PROCESSING EFFECT ON OLEORESIN RETENTION OF *AKABARE* CHILLI (*CAPSICUM CHINENSE)*

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Processing Effect on Oleoresin Retention of *Akabare* Chilli (*Capsicum chinense*)

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Approval Letter

This *dissertation* entitled *Processing Effect on Oleoresin Retention of Dried Akabare* Chilli (*Capsicum chinense*) presented by Rajesh Rai has been accepted as the partial fulfillment of the requirements for B. Tech. degree in Food Technology

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Abstract

Akabare chili (*Capsicum chinense*) is one of the intensely species of chilli peppers of the *Capsicum* genus. Ripened and fully matured akabare chillies grown in Sidhuwa and Danabari (Dhankuta District) were collected and analyzed for length, breadth and Weight. Moisture contents were 87.4% and 84.45% and oleoresin contents were 1.67% (wb) and 1.56% (wb) in Sidhuwa and Danabari samples respectively under chemical analysis.

Blanching was considered as pre-treatment method and found 2 min as optimizing time. There was no significant effect ($p \leq 0.05$) of blanching in oleoresin contents of dried chillies for Cabinet drier, Solar drier and Sun drying. Drying methods caused the significant different ($p \leq 0.05$) in oleoresin content and *Akabare* chilli has maximum oleoresin content with compared to sun and solar drying methods at 60 °C on wet basis. Extraction time also significantly affected ($p \leq 0.05$) the yield. 12 h of extraction time gave the maximum yield of oleoresin compared with 4h, 8h, 12h and 16h. This dissertation works showed the oleoresin retention of chilies depend on Processing effect.

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List of Abbreviations

Abbreviation	Full form
SHU	Scoville Heat Unit
Temp	Temperature
LSD	Least Significance Difference
CCT	Central Campus of Technology

PART I

Introduction

1.1 General introduction

The chilli pepper plants under the genus *Capsicum.* It is belonged to a dicotyledonous group of flowering plants of family *Solanaceae* (Night shade family). Chillies are termed as aji, paprika, capsicum, etc in different parts of the world. The Genus Capsicum which is commonly known as red chille, chilli pepper, hot red pepper, tabasco, paprika, cayenne, etc. It has pungency behavior for food, gives color in food and uses in different products as ingredients (Hawkes *et al.,* 1979).

It was believed that chilli was originated from the hot pepper species cultivated in the South American country of Chile (De, 1992). It has been a part of the human diet since about 7500 B.C. it was the ancient ancestors of the native people who took the wild chilli piquin and selected the various types growing chilli plants. Chilli was used in their food in Mexico, Andes, Tamaulipas, Tehuacan, etc between 5200 and 3400 B.C. Domestication might have taken place 10,000-12000 years ago(Heiser, 1976). The American origin of *Capsicum* was first reported in 1494 by Chanca, a physician who accompanied Columbus on his second voyage to the West Indies. Chillies may have been used by the indigenous people as a medicine, a practice common among the Mayans. By the time the Spanish arrived in Mexico, Aztec plant breeders had already developed dozens of varieties. These were taken to Asian countries by Portuguese. By the middle of the seventeenth century, the Capsicum was cultivated throughout southern and middle Europe as a spice and medicinal drug. One species was introduced to Japan and about five species were introduced into India, of which *Capsicum annuum* and *Capsicum frutescens* were cultivated on a large scale (Anonymous, 1992).

Dalle khursani or *akabare khursani* are the common name of chilli in Nepal. These chillies are mostly grown in the eastern part of country especially in Dhankuta, Illam, Panchthar, Terathum, etc. Locally available chillies are green in raw and dark red in ripen stage. It has ball like structure and very hot. There is high market price of chillies. It is sold around the different parts of country, even to eastern side of India in different forms. It is highly perishable and uses for its pungency and flavor (khanal, 2009).

Fresh *akabare* chillies can be preserved in different way. Salt concentration in vinegar is the one of the preservative method which may be used by consumers. Mold and other spoilages can be easily checked out by this process at 4% salt in vinegar (Bhattarai, 2011). Chilles are used in traditional items in locality especially in *dhule achar, khalpi,* etc. It is the major ingredient of traditional achar. There are number of spicy traditional food products that are made in our country (Adhikari, 2012).

1.2 Statement of the Problem and justification

Chilies are mostly grown in the world as warm-season crop. They are found in wide variety including cultivated and wild type. The wide variety of use includes flavoring in food manufacturing, coloring in cosmetics and imparting heat to medicines. It has high rich in antioxidant vitamins C, E and A (Bosland and Votava, 2000).

Oleoresin is a viscous liquid derived by polar solvent extraction from ground powder of any Capsicum species. It is also called as concentrated liquid form of the spice. It has the aroma of the spice and possess the attribute to taste such as pungency. It is one of the high valued spice of Nepal. Chilli is perishable and grown in between Bhadra to Kartik. Generally, *Capsicum chinnese* is cultivated in the eastern side of Nepal (Bokhim, 2007). Chilli is important spice for Health status of Human. Cancers, Ulcers, Diabetic Neuropathy, Elevated Cholesterol, etc are highly controlled by the use of Chillies (Pawar *et al.*, 2011). The main content of the chili is oleoresin which plays the vital role for its importance. So, chilies are mainly dried for the further use (Adebiyi, 2008).

Drying methods can play the important role in oleoresin content. Blanched chillies are acted as the determining factor for the loss of the oleoresin content. Especially sun and solar drying methods are used in our locality which may loss the valuable components as flavor, taste, etc. Industrially, Mechanical Drying is the suitable method for the drying of chillies in high amount for manufacture of products.

1.3 Objectives

1.3.1 General objectives

The general objective of the work was to study Processing Effect on Oleoresin Retention of *Akabare* Chilli *(Capsicum chinense).*

1.3.2 Specific objectives

The Specific objectives are:-

a. To determine the physical parameters and chemical constituents of fresh *akabare* chilli.

b. To optimize the blanching time and study the effect of blanching in oleoresin retention.

c. To study the effect of drying methods in oleoresin of *Akabare* chilli.

d. To study the effect of extraction time on retention of oleoresin.

1.4 Significance of the study

Chillies have been consumed and used in different food products all over the world. Demand of it is increasing every year. The chillies are simply used as vegetable items in our local locality. Generally, chillies are mostly preferred in food stuffs and use in preparation of the pickles. Nowadays, it is produced in huge amount because it has large market. Taste and flavor and medicinal properties of Pungency of chillies are very important for human health. Sun drying is carried out commonly among people. It directly losses the oleoresin of chillies. Chilli is known for its pungency component. Sale of chillies is suitable way to get good income source of farmers. So, farmers can run the small scale agro based industry which may provide employments to many workers. *Akabare* chillies can be dried for oleoresin extraction. Small scale oleoresin extraction process gives the attractive of job. Such activities increase the income of local people.

This dissertation will give proper knowledge behind processing effect on oleoresin retention of *Akabare* chilli. Hence, it will help in contribution of socio-economic development of country.

1.5 Limitation of the study

a. *Akabare* chilli is mostly found in the eastern side of Nepal. So, it is hard to collect from all growing area. Only from the two places, samples were collected.

b. Only bright red *akabare* were used in the laboratory work.

PART II

Literature review

2.1 Chilli

2.1.1 Historical background

The chilli pepper is thought to have originated in the Andean region of Bolivia, Peru, and Ecuador almost 10,000 years ago. Since 7000 BC, chilli peppers have been part of the diets of Mayans and Aztecs in Central Mexico and the Yucatan. They were widely cultivated when the Spanish first landed in the Americas. Known to the natives of the tropical Americas for millennia, Capsicum, or Cayenne Pepper, was introduced to Europe by Christopher Columbus and became known as Guinea Pepper. They were taken to India by the Portuguese and to Southeast Asia by the Arabs, Indians, and Portuguese. Chillies dominate the flavors of many cultures- south Indians, Sri Lankans, Southeast Asians, Latin Americans, and the Caribbean islanders. The sophisticated use of different chillies that began with the ancient Mayans and Aztecs continues around the world today (Raghavan, 2007).

The exact origin of the word Capsicum remains somewhat of a mystery. However, it is assumed to be a derivative of the Greek word kapto, means to bite and an appropriate reference to its fiery pods. Capsicum is the fruit of a shrub-like tropical plant and is technically considered a berry. Its designation as a ‘pepper’ can be traced back to Columbus, who equated its hot taste sensation with that of black pepper (Anonymous, 1996). Capsicum annum L. produces a single flower and thus a single fruit per branching node. But, Capsicum chinense yields two or more flowers per node.

2.1.2 Genus *Capsicum*

The genus Capsicum belongs to the family Solanaceae. The scientific classification of chilli is given as

Kingdom: Plantae

(unranked): Angiosperms

(unranked): Eudicots

(unranked): Asterids

Order: Solanales

Family: Solanaceae

Genus: *Capsicum*

Within the genus Capsicum, five species are commonly recognized. They are *Capsicum annuum, Capsicum baccatum, Capsicum chinense, Capsicum frutescens and Capsicum pubescens.* 20 wild species have been documented. The classification system for this genus is somewhat confusing in the literature. In Spain, the Castilian word pimiento refers to any Capsicum species, but in the USA, pimiento or pimento refers only to thick-walled, heart-shaped, non-pungent fruits from the species *Capsicum annuum*. The Hungarians call all *Capsicum annuum* fruits paprika, but paprika is defined in the world market as a ground, red powder derived from dried fruits with the desirable color and flavor qualities. The word chilli is the common name for any Capsicum species in Mexico, Central America and the Southwestern USA. In Asia, the spelling chilli is more common and is always associated with highly pungent varieties of *Capsicum annuum* and *Capsicum frutescens* while the non-pungent sweet bell peppers are referred to as *Capsicum*. Pungent fruits of all cultivated *Capsicum* species as a collective class are called chillies in the Food and Agriculture Organization (FAO) Yearbook. Chillies are grown primarily in East Africa, but they are merely small-fruited, highly pungent forms of *Capsicum annuum* or *Capsicum frutescens* (Berke and Shieh, 2001).

Pepper has generic term describing the fruits of any Capsicum species, both pungent and non-pungent. Chilli is the any pungent variety of any Capsicum species, but primarily *Capsicum chinense*. Chillies variety may be used to produce red pepper oleoresin or Capsicum oleoresin. Paprika is a ground, bright red, usually non-pungent powder used primarily for its color and flavor in processed foods; all paprika varieties are *Capsicum annuum*. Paprika fruits are used to produce paprika oleoresin. Oleoresin is a viscous liquid derived by polar solvent extraction from ground powder of any Capsicum species; there are three types of oleoresin: paprika which is used for color, red pepper which is used for color and pungency, and Capsicum which is used for pungency.

2.1.3 General composition

Chilli contains many chemicals, including water, fatty oils, steam-volatile oil, carotenoids, capsaicinoids, resin, protein, fibre and mineral elements. Many of these chemicals have importance for nutritional value, taste, colour and aroma. The two most important groups of chemicals found in chilli are the carotenoids and capsaicinoids (Bosland and Votava, 2000).

Water is the main constituent in peppers. In chilli, the amount of water is dependent on the age and type of pod harvested. Spice varieties allowed to dry on the plant may contain 70% water. Chilli fruits contain sugar, pentosans and raw fibre. Glucose accounts for 90– 98% of the sugar content of red mature paprika pod. The amount of sugar in a pod varies by cultivar, agroclimatic conditions and type. Total and reducing sugars are at maximum levels in red succulent fruits (Zachariah and Gobinath, 2008).

When the microelements were investigated it was found that iron presence is the largest concentration, followed by bromide and manganese. Other microelements found were cadmium, calcium, cobalt, copper, magnesium, phosphorus, potassium, sodium and zinc. Fruits of the Capsicum species have a relatively low volatile oil mostly in paprika. The characteristic aroma and flavour of fresh fruit is imparted by the volatile oil (Pruthi, 2003).

Lysine, arginine, proline, tyrosine, tryptophan, methionine, valine, phenylalanine, leucine, lutamic acid, glycine, asparagines, threonine and alanine are found in chilli. Asparagine, glutamine, glutamic acid and tryptophan account for 95% of the free amino acids. A small amount of aspartic acid was detected. The total amount of ascorbic acid in fruits was 121 mg/100g fresh weight. Analysis of chemical constituents in fruits of red pepper (cv. Bugang) revealed five natural capsaicinoids. They were capsaicin, nordihydrocapsaicin, dihydrocapsaicin, vanillyl decanamide and homodihydrocapsaicin. The concentration of total capsaicinoids in fruits was 5.4 mg/100 g FW. Eleven carotenoids were identified, with a total concentration of 65 mg/100 g FW. The concentration of free amino acids in fruits was 0.9 g/100 g (Kim *et al.*, 1997).

Cellulose and other fibrous material may account for up to 20% of the dry weight of pericarp tissue. The skins contain 77% soluble fibre and 80% total dietary fibre. This amount of fibre is greater than in either rice or oats (Adeyeyei and Otokiti, 1999).

2.1.4 Pungency and capsaicinoids

Pungency is produced by the capsaicinoids, a group of alkaloid compounds that are found only in the plant genus, Capsicum. The nature of the pungency has been established as a mixture of seven homologous branched-chain alkyl vanillylamides. They are often called capsaicin after the most prevalent compound. Dihydrocapsaicin is usually the second most prevalent capsaicinoid, while the other five compounds, norcapsaicin, nordihydrocapsaicin, nornordihydrocapsaicin, homocapsaicin and homodihydrocapsaicin, are considered minor capsaicinoids because of their relatively low abundance in most natural products. Capsaicin is a powerful and stable alkaloid that can be detected by human taste buds in solutions of ten parts per million. Capsaicin‟s composition ($C_{18}H_{27}NO_3$) is similar to piperine ($C_{17}H_{19}NO_3$), which gives black pepper its bite (Zachariah and Gobinath, 2008).

Dihydrocapsaicin accounts for about 22% of the total capsaicinoids mixture and has about the same pungency as capsaicin. Capsaicinoids are ingested mainly as naturally occurring, pungency-producing components of the Capsicum species (chilli, cayenne pepper, red pepper). They range typically from 0.1 mg/g in chilli pepper to 2.5 mg/g in red pepper and 60 mg/g in oleoresin red pepper. Pepper varieties from C. frutescens, C. annuum and C. chinense were found to contain 0.22–20.00 mg total capsaicinoids/gram. Cayenne pepper samples had mean capsaicin and dihydrocapsaicin contents of 1.32 and 0.83 mg/gram, respectively (Zachariah and Gobinath, 2008).

Capsaicinoids are controlled by a range of factors like genetics, position of fruit and interaction of the plant and environment Heat is perceived to be due to the interaction of the capsaicinoids with the nerve cells of the skin and mucous membranes, which triggers responses similar to the ones caused by thermal heat. For trade, it is important to measure heat levels adequately. This allows standardization of products. However, responses are very subjective, due to tasters getting used to capsaicinoids over time, showing reduced responses to similar heat stimuli. The commercial method of determining heat levels in chillies is to measure pungency as Scoville heat units (SHU) (Zachariah and Gobinath, 2008).

2.1.5 Color and pigments

The color of chilli spice powder is due to the presence of red-pigmented carotenoids. The main pigments are capsanthin, capsorubin, zeaxanthin and cryptoxanthin. Carotenoids are very stable in intact plant tissue. However, when chillies are processed by drying and then grinding into spice powder, the carotenoids auto-oxidize easily, due to the effects of heat, light and oxygen. This leads to a more orange and less intense coloration that devalues the spice powder. In addition, carotenoids have provitamin A activity (Daood *et al.*, 2006).

Carotenoids control pod color, with approximately 20 carotenoids contributing to the color of the powder. Carotenoid compounds are yellow-to-red pigments of aliphatic or alicyclic structures composed of isoprene units, which are normally fat-soluble colours. The keto-carotenoids, capsanthin, capsorubin and cryptocapsin are unique Capsicum carotenoids. The major red color in chilli comes from the carotenoids capsanthin and capsorubin, while the yellow-orange color is from β-carotene and violaxanthin. Capsanthin, the major carotenoid in ripe fruits, contributes up to 60% of the total carotenoids. Capsanthin and capsorubin increase proportionally with advanced stages of ripeness, with capsanthin being the more stable of the two. The amount of carotenoids in fruit tissue depends on factors such as cultivar, maturity stage and growing conditions (Reeves, 1987).

The changes in carotenoid pigment composition of Capsicum cv. Bovet 4 fruits (grown in Hungary) during ripening. In the chromatograms, 56 peaks were detected and 34 carotenoids were identified. In ripe fruits, capsanthin, capsorubin, zeaxanthin, cucurbitaxanthin A and β-carotene were the main carotenoids, the remainder being capsanthin 5,6-epoxide, capsanthin 3,6-epoxide, karpoxanthin, cucurbitaxanthin B, violaxanthin, cycloviolaxanthin, antheraxanthin, capsanthone, nigroxanthin, β-cryptoxanthin and several cis isomers and furanoid oxides (Zachariah and Gobinath, 2008).

2.1.6 Clinical application of chilli

Capsicum is a remarkable whole body stimulant that can boost blood flow, tone the nervous system, relieve indigestion, promote sweating, help to cauterize and heal ulcers, ease persistent pain and fight off infection. One very authoritative work on African plants suggests that Capsicum‟s “regular ingestion is highly beneficial in hemorrhoids, varicose veins, anorexia, liver congestion and vascular conditions. So the indigenous inhabitants of

Africa and of the Antilles are remarkably free form all of these conditions as they use Capsicum fruit in their diet." (Lenden *et al.*, 1984) This may be possibly found in case of Nepalese too, whose diet consists of appreciable amount of capsicum. Most of the therapeutic actions of Capsicum are attributed to the alkaloid or glucoside content of the herb (Jurenitsch, 1991).

2.1.7 Market products

Many different varieties of the genus Capsicum are widely grown for their fruits, which may be eaten fresh, cooked, as a dried powder, in a sauce, or processed into oleoresin (Poulos, 1993) There are three major products traded on the world market for use in food processing: paprika, oleoresin, and dried chilli (both whole and in powdered form). Some fresh fruits and some fermented mash are used for food processing, but these are relatively minor amounts and by necessity they are produced close to the processing facility (Berke and Shieh, 2001) Peppers are used as a colorant, flavoring, and/or as a source of pungency, depending on the processed product. Peppers can be used fresh, dried, fermented, or as an oleoresin extract. They can be used whole, chopped, coarsely ground, or finely ground, with or without seeds. Various types of processed products containing primarily peppers include pickled fruits, chilli sauce, chilli powder (also known as cayenne powder), crushed red pepper flakes (with or without seeds), fermented mash, paprika, and three types of oleoresin. Other processed products that contain a significant proportion of peppers include fresh and processed salsas, curry powders, barbecue seasonings, chilli powder (a 13 mixture of chilli powder, oregano, cumin, and garlic powder), and many other foods (Govindarajan, 1986).

2.1.8 Main uses in food processing

There are many uses of peppers in food processing, including as a food colorant, as a source of pungency in food, as a source of flavor, as a source of pain relief for pharmaceutical use, and as a repellent. In many cases two or more of these properties are included in the same product; for example, paprika may be a source of color, pungency, and flavor (Govindarajan, 1986).

2.1.8.1 Color

People whose diets are largely colorless starches, such as rice or maize, use peppers to add color to their bland, achromatic diets. Paprika, paprika oleoresin, red pepper oleoresin, and dried chilli may all serve as a source of red color in various processed products, but the primary sources of red color are paprika and paprika oleoresin. Paprika is used in many products where no pungency is desired, but the color, flavor, and texture of a finely ground powder is desired. These include processed lunchmeats, sausages, cheeses and other dairy products, soups, sauces, and snacks such as potato chips. Paprika oleoresin is used as a color and flavor additive in many products where the texture is important and small particles of paprika powder would be undesirable (Govindarajan, 1986).

2.1.8.2 Pungency

Red pepper oleoresin is used as a source of both color and pungency in canned meats, sausages, smoked pork, sandwich spreads, soups, and in dispersed form in some drinks such as ginger ale. Capsicum oleoresin is used as a source of pungency in many products, especially chilli sauces with extremely high SHU ratings. Oleoresin has considerable advantages over dried chilli including more stable color retention, easier to handle compared to the rather bulky dried chilli, and the ability to mix and dilute oleoresin with other substances to produce a range of color and/or pungency values. Dried chilli is also used as a source of both color and pungency, particularly in the production of crushed red peppers, chilli powder and chilli sauces (Berke and Shieh, 2001).

2.1.9.3 Flavor

Paprika is valued for its flavor in many products in addition to its color. Dried chilli is also valued for its contribution to flavor in chilli sauces and chilli powders. The flavoring principle is associated with volatile aromatic compounds and color. As a general rule, when the color of paprika or chilli powder fades, the flavor also disappears (Berke and Shieh, 2001).

2.1.9 Functional properties and toxicity of chilli

Peppers are well-known for their health benefits. Herbalists have long promoted peppers for their health-enhancing effects. These include clearing the lungs and sinuses, protecting

the stomach by increasing the flow of digestive juices, triggering the brain to release endorphins (natural painkillers), making your mouth water, which helps to neutralize cavity-causing acids, and helping protect the body against cancer through antioxidant activity (Andrews, 1995).

2.1.9.1 Toxicity

The acute toxicity of capsaicin has been measured in several animal species. In mice, the LD50 values for capsanthin depended on the mode of administration, ranging from 0.56 (intravenous) to 512 (dermal) mg/kg body weight. Death was due to respiratory paralysis. To reach the LD50 value for human oral administration, the average person would have to drink 1.5 quarts of Tabasco sauce. The painfulness of capsanthin is a self limiting factor in their role as a human food ingredient; you can only eat so much at one time. No death has ever been recorded due to capsanthin-induced respiratory failure, and the investigators concluded that the acute toxicity of capsanthin as a food additive in man was negligible The effect of sub-chronic toxic doses has been examined in rats. Adult rats exhibited no noticeable behavioral or physiological changes when given sub-chronic doses of crude chilli extract by stomach tube for 60 days. Food consumption was significantly higher but body weight was lower than the control group after 60 days (Glinsukon *et al.*, 1980).

2.2 *Akabare* chilli

The *akabare* chilli (*Capsicum chinense*) is one of the most intensely spicy species of chilli peppers of the *Capsicum* genus. It is one of the very hot and high valued chilli and is highly perishable and available only for short period during the month of Bhadra to Kartik especially in the Eastern part of the Nepal. Chilli fruits show climacteric behavior as long as they are attached to the plant, but when detached, it is non-climacteric. Unripened habaneros are green, and they get colored as they mature. Common colors are orange and red, but white, brown, and pink are also seen. Typically a ripe habanero is 2–6 cm long . Green or deep green harvested fruit fails to fully color red, while fruit that are harvested at or after the color break stage visually complete their red color development within 7-9 days. The fruits are sensitive to Ethylene and to chilling injury when stored below 10 ºC (Bokhim, 2007).

2.2.1 Classification

The scientific classification of Habanero chilli (*akabare*) is given as follows.

Kingdom: Plantae

(unranked): Angiosperms

Order: Solanales

Family: Solanaceae

Genus: *Capsicum*

Species: *chinense*

Binomial name: *Capsicum chinense* Jacq. (Manju and Sreelathakumary, 2002)

2.2.2 Production

Ilam is leading in the production of akabare with existing area being involved is 145 ha land with the production of 550 metric ton every year. The area of production is being expanded every year to other eastern district of Nepal, such as Taplejung, Panchthar, Tehrathum, Bhojpur and Dhankuta district. In recent years akabare is cultivated as commercial farming in these hilly areas. *Akabare* chilli is an important Highly Value Crops (HVC) for cash generation in eastern hilly region of Nepal. Nepal government has launched 20 years Agriculture Perspective Plan (APP) from 1995 to assist the nation by increasing the research and development (R&D) work in agriculture sector. According to APP, the annual growth rate of HVC crops is assumed to accelerate from 4.8% during the year of 1995 to 5.8% during the end period (2014), with corresponding increase in agriculture GDP from 13% to 15%. The success in the promotion if these crops in hills are dependent on the basic infrastructure and appropriate post harvest technology applied (Bhurtel *et al.*, 1996).

2.2.3 Consumption and preservation pattern

The pickle may be either fermented or unfermented. The unfermented pickle is made in the household level as well as in small scale commercially. But majorly unfermented pickle found commercially comprises of preserving chillies in very high concentration of salt i.e.,

15-20%. This results in unwanted features in the product such as excessive shrinkage, and not much appreciated by the consumer because of its high salt content (Bokhim, 2007) The dried akabare are made by drying the fresh chilli pods in sun for few days to weeks. No any mechanical drying method is followed for drying, thus the product resulted from sun drying has not so appreciable properties. The paste form of the chillies is limited to some small scale pickle producing cottage industries (Khadka, 2010).

2.3 Blanching

Heat treatment of food for a short period prior to canning, freezing and dehydration followed by cooling is called blanching. It is a pre-treatment between preparation and subsequent processing. It is generally applied to fruits and vegetables, and primarily carried out to inactivate enzymes. Unblanched frozen, dried or preserved foods undergo relatively rapid changes during storage, such as in color, flavor, texture and nutritive value due to continous enzymatic activity. Indeed, the milder heat treatment that accomplishes the desired heat objectives usually yields the best product. enzymes such as lipoxygenase, polyphenoloxidase, polygalacturanase and chlorophyllase, cause loss of nutrition, flavor and texture. In addition, peroxidase and catalase are the two most heat resistant and widely distributed enzymes. Although they are not implicated as a cause of deterioration during storage, their activity is used to evaluate the efficiency of blanching. If both of these enzymes are inactivated, then it can be safely assumed that other significant enzymes are also inactivated. Peroxidase is the most heat resistant of the two and the absence of residual peroxidase activity indicates that other less heat resistant enzymes are also destroyed (Kharel, 2004).

2.3.1 Effect on foods by blanching

The heat received by the food during blanching inevitably causes some changes to sensory and nutritional qualities. In, general, the time-temperature combination used for blanching is a compromise which ensures adequate inactivation but prevents excessive softening and loss of flavor in the foods(Fellows, 2000).

2.3.1.1 Flavor

In fruits and vegetables the change in flavor is due to complex reactions that involve the degradation, recombination and volatilization of aldehydes, ketones, sugars, lactones, 19 amino acids, and organic acids. Major changes however occur in the volatile flavor components, being lost while heat treated being the most detrimental one (Fellows, 2000).

2.3.1.2 Color

Blanching brightens the color of some foods by removing air and dust on the surface and thus altering the wave length of reflected light. It enhances the retention of colors of vegetables like peas, broccoli, spinach, etc. It also decreases the moisture variation of the products (Fellows, 2000).

2.3.1.3 Texture

Two types of tissue damage occur during the heating of plant material. They are destruction or damage to the semi permeable cell membrane, and disruption of the intercellular structures with resultant cell separation. The effect of these type of tissue damage are a loss in cell turgor and cellular adhesion, which gives rise to loss in crispness and softening of the heat processed product. In fruits and vegetables, softening is caused by hydrolysis of pectic materials, gelatinization of starches, and partial solubilization of hemicelluloses, combined with a loss of cell turgor (Fellows, 2000).

2.3.1.4 Nutrients

Some minerals, water soluble vitamins and other water soluble components are lost during blanching. Losses of vitamins are mostly due to leaching, thermal destruction and to lesser extent oxidation (Fellows, 2000).

2.3.2 Methods of blanching

It is a mild heat treatment but not a method of preservation. During blanching raw food material is immersed in hot water or exposed to live steam. Water temperature must be well controlled at desired level. The blanching operation varies according to the maturity and type of vegetables used. In practice, immersion blanching and steam blanching are two

general methods of blanching. Less frequently, microwave blanching can be used (Kharel, 2004).

2.3.2.1 Immersion blanching

It involves passing the food at a controlled rate through a perforated drum rotating in a tank of water which is thermostatically controlled to the blanching temperature (70- 100°C). In a small plant, food to be blanched is passed on the wire of a perforated basket, which is first dipped in hot water for a short period of time (2-5 min) and then in cold water. Hard water toughens tissues and destroys the natural texture of foods. A disadvantage of immersion blanching is that water soluble nutrient will pass into the blanching water, but an important advantage is that undesirable oxidation can be easily controlled by appropriate additions to the blanching bath (Kharel, 2004).

2.3.2.2 Steam blanching

It uses saturated steam at atmospheric or at low pressure ($150KN/m^2$). The food is conveyed through the steam chamber on a mesh belt or by the means of helical screw, the residence time being controlled by the conveyer speed. Typical equipment is 15 m long, 1 to 1.5 m wide and up to 2 m high. In conventional blanching there is often poor uniformity of heating in the multiple layers of food. The time temperature combination required, ensuring enzyme inactivation at the center of the bed results in the overheating of food at the edges and this results in losses in texture. In the first stage, food is heated in a single layer at a required temperature, and in the second stage, a deep bed of food is held for sufficient time to allow complete enzymes inactivation. This reduces the steaming time from a conventional 3 minutes to about 75 seconds (25 seconds for heating and 50 seconds for holding). The blanched product is discharged through an outlet into a cooler (Kharel, 2004).

2.3.2.3 Microwave blanching

This is applied to fruits and vegetables packaged in film bags and would appear to offer some advantage such as microbiological cleanliness and low losses of nutrients. Blanching with microwave energy in order to apply heat at the center of large items before the surface

are overcooked, is receiving interest in application but is not used commercially on a large scale due to its high cost (Kharel, 2004).

2.4 Methods of drying of *akabare* chilli

Mainly three types of drying methods are used. They are follow:

2.4.1 Sun drying

It is process of drying the food and food products in direct exposure of sunlight. Sun drying of fruits and vegetables is still practised largely unchanged from ancient times. Traditional sun drying takes place by storing the product under direct sunlight. It is only possible in aresas where in an average year, the weather allows foods to be dried immediately after harvest. The main advantages of sun drying are low capital and operating costs and the fact that little expertise is required. The main disadvantages of this method are as follows: contaminzation, theft or damage by birds, rats or insects; slow or intermittent dr5ying and no protection from rain or dew that wets the product, encoruages mould growth and may result in a relatively high final moisture content; low and vairable quality of products due to over or under drying (Fellows, 2000).

2.4.2 Solar drying

Solar drying method is suitable method as it works better than sun drier. It gives faster drying rates by heating the air to 10-35 ºC above ambient, which causes the air to maove faster through the dryer, reduces its humidity and deter insects. The faster drying reduces the risk of apoilage, improves quality of the product and gives a higher throughput, so reducing the drying area that is needed. However care is needed when drying fruits to prevent too rapid drying, which will prevent complete drying and would result in case hardening and subsequent mould growth. Solar driers also protect foods form dust, insects, birds and animals. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs (Weiss and Buchinger).

2.4.3 Cabinet drying

Cabinet drier consists of an insulated cabinet fitted with shallow mesh or perforated trays, each of which carries a thin layer of food. Hot air is circulated through the cabinet tray. A

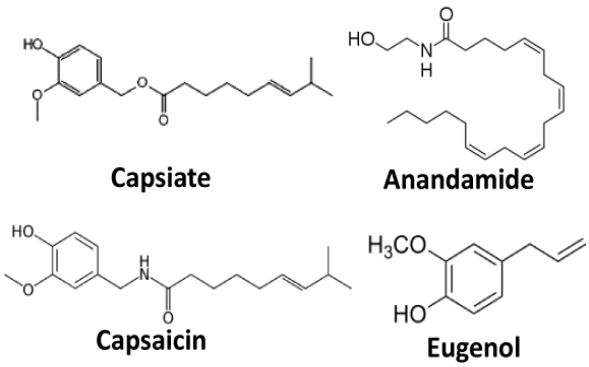
system of duct and baffles is used to direct air, over or through each tray, to promote uniform air distribution. Cabinet drying are usually used for small scale operations comparatively inexpensive, low maintenance cost, commonly used to dry fruit and vegetable pieces (Fellows, 2000).

2.5 Oleoresin

The total flavor extracts prepared by solvent extraction of the ground spices are known as Oleoresins. It is a viscous liquid derived by polar solvent extraction from ground powder of any Capsicum species. It is also called as concentrated liquid form of the spice. It has the aroma of the spice and posses the attribute to taste such as pungency. It is naturally occuring flavoring and colouring substances. It is found in ground fruit pods, with or without the seeds (Mini *et al.,* 1998). Capsaicin is the major flavoring component and Capsanthin and capsorubin are the coloring agents in chillies. It reproduces the character of the respective capsicum. It is complete and balanched, consistent and standardised components (Madhumathy *et al.*, 2007).

Capsicum oleoresins contain a complex mixture of essential oils, waxes, coloured materials (mainly capsanthin, capsorubin, zeaxanthin, cryptoxanthin and lutein), and several capsaicinoids. It also consists pharmaceutical ingredients (Hui Yiu and Barta, 2006) .

It mainly uses for the treatment of diabetic neuropathy, osteoarthritis, post-herpetic neuralgia and psoriasis (Jin *et al.*, 2009), as well as there are many patents on insecticides, insect or animal repellents, and pesticides containing capsaicinoids (Eich, 2008). The permissible limit of solvents in the oleoresins are very low i.e, 30-60 ppm. It is used frequently as added suitable food grade diluents, preservatives and antioxidants. It is consumed by broad spectrum of manufacture of beverages, soup powders, curry powders, confectionaries, noodles, canned meats, sauces, poultry products and so on.



(Thiele *et al.*, 2008)

Figure. 2.1 Different forms of capsaicinoid.

Oleoresins are extraced by solvent extraction process, Supercritical fluid extraction process or steam distillation process.It is difficult to use directly because they are too concentrated and difficult to disperse. Hot spots may result in the product due to the incomplete dispersion. There are around six different solvents used for oleoresin extraction: acetone, ethyl alcohol, dichoroethane, hexane, benzene and ethyl acetate. Ehyl acetate produces the maximum efficiency for capsaicin extraction. Solvent should be chemically pure and free from any high boiling residues which impart unpleasant odors to the oleoresins. The solvent should have low boiling point range. Extracted oleoresin is a viscous, dark red liquid (Jaren-Galan *et al.*, 1999).

2.5.1 Types of extraction process of oleoresin

a. Solvent extraction process: Oleoresins are obtained from spices by extraction with a non-aqueous solvent followed by removal of the solvent by evaporation. To start with various raw spices are cleaned and then ground to the required mesh size. Then extraction is undertaken with the help of proper solvent. Solvents that can be used are hexane, acetone, ethylene dichloride, or alcohol. Extraction is done by percolation of the solvents at room temperature through a bed of ground spice packed in a SS percolator. Then the dark viscous extract containing not less than 10% of total soluble solids are drawn off and distilled under reduced pressure to remove the excess of solvent.

b. Supercritical fluid extraction process: A supercritical fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do

not exist. The advantages of supercritical fluid extraction (compared with liquid extraction) are that it is relatively rapid because of the low viscosities and high diffusivities associated with supercritical fluids. The extraction can be selective to some extent by controlling the density of the medium and the extracted material is easily recovered by simply depressurizing, allowing the supercritical fluid to return to gas phase and evaporate leaving no or little solvent residues. Carbon dioxide is the most common supercritical solvent.

c. Steam distillation process: Different processing methods are required to extract essential oils from different plants. Most oils are extracted using steam distillation, during which the plant material is permeated with steam. As the plant tissues break down, the essential oils and water vapor are released, then collected and cooled. The volatile essential oil condenses, separates and is easily isolated. In this process the steam is prepared in a separate chamber and piped into the tank. This is more expensive than the other methods. This is especially good for plant materials with high boiling point oils. In this method the temperature and pressure can be increased for certain oils. The rate of distillation and yield of oil are high.

2.5.2 Factors affecting the quality and quantity of oleoresin extraction.

a. Solvent: Solvent plays important role in the extraction of oleoresin content. It contains the volatile essential oils, non-volatile pungent principles, colors, fats and other substances extractable from the spice by solvents. Since, it is hard to disperse, appropriate amount of solvent must be taken for extraction. Generally, low boiling point containing solvents are used. Alcohol, acetone, hexane, etc are used. The main purpose of solvent is to dissolve all the oleoresin and extract it in more amounts. It percolates down all pungent principles, resins, colors and fatty oils during process. Very low boiling point containing solvent should not be used because it causes the excessive loss of solvent.

Generally, Petroleum ether, Acetone, Hexane, etc are used for extraction of Oleoresin. Some of the properties of extraction solvents were given in table 2.1.

Table. 2.1 Different types of Solvent

Name of Solvent	Ether	Hexane	Acetone
Molecular weight	86.18	86.18	58.08
Boiling point, °C	60-80	68.7	56.29
Freezing point, °C	-95	-95.3	-94.7
Refractive index	1.42	1.37	1.35
Vapor pressure, Torr	256	124	184.5
Viscosity, cP at 20 °C	0.77	0.31	0.36

b. Temperature during drying: Very high and very low heat should not be given chillies during drying method. Since, high volatile components of oleoresin may be evaporated by high temperature. Low temperature may not destroy all the cells properly so that it may not give more amount of oleoresin during extraction.

c. Time of drying: More drying time may manage to destroy cells of pod of chillies very well. It helps to carry out the pungency principles, fats and colors easily.

d. Maturity of Fruit: Mainly the oleoresin contents are allocated in pods of chillies. There is less number of pods in immature chillies. Immature chillies have immature cells where pungency principles are found in fewer amounts. So, fully ripened and red matured chillies should be taken in order to get high amount of oleoresin content during solvent extraction.

e. Pre-treatment before drying: It plays important role in the extraction of oleoresin. The main objective of it is to set the pigment, remove the gases and inactivate the enzymes. It also removes pesticides residues and radio-nuclei from surface of chillies and also toxic components. So, pure amount of oleoresin content is extracted.

f. Particles size of materials: The size of particles of materials are mainly based as coarse, medium and fine one. There is difficulty in extraction of coarse and medium sized materials. So, high chance of oleoresin extraction can be done in fine size of material.

PART III

Materials and methods

3.1 Materials

3.1.1 *Akabare* chilli

Well known *Akabare* chillies of Sidhuwa and Danabari of Dhankuta district were brought for the Dissertation. The *akabare* used for the experiment were of the same variety, same maturity as informed by farmers and visually indicated by bright red color. The fresh bright red colored *akabare* were harvested manually by plucking with hands. Care was taken that none of the pods were punctured while plucking. The plucked chillies were brought to laboratory situated in Dharan by loosely packing in black polyethene bags, so that there is no loss in moisture.

3.1.2 Extractive solvent

Petroleum Ether was the solvent that is used during the extraction of *akabare* chilli. It has b.pt. of 60-80 °C. It consists of parrafins with chain length of C_5 to C_9, cyclo-paraffin and aromatic hydrocarbons. It was cared well because of its inflammableness. Limited amount of heat was given through the heating equipment.

3.1.3 Blanching

Heat treatment of food for a short period prior to canning, freezing and dehydration followed by cooling is called blanching. Immersion type of blanching was taken for the blanching of chillies. Tap water was heated up to 98±2°C for it. Both Sidhuwa and Danabari samples were immersed in heated water for different time duration. Time was varied in 0, 1, 2, 3, 4 and 5 min respectively. Then it was cooled in water for some seconds. After that, it was taken for enzyme inactivation method to determine blanching time. Mainly Catalase and Peroxidase test were done for determining the blanching time of chillies.

3.1.4 Drying

cabinet drying, solar drying and sun drying methods were used as drying methods for chilli sample. Cabinet drying was maintained in mechanical drier at constant temperature of 60°C for 6h (till chillies were totally shrinked). It took less time duration for the drying of materials. Solar drying is carried out in glass cupboard for 3 days at (40-45°C). Sun drying is done on the clean and dry surface of floor of Laboratory at (26-27°C) for 5 days. Generally, Drying was done till the chillies were grinded well in form of powder. Both variety of Blanched ripened and ripened chillies were dried with in same temperature and time duration.

3.1.5 Apparatus required

a) Weighing balance
b) Incubator
c) Thermometer
d) Beaker
e) Glass wares
f) Mortar and pestle
g) Gas burner
h) Soxhlet apparatus
i) Muslin Cloth
j) Watch Glass
k) Desiccator
l) Petri plates
m) Knife
n) Chopping board

3.1.6 Chemicals required

a) Petroleum Ether. (b.pt-80 °C)
b) Hydrogen Peroxide (H_2O_2)
c) Alcoho
d) Lysol
e) Water

3.2 Method

3.2.1 Method of drying of chilli

During the laboratory analysis of *akabare* chillies, around 5 kg of *dalle khursani* were brought from Sidhuwa and Danabari of Dhankuta district. It was taken very safely with in Lab. Matured and fully ripened red chillies were considered for the grading and sorting processes.

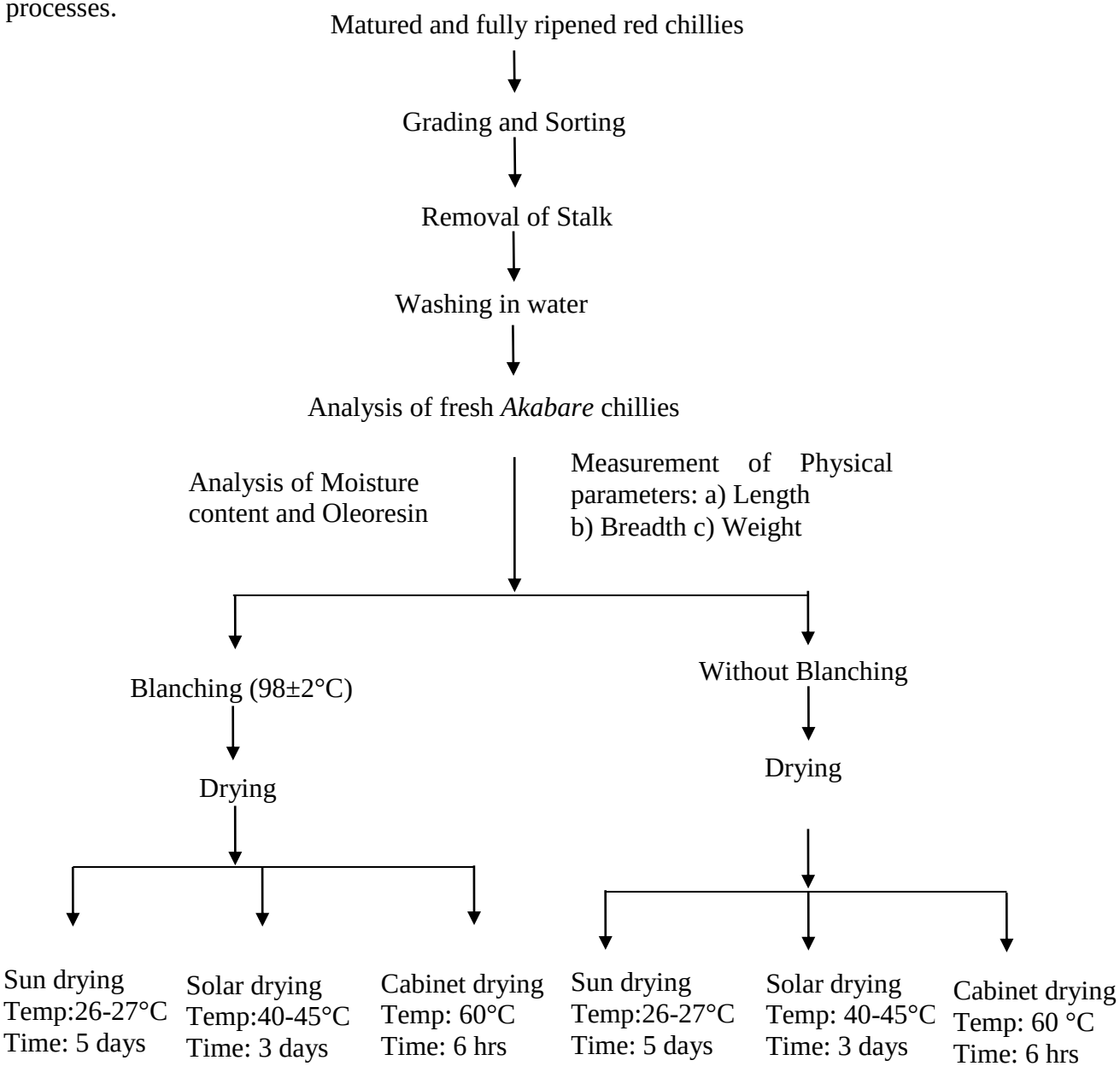


Figure- 3.1 Process flow chart for preparation of dried chilli

The physical parameters like length, breadth and weight were taken at approximately for the analysis. Mainly the similar shape and size of chilli were taken for washing purposes. Clean water was used to remove the dust and dirt of the graded chilli.

Cleaned chilles were measured to calculate the moisture content in hot air oven at 60˚C for 2h. Remaining chillies were carried for both unblanching and blanching process. Unblanched chillies were directly taken to the drying Methods. Three types of drying systems were taken. Cabinet drying, solar drying and sun drying were the methods that used for drying purposes of *akabare* chillies. Cabinet drying was mechanical method used for 60˚C for 6h. Solar drying method was taken at 40-45 °C for 3 days. Sun drying method was taken for 5 days in day time at 26-27 °C. 98±2 ˚C temperature was maintained for the Immersion blanching process. The main purpose of blanching was to inactivate the enzymes activities. Catalase test and Peroxidase test were done to determine the blanching time of cleaned chilli.

3.2.2 Method of oleoresin extraction

Dried chilli were taken in abundant amount. It was grinded in Mortar and Pistal. Only Coarse sizes of dried chilli were considered for extraction process. Around 25 mesh size of dried particles were taken for Soxhlet apparatus for distillation. Petroleum Ether was taken as extractive solvent having b.pt. 60-80°C.

Dried blanched and unblanched chilli were taken and grinded with coarse particles. Distillation was carried for more than 25 cycles. Desolventization was done to get oleoresin. Finally, pure concentrated oleoresin content was found and packed in air tight amber colored bottle.

3.3 Analytical procedures

3.3.1 Analysis of physical parameter

The physical parameters of *akabare* such as, length, breadth and weight per ball were recorded with the help of electronic balance and vernier calipers.

3.3.2 Determination of Moisture content

Moisture content was determined of Ripened chilli of Sidhuwa and Danabari chilli sample. Moisture content was determined by heating in an oven at 100±5 °C (Rangana, 1994).

3.3.3 Determination of the oleoresin

Oleoresin content was determined separately by different drying methods. Both unblanched and blanched dried chilli was determined. Oleoresin content was calculated by using soxhlet apparatus(Rangana, 1994).

3.3.4 Determination of blanching time

Blanching time was determined by Catalase test and Peroxidase test. Cleaned fresh akabare chilli were taken in boiling water by small thread. The blanching time was ranged in between 0 to 3 min. Equal volume of water was taken for grinding in clean mortar and pestle. The grinded content was strained through filter paper in another clean test tube. For catalase test, 5 ml of content was taken and 2 ml of 3% of H_2O_2 along clear enzyme extract for some minutes. The evolution of gas bubbles from the mixture indicates the presence of catalase. For peroxidase test, 5 ml of content was taken and to it 1 ml of 1% guaicol solution (in 60% alcohol) and 1ml 0.5% of H_2O_2 added. The tube was allowed to stand for 15 min. There was the development of brown color which indicates the presence of peroxidase.

3.3.5 Data analysis

The determination of all the readings was conducted in triplicates. The data were analyzed by using Statistical tool (Genstat Discovery Edition 3, 2008) at 5% level of significance. The means were compared using LSD.

PART IV

Results and discussion

Red ripened chilli were used for retention of oleoresin. Half of brought *Akabare* chilli were blanched with catalase and peroxidase test for inactivation of enzyme. Different drying methods were used and extraction was done in soxhlet apparatus. Extraction was done with variable time duration for retention of oleoresin.

4.1 Physical parameters of fresh *akabare*

The average length of Sidhuwa and Danabari *akabare* were found to be 2.8(0.02) cm and 2.7(0.02) cm, breadth as 2.28(0.02) cm and 2.31(0.01) cm, and weight as 3.51(0.02) g and 3.35(0.02) gm respectively. The *akabare* chillies length was found to be 1.4-2.81 cm, width as 1.2-2.35 cm and weight as 1.5-4 g (Bokhim, 2007). But, the length, breadth and weight of chillies are different in different places.

4.2 Moisture and oleoresin content of fresh *akabre*

The moisture and oleoresin content of the fresh *akabre* from Sidhuwa and Danabari samples were determined. The anlytical result is given in Table 4.1

Table 4.1 Moisture and oleoresin content of fresh *akabre* chillies.

Moisture % (Sidhuwa)	87.4(0.97) %
Moisture % (Danabari)	84.45(0.82) %
Oleoresin % (Sidhuwa) (wb)	1.67(0.02)%
Oleoresin % (Danabari) (wb)	1.55(0.01)%

91.3% of moisture content is found in capsicum (K.C. and Rai, 2007). In above moisture contents of both chillies, moisture contents were found low which may due to loos of moisture during handling and delivering activities until the laboratory.

The oleoresin found in chilli of Sidhuwa sample was 13.25% (db) and Danabari was 10.03% (db). 9-14% (db) of oleoresin content was found in *akabare* chillie (Lewis, 1984). So, the result obtained from Sidhuwa was found different with Danabari.

4.3 Optimization of blanching time based on enzyme inactivation

Mainly the blanching treatment is affected by the enzyme activity. The size, shape and heat conductivity are also played role in blanching (Reyes De Corcuera *et al.*). Blanching should be maintained with in appropriate stage so that there may not the damage of vegetables. Blanching is done to check out the catalase and peroxidase enzymes in order to reduce the losses of mineral salts, vitamins, sugars (Kordylas, 1990). The blanching temperature can be set to 85-95°C instead of 100°C (Jones, 1996).

The residual catalase and peroxidase activity after blanching were measured by catalase and peroxidase visual test methods and the result obtained are shown in Table 4.2. and Table 4.3

Table 4.2 Blanching time optimization based on catalase and peroxidase enzyme inactivation of Sidhuwa chilli sample.

	Blanching time (s)				
	30	60	90	120	150
Catalase test for sample at 98±2°C	+	+	+	-	-
Peroxidase test for sample at 98±2°C	+	+	+	-	-

Table 4.3 Blanching time optimization based on catalase and peroxidase enzyme inactivation of Danabari chilli sample.

	Blanching time (s)				
	30	60	90	120	150
Catalase test for sample at 98±2°C	+	+	+	-	-
Peroxidase test for sample at 98±2°C	+	+	+	-	-

4.4 Effect of blanching on oleoresin retention.

Blanching is the mild treatment of heat done for cetain interval of time to inactivate the enzymmes. 2 min was considered as the blanching time got by optimization of enzyme inactivation method. Both unblanched and blanched chillies were grinded and used for the extraction of oleoresin content. The result of oleoresin content with the effect of blanching were shown in fig. 4.1

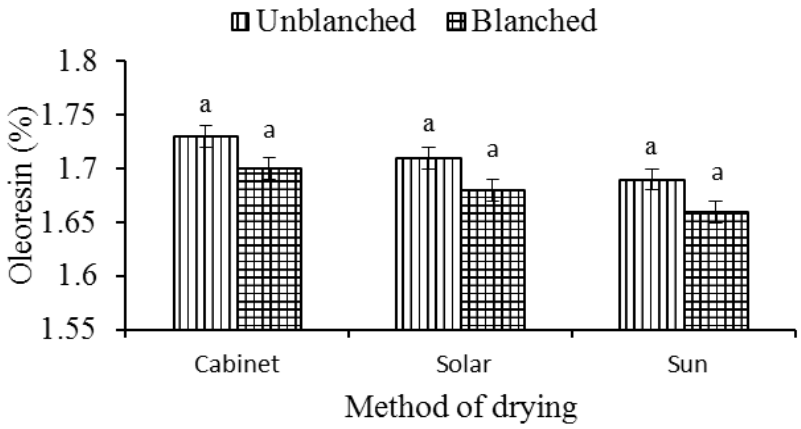


Fig. 4.1 Effect of blanching on oleoresin of Sidhuwa chilli sample.

The mean value of unblanched sample of Sidhuwa were found to be 1.73%, 1.71% and 1.69% in cabinet, solar and sun drying methods respectively. The mean value of blanched sample of Sidhuwa were found to be 1.7%, 1.68% and 1.66% in cabinet, solar and sun drying methods. According to statistical analysis, oleoresin content of unblanched chillies of Sidhuwa samples were not significantly different with each other at 5% level of significance with blanched chillies at same drying method. The result of oleoresin content with the effect of blanching were shown in fig. 4.2

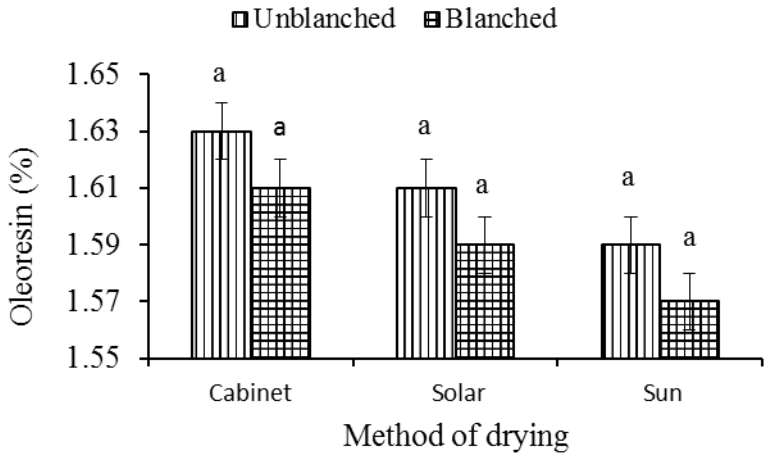


Fig. 4.2 Effect of blanching on oleoresin of Danabari chilli sample.

The amount of oleoresin was found to be unchanged in both dried chillies. In Blanched Danabari sample, the mean value of oleoresin contents of cabinet, solar and sun drying were found as 1.61%, 1.59% and 1.57% respectively. The mean value of oleoresin contents of unblanched dried sample of Danabari were found to be 1.63%, 1.61% and 1.59% in cabinet, solar and sun drying respectively. The amount of oleoresin content was same in both unblanched chillies and blanched chillies. At statistical analysis of variance, the extracted oleoresin contents of unblanched chillies of Danabari samples were not found to be significantly different to each other at 5% level of signifincance than blanched chillies.

There were presence of active enzymes in ripened chillies. Enzymes like Pectinases, Cellulases, Xylanases were helping in break open the cell wall. So, it leaded to high extraction of oleoresin contents in extraction process. But, blanching was mild heat treatment which destroys all the usefull enzymes for breaking cells of pericarp of chillies. So, blanching obstructed the oleroresin extraction (Kedai, 2013).

Blanching directly destroyed the cells of pericarp of chiilies where maximum amount of oleoresin contents was found. The cells are intact and flavoring compounds are not emitted in unblanched chillies. Hence, the blanching strongly affected the flavoring components of chillies (Khader, 2001). In order to get more amount of oleoresin contents, enzyme assisted techniques are applied at different concentration of enzymes and particular pH.(Kurmudle *et al.*, 2013) .

4.5 Effect of drying method on oleoresin content.

Drying method plays an important role in oleoresin content. Cleaned chillies were dried in three different drying method. They are sun, solar and cabinet. Cabinet drying was the mechanical drying method. The amount of oleoresin extracted with varying different drying methods were given in fig. 4.3.

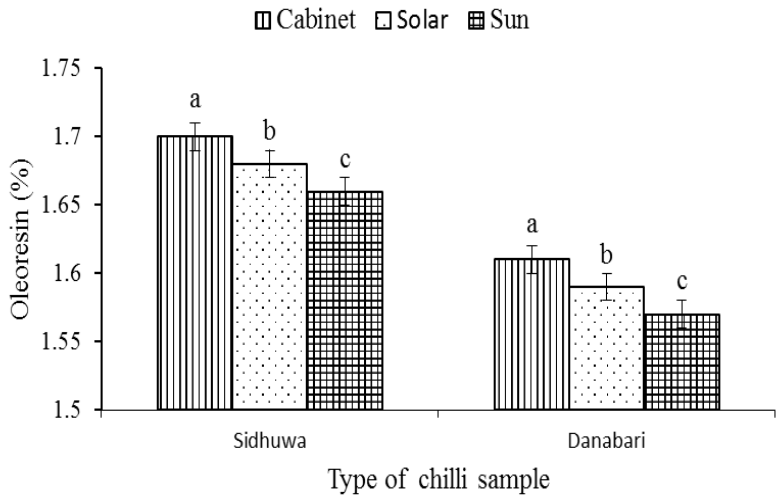


Fig. 4.3 Effect of drying methods on oleoresin of blanched sample.

Oleoresin contents were extracted by solvent extraction method. The mean value of oleoresin content in blanched dried sample of Sidhuwa were found to be 1.66%, 1.68% and 1.70% in Sun, Solar and Cabinet drying methods respectively. Similarly, the mean value of oleoresin content of blanched dried sample of Danabari were found to be 1.57%, 1.59% and 1.61% in Sun, Solar and Cabinet drying methods. The amount of Oleoresin contents in Cabinet drying of chillies was highest than other drying methods. According to statistical analysis, extracted oleoresin content of all drying methods of dried chillies were significantly different with each other at 5% level of significance. The amount of extracted oleoresin were shown in below fig. 4.4.

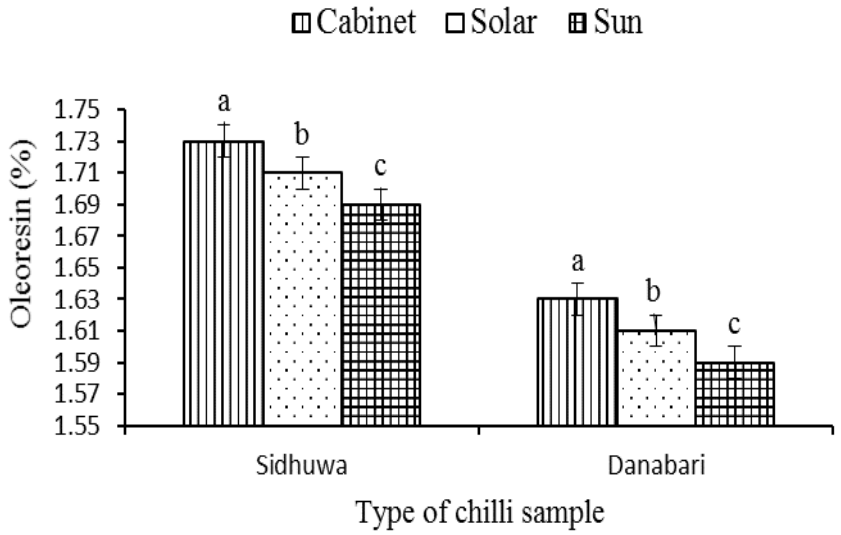


Fig. 4.4 Effect of drying methods on oleoresin of unblanched chilli sample.

In unblanched Danabari variety, the mean value of oleoresin contents of Cabinet, Solar and Sun drying were found as 1.63%, 1.61% and 1.59% respectively. The mean value of oleoresin content of ublanched dried sample of Sidhuwa were found to be 1.73%, 1.71% and 1.69% in Cabinet, Solar and Sun drying respectively. All these values of oleoresin were in wet weight basis. The highest oleoresin content was found in cabinet drying method. At statistical analysis of variance, the extracted oleoresin contents were found to be significantly different to each other at 5% level of signifincance.

In case of Sun Drying, it takes more time to rupture the cells of pericarp of chillies because of intense temperature. As Solar Drying has also low heat than mechanical drying method. But, it has more temperature than Sun drying. So,there is less amount of dissolution of oleroresin contents during extraction process. The mechanical drying method has high heating process. So, it helps more ruptures of cells and leads to more extraction of oleoresins. So, less amount of oleoresin was extracted in low temperature oriented drying methods (Muralidharan, 1993).

Mechanical drying is bettter method of drying compared with solar and sun drying (Shrestha, 1993). But, the high temperature leads to discoloration of pigments. The color is also degraded for long duration storage. So, Naturally convetive dried method is highly preferable (Topuz *et al.*, 2009). Natural convective drying is suitable than Freeze drying and Oven drying for extraction of oleoresin content (Topuz *et al.*, 2011). High temperature

also plays role to degrade the quality of chillies. It mainly vapourizes the volatile contents which is important components of chillies (Ramesh *et al.*, 2001).

4.6 Effect of extraction time in oleoresin content.

During the extraction of Oleoresin contents, only single type of solvent i.e. Petroleum Ether was used. But, different time duratrion were maintained during extraction process to get out the actual change of oleoresins. The coarse particle size of blanched chillies were taken for this process. Around 4 hr time interval were maintained for 4 hr, 8 hr, 12 hr and 16 h and got the variable data which were given in fig 4.5.

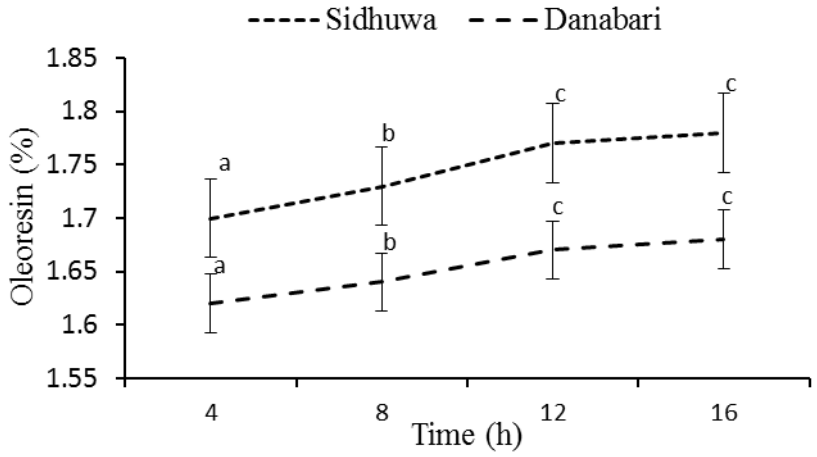


Fig. 4.5 Effect of Extraction time on oleoresin of blanched chilli sample.

There were slight change in the amount of oleoresin contents in change of extraction time duration. The highest amount of oleoresins was found in 12h in both Sidhuwa and Danabari chilli sample. At statistical analysis, the extracted oleoresin content of blanched sidhuwa variety at 4h, 8h and 12h were significantly different to each other at 5% level of significance. Oleoresin content at time 12h and 16h were not significantly different to each other. Similarly, the extracted oleoresin contents of blanched danabari chilli sample at 4h, 8h and 12r were significantly different to each other at 5% level of significance. Oleoresin extracted at 12h and 16h were not found to be significantly different to each other. The amount of oleoresin in different extraction time were given in below fig. 4.6.

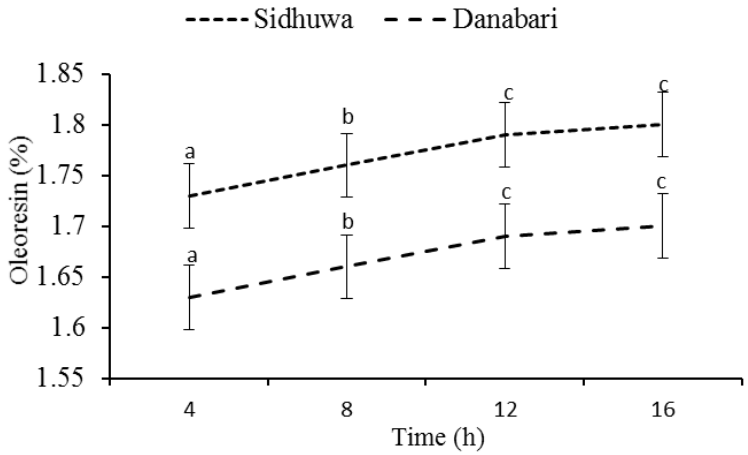


Fig. 4.6 Effect of Extraction time on oleoresin of unblanched chilli sample.

The amount of extracted oleoresin was found high in 12 h of both sample of chillies. At statistical analysis, the extracted oleoresin contents of Sidhuwa sample at 4 hrs, 8 hrs, 12 hrs were significantly different to each other at 5% level of significance. But, oleoresin content at 12 hrs and 16 hrs were not significantly different with each other. Similarly, the extracted oleoresin contents of blanched danabari variety at 4 hrs, 8 hrs and 12 hrs were significantly different to each other at 5% level of significcance. oleoresin content at 12 hrs and 16 hrs were not significantly different with each other.

There were not any significant difference at 5% level of significance at last 12 hrs and 16 hrs because there was little change of oleoresin contents. Hence, the maximum extractive time for dried chillies sample was 12 hours. Since, the oleoresin content was found in small amount. There were small increase in oleoresin content in 4 hrs of time interval. Mainly the concentrated form of flavoring components were found in pods of seeds. So, it took more time to rupture and got outside.

In first 4 hrs, it was not enough time duration for distruction of all cells. That's way, it takes more time for oleoresin extraction (Guragain, 2002). Generally, the dissolution of oleoresin contents take more time. It does not readily extract the complete pungent principles and other coloring compounds from the structure of cells. So, 4 hrs was not sufficient for the extraction of oleoresin contents (Azian *et al.*, 2004)

Part V

Conclusions and recommendations

5.1 Conclusion

On the basis of experimental results, the following conclusions were drawn:

a. The average length, breadth and weight and were found to be 2.80 cm length, 2.28 cm breadth, 3.51 g weight for Sidhuwa variety and 2.7 cm length, 2.33 cm breadth and 3.35 g weight for Danabari variety, and moisture content were 87.4% and 84.45% respectively.

b. 2 min is optimizing time of akabare chilli and there were no significant difference in oleoresin content of both unblanched and blanched dried chilli.

c. Mechanical drying method was considered more reliable for the extraction of oleoresin than Sun and Solar. Drying at 60 °C for 6h of chilies in cabinet drier had more oleoresin than in Sun drying for 5 days and Solar drier for 3 days.

d. Extraction time influenced the extraction of oleoresin contents. Using same type of solvent in different time in extraction process, more time extracted more amounts of oleoresin contents than short extraction time.

5.2 Recommendations

The following recommendations are made for further study.

a. Study the different kind of extraction solvent for retention of oleoresin of chilli.

b. Study the different size of dried chilli for oleoresin retention.

Part VI

Summary

There are many types of spices that are found in Nepal. Chilli is one of the highly used vegetable of our community. *Akabare* or *dalle khursani* is common among chilli varieties. *Capsicum chinense* is the scientific name of it. It is found commonly in the eastern region of Nepal. It is green in unripened stage and dark red in ripened age. It is expensive than other chilli species. Ilam, Panchthar, Tehrathum, Bhojpur, Dhankuta and Taplejung are the leading districts for the production of *Akabare* chilies. It is grown in commercial basis nowadays in Hilly region of eastern side of Nepal. It is started that it is cultivated to some of districts in central and western regions.

It has high demand in our country because of its medicinal important. People are knowing its importance more nowadays. But, there is not any scientific way of cultivation of chillies. So, limited amount of chillies are produced annually. Due to lack of Infrastructure of development, farmer may not get appropriate transportation facility to sell their products. Consumers consume it just without knowing its valuable because oleoresin content is one of the important components that they found in it.

So, the aim of this research was to give the proper idea about technique to extract the oleoresin in high amount. At first, pretreatment was carried out. Immersion blanching was carried out. After it, Drying was carried out in different methods. Single extraction method was used with varying the extractive time.

Two varieties of chillies were brought from Sidhuwa and Danabari of Dhankuta district. Chilli were matured and ripened dark red and sensible care were given to transport it up to the laboratory of CCT. Preliminary operations consisting of sorting and grading, removing stalk and washing were done with care. Chilli were analyzed and found average length, breadth and weight and were found to be 2.80 cm length, 2.28 cm breadth, 3.51 g weight for Sidhuwa variety and 2.7 cm length, 2.31 cm breadth and 3.356 gm weight for Danabari variety. Chillies were then chemically analyzed and results obtained were 87.4% moisture content in Sidhuwa variety and 84.45% moisture content in Danabari.

In Blanching method, Immersion blanching was taken for different time period i.e. 0 min, 1 min, 2 min, 3 min, 4 min and 5 min respectively. Optimization of blanching time was done by Enzyme inactivation methods. 2 min was optimized at boiling water at temperature i.e. 98±2 °C.

Mainly, the cabinet (mechanical) drying, solar drying and sun drying were maintained for drying purposes. Cabinet drying method was maintained at 60°C for 6 hours. Solar Drier for 40-45 °C for 3 days and Sun Drying were carried out at 26-27 °C for 5 days for both blanched and unblanched chillies. The dried chillies were grinded in Motar and Pestle up to coarse particle of 20-25 mesh size.

Solvent extraction was carried out to extract the oleoresin contents by using Petroleum Benzene as solvent. Extraction was carried out for 6h, highest amount of oleoresin contents was extracted in cabinet drying of Sidhuwa sample. Oleoresin contents of Danabari variety was comparatively low than Sidhuwa. It meant that land topography might be played some reason for the oleoresin contents. unblanched chilies had high amount of oleoresin contents than simply dried chilies because high temperature ruptured cell of pods of seeds completely.

Extractive time was also varied in 4h, 8h, 12h and 16h for the cabinet dried chilli. More time duration made more destruction of cells. Hence, appropriate drying method should be carried out for high extraction of Oleoresin. Method helps to retent flavoring and coloring components from *akabare* chilli. It may give the idea to large industry to follow these techniques while producing the chillies products too.

References

Adebiyi, A. P. (2008). Rice bran protein-based edible coating. *Int. J. of Food Science and Technology*. **43** (3), 476-483.

Adeyeyei, E. I. and Otokiti, M. K. O. (1999). Proximate composition and some nutritionally valuable minerals of two varieties of *Capsicum annum* L. *Discovery and Innovation*. **11** (1/2), 75-81.

Adhikari, B. R. (2012). Preparation, quality evaluation and shelf life study of dhule achar, A traditional pickle of nepal. B. Tech (Food) Thesis. Tribhuvan Univ., Nepal.

Andrews, J. (1995). "Peppers: The Domesticated Capsicums". Univ. of Texas Press. Austin, Texas.

Anonymous. (1992). A dictionary of indian raw materials and industrial products *capsicum*. *In:* "The Wealth of India" (Vol. 3).). pp. 218-264. New Delhi.

Anonymous. (1996). *Capsicum* therapeutic power house and herbal catalyst [Report]. Woodland publishing Inc., Pleasant Groove, UT,

Azian, M. N., Kamal, A. A. M. and Azlina, M. N. (2004). The Changes of cell structure in ginger during processing. *J. of Food Engineering* **62**, 359-364.

Berke, T. G. and Shieh, S. C. (2001). "Handbook of herbs and spices". Woodhead Publishing Ltd. Cambridge, England.

Bhattarai, R. (2011). Study on the effect of blanching time and salt concentration in vinegar, for the preservation of fresh *akabare* chilli. B. Tech (Food) Thesis. Tribhuvan Univ., Nepal.

Bhurtel, P. R., Regmi, K. R. and Sapkota, R. P. (1996). Horticulture research in NARC: status and prospectus. Presented at 1st national workshop on horticultural research at Lumle horticulture research centre.

Bokhim, H. (2007). "Study on post harvest loss of *akabare*". Department of Food Technology and quality control (Ministry of Agriculture and Cooperative), Nepal.

Bosland, P. W. and Votava, E. J. (2000). "Peppers: Vegetable and Spice *Capsicum*" (2nd ed.). CABI. U.S.A.

Daood, H. G., Tomoskozi-Farkas, R. and Kapitany, J. (2006). Antioxidant content of bio and conventional spice red pepper (*Capsicum annum* L) as determined by HPLC. *Acta Agronomica Hungarica*. **54** (2), 133-140.

De, A. K. (1992). "Capsaicin: The Wonder Drug from Chilli, Everyman's Science".New Delhi, India.

Dray, A. (1992). Mechanism of action of capsaicin like molecules on sensory neurons. *Life Science*. **51** (23), 1759-1765.

Eich, E. (2008). "Solanaceae and Convolvulaceae: Secondary Metabolites".Springer (Germany).

Fellows, P. J. (2000). "Food Processing Technology: Principles and Practices" (2nd ed.). Wood Head Publ. Ltd. Cambridge, England.

Glinsukon, T., Stitmunnauthum, V., Toskulkao, C., Buranawuti, T. and Tangkrisanavinont, V. (1980). Acute toxicity of capsaicin in several animal species. *Toxicon*. **18**, 215-220.

Govindarajan, T. (1986). Capsicum-production, technology, chemistry and quality. Part II. Processed products, standards, world production and trade. *CRC Critical Reviews in Food Science and Nutrition*. **23** (3), 207-288.

Guragain, H. (2002). Extraction of Ginger Oleoresin and its Quality Evaluation. B. Tech (Food) Thesis. Tribhuvan University, Nepal.

Hawkes, J. G., Lester, R. N. and Skelding. (1979). "The Biology and Taxonomy of the Solanaceae". Academic Press, London.

Heiser, C. B. (1976). Peppers Capsicum (Solanaceae). *In:* "The Evolution of Crops Plants". (N. W. Simmonds, Ed.). pp. 265-268. Longman Press, London.

Hui Yiu, H. and Barta, J. (2006). "Handbook of fruits land fruits processing ". Blackwell Publishing. Iowa, USA.

Jaren-Galan, M., Nienaber, U. and Schwartz, S. J. (1999). Paprika *(Capsicum annum)* Oleoresin Extraction with Supercritical Carbon Dioxide. *Agric. Food. Chem.* **47**, 3558-3564.

Jin, R., Pan, J., Xie, H., Zhou, B. and Xia, X. (2009). Separation and Quantitative Analysis of Capsaicinoids in Chilli Peppers by Reversed-Phase Argentation L.C. Chromatographian. **70** (5-6), 1011.

Jones, A. (1996). Biotechnology, building on farmers knowledge. *In:* "Food Processing".). Macmillian, UK.

Jurenitsch, J. (1991). Identification of cultivated taxa of Capsicum: taxonomy, anatomy and composition of pungent principle. *Chemical Abstracts*. **1977**, 35677.

K.C., J. B. and Rai, B. K. (2007). Appendix. *In:* "Essential of Food Chemistry".). Anamnagar, Kathmandu, Nepal.

Kedai, R. (2013). Effect of Enzyme Treatment on Preparation of chili Oleoresin and its Food Application. *Institutional Repository of CSIR-CFTRI*.

Khader, V. (2001). Introduction to food science. *In:* "Textbook of Food Science and Technology".). pp. 1-38. New Delhi. Indian Council of Agricultural Research.

Khadka, H. (2010). "Discussion on commercial *akabare* production and preservation".

khanal, B. (2009). "A study on post harvest losses os *akabare chilli (Capsicum chinense)*". *Class Seminar* Central Department of Food Technology, Institute of Science and Technology, Dharan, Nepal.

Kharel, G. P. (2004). Post harvest operations: Blanching. *Principle of Food Preservation*. **32**, 57-64.

Kim, S. H., Kim, Y. H., Lee, Z. W., Kim, B. D. and Ha, K. S. (1997). Analysis of chemical constituents in fruits of red pepper. *J. of the Korean Society for Horticultural Science*. **38** (4), 384-390.

Kordylas, J. M. (1990). "Processing and preservation of tropical and subtropical foods".

Kurmudle, N., Kagliwal, L. D., Bankar, S. B. and Singhal, R. S. (2013). Enzyme-assisted extraction for enhanced yields of turmeric oleoresin and its constituents. *Food Bioscience*. **3**, 36-41.

Lenden, H., Smith, M. D., Donatelle, M. D. and Vaughn, B. (1984). "Basic Natural Nutrition". Woodland Publishing. Pleasant Grove, Utah.

Lewis, D. Y. S. (1984). Spice oils. *In:* "Spices and herbs for the food industry".). pp. 21-26. Orpington, England. Food Trade Press.

Madhumathy, A. P., Aivazi, A. and Vijayan, V. A. (2007). "Larvicidal efficacy of *capsicum annum* against Ano;heles stephensi and Culex quinquefasciatus". Vol. 43. J. Vet. Borne.

Manju, P. R. and Sreelathakumary, I. (2002). Genetic variability, heritability and genetic advance in hot chilli (*Capsicum chinense* Jacq.). *J. of Tropical Agriculture*. **40**.

Mini, C., Vahab, M. A., Augustine, A. and Rajan, S. (1998). Standarisation of solvent for chilli Oleoresin extraction. *South Indian Horticulture*. **46** (3-6), 309-311.

Muralidharan, S. (1993). Effect of maturity and drying temperature on extraction of pepper essential oil and oleoresin. *Asian Inst. of Technol.*, .

Pawar, S. S., Bharude, N. V., Sonone, S. S., Deshmukh, R. S., Raut, A. K. and Umarkar, A. R. (2011). Chillies as food, spice and medicine: a perspective. *Int. J. of Pharmacy and Biological Sciences*. **1** (3), 311-318.

Poulos, J. M. (1993). Capsicum L. *In:* "Plant Resources of South-East Asia No. 8: Vegetables". (J. S. Siemonsma and K. Piluek, Eds.). pp. 136-140. The Netherlands. Pudoc Scientific Publishers Wageningen.

Pruthi, J. S. (2003). Chemistry and quality control of capsicums and capsicum products. *In:* "*Capsicum*". (A. K. De, Ed.). Faylor and Francis, London and New York.

Raghavan, S. (2007). "Handbook of Spices, Seasonings and Flavorings". CRC Press, Taylor & Francis Group Boca Raton.

Ramesh, M. N., Wolf, W., Tevini, D. and Jung, G. (2001). Influence of processing parameters on the drying of spice paparika. *J. of Food Engg*. **49** (1), 63-72.

Rangana, S. (1994). "Handbook of Analysis and Quality control for fruit and vegetable products". Tata McGraw-Hill Publishing Company Limited. New Delhi.

Reeves, M. J. (1987). Re-evaluation of *capsicum* color data. *J. of Food Science*. **52**, 1047-1049.

Reyes De Corcuera, J. I., Cavalieri, R. P. and Powers, J. R. "Blanching of Foods". Washington State Univ., Washington, U.S.A.

Shrestha, T. (1993). A Comparative study on mechanical to solar dried ginger products. B.Tech Dissertation. Tribhuvan Univ., Nepal.

Thiele, R., Mueller-Seitz, E. and Petz, M. (2008). Chili pepper fruits presumed precursors of fatty acids characteristic for capsaicinoids. *Agricultural Food Chemistry*. **56**, 4219-4224.

Topuz, A., Dincer, C., Ozdemir, K. S., Feng, H. and Kushad, M. (2011). Influence of different drying methods on carotenoids and capsaicinoids of paprika (Cv. Jalapeno). *Food Chemistry*. **129** (3), 860-865.

Topuz, A., Feng, H. and Kusahad, M. (2009). The effect of drying method and storage on color characteristics of paprika. *Food Science and Technology*. **42** (10), 1667-1673.

Weiss, W. and Buchinger, J. Solar drying. Institute for Sustainable Technologies. [Accessed 3 February, 2016].

Zachariah, T. J. and Gobinath, P. (2008). Paprika and chilli. *In:* "Chemistry of Spices" 69-75. (V. A. Parthasarathy, B. Chempakam and T. J. Zachariah, Eds.). Wallingford, UK. CAB International.

Appendices

Appendix A

Table A.1 ANOVA (no blocking) results of blanching on oleoresin of Sun dried chilli sample of Sidhuwa at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	1	0.00135	0.00135	13.50	0.061
Residual	4	0.0004	0.00001		
Total	5	0.00175			

Since $p \leq 0.05$, effect of blanching on oleoresin of sun dried chilli of Sidhuwa is not significant.

Table A.2 ANOVA (no blocking) results of blanching on oleoresin of solar dried chilli sample of Sidhuwa at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	1	0.00106	0.00106	4.92	0.091
Residual	4	0.000866	0.000021		
Total	5	0.001933			

Since $p \leq 0.05$, effect of blanching on oleoresin of solar dried chilli of Sidhuwa is not significant.

Table A.3 One factor ANOVA (no blocking) results of blanching on cabinet dried chilli sample of Sidhuwa at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	1	0.001066	0.001066	6.4	0.065
Residual	4	0.00066	0.00001667		
Total	5	0.001733			

Since $p \leq 0.05$, effect of blanching on cabinet dried chilli of Sidhuwa is not significant.

Table A.4 One factor ANOVA (no blocking) results of blanching on Sun dried chilli sample of Danabari at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	3	0.0009	0.0030	6.0	0.146
Residual	2	0.0001	0.00005		
Total	5	0.00100			

Since $p \leq 0.05$, effect of blanching on sun dried chilli of Danabari is not significant.

Table A.5 One factor ANOVA (no blocking) results of blanching of Solar dried chilli sample of Danabari at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	1	0.0006	0.0060	6.0	0.070
Residual	4	0.0004	0.0001		
Total	5	0.00100			

Since $p \leq 0.05$, effect of blanching solar dried chilli of Danabari is not significant.

Table A.6 One factor ANOVA (no blocking) results of blanching of Cabinet dried sample of Danabari at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	1	0.0006	0.0060	6.0	0.070
Residual	4	0.0004	0.0001		
Total	5	0.00100			

Since $p \leq 0.05$, effect of blanching on cabinet dried chilli of Danabari is not significant.

Appendix B

Table B.1 ANOVA (no blocking) results oleoresin on dried blanched chilli sample of Sidhuwa at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	2	0.0024	0.0012	12.00	0.049
Residual	6	0.0006	0.0001		
Total	8	0.00300			

Since $p \leq 0.05$, effect of drying method on oleoresin of blanched Sidhuwa chilli sample is significant different and LSD testing is necessary.

Table B.2 ANOVA (no blocking) results oleoresin on dried blanched chilli sample of Danabari at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	2	0.0024	0.0012	12.00	0.057
Residual	6	0.0006	0.0001		
Total	8	0.00300			

Since $p \leq 0.05$, effect of blanched dried chilli on oleoresin of Danabari is significant different and LSD testing is necessary.

Table B.3 ANOVA (no blocking) results of drying method on oleoresin of unblanched chilli sample of Sidhuwa at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	2	0.0024	0.0012	12.00	0.068
Residual	6	0.0006	0.0001		
Total	8	0.00300			

Since $p \leq 0.05$, effect of drying methods on oleoresin of unblanched chilli sample of Sidhuwa have significant difference and LSD testing is necessary.

Table B.4 ANOVA (no blocking) results of drying methods on oleoresin of unblanched chilli sample of Danabari at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	2	0.0024	0.0012	12.00	0.071
Residual	6	0.0006	0.0001		
Total	8	0.00300			

Since $p \leq 0.05$, effect of drying methods on oleoresin of unblanched chilli sample of Danabari have significant difference and LSD testing is necessary.

Appendix C

Table C.1 ANOVA (no blocking) results of Extraction time on oleoresin of blanched dried chilli of Sidhuwa sample for different time at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	3	0.0123	0.0041	41.00	<.001
Residual	8	0.0008	0.0001		
Total	11	0.0131			

Since $p \leq 0.05$, effect of blanched Sidhuwa chilli sample for extraction of oleoresin for different time have significantly difference and LSD testing is necessary.

Table C.2 ANOVA (no blocking) results of Extraction time on oleoresin of blanched dried chilli of Danabari sample for different time at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	3	0.0068	0.002275	22.75	<.001
Residual	8	0.0008	0.0001		
Total	11	0.00765			

Since $p \leq 0.05$, effect of blanched dried chilli for extraction of oleoresin for different time have significant difference and LSD testing is necessary.

Table C.3 ANOVA (no blocking) results of extraction time on oleoresin of unblanched dried chilli of Sidhuwa sample for different time at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	3	0.009	0.003	30.00	<.001
Residual	8	0.0008	0.0001		
Total	11	0.0098			

Since $p \leq 0.05$, effect of unblanched dried chilli sample on oleoresin of Sidhuwa for extraction of oleoresin for different time are significantly different and LSD testing is necessary.

Table C.4 ANOVA (no blocking) results of extraction time on oleoresin of unblanched dried chilli of Danabari sample for different time at 5% level of significance.

Source of Variation	d.f.	s.s.	m.s.	v.r.	F.pr.
Method	3	0.009	0.003	30.00	<.001
Residual	8	0.0008	0.0001		
Total	11	0.0098			

Since $p \leq 0.05$, effect of unblanched dried chilli sample on oleoresin of Danabari are significantly different and LSD testing is necessary.

PHOTO GALLERY

Fresh *akabare* chilli

Dried *akabare* of unblanched and blanched chilli