms of yield. Paneer of good quality can never hold moisture beyond 60% and thus the value of 70% as the maximum limit for moisture in paneer as stipulated in PFA standards appears to be too high. The yield of paneer mainly depends on the fat and SNF of milk as well as on the moisture, fat and protein retained in the paneer (Bhattacharya *et al.*, 1971; Sachdeva and Singh, 1988). The yield and TS recovery increased with increase in heating temperature while solids in whey decreased. This is due to complex formation between whey proteins and casein. At higher temperature, casein acts as scavenger for serum proteins, which are otherwise lost in whey. Sachdeva and Singh (1988) recommended a final heating temperature of 90ºC (without holding) to be the most suitable for the manufacture of paneer. In order to maximize the total solids recovery, it is desirable to heat the buffalo milk to 90°C without holding. Milk heated at 90ºC without any holding, results paneer with a total solids recovery of about 66% (Sachdeva and Singh, 1988).

The sample formulation with 12% coconut milk had the highest yield. It is due to the significantly higher retention of milk fat into the curd. Smitha *et al.* (2014) concluded that the highest yield of paneer was obtained at coagulation temperature of 70ºC with optimum moisture percentage. They also observed that when milk was coagulated at 70ºC, the yield was more influenced by fat. The yield in percentage of all paneer samples is shown in the figure above. The yield of prepared paneer were found to be slightly less than that found by Smitha *et al.* (2014).

4.6 Cost evaluation

The total cost associated with the best product was calculated and the cost of coconut paneer was NRs. 573 per kg, excluding labor cost, packaging cost and tax. The cost of market paneer was NRs.750 per kg which was higher than the cost of coconut paneer. Replacing of milk fat with vegetable fat and usage of other filling agents are helpful in reducing the production cost of paneer. Mass production further reduces this cost. The cost calculation is given in Appendix C. If the by product can be utilized from the grinded coconut, then the cost can be reduced even more which is suitable for all groups of families in society.

Part V

Conclusion and recommendations

5.1 Conclusions

The work was carried out to study the acceptability of coconut paneer and to observe the effect of blending of coconut milk on the preparation of coconut paneer. From the research following conclusions were made:

- Coconut paneer with 87% standard milk and 12% coconut milk was found to be best.
- Coconut milk had significant effect on the color, flavor, body and texture of the paneer.
- The chemical analysis of best product showed an increase in protein, fat, minerals and pH in comparison to control paneer.

5.2 Recommendations

Based on the present study following recommendations have been made:

- Shelf life of paneer samples can be studied using different preservation techniques.
- For commercial scale production, calcium phosphate incorporation can be done to increase the yield of paneer.
- Effect of coagulating agent other than citric acid can be studied.

Part VI

Summary

Paneer is a high protein food prepared after coagulating the milk. Paneer is a high nutrient diet containing a good amount of fat and protein. Because of high protein and fat content and easy availability of milk; paneer production can be done as an alternative to the meat protein. It is also becoming a great animal protein supplement for vegetarians. So present work is conducted to study the consumer acceptance of coconut milk paneer and its chemical quality.

For the study, coconut and standard milk were purchased from local market of Dharan. Coconut milk was prepared by mixing the shredded pulp of coconut with an equal weight of warm drinking water (60°C) in a blender, filtered through a double-layered muslin cloth, and manually squeezed with a twisting motion to extract most of the milk. Design Expert ® 10 for two variables (coconut milk and milk) was designed for experimental combinations. Using coconut milk and standard milk, the mix was prepared as calculated in the formulation, heated, coagulated, pressed, whey separated, and cut in desired sizes and dipped in chilled water at $4^{o}C$.

The prepared paneer was analyzed chemically and by sensory analysis. From sensory analysis, the sample with 87% milk and 12% coconut milk was found to be the best. It was found that coconut milk had significant effect on color, flavor, body, texture and overall acceptability of coconut milk blend paneer. The chemical composition of the best coconut milk incorporated paneer was analyzed. Moisture content, total solid, fat, protein, fiber, ash content, pH and acidity of best sample C were found out to be 52.63, 47.37, 23.24, 19.12, 0.92, 2.51, 6.5 and 0.29% respectively.

From this study, it is concluded that coconut milk can be successfully used in the manufacture of paneer. The major concern with milk paneer is, its high fat content especially saturated fat. Reducing the fat content of paneer to a greater extent will affect the product quality. So, replacing milk fat with healthy vegetable fat in paneer production is ideal and economical. Although saturated, the lauric acid component of coconut is considered as an ideal dietary fat. It is easily metabolized in the body for energy and helps to reduce fat accumulation in the body. In the rapidly changing socio-economic scenario, novel ways of value addition are essential to meet consumer needs for health food.

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Appendices

Appendix A

Specimen card for sensory evaluation of coconut paneer

Hedonic Rating Test

Name of Panelist: ……………… Date: …………

Kindly observe the given samples of product A to H. Use appropriate scale to show your attitude by checking at the point best described your opinion regarding products.

Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Color								
Flavor								
Body								
Texture								
Overall acceptability								

Judge the above characteristics on the 1-9 scale as below:

Like extremely-9 Like slightly-6 Dislike moderately-3

Like very much-8 Neither like nor dislike-5 Dislike very much-2

Like moderately-7 Dislike slightly-4 Dislike extremely-1

Comments………………………………………………………………………………

………………………………………………………………………………………..

……………….

Signature

Appendix B

ANOVA for sensory analysis of coconut paneer

Two-way ANOVA (No blocking) for color.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
sample	7	48.8750	6.9821	27.93	<.001
panelists	8	1.7778	0.2222	0.89	0.532
Residual	56	14.0000	0.2500		
Total	71	64.6528			

Two-way ANOVA (No blocking) for flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	7	55.9444	7.9921	39.59	<.001
Panelists	8	2.6944	0.3368	1.67	0.127
Residual	56	11.3056	0.2019		
Total	71	69.9444			

Two-way ANOVA (No blocking) for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	7	45.5417	6.5060	27.33	<.001
Panelists	8	1.7778	0.2222	0.93	0.497
Residual	56	13.3333	0.2381		
Total	71	60.6528			

Two-way ANOVA (No blocking) for shape

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	7	48.6667	6.9524	30.94	<.001
Panelists	8	2.5278	0.3160	1.41	0.214
Residual	56	12.5833	0.2247		
Total	71	63.7778			

Two-way ANOVA (No blocking) for overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	8	55.0556	7.8651	39.34	<.001
Panelists	10	3.2500	0.4062	2.03	0.059
Residual	56	11.1944	0.1999		
Total	71	69.5000			

Appendix C

Cost evaluation of the product

Ingredients	Quantity	Rate NRs	Quantity used	Rate NRs
Fresh milk	1000g	90	87.71gm	7.8939
Coconut milk	500g	50	12.29gm	1.229
Citric acid	1000g	900	0.2g	0.18
Overhead cost	20%			1.84
Total costing				11.4 per 16g

Color plates

Plate 1 Heating milk.

Plate 2 Chemical analysis of the best product.

Plate 3 Sensory analysis of paneer.

Plate 4 Different formulations of coconut paneer.

Plate 5 Paneer removed after pressing.