PREPARATION AND QUALITY EVALUATION OF *MASYEURA* PREPARED FROM CHAYOTE *(Sechium edule)* AND BLACK GRAM *DAHL* (*Phaseolus mungo*)

by

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Preparation and Quality Evaluation of *Masyeura* Prepared from Chayote *(Sechium edule)* and Black Gram *Dahl* (*Phaseolus mungo*)

A dissertation submitted to the Department of Food Technology, Central Campus of Technology, Tribhuvan University in partial fulfillment of the requirements for the degree of B.Tech. in Food Technology

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Approval Letter

This *dissertation* entitled *Preparation and Quality Evaluation of Masyeura Prepared from Chayote (Sechium edule) and Black Gram Dahl (Phaseolus mungo)* presented by Gita Prasad Dhakal has been accepted as the partial fulfillment of the requirements for the B. Tech in Food Technology.

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Abstract

The *Masyeura* is one of the traditional fermentation based dried food product made by blending soaked ground black gram dough and shredded ash gourd pulp. Since, many other underutilized foods having potential to exploit the advantage of *Masyeura* has been kept ideal; here an attempt has been made to study on use of chayote (*Sechium edule*) as vegetable.

Black gram and two varieties of chayote *viz.* green and white whose blanched and un-blanched shreds were mixed in proportion of 50-50, 40-60 and 60-40 part with black gram dahl paste respectively followed by deposition and drying for preparation of *Masyeura.* The samples were subjected for analysis of rehydration ratio, bulk density, and sensory analysis in uncooked form. *Masyeura* made from blanched shreds of green chayote mixed with black gram paste in all proportion was found to be significantly superior. The selected samples were cooked and subjected for sensory analysis along with control. In sensory analysis of cooked *Masyeura*, the product made by black gram paste and green chayote's blanched shred at proportion 60-40 was found out significantly superior ($p>0.05$). The superior product was analyzed for proximate composition, vitamin, microbiological quality, chemical changes during storage period and cost. The moisture, protein, fat, carbohydrate, crude fiber, total ash, and vitamin C of the product were found as 9.9 %, 20.1 %, 0.31 %, 61.87 %, 4.6 %, 3.2 %, 6 mg/100g respectively. The food can supply 341.23 Kcals/100 gm. The cost of *Masyeura* was calculated as Rs 18.04/100g. During the study of storage stability of product for one month the rate of increase in the acidity was 0.0013 % per day in case of high density polyethylene (HDPE), while 0.00136 % per day in case of low density polyethylene (LDPE) which was not significantly different ($p>0.05$). Similarly, the rate of increase in the moisture was 0.0021% per day in case of HDPE, while 0.0026% per day in case of LDPE, where the use of HDPE was significantly superior to LDPE. Thus, HDPE is recommended for packaging of *Masyeura.* Finally, if this product would develop it will play an important role in utilizing the underutilized crops.

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Part I

Introduction

1.1 Background

The *Masyeura* is one of the traditional dried food product of Nepal. It has been known from the very beginning and is very difficult to trace its origin owing to the lack of any published work. The product is made from mixture of pulses and vegetables (Subedi, 1999).

The word *Masyeura* is originated from the word *mashyauto* which means lump of ground soaked pulse. The dehulled ground and soaked pulse is either mixed with fine pieces of vegetables or shredded vegetables. The most common vegetables used in the preparation of *Masyeura* are either ash gourd, raddish, bottle gourd, cabbage, potato or taro (Subedi, 1999).

It is one of the very popular food products of Nepal. It is widely prepared and extensively consumed with little modification in ingredients according to availability of various raw materials. It is mostly used in the preparation of vegetable curry. Further it is prepared during winter season and once dried, can be stored for further uses (Karki, 2041).
It can be used at any season. Traditionally it is prepared when pulses are surplus during winter season while drying is done by sun. The composition of *Masyeura* may vary according to availaibility of raw materials. Black gram (*Phaseolus mungo*) is common component in hilly regions where as Green gram (*Phaseolus aureus)* in Terai region (Deo, 2003).

This traditional food product is favorite for all classes of people and is used for serving as *tarkari* for guest in both rural and urban communities. *Masyeura* is prepared in several ways in different parts of Nepal. The Ingredients used to make recipes vary widely from region to region (Lama, 1988).

Masyeura is favorite product for all classes of people. It is used by most of the vegetarians as delicious food and soup. In eastern terai region of Nepal *Rekauch* is very popular which is similar to *Masyeura* used in the hilly region. The method of preparation of both *rekauch* and *Masyeura* are similar, only the difference is that in *rekauch* whole leaves are mixed with *mashyauto* without cutting then sundried. After drying the leaves shrinks (Gajurel and Vaidya, 1979). Similarly, North Indian *"Wari"* and south Indian *"Sandige"* are similar to *Masyeura*. It is partially fermented indigenous food and used as an adjunct in curries (Deo, 2003).

At time of cooking *Masyeura* is fried in oil, mixed with curry to make a soup and served with rice as a side dish (Gajurel and Vaidya, 1979).

Till date very few researches had been made on *Masyeura*. Those had been made, the use vegetables had been confined to colocosia, ash gourd and black gram. Subba (1985), Lama (1988), Subedi (1999) and Deo (2003) has attempted a research on *Masyeura* based on colocosia and black gram at ratio 2:1. Since many other underutilized food having potential to exploit the advantage of *Masyeura* has been kept ideal. Here an attempt has been made to study on use of chayote (*Sechium edule*) *iscus* as vegetable, replacing colocosia. Therefore in the present study *Masyeura* has been prepared from two ingredients; Black gram and chayote. The chayote used here is of two varieties i.e. green and white.

1.2 Justification

Chayote contains more than 85% moisture. It can be preserved for about 6-7 days at room temperature, the main problem arising during chayote preservation at ambient temperature is that the vegetable begins to germinate and drops constantly in weight which leads to the development of pathogens. Chayote is produced in large quantity in hilly region of Nepal but due to its ineffective market system, transportation problem, chayote produce is not effectively utilized. Chayote is a perishable produce, it is forced to sell in low price thus preservation in peak growing season is must to gain profit in lean season. The production is easy, requires small land but the produce being highly perishable; development of processed chayote is necessary to lift up farmers economic gain and livelihood. Of the different processing methods preparation of *Masyeura* by involving fermentation and drying can be the effective method of processing for small scale as well as large scale chayote grower due to ease of processing and cost effectiveness. The underutilized crop being used can be of good market valued product as it is easy to reconstitute and contains considerable amount of nutrients. After preparation of *Masyeura*, it can be sold in off-season in reasonable price. Large excess of chayote can be utilized preventing loss.

1.3 Objectives

1.3.1 General objective

The main objective was to prepare a *Masyeura* using chayote and black gram and study their qualitative behavior.

1.3.2 Specific objectives

a. To study the effect of beneficial treatment (blanching) of vegetable on quality of *Masyeura.*
b. To study the effect of proportion of vegetable and legumes on physical and sensory analysis of *Masyeura*.
c. To perform physiochemical analysis of *Masyeura.*
d. To evaluate microbiological quality of the *Masyeura*.
e. To study the chemical change during storage on selected packaging material.

1.4 Significance of study

The present study is an effort towards finding out the possibility of using underutilized crops (Chayote) as *Masyeura* a traditionally dried fermented product. The work has been targeted to give some solution to all cultivars of chayote in Nepal who are being supposed to suffocate from lack of market of chayote. They have been forced to waste out the potent crop as feed for animal. The study was also focused for modification of consumption pattern of chayote. Most of people ignore chayote due to its dull taste in nature. So if it can be utilized by preparing *Masyeura* it would be beneficial that a nutritious and palatable product would develop and advantage from all side would be achieved.

1.5 Limitations

a. Effect of other treatment (sulphitation) could not be studied.
b. Effect of different drying methods could not be compared.
c. Detail analysis of vitamin and minerals, trace element, amino acid composition and different biochemical change and properties of product could not perform due to the limitation of the required facilities in laboratory.
d. Due to insufficient time available for dissertation work storage changes of product couldn’t be studied for enough length of time.

Part II

Literature Review

2.1 Pulses

Pulses are the edible seeds of pod bearing plants belonging to the family *Luguminosae*, sub family *Paplionaceae* and widely grown throughout the world (Manay and Shadakasharaswamy, 1998).

They are valued as food because of their high protein content. Legumes are the meat of the vegetable world and are close to animal flesh in protein food value. It is used in fresh or dried form. Pulses have an important contribution to the diet of all classes of people in east than the west (Davidson *et al.*, 1975). Legume crops have a worldwide distribution. Legumes were domisticated early than other crops in history where agriculture was originated (Muller, 1988).

Leguminosae includes approximately 600 genera with about 13000 species. Out of this great numbers, only about 10 to 12 are of economic importance today. In Nepal, 17 different varieties of pulses are available. Among those black gram (*Phaseolus mungo*) is the major pulse grown on temperate and sub tropical parts of Nepal. The total area covered by pulses as whole in Nepal is estimated to be about 319 thousand hectors with the annual production of 262 thousand metric tons (MoAC, 2010). Majority of pulses area and production are confined to terai and inner terai, and winter legumes contribute the major share in area and production. Winter grain legumes crops such as lentil, chickpea, grasspea, fieldpea and fababean are grown entirely dependent on residual soil moisture after the harvest of rice (Neupane *et al.*, 2011).

Legumes are low in the sulphur containing amino acids i.e. methonine and cystine. Legumes have certain nutritional disadvantages. Apart from their methonine and cystine deficiency their digestibility appears to be low and high proportion of legumes in diet causes flatulence. Also toxicity in them is a serious matter (Muller, 1988).

2.1.2 Toxic constitutes of pulses and improvements

For nutritional purpose any substance that interfere with normal growth, reproduction or health, when consumed regularly in the amount existing in a normal component of a diet should be considered as harmful and toxic. Sometimes, it may cause the adverse physiological effects whether it is chronic effect such as growth inhibition, paralysis, glandular dis-orderness or an acute lethal effect resulting death.

Pulses contain some toxic substances. The nature of toxic substance may vary on the basis of its origin. They may be exogenous i.e. taken up from the soil like selenium, copper, molybdenum and so on or endogenous i.e. produced by plant itself. The toxic substances found in the pulses are trypsin inhibitor, haemaglutinins, (substances which agglutinates red cells and destroy them) chymotrypsin, saponin, goitrogenic factors, cyanogenic glycosides, alkaloids, factors causing lathyrism and favism.

Soaking, heating and fermentation can reduce or eliminate most of the toxic factors of the pulses. Correct application of heat in cooking pulses can eliminate most toxic factors without impairment of nutritional value. Cooking also contributes towards pulse digestibility. Heat causes the denaturation of protein responsible trypsin inhibition, haemaglutination and enzyme responsible for the hydrolysis of cyanogenic glycosides (Manay and Shadakasharaswamy, 1998).

2.2 Black gram (*Phaseolus mungo*)

Black gram belongs to the family *phaseolus*. Black gram is one of the best pulse and highly priced pulse crop grown in Nepal. The seed have usually a dark brown skin. It is highly nutritious, palatable and easily digestible. Regarding the nutritionals remit black gram comes under the first order which is most important pulse of *Phaseolus* group (Regmi, 1982). The composition table has shown in table 2.1

Black gram is originated in India where it is the most widely grown (Cobely and Steele, 1976). According to, MoAC (2010) area under black gram is 33779, hectors and the yield of black gram is 790 kg per hector) in Nepal.

Table 2.1: Composition of black gram (values/ 100 g)

Parameters	*Phaseolus mungo*
Moisture (g)	10.90
Protein (g)	24.00
Fat (g)	1.40
Fibre (g)	0.90
Carbohydrate (g)	60.30
Calcium (g)	0.02
Phosphorous (g)	0.37
Iron (mg)	9.80
Calorific Values (kcal)	350.00
Vitamin(I.U.)	64.00
Vitamin B_1 (mg)	0.45
Nicotonic acid	2.00
Riboflavin (mg)	0.22

Source: (Swaminathan and Bhagwan, 1976)

2.3 Chayote (*Sechium edule*)

The chayote (*Sechium edule*), also known as christophene, vegetable pear, mirliton, Alligator pear (South Louisiana), choko (Australia, New Zealand), starpreciantè, Citrayota, citrayote (Ecuador and Colombia), chuchu (Brazil), chow chow and '*vilaiti vanga*' (India) Sayote (Philippines), güisquil (Guatemala, El Salvador), or pear squash, *iskus* (Nepal) is an edible plant that belongs to the gourd family Cucurbitaceae along with melons, Cucumbers and squash (Ram, 1994).

In the most common variety, the fruit is roughly pear shaped, somewhat flattened and with coarse wrinkles, ranging from 10 to 20 cm in length. It looks like a green pear and it has a thin green skin fused with the white flesh, and a single large flattened pit. The flesh has a fairly bland taste, and a texture described as a cross between a potato and a cucumber. Although generally discarded, the seed has a nutty flavor and may be eaten as part of the fruit (Jeffrey, 1990).

Chayote vine can be grown on the ground, but it is a climbing plant that will grow onto anything and can easily rise as high as 12 meters when it can reach a tree or house. Its leaves are heart-shaped, 10–25 cm wide and with tendrils on the stem. The flowers are cream-colored or somewhat green that comes out beneath a leaf or branch. If the plant is male, the flowers will show in clusters. The plant's fruit is light green and elongated with deep ridges lengthwise. The word "chayote" is Spanish, borrowed from the Nahuatl word chayohtli. Chayote was one of the many foods introduced to Europe by early explorers, who brought back a wide assortment of botanical samples. The age of conquest also spread the plant south from Mexico, ultimately causing it to be integrated into the cuisine of many other Latin American nations (Cook, 1901).

Chayote is native to Mesoamerica where it is a very important ingredient to the diet. Other warm regions around the globe have been successful in cultivating it as well. The main growing regions are Costa Rica and Veracruz, Mexico. Costa Rican chayotes are predominantly exported to the European Union whereas Veracruz is the main exporter of chayotes to the United States (Cook, 1901).

The fruit need to be peeled and can be eaten raw in salads. Cooked or raw, it has a very mild flavor by itself, and is commonly served with seasonings (e.g., salt, butter and pepper in Australia) or in a dish with other vegetables and/or flavorings (Koirala, 2013). It can also be boiled, stuffed, mashed, baked, fried, or pickled. Both fruit and seed are rich in amino acids and vitamin C. Fresh green fruit are firm and without brown spots or signs of sprouting. Smaller ones are tendered (Pittier, 1910).

2.3.1 Botanical description

The chayote is an herbaceous, perennial, monoecious, vigorous creeper or climbing plant. It grows from a single, thick root, which produces adventitious tuberous roots. The stems are angular-grooved and glabrous, and several grow simultaneously from a single root, at least in the cultivated plants. They thicken towards the base and appear woody, while towards the apex there are many thin, firm, herbaceous branches (Aung *et al.*, 1990). The white fleshed fruit contains a single, large seed. Male and female flowers are found on the same plant, flowering during the cooler months of the year (Cook, 1901).

The flowers are unisexual, normally pentamerous, coaxillary and with ten nectarines in the form of a pore at the base of the calyx. The staminate flowers grow in auxiliary racemose inflorescences that are 10 to 30 cm long, and the groups of flowers are distributed at intervals along the rachis. The calyx is patteliform and 5 mm wide, the sepals triangular and 3 to 6 mm long, the petals triangular, greenish to greenish-white and measure 4 to 8 x 2 to 3 mm. There are five stamens, and the filaments are fused almost along their total length, forming a thickened column which separates at the apex into three or five short branches. The pistillate flowers are normally on the same axilla as the staminate flowers; they are usually solitary but are occasionally in pairs; the ovary is globose, ovoid or piriform, glabrous, inerm and unilocular; the perianth is as in the staminate flowers but has slightly different dimensions; the styles are fused in a slender column and the nectaries are generally less evident than in the staminate flowers. The fruit is solitary or rarely occurs in pairs; it is viviparous, fleshy and sometimes longitudinally it is of very different shapes and sizes, indumentums, number and type of spines; it is white and yellowish, or pale green to dark green with a pale green to whitish flesh that is bitter in the wild plants and not bitter in the cultivated ones. The seed is ovoid and compressed with a soft and smooth testa (Aung *et al.*, 1990)

The results of studies have shown that *Sechium* is a well-defined genus composed of 11 species. Of these, nine are wild species distributed throughout central and southern Mexico, up to Panama. Of the two remaining species, *S. tacaco* is only cultivated in Costa Rica, and the other, *S. edule*, as mentioned above, is widely cultivated throughout the America, Asia and other regions of the world, with wild populations in southern Mexico (Koirala, 2013). The scientific classification has been shown on Table 2.2.

Table 2.2: Scientific classification

Kingdom: Plantae

Order: Cucurbitales

Family: Cucurbitaceae

Genus: *Sechium*

Species: *edule*

Variety: White and Green

Source: (Aung *et al.*, 1990)

2.3.2 The origins of chayote

From the ethno historical record, we know that, at least in Mexico, chayote has been cultivated since pre-Colombian times. The first description of chayote was probably that of Francisco Hernandez, who was in Mexico from 1550 to 1560 but the crop was not introduced into the southern part of the continent until after the arrival of the Spanish. These clearly indicate that the species was originally concentrated in Mexico and Central America. In many cases, these same names (especially that of Nahuatl origin,‘chayote’) with only slight modifications, are used in other areas of the world where the species was introduced. Pre-Colombian decorated pottery has been found in Mexico and Central America which clearly depicts chayote (Cook, 1901).

It is the eco geographic distribution of *S. edule* under cultivation, and that of its wild relatives, however, which provides the greatest evidence for establishing the centre of origin of this crop. Reports of explorations carried out during different periods by various people and institutions all concur that the widest variety of cultivated chayote is found in southern Mexico, Guatemala and Costa Rica, at altitudes of 500-1500 m (Pittier, 1910).

In 16th century the Portuguese introduced the chayote to India during their colonization period and it spread throughout south Asia (Chakravarty, 1990).

2.3.3 Environmental Requirements for chayote growth

Chayote grows best with moderate rainfall and in the slightly cooler areas of the tropics. It thrives in areas receiving evenly distributed light rainfall, although short dry periods are tolerated (Koirala, 2013).

Fruit production is highest when nighttime temperatures range from 59-68° F (15-20°C). Some chayote varieties may not fruit in areas with continual high night time temperatures. It grows in both full and light shade. Well-drained sandy loams are preferred, but clay soils are generally suitable. It does not tolerate waterlogged soils. Chayote will produce fruits in alkaline soils, but soil pH of 5-6 is most appropriate. Soils with a high level of organic matter are preferable (Jeffrey, 1990).

2.3.4 Ecology of chayote growth

Chayote is traditionally cultivated in empty patches, backyards and market gardens as well as in plantations for commercial purposes. It is a medium- to high-altitude crop (300-2000 m), it requires a high relative humidity (80-85%), well-distributed annual precipitation of at least 1500-2000 mm and 12 hours daylight to initiate flowering (Jeffrey, 1990). The most suitable average temperature is 13-21°C. Temperatures of less than 13°C damage small or unripe fruit while those above 28°C favor excessive growth and the falling of flowers and unripe fruit, all of which reduces production (Newstrom, 1990). Flores (1989) points out those chayotes for export grow best on sites located at 1000-1200 m. While topography and stoniness do not seem to be important factors for the cultivation of chayotes, other soil factors do. Productivity is greater in deep soil with plenty of organic matter but is affected negatively by clay or sandy soils which retain moisture and encourage the development of diseases, especially those caused by fungi. The above indicates that chayote is highly susceptible to frosts, droughts and excessive humidity, as well as to certain soil factors. However, in spite of this, herbarium and germplasm records as well as field observations show that there is a wide geographical/altitudinal distribution for most of the genetic diversity of this crop. In fact, according to Aung *et al.* (1990) it is possible to grow chayote in temperate regions during summer and early fall months, although the fruits should be pre sprouted and the plantlets grown under greenhouse conditions before setting them outdoors when danger of frost has passed.

2.3.5 Harvesting methodology of chayote

One plant can produce even more than 300 fruits per year. Yields of 22-28 Tonnes per hector have been reported from commercial plantations (Jeffrey, 1990). Chayote fruits are harvested manually as often as required depending, obviously, on the productivity of the plant. On commercial plantations, however, given the uniformity of the materials used, harvesting is programmed and much more systematic. It involves the collection of fruits 2-4 days per week during the production time, as well as the selection and classification of fruits for export and home markets. In general, the most common strategy is to devote 1 day a week to harvest fruits for exportation and the remaining days to harvest the fruits for local markets.

Once the fruits have been collected and selected, they are put in wooden boxes and sent to the packers there, a second selection process takes place after which the fruits are packed in cardboard boxes and plastic bags with anti-transparent and fungicides; these are then sent in refrigerated containers (Flores, 1989).

2.3.6 Uses and Preparation

Chayote is most commonly cultivated for its edible fruit. Generally the whole fruit is eaten, seed and all. Chayote is peeled, cut in cubes, and added to soups and stews. It can also be baked and eaten like squash, flavored in a variety of ways to suit local customs. The mature seed is soft and has a nutty flavor when boiled. The roots are edible as well, and can be eaten raw, boiled, roasted or fried, tasting similar to a yam. The main root is carefully harvested after two years without disturbing the small roots, leaving the plant intact. The young leaves and tender shoots are nutritionally quite valuable. The climbing tendrils are removed from the shoots, as they can be fibrous. The young leaves and shoots are an appetizing cooked green vegetable, and often added to soups and stews (Ram, 1994).

2.3.7 Chemical composition of chayote

The edible parts of *S. edule* are relatively low in fibre, protein and vitamins compared with other vegetables. Nevertheless, they have a high calorie and carbohydrate content, especially in young stems, root and seed, and the micro and macronutrient content of the fruit is adequate. The fruits, and the seed especially, are rich in several important amino acids such as aspartic acid, glutamic acid, alanine, arginine, cistein, phenylalanine, glycine, histidine, isoleucine, leucine, methionine (only in the fruit), proline, serine, tyrosine, threonine and valine (Flores, 1989). Many of these nutritional characteristics make chayote particularly suitable for hospital diets (Liebrecht and Seraphine, 1964). The chemical composition of chayote is given in Table 2.3.

2.3.8 Uses of chayote

Chayote is used in many ways in different parts of the world. The softness of the fruit flesh makes it particularly suitable for giving consistency to baby foods, juices, sauces and pastes. Because of the flexibility and strength of the stems, they are used in some places, such as Reunion, in handicrafts to make baskets and hats (Newstrom, 1990). In India, as in the Americas, the fruit and roots are not only used as food but also as fodder for cattle (Chakravarty, 1990).

Medicinal use of chayote has also been documented in the literature. Data compiled in recent studies highlight the use of decoctions made from the leaves or fruits to relieve urine retention and burning during urination or to dissolve kidney stones, and as a complementary treatment for arteriosclerosis and hypertension (Flores, 1989). In the Yucatan Peninsula, where kidney disorders are frequent, these decoctions are considered to be effective and have been in use since colonial times (Alvarado *et al.*, 1992).The diuretic properties of the leaves and seeds, and the cardiovascular and anti-inflammatory properties of the leaves and fruit, have been confirmed by pharmacological studies. Dehydration of the fruit has been carried out in Mexico and other countries in an attempt to increase the shelf life of chayote and make it more widely available, perhaps even for industrial use. Results are said to be promising; jams and other types of sweets have been manufactured and dehydrated fruits have been conserved for later use as a vegetable. On the other hand, some countries, such as the Philippines, have successfully used chayote plants in mixed plantations designed specifically for soil recovery and/or conservation (Cheng *et al.*, 1995).

Table 2.3: Chemical composition of Chayote

Component	Fruit	Seed	Stem	Root
Calories	26-31	-	60	79
Moisture (%)	89-93	-	89.7	79.7
Soluble sugar (%)	3.3	4.2	0.3	0.6
Starch (%)	0.2	1.9	0.7	13.6
Protein (%)	0.9-1.1	5.5	4	2
Fat (%)	0.1-0.3	-	0.4	0.2
Carbohydrate (%)	3.5-7.7	60	4.7	17.8
Fiber (%)	0.4-1.0	-	1.2	0.4
Ashes (%)	0.4-0.6	-	1.2	1
Ca (mg)	19-Dec	-	58	7
Fe (mg)	0.2-0.6	-	2.5	0.8
P (mg)	4.0-30.0	-	108	34
Vitamin A (mg)	5	-	615	-
Thiamin (mg)	0.03	-	0.08	0.05
Riboflavin (mg)	0.04	-	0.18	0.03
Niacin (mg)	0.05	-	1.1	0.9
Ascorbic acid (mg)	11.0-20.0	-	16	19

Source: (Saade, 1996)

2.3.9 Shelf life of freshly harvested chayote

How the fruits are taken care of when harvested is of paramount importance from a commercial perspective, particularly in view of the fact that chayotes stored at ambient temperature spoil completely after 7 days. Tests carried out to date to find the most efficient ways of protecting fruit packed for export show that the use of plastic bags greatly reduces loss of humidity although it increases the incidence of pathogens such as Mycovellosiella cucurbiticola. This, however, can be controlled through the use of anti-transpirants, which also reduce chilling injury.

Tests at temperatures of 13-14°C and 80-90 % humidity have shown that fruit begins to germinate after a week; drops constantly in weight and pathogens develop (Alvarado *et al.*, 1992).

2.3.10 Status of chayote production and development in Nepal

Chayote is the 17th most neglected and underutilized crop in Nepal and south Asia. According to Ministry of Agriculture and Co-operatives the per annum production of chayote in Nepal is 19439 metric ton. Table 2.4 shows the production of chayote in year 067/068 in different development regions of Nepal.

Table 2.4: Status of Chayote production in different development regions of Nepal

Development region production	(metric ton)
Eastern	2778
Central	7514
Western	2999
Mid-western	4532
Far western	1616

Source: (Nepal, 2011)

In 1992, chayote gene bank was set up in Nepal, as a result of a chayote breeding programme funded by the US Agency for International Development (USAID), and led by Moha Dutta Sharma of the Institute of Agriculture and Animal Sciences (IAAS), Tribhuvan University (Sharma *et al.*, 1995).The three main objectives of this project are to:

a) Evaluate germ plasma collected from Mexico, Costa Rica and India, in order to select plants demonstrating adaptability to annual cultivation (early maturity, compact habit), marketable qualities (excellent flavor, appropriate size and texture), and desirable agronomic characters (high yield, resistance to drought and heat)

b) Develop cultural practices to optimize fruit, tuber, or shoot production in tropical, subtropical and temperate regions of Nepal.

c)To disseminate the improved lines and agronomic information resulting from the project to subsistence and commercial growers, research scientists and government agencies in Nepal and abroad.

2.4 Nutritive value of Legumes for *Masyeura*

Leguminous plants belong to family of leguminosea. The seed of leguminous plants are known as legumes/pulses (Swaminathan, 2004). Legumes are good foods for young children because they have a high protein content and are usually inexpensive, or grown at own field. Although the protein in most legumes is only of moderate quality, it is supplementing other food proteins notably the cereals (Doughty and Walker, 1982).

Food legumes are comparatively rich in lysine and threonine and therefore a combination of cereal protein and legume protein comes very close to providing an ideal source of methionine and cystine and legumes is in the large part offset by the higher proportions of these amino acids present in most cereals. The nutritional complementary of cereals and legumes is of great importance, particularly for the people of the less developed world (Siegel and Fawlett, 1970). Many of the legumes contain toxic factors such as trypsin inhibitor, haematoglutinins etc which can be removed by heat treatment before consumption (J. Shrestha, 1989).

2.5 Natural fermentation

Fermented foods from an important part of diet and such foods are prepared from plant and animal materials by processes in which microorganisms play an important role by modifying the material physically, nutritionally and organoleptically. Most indigenous or traditional fermented foods from cereals, beans, pulses, tubers, and vegetables are prepared by process of solid substrate fermentation in which the substrate is allowed to ferment naturally or spontaneously (Aidoo, 1986)

Microorganisms are associated in a variety of ways with all of the food we eat. Naturally occurring foods such as fruits and vegetables normally contain some microorganisms. Food can serve as a medium for the growth of microorganisms and this growth may cause the food to undergo decomposition and spoilage. But still other microorganisms are used in the preparation and preservation of food products (Pelczar *et al.*, 1998).

Fermented foods are the result of the activity of few species of microorganism among the thousand species of bacteria, yeast and mold and sometimes the combination of all those (Pederson, 1971)

Pure culture fermentation seldom occurs naturally. The requirements for growth supplied by natural constituents of food are so similar for both yeast and bacteria i.e. mixed fermentation normally occurs. The lactic acid producing bacteria, the acetic acid producing bacteria, certain alcohol producing yeast and certain mold are highly specialized in food fermentation processes (Pederson, 1971).

Nearly all vegetable substances whether leafy or tuberous provide sufficient nutrients for the growth of lactic acid bacteria (Pederson, 1971). Fresh vegetables contains numerous and varied epiphytic micro flora, including many potential spoilage microorganisms and a small population of lactic acid bacteria. The natural or spontaneous fermentation of vegetables is a therefore result of concerted action of these microorganisms (Rose, 1982).

In vegetables, one or more species of lactic acid bacteria plays an important role. Their production of organic acid not only contributes to desired taste and flavor of the final product but also makes the substrate unfavorable for proliferation of spoilage and other undesirable microorganisms. At the same time the acid makes the substrate more suitable for growth of microorganisms that improve the properties of the food (Rose, 1982).

Aerobic mesophilic counts in *Masyeura* are 108 cfu/g, and the loads of LAB and yeast are 107 cfu/g and 104 cfu/g, respectively (Tamang, 2010). The presence of a high number of LAB in *Masyeura* fermentation may be due to the predominance of LAB in dehulled black grams, which has been reported earlier in a similar black gram fermented product *idli* (Mukherjee *et al.*, 1965). *Masyeura* is slightly acidic, with the pH ranging from 5.6 to 6.3. Microorganisms isolated from *Masyeura* of Sikkim are bacteria (*Lb. fermentum, Lb. salivarius, P. pentosaceous, E. durans, Bacillus subtilis, B. mycoides, B. pumilus,* and *B. laterosporous*) and yeasts (*Saccharomyces cerevisiae, Pichia burtonii,* and *Candida castellii*), and molds are absent (Tamang, 2010). Microorganisms isolated from *Masyeura* of Nepal consist of bacteria (*P. pentosaceous, P. acidilactic, and Lb. spp.),* yeasts (*Saccharomyces cerevisiae* and *Candida versatilis*), and molds (*Cladosporium spp., Penicillium spp.,* and *Aspergillus niger*) (Dahal *et al.*, 2003).

2.6 Technology of *Masyeura* preparation

Masyeura is traditional legume-based savory of Nepal and has been used by most of the vegetarians as a substitute for meat (Gajurel and Vaidya, 1979)

Masyeura preparation by traditional method has scientific value. Protein content of pulses plays an important role in the formation of a characteristic texture of the product. Pulses possess foam-forming ability, which produce the resultant product of a low density.

Pulses are important ingredient used in *Masyeura* preparation. Either black gram or green gram may be used for the *Masyeura* preparation. But in Nepal, black gram is a main ingredient for choice.

Split pulses are taken and all the foreign particles and dust are removed. Pulses are soaked in ample amount of water overnight and then washed thoroughly. Soaking is a pre-treatment for decortications of grains, facilitate removal of the husk. (Reported that husk takes up more water than rest of grain and gets easily separated.) The husk can be removed by scrubbing with hand.

Soaking also eliminates the anti-nutritional factors by leaching out and makes food safe to consume. The activities of trypsin inhibitors and haemagglutinin are destroyed by about 28% and 75% respectively by soaking in case of beans (Kakode and Evans, 1996). It appeared therefore, that these anti-nutritional factors are destroyed or inactivated or possibly leached out of the beans as a result of soaking process. Then, the soaked pulse are ground into thick paste using a wet grinder.

Gajurel and Vaidya (1979) reported that *Masyeura* could be prepared by mixing black gram and colocasia in ratio 1:4. But according to Subba (1985) and Subedi (1999), it can be prepared by taking black gram and colocasia in ratio 2:1. The paste of black gram and colocasia is whisked well until it becomes light and fluffy due to incorporation of air. As reported by Dahal *et al.* (2003) blend of paste and vegetable could be made of equal proportion. Finally, the blended product is made into small lumps or balls.

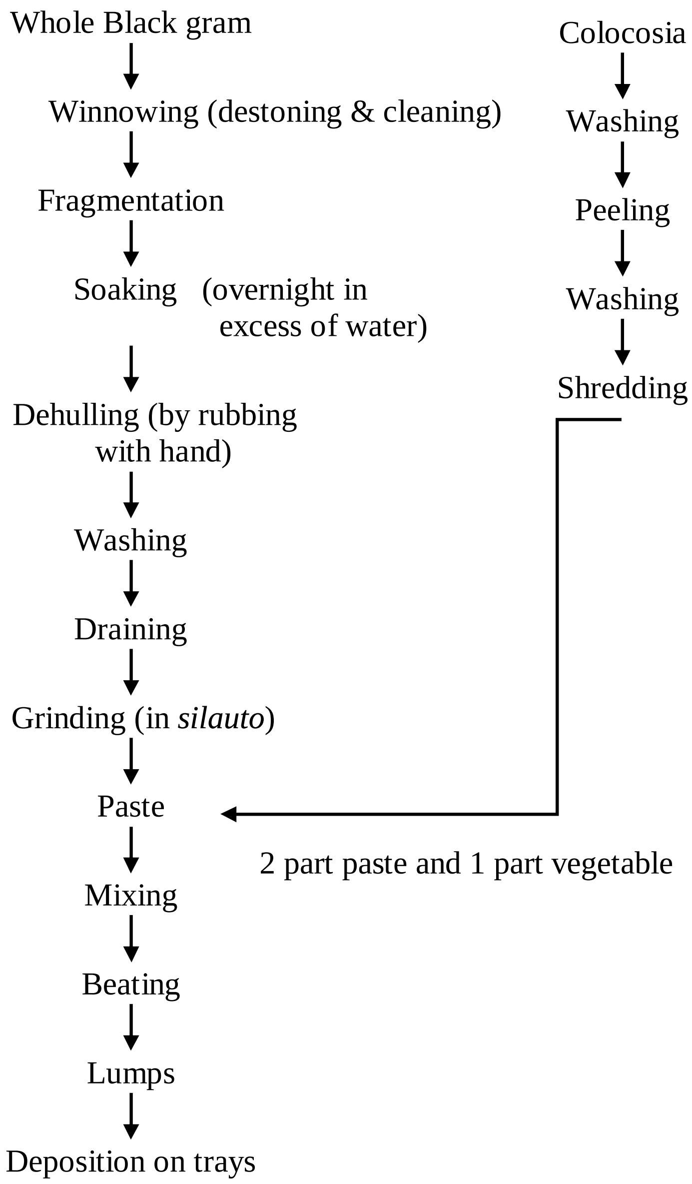
In traditional method, the balls are spread on bamboo trays sprinkled with wheat flour. Finally, they are subjected to sun drying for 3-4 days (Gajurel and Vaidya, 1979). Lumps of *Masyeura* begin to detach from the trays under complete drying condition and can be easily picked up.

The *Masyeura* can also be dried in cabinet drier at temperature 50-55 ^{0}C for 12-15 hrs even more if needed (Subba, 1985). The dried *Masyeura* are collected and stored.

Regarding the cooking quality they can be improved by making right combination of ingredients and using dehulled pulses. The toughening of *Masyeura* is due to the protein content of the black gram that holds the vegetables tightly and gives characteristic texture. For good *Masyeura*, it should be light, porous in nature and the bulk density should be less (Subedi, 1999).

2.6.1 Flow sheet of traditional method of *Masyeura* preparation

According Subedi (1999) to the traditional method of *Masyeura* preparation is shown in Fig 2.1.



↓

Sun drying (3-4 days)

↓

Masyeura (Moisture content 9-10%)

Fig 2.1 Traditional method of *Masyeura* preparation

2.6.2 Pre treatment on vegetables

2.6.2.3 Blanching

Heat treatment of foods for a short period prior to canning, freezing and dehydration followed by cooling is called blanching. It is generally applied to fruits and vegetables, and primarily carried out to inactivate enzymes (Kharel and Hashinaga, 2004)

Blanching is a critical step in processing fruit and vegetables due to the changes it causes such as enzyme inactivation, air removal, and leaching of nutrients. This process has an important effect on texture and moisture transfer (Bhalla, 1986).

Blanching serves a variety of functions, one of the main ones being to destroy enzymatic activity in preservation but as a pre-treatment which is normally carried out between the preparation of the raw material vegetables and some fruits, prior to further processing. As such, it is not intended as a sole method of and later operations (particularly heat sterilization, dehydration and freezing) (Wilhelm *et al.*, 2005).

2.6.2.3.1 Effect of blanching on quality of dried product

a) 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 a lesser extent, oxidation. The extent of vitamin loss depends on a number of factors including:

• The maturity of the food and variety

• Methods used in preparation of the food, particularly the extent of cutting, slicing

• The surface-area-to-volume ratio of the pieces of food

• Method of blanching

• Time and temperature of blanching (lower vitamin losses at higher temperatures for shorter times)

• The method of cooling

• The ratio of water to food.

b) Color and flavor

Blanching brightens the color of some foods by removing air and dust on the surface and thus altering the wavelength of reflected light. The time and temperature of blanching also influence the change in food pigments according to their D value.

Heat during blanching inactivates the natural enzymes present in foods and thus oxidative and other types of chemical reactions are also inhibited, which, otherwise may affect the color of the product during subsequent processing (Kharel and Hashinaga, 2004).

When correctly blanched, most foods have no significant changes to flavor or aroma, but under-blanching can lead to the development of off-flavors during storage of dried or frozen foods (Fellows, 2000)

c) Texture

One of the purposes of blanching is to soften the texture of vegetables to facilitate filling into containers prior to canning. However, when used for freezing or drying, the time–temperature conditions needed to achieve enzyme inactivation cause an excessive loss of texture in some types of food (for example certain varieties of potato) and in large pieces of food. Calcium chloride (1–2%) is therefore added to blancher water to form insoluble calcium pectate complexes and thus to maintain firmness in the tissues (Fellows, 2000).

2.6.3 Soaking

Soaking is a pretreatment for decortications of grain and legumes to facilitate the removal of the husk or skin. Non corticated legumes that are soaked in water for a short time lead themselves to easy husk removal. Siegel and Fawlett (1970) reported that the husk takes up more water than the rest of grain, whereby it becomes easily separable.

A temperature of 20-25ºC is recommended with steeping times of 16-20 hours for legumes (Hough *et al.* (1975) and Kent (1983)).

2.6.4 Drying

Drying is a thermo-physical and physicochemical process by which the excess moisture from the product is removed. The purpose of dehydration is to enhance storability and minimize packaging and handling cost. Pretreatment, drying temperature, drying time, drying method and moisture content of the product highly influence the final quality. Several drying techniques such as sun-drying, solar drying, hot-air, tray and cabinet drying, fluidized bed drying, vacuum drying, infra-red drying, microwave drying, freeze drying and osmotic dehydration have been used successfully for vegetables to prolong their self life and storability. Drying times may vary, depending on the type and amount of food, thickness and evenness of the slices, percentage of water in the food, humidity and temperature of air, altitude and the model of dryer used for drying (Chandra, 2006).

Subba (1985) recommended a temperature of 50-55ºC for 12 – 15 hrs and Dahal *et al.* (2003) recommended 16 hrs at temperature 50^{o}C for drying of *Masyeura*.

2.6.5 Packaging of *Masyeura*

If the climate is dry, it may not be necessary to package dried foods as they will not pick up moisture from the air. However, a humid climate is likely to result in dried foods gaining moisture and going mouldy. The stability of dried foods depends not only on the humidity of the air at which a food neither gains nor loses weight (the 'Equilibrium Relative Humidity'), but also on the type of food. Different foods can be grouped according to their ability to absorb moisture from the air. The two groups are hygroscopic, which absorb moisture easily and non-hygroscopic, which do not absorb moisture. This difference determines the packaging requirement for different products. Dried vegetables are usually packaged in one of the many different types of plastic film. Although thin polythene film is usually the cheapest and most widely available material, it is suitable for storing dried product as *Masyeura* for a short time before they pick up moisture, soften and go mouldy. Polypropylene has better barrier properties and therefore gives a longer shelf life, but it is usually more expensive and it may not be available in many countries (Repository, 2014).

Packaging and storage studies showed changes in moisture content and appearance of moulds or insects during storage at room temperature. Products had a shelf life of 6 months at room temperature in 120 gauge polypropylene bags for product *wari* similar to *Masyeura* (Kulkarni *et al.*, 1997).

2.7 Packaging

Packaging is defined as a coordinated system of preparation of goods for shipment, distribution, storage and marketing at optimum cost, compatible with the requirement of the product. Packaging is an essential part of processing and distributing foods. Whereas preservation is the major role of packaging, there are several functions for packaging, each of which must be understood by the food manufacturer (Potter and Hotchkiss, 2005).

According to Paine and Paine (1983), definitions of packaging;

a. A coordinated system of preparing goods for transport, distributions, storage, retailing and end-use.
b. A means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost.
c. A techno-economic function aimed at minimizing costs of delivery while maximizing sales (and hence profits).

2.7.1 Food packaging materials and forms

There are relatively few materials used in food packaging; metal, glass, paper and paperboard, plastics, and minor amounts of wood and cotton fibre. However, within each of these categories many types of packaging materials or combination of materials are available. In the case of polypropylene film alone, there are dozens of types of films and laminates varying in moisture permeability, gas permeability, flexibility, stretch, burst strength, and so on. Often, a new food product requires its own special package since optimum protection, economic considerations, and merchandising requirements change rapidly with variations in product composition, weight and form, and performance demands. Packaging material are found in a wide variety of forms including the following: Rigid metal cans and drums; flexible aluminum foils; glass jars and bottles; rigid and semi rigid plastics can and bottles; flexible plastics made from many different films used for bags, pouches, and wraps; paper, paperboard, and wood products in boxes, pouches and bags; and laminates or multilayer in which paper, plastic, and foil are combined to achieve properties unattainable with any single component. (Potter and Hotchkiss, 2005).

2.7.2 Types of containers

The most commonly used containers for packaging of food products are: Pouches, Cartoons, Metal cans, Rigid plastic containers, Papers, Paperboard, Plastic materials like

Cellophane, Polyethylene, Plastic films, Polypropylene, Laminating films, foils etc (Shah, 1993).

2.7.3 Special feature for dried fermented products

The most critical factors for dry products in relation to packaging are moisture uptake leading to loss of crispiness and oxidation of fats resulting in development of rancidity. Other modes of deterioration include oxidation of vitamins, breakage of products, loss of aroma, discoloration, mould growth, staling, and fat bloom depending on the product. Thus, the most important requirements for the packaging materials include high moisture, oxygen, and light barrier properties and high mechanical strength (Paudel, 2011).

Masyeura are dried fermented products. The moisture content is generally from 8-10%. However a humid climate is likely to result in dried foods gaining moisture and going mouldy it may be susceptible to moisture gain which consequently softens the product and increase in acidity above the acceptable range. Increase in acidity though itself may be one of the preservation effect for fermented food but sour taste on *Masyeura* is not acceptable. So the consideration that has to take in mind is the prevention from increment of moisture and acidity (Subedi, 1999). Here is short description about these aspects of the products.

2.7.3.1 Reducing oxygen in the package

Most obvious change in acidity is by action of microorganism involved in fermentation. It is therefore believed that product contents high acidity if there is longer fermentation time (Deo, 2003). To control the esthetic deterioration (undesirable characteristic change in flavor and odor) inert filling is practiced e.g. nitrogen, carbon dioxide or vacuum pack is profitable for long time storage (Shah, 1993).

2.7.3.2 Reducing moisture vapor transfer

Moisture is the most important factor for stability of the dried product. So, the moisture barrier type material should be necessary. This property is simply tested by weighing the sample at certain interval and gain or loss in weight is observed, it indicates bad barrier properties (Shah, 1993).

The moisture barrier properties of some important materials are shown in Table 2.5

Table 2.5: Moisture barrier properties of some important materials

S.N.	Film	Water vapour transmission rate (gm/100in sq./24 hr/mm thickness)
1	Aluminium foil	0.01-0.02
2	Oriented polypropylene	0.2-0.4
3	Nitrocellulose-coated cellophane	0.7-1.0
4	Polymer coated cellophane	0.5-0.8
5	Unoriented polypropylene	0.6-0.9
6	Low Density Polythelene	1.0-2.0
7	Polymer coated oriented poly propylene	0.3-0.4

Source: Shah (1993)

2.7.4 Plastics as packaging materials

The share of plastics in the packaging market has been growing at remarkable pace, partially replacing paper, glass, and metal. Because of their unique combination of properties, plastics have expanded the packaging industry to sophisticated levels. Plastics containers are light weight, breakage resistant, transparent, flexible, squeezable, moldable in complex shapes, easily colored and printed, retortable, sterilizable, reusable, and recyclable. Plastics have many positive tradeoffs within their array of versatile properties, including easy processing, good mechanical properties, large range of processing temperature, lowest density among packaging materials, and (for better or worse) they are permeable materials. In addition, plastics are economically competitive in cost with paper, glass, steel, and aluminium (Hernandez, 1997).

2.7.5 Selection of proper packaging materials

Description of packaging materials is very complicated subject because in the modern development of plastic technology additional developments in design, use, merits and demerits are added day by day. Detail information is not possible here so on the basis of requirement of the product and the availability of packaging material and other technical constraints, only two types of packaging materials are preferred. So plastic packages that is going to be used in the work is described here in short, they are;

a. Higher Density Polyethylene (HDPE)
b. Lower Density Polyethylene (LDPE)

2.7.5.1 Higher Density Polyethylene (HDPE)

This belongs to a family of polymers of hydrocarbons which have one double bond per monomer. Because it contains only carbon and hydrogen, when burned it forms carbon dioxide, carbonic acid and water. HDPE is produced at lower temperatures and atmospheric pressure as a liquid phase process. It softens at 120 – 130ºC and so it can be used for hot filling, steam sterlizing or cook in the bag applications. Due to its greater rigidity it can be used in thinner gauges thereby saving money. It has excellent retention of essential oils such as aromas. In general the polyethenes are soft and flexible in film form with good impact resistance. However, they can be hard to open. They are very resistant to water and water vapor; the higher the density, the greater the resistance i.e. the lower the value of WVTR, but the oxygen transmission rate is high (Athalye, 1991). Main advantages of high density polyethylene are,

a. Water proofness, low gas and water vapor permeability.
b. Good aroma retention.
c. It is heat sealable, can be oriented and made into bags.
d. It is useful in wrapping meat, fish and dried foods.

2.7.5.2 Low Density Polyethylene (LDPE)

LDPE is formed at high pressures (1000–3000 atm). These results in long branched chains, weakly linked to each other by van der Waals forces (but strong overall force due to length). The branching is random, and so LDPE is an atactic polymer. It may be used at temperatures up to 95° Celsius for short periods and at 80° Celsius continuously (Athalye, 1991). Main advantages of LDPE are,

a. Low cost
b. Impact resistant from -40 ^{o}C to 90 ^{o}C
c. Moisture resistance
d. Good chemical resistance
e. Food grades available
f. Readily processed by all thermoplastic methods

For best WVTR and barrier properties, the preferences are (Athalye, 1991);

a. Aluminium foil and metallized films for the best barrier
b. PVDC and EVOH for the best non-foil barrier
c. PP, HDPE, LDPE for good protection

d. Poly-coated paper for limited protection
e. Paper or permeable cellulose film for allowing the product to breathe.

2.7.6 Safety of food packaging

2.7.6.1 Migration from plastics

It is important to know that plastics are not completely inert to foods. Aside from the permeation of gases and vapors, it is also possible that components of the plastics can migrate to the food and would then be consumed with the food. This raises concern for the safety of some plastics. For this reason, all plastics used in food contact must have specific approval from regulatory agencies for the intended use. Food manufacturers must get written assurance from the plastic manufacturer that their container wrap meets all requirements for use in food contact (Potter and Hotchkiss, 2005).

2.7.6.2 Contamination

It is primarily which acts as a barrier to contamination of foods. Preventing recontamination of thermally processed low-acid food which are stored at room temperature is especially serious. Recontamination with pathogens bacteria such as *Clostridium botulinum* can lead to outbreaks of food-borne disease. One example occurred when fish had been processed in defective metal cans which contained small holes. Several people ended up with botulism, which is often fatal (Potter and Hotchkiss, 2005).

2.8 Shelf-life determination

Shelf life is the time between the product being harvested or processed and packed until its quality has deteriorated to an unacceptable level. This may be due to organoleptic reasons such as a loss of texture or flavor or to microbial reasons such as mold growth, etc. Therefore the shelf life is the time during which the product can be consumed. Canned foods are shelf stable at ambient temperatures for several years due to the sterilization process, whereas fresh foods such as milk and bread have a relatively short life and are often described as perishable. Packaging must be suitable to protect the product from the external hazards, such as moisture, light, oxygen, microbial contamination, impacts, drops, etc. In selecting a suitable packaging material, consideration must be given to the hazards to which the product will be subjected. The food products may deteriorate due to rancidity, staling, microbial spoilage, enzymatic reactions, etc and of the processes used to retard deterioration include sterilization, pasteurization, freezing, and aseptic processing (Paudel, 2011).

The shelf-life of the product in the package under specified conditions can be confirmed by several methods, viz., (1) weight gain or loss method, (2) method based on testing the performance of the product, and (3) biochemical changes during storage. All these tests are related to water vapor and oxygen permeability of the packaging material, which in turn indicates the increase of moisture content and acidity of the product overtime. All shelf-life assessment methods use accelerated and controlled conditions so that an accurate prediction of shelf-life can be possible within a short time (Kumar, 2001).

Storage temperature conditions should then be chosen which fit the product and give reliable results in a reasonable amount of time. Common temperatures used would be 20, 25 30, 40, and 55°C (68, 77, 86, 104, and 131°F). A control, stored at 0°F, can also be used. The frequency of the analytical testing is the next important decision. The higher the storage temperature, the more frequent should be the testing. Weekly tests are common for most products (Sewald and DeVries, 2000).

2.9 Uses of *Masyeura*

The use of *Masyeura* can be listed as follows.

- used as soup,
- as a adjunct in curries
- even as curry during off season.

2.10 Desirable Characteristics of *Masyeura*

The desirable characteristics of *Masyeura* can be listed below (Subedi, 1999).

- Dry (any moisture remained may spoil the product).
- Less fragile
- Creamy white color
- High rehydration ratio
- Low bulk density
- Fleshy on chewing
- Mild sour nature on flavor and taste
- Absent of any off flavor

2.10 Defects and spoilage on *Masyeura*

The defects on *Masyeura* experienced can be listed below (R. Shrestha, 2013).

- Hard in texture which results longer time on cooking. It is the result of hard and coarse dough.
- Flat shape will occur if the paste made in thin.
- Fragile if paste in thin
- Blackening of product if iron or copper vessel has been used during processing.
- Off flavor and Sour on taste on prolonged fermentation.
- Growth of pest and mold if sufficient moisture has not been removed

2.11 Works carried out in *Masyeura*

1.Preparation and study of *Masyeura* – a traditional food product (Subba, 1985). Ingredients used: black gram and colocosia. The products were sun dried. Different ratio of pulses and vegetables were used but the ratio 2:1 was found to the best.

2.Preparation and quality evaluation of *Masyeura*- based on locally available raw materials (Lama, 1988). Ingredients used: Pulses (black gram and green gram, vegetables (colocosia, chayote, and bottle gourd) and green leafy vegetable (rape leaves). Rape leaves were used to replace 25% of fruit vegetables. The ratio of pulse and vegetable used were 2:1. The products were cabinet dried.

3.Formulation and preparation of protein rich *Masyeura* (Subedi, 1999). Ingredients used: black gram, colocosia and soybean. Soybean was used in different quantity. The ratio of pulse and vegetables used were 2:1. The products were cabinet dried.

4. Study on the effect of fermentation time and temperature on the quality of *Masyeura* (Deo, 2003). *Masyeura* was prepared from black gram and colocosia with ratio 2:1.

Part III

Materials and Methods

3.1 Materials

3.1.1 Pulses

Split pulse black gram, (*Phaseolus mungo*) brought from local market of Dharan.

3.1.2 Vegetables

Chayote fruit (*Schieum edule*) local name *iscuss* cultivated throughout hilly region of eastern Nepal of two varieties white and green was brought from Dharan Bazzar.

3.1.3 Apparatus

Peeler: The abrasive peeler is used to peel the skin of chayote.

Knives: Stainless Knives were used for the purpose of cutting.

Shredder: Stainless shredder are used for shredding of chayote

Blender: The blender consists of sharp blades and rotates in high speed it makes paste of black gram.

Dryer: Electric dryer was used to dry the product.

3.1.4 Packaging material

HDPE and LDPE were used for the packaging of the product. The material available in Dharan market was used.

3.2 Methods

3.2.1 Preliminary operation

3.2.1.1 Black Gram

Black gram was winnowed and washed to remove dirt, dust, husk and foreign materials. Then it was soaked overnight in excess water. The soaked black gram was dehulled by scrubbing on palm and washed. It was then ground into thick paste using a wet grinder.

3.2.1.2 Chayote

The chayote was peeled, washed, sliced and was shredded.

3.2.2 Variation

3.2.2.1 Varieties of chayote

The chayote taken for preparation of *Masyeura* was of two varieties *viz.* green and white.

3.2.2.2 Process variation

The process variation was blanching and un-blanching the shreds of each chayote varieties. The blanching adequacy test was done to optimize the blanching time and temperature. For optimization 10 g of shredded chayote was blanched in plain water at 85ºC for 0, 30, 60, 90, 120, 150, 180, 210 seconds followed by cooling in cold water.

3.2.2.3 Proportional variation

The blanched and unblanched shreds were then varyingly mixed with paste of dahl in different proportional ratio. As according to (Subba, 1985), (Lama, 1988) (Subedi, 1999) the ratio of black gram and vegetable at 2:1 gave the best result. According to Dahal *et al.* (2003) the *Masyeura* can be made from equal proportion of dahl paste and colocosia. But in this turn being the vegetable replaced by chayote instead of colocosia the variation of black gram paste and chayote was done by 50-50, 40-60 and 60-40 part i.e. at ratio 1:1, 4:6, and 6:4 in both varieties of chayote blanched and unblanched. The flow chart for preparation of *Masyeura* is shown in Fig 3.1

3.2.3 Product preparation

3.2.3.1 Dough Preparation

The shredded mass of chayote and paste of dahl was mixed as per calculated amount on wet basis. The dough was prepared of each variety, blanched and unblanched in ratio of 1:1, 4:6 and 6:4.

Then the mixture was beaten by hand. The fully consistent paste was made and small lumps of the mixture were made on trays.

3.2.3.2 Fermentation

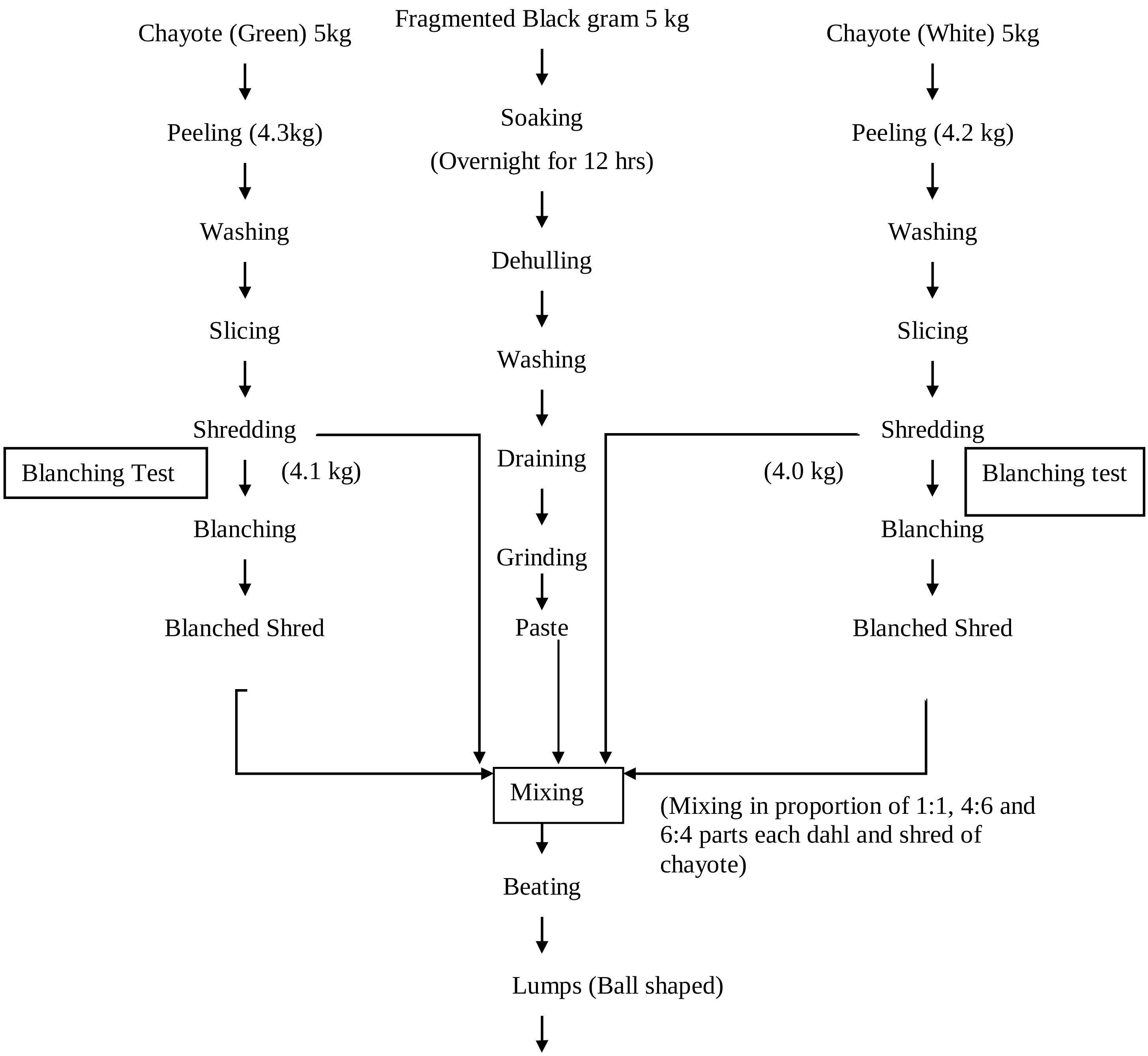
The lumps of *Masyeura* was kept for fermentation for overnight for 12 hrs at room temperature (25^{o}C) (Dahal *et al.*, 2003).

3.2.3.3 Drying

The lumps of *Masyeura* kept for fermentation was then dried on cabinet dryer for 16 hrs at constant temperature of 50 ^{o}C (Dahal *et al.*, 2003).

3.2.3.4 Packaging

After completion of proper drying, the products were packed immediately in polythene bags. Then it was re-packed in experimental packaging material HDPE and LDPE and sealed by heat sealer. The package were kept at room temperature condition i.e., at 25±3ºC, RH 80%.



Deposition on trays

↓

Fermentation (overnight for 12 hrs at 25°C)

↓

Cabinet Drying (50 °C for 16 hrs)

↓

Masyeura (moisture content to 9-10 %)

Fig 3.1 Outline for the preparation of *Masyeura* (in pilot plant scale).

3.2.4 Evaluation of Prepared *Masyeura*

The prepared *Masyeura* were coded as shown in Table 3.1

3.2.4.1 Physical analysis

3.2.4.1.1 Determination of rehydration ratio

Determination of rehydration ratio of the sample was carried out according to Ranganna (2010).

$$\text{Rehydration ratio} = \frac{\text{Wt. of rehydrated sample}}{\text{Wt. of dehydrated Sample}}$$

3.2.4.1.2 Determination of bulk density

Representative samples were taken from each lot, weighed and their volumes were determined by using sound mustard seed in a graduated cylinder (Deo, 2003).

$$\text{Bulk density} = \frac{\text{Wt. of sample}}{\text{Gross volume of Sample}}$$

3.2.4.2 Sensory analysis of *Masyeura*

The Sensory evaluation was carried out by hedonic rating using 9 point numerical score described by Ranganna (2010). 10 panelist including teachers and students of CCT carried out the evaluation. Sensory evaluation was carried out on the quality attributes *viz.* color, flavor, texture and overall acceptability for uncooked *Masyeura* and the attribute taste was added for cooked *Masyeura*. The superior variations found from analysis of uncooked *Masyeura* were selected for cooking which was compared to sensory attributes of *Masyeura* made from black gram and colocasia at ratio 2:1 (Subedi, 1999). Sensory evaluation was carried out in individual booth with adequate light and free from obnoxious odors. Each panelist was provided 4 samples (uncooked) of each proportion and 4 samples (cooked) coded random numbers and evaluation card (Appendix A).

Table 3.1: Sample Code for prepared *Masyeura*

Code	Proportion	Variety
A11	50 part paste and 50 part shred (1:1)	Green Unblanched
B11	50 part paste and 50 part shred (1:1)	White Unblanched
C11	50 part paste and 50 part shred (1:1)	Green Blanched
D11	50 part paste and 50 part shred (1:1)	White Blanched
A46	40 part paste and 60 part shred (4:6)	Green Unblanched
B46	40 part paste and 60 part shred (4:6)	White Unblanched
C46	40 part paste and 60 part shred (4:6)	Green Blanched
D46	40 part paste and 60 part shred (4:6)	White Blanched
A64	60 part paste and 40 part shred (6:4)	Green Unblanched
B64	60 part paste and 40 part shred (6:4)	White Unblanched
C64	60 part paste and 40 part shred (6:4)	Green Blanched
D64	60 part paste and 40 part shred (6:4)	White Blanched

3.2.4.2 Sensory analysis of *Masyeura*

The Sensory evaluation was carried out by hedonic rating using 9 point numerical score described by Ranganna (2010). 10 panelist including teachers and students of CCT carried out the evaluation. Sensory evaluation was carried out on the quality attributes *viz*. color, flavor, texture and overall acceptability for uncooked *Masyeura* and the attribute taste was added for cooked *Masyeura*. The superior variations found from analysis of uncooked *Masyeura* were selected for cooking which was compared to sensory attributes of *Masyeura* made from black gram and colocasia at ratio 2:1 (Subedi, 1999). Sensory evaluation was carried out in individual booth with adequate light and free from obnoxious odors. Each panelist was provided 4 samples (uncooked) of each proportion and 4 samples (cooked) coded random numbers and evaluation card (Appendix A).

3.2.4.3 Soup Preparation for sensory analysis

Each sample was prepared and cooked, following the same recipe and methods of cooking under the same condition. It was first fried in oil of temperature 200 ^{o}C for 1.5 to 2 minutes till brown color was seen and was thoroughly cooked in boiling water for 15 minutes (Gajurel and Vaidya, 1979). The recipe of *Masyeura* preparation for the evaluation was as follows:

Masyeura = 30 g

Cooking oil = 20 ml

Water = 60 ml

The panelist provided with different coded samples was asked to evaluate the most acceptable *Masyeura* prepared at different proportion of varieties and processing.

3.2.4.4 Proximate Analysis

The determination of major components (moisture, minerals, carbohydrates, lipids and proteins) is called proximate analysis. The components analyzed are called proximate constituents. The proximate constituents are not limited to the components stated above. In the case of acid food, for example, the acid content has to be considered as a proximate constituent. Proximate analysis gives useful information, particularly from the nutritional and biochemical points of views. The result is 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 instance, crude protein, crude fat, crude fiber, etc. Proximate constituents therefore represent only a category of compound present in a biological material. Analysis of particular element or compound, such as vitamins, reducing sugars, etc., is termed ultimate analysis. In other words, ultimate analysis is a more detailed analysis of proximate constituents. The best product was subjected for proximate analysis (Rai and K.C., 2007).

3.2.4.4.1 Moisture content

Moisture content was determined using hot air oven method as per Ranganna (2010).

3.2.4.4.2 Crude protein

Crude protein was determined by Micro Kjeldahl method as per Ranganna (2010).

3.2.4.4.3 Crude fat

Fat content in the product was determined by soxhlet extraction method as per Ranganna (2010)

3.2.4.4.4 Total ash

Total ash was determined by ashing in electric muffle furnace as per Ranganna (2010)

3.2.4.4.5 Crude fiber

Crude fiber was determined by washing the defatted sample with 1.25% H_2SO_4 and 1.25 % NaOH as per Ranganna (2010).

3.2.4.4.6 Total carbohydrate

Total carbohydrate was determined by difference method.
Total carbohydrate (%) = 100- (moisture + protein + fat + crude fiber + ash) %

3.2.4.4.7 Vitamin C

Vitamin C content was determined as per Rai and K.C. (2007)

3.2.4.5 Evaluation of Microbiological Quality

3.2.4.5.1 Total Plate Count (TPC)

TPC was carried out using the method of AOAC (1990)

3.2.4.5.2 Yeast and Mold

Yeast and Mold was determined according to AOAC (1990).

3.2.5 Changes during storage period

Following chemical analysis were carried out in each interval of one week.

3.2.5.1 Chemical analysis

3.2.5.1.1 Acidity

Acidity value was determined according to Ranganna (2010)

3.2.5.1.2 Moisture

Moisture content was determined according to Ranganna (2010)

3.2.6 Cost Calculation

The cost of *Masyeura* preparation was calculated including a profit of 10%.

3.2.7 Data analysis

Data on sensory analysis were tabulated for comparison and were graphically represented using Microsoft Excel-2007. Data were statistically processed by GenStat Discovery

Edition 3, GenStat Procedure Library Release PL15.2, Version 7.22 DE (Copyright 2008, VSN International Ltd) for Analysis of Variance (ANOVA). Means of the data were separated whether they are significant or not by using LSD (least square difference) method at 5% level of significance.

Part IV

Results and Discussion

4.1 Chemical Composition of Raw materials

4.1.1 Black gram

The basic raw material for preparation of *Masyeura*, black gram was subjected for proximate analysis. The result of proximate analysis is shown on table 4.1.

Table 4.1: Chemical composition of black gram

Parameters	Reference value	Experimental Value
Moisture (%)	10.9	8.9 (0.13)
Protein (%)	24.0	22.1 (0.19)
Fat (%)	1.4	1.2 (0.42)
Ash (%)	4.3	3.2 (0.12)
Crude fiber (%)	0.9	0.9 (0.2)
Carbohydrate (%)	58.5	63.7 (0.73)

The experimental values are the means of triplicate samples and the values in the parenthesis are standard deviation.

The value obtained of moisture content, protein and fat was quite below as stated by (Swaminathan and Bhagwan). This variation in moisture may be due to variation in maturity of pulse and also the storage condition of raw material. The variation in protein content and fat may be due to the various factors such as nature of soil, environmental conditions for cultivation and varieties of raw materials. The ash content was lower than the reported value 4.3 % by Siegel and Fawlett (1970). The values for crude fiber were within the range stated by Swaminathan and Bhagwan (1976).

4.1.2 Chayote

As the raw material for preparation for *Masyeura* was trialed for chayote its proximate analysis were performed. The obtained value for green and white variety is shown on table 4.2

Table 4.2: Chemical Composition of Chayote

Parameters	Reference value	Experimental value (Green)	Experimental value (White)
Moisture (%)	89-93	92.8 (0.23)	89.10 (0.35)
Protein (%)	0.9-1.1	1.1 (0.29)	1.2 (0.12)
Fat (%)	0.1-0.3	0.1 (0.38)	0.2 (0.25)
Ash (%)	0.4-0.6	0.5 (0.12)	0.7 (0.2)
Crude fiber (%)	0.4-0.1	0.6 (0.2)	0.9(0.42)
Carbohydrate (%)	3.5-7.7	4.9 (0.63)	7.9 (0.73)
AscorbicAcid (mg/100gm)	11-20	14.7(0.14)	17.2(0.19)

The experimental values are the means of triplicate samples and the values in the parenthesis are standard deviation.

The amount of moisture content, protein, fat, ash, crude fiber, carbohydrate and vitamin C in chayote were within the range similar to 89-93.4, 0.9-1.1, 0.1-0.3, 0.4-0.6, 0.4-1.0, 3.5-7.7 and 11-20 mg value as given by (Saade, 1996). This shows very much similarity to chayote of green and white variety.

4.2 Optimization of blanching time

The cleaned, washed chayote was sliced and blanched for 0 sec, 30 sec, 60 sec, 90 sec, 120 sec, 150 sec, 180 sec and 210 sec. The peroxidase test on respected time has been shown on table 4.3.

Table 4.3: Peroxidase test for chayote blanching at 85ºC

Sample no	0 sec	30 sec	60 sec	90 sec	120sec	150sec	180sec	210sec
1	+	+	+	+	+	+	-	-
2	+	+	+	+	+	+	-	-
3	+	+	+	+	+	+	-	-

(‘+’ indicates the positive peroxidase test, ‘_’ denotes the negative peroxidase test)

The blanching time was found to be 180 sec at 85 ^oC in plain water. The work carried out by Azizi and Ranganna (1993) suggested the time of 3 min at the boiling temperature of water to be sufficient for blanching of fruits and vegetables. These test were found to be same for both varieties of chayote.

4.3 Physical Analysis of *Masyeura*

All the samples were analysed for rehydration ratio and bulk density. The values are tabulated in appendix D.1

4.3.1 Rehydration ratio

The effect of proportion of pulse and vegetable with treatments in *Masyeura* is shown in Fig 4.1.

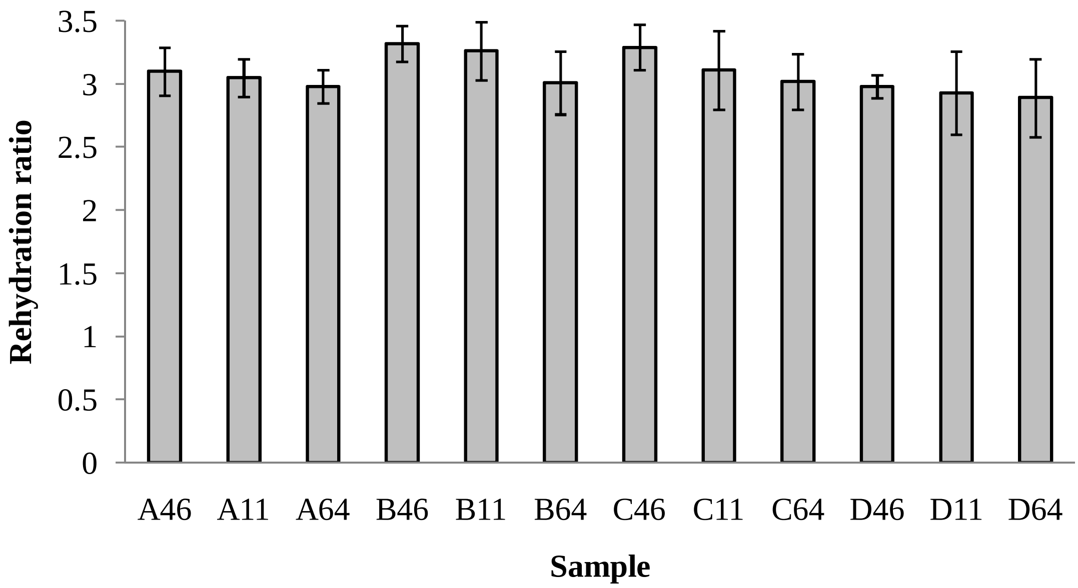


Fig 4.1 Effect of pulse and chayote proportion on rehydration ratio of *Masyeura*

Note: They are the mean of triplicate samples. The error bar in the figure shows the standard deviation from mean.

Reconstitution or rehydration is the restoration of a dehydrated food product to essentially its original edible position by the simple addition of water. More the ratio, closer will be the dehydrated product towards its original position (Considine and Considine, 1982). As the product is rehydrated prior to consumption the rehydration ratio analysis is thought to be important analysis to be done. Dehydration rate tends to follow rehydration rate i.e. faster the drying better would be the rehydration values. Usually, products having higher rehydration values are preferred (Subedi, 1999). From graphical analysis it was revealed that the products having higher proportion of pulses have lower rehydration ratio than the products having lower proportion of pulses. Similar result has been reported by Subedi (1999) but they were not significantly difference (p>0.05) to each other as shown in appendix C. This may be due to longer time taken by product to get dried which contains higher proportion of pulse.

4.3.2 Bulk density

The effect of proportion of black gram paste and vegetable shred on bulk density has been shown on figure 4.2.

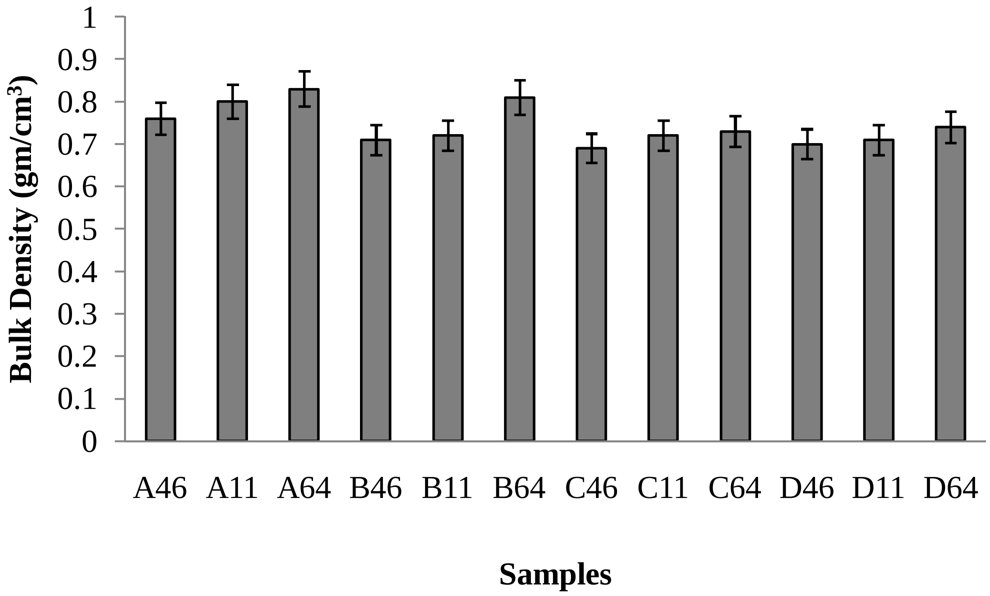


Fig 4.2 Effect of pulse and chayote ratio on bulk density of *Masyeura*

Note: They are the mean of triplicate samples. The error bar in the figure shows the standard deviation from mean.

Bulk density is defined as the weight of grain in a fixed volume. From the graphical analysis the bulk density of the products having higher proportion of pulses has higher value than the products having lower proportion of pulses. ANOVA showed that there is significant difference between samples at 95 % level of confidence. Subba (1985) reported that increasing the vegetables in the formulation keeping the amount of black gram constant, the bulk density decreases proportionally. Low bulk density may be the result of porous product.

4.4 Sensory analysis of uncooked *Masyeura*

The prepared *Masyeura* were subjected for sensory analysis. The samples were provided to 10 semi trained panelist. The semi trained panelists evaluated for various parameters of

Masyeura namely, color, flavor, shape, texture and overall acceptability. The panelists were requested to provide scores in the score sheets as per their perception. Data were analyzed statistically and superior product was found out.

4.4.1 Effect of treatment and variety on color of *Masyeura*

The prepared *Masyeura* of ratio 1:1, 4:6 and 6:4 has been subjected for analysis. The effect of treatment and variety on color has been shown on Fig 4.3.

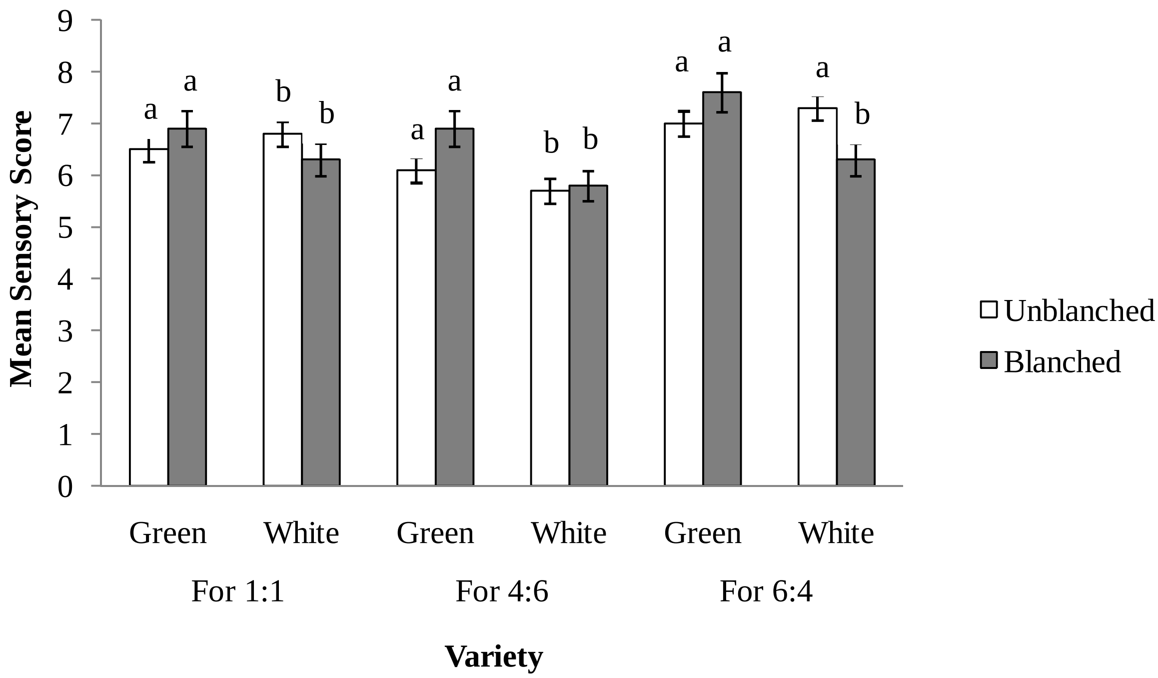


Fig 4.3 Average sensory score for color with different treatments and varieties.

Note: This graph consist combined plot for different proportion. The letter above bar denotes significant difference and is confined to each proportion separately. No comparison within proportion is done.

The average sensory score for color was 6.5, 6.9, 6.8, and 6.3 for sample A11, C11, B11, and D11 respectively at mixing proportion of 1:1. Analysis of variance showed that there is significant effect ($p<0.05$) on color due to variety but not due to treatment. LSD showed that C11, B11 is significantly different to D11, where C11 got the highest mean score.

Similarly, the average sensory score for color was 6.1, 6.9, 5.7 and 5.8 for sample A46, C46, B46, and D46 at mixing proportion of 4:6 respectively. Analysis of variance showed that there is significant effect ($p<0.05$) on color due to variety but not due to treatment.

LSD between sample showed there is significant different between C46 with B46 and D46, C46 got the highest sensory score.

Again, the average sensory score for color was 7, 7.6, 7.3, and 6.3 for sample A64, C64, B64, and D64 at mixing proportion of 6:4 respectively. Analysis of variance showed that there is no significant effect ($p>0.05$) on color due to variety and treatment alone but has significant difference ($p<0.05$) due to interaction between variety and treatment. LSD showed that C64 and B64 was significantly different with D64, where C64 got significantly highest sensory score.

4.4.2 Effect of treatment and variety on flavor of *Masyeura*

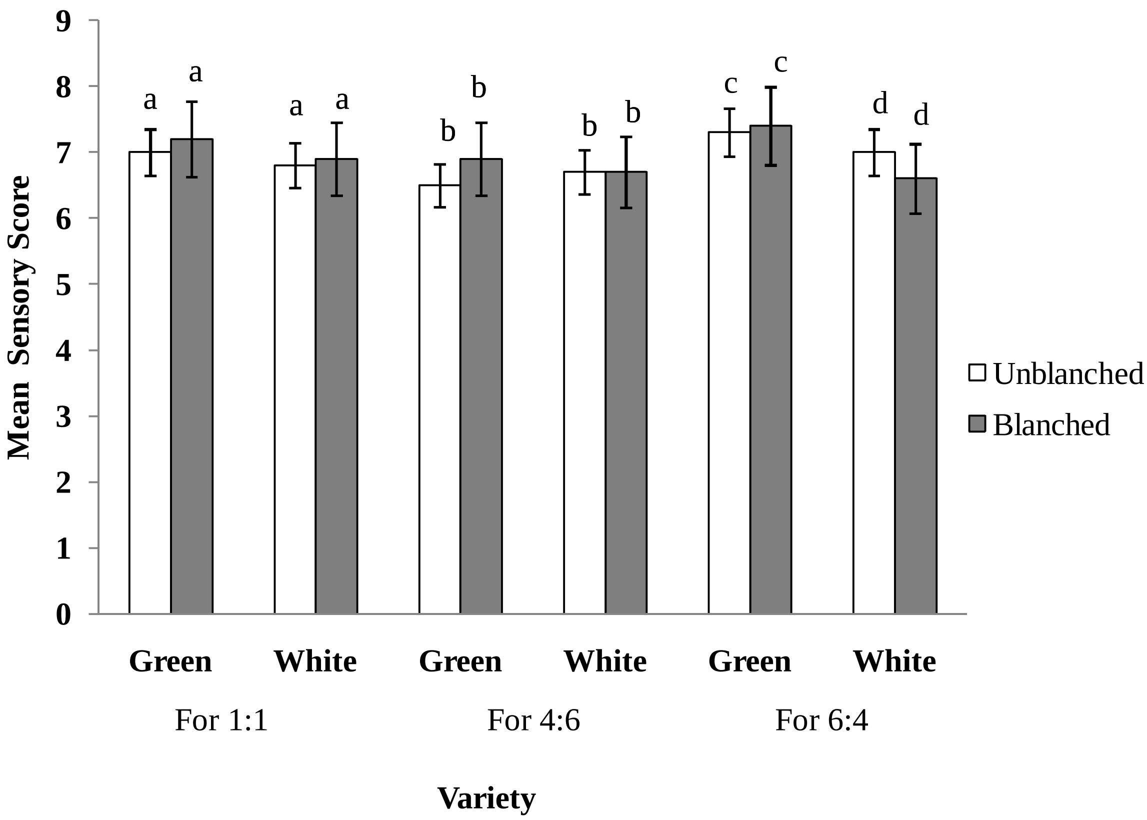


Fig 4.4 Average sensory score for flavor with different treatments and varieties.

Note: This graph consist combined plot for different proportion. The letter above bar denotes significant difference and is confined to each proportion separately. No comparison within proportion is done.

The average sensory score for flavor was 7, 7.2, 6.8, and 6.9 for sample A11, C11, B11, and D11 respectively at mixing proportion of 1:1. Analysis of variance showed that there is no any significant effect (p>0.05) on flavor due to variety and treatment. However, Fig 4.4 shows clear that C11 has got the highest mean sensory score.

Similarly, the average sensory score for flavor at proportion 4:6 was 6.5, 6.9, 6.7 and 6.7 for sample A46, C46, B46, and D46 respectively. Analysis of variance showed that there is no any significant effect (p>0.05) on flavor due to variety and treatment but sample C46 has got the highest sensory score.

Again, the average sensory score for flavor for *masyeura* at proportion 6:4 was 7.3, 7.4, 7, and 6.6 for sample A64, C64, B64, and D64 respectively. Analysis of variance showed that there is significant effect (p<0.05) on flavor due to variety alone. LSD showed that D64 was significantly inferior with A64 and C64. However C64 has got significantly highest sensory score.

4.4.3 Effect of treatment and variety on texture of *Masyeura*

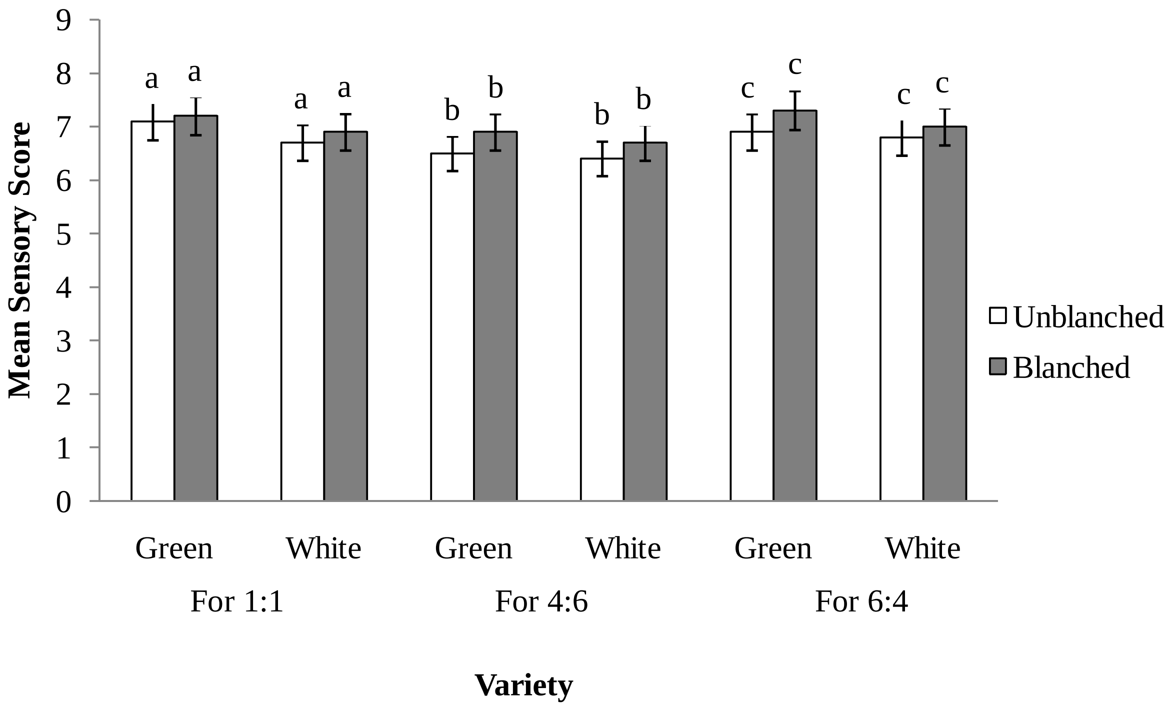


Fig 4.5 Average sensory score for texture with different treatments and varieties

Note: This graph consist combined plot for different proportion. The letter above bar denotes significant difference and is confined to each proportion separately. No comparison within proportion is done.

The average sensory score for texture was 7, 1, 7.2, 6.7 and 6.9 for sample A11, C11, B11, and D11 respectively at mixing proportion of 1:1. Analysis of variance showed that there is no any significant effect (p>0.05) on texture due to variety and treatment. However C11 has got the highest mean sensory score. It is clearly shown in Fig 4.5.

Similarly, the average sensory score for texture at proportion 4:6 was 6.5, 6.9, 6.4 and 6.7 for sample A46, C46, B46, and D46 respectively. Analysis of variance showed that there is no any significant effect (p>0.05) on texture due to variety and treatment but sample C46 has got the highest sensory score.

Again, the average sensory score for texture for *Masyeura* at proportion 6:4 was 6.9, 7.3, 6.8, and 7 for sample A64, C64, B64, and D64 respectively. Analysis of variance showed that there is no any significant effect (p>0.05) on texture due to variety and treatment. However C64 has got significantly highest sensory score.

4.4.4 Effect of treatment and variety on shape of *Masyeura*

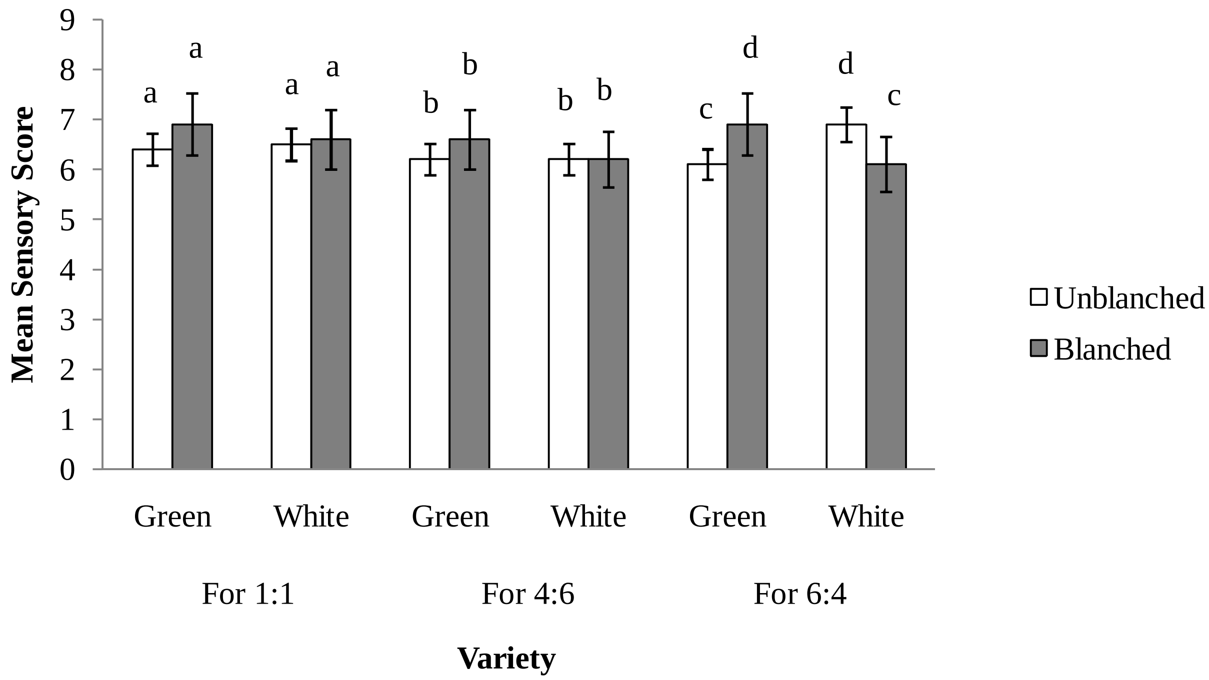


Fig 4.6 Average sensory score for shape with different treatments and varieties

Note: Fig 4.6 consist combined plot for different proportion. The letter above bar denotes significant difference and is confined to each proportion separately. No comparison within proportion is done.

The average sensory score for shape was 6.4, 6.9, 6.5, and 6.6 for sample A11, C11, B11, and D11 respectively at mixing proportion of 1:1. Analysis of variance showed that there is no any significant effect ($p>0.05$) on shape due to variety and treatment. However C11 has got the highest mean sensory score.

Similarly, the average sensory score for shape at proportion 4:6 was 6.2, 6.6, 6.2 and 6.2 for sample A46, C46, B46, and D46 respectively. Analysis of variance showed that there is no any significant effect ($p>0.05$) on shape due to variety and treatment but sample C46 has got the highest sensory score.

Again, the average sensory score for shape for *Masyeura* at proportion 6:4 was 6.1, 6.9, 6.9, and 6.1 for sample A64, C64, B64, and D64 respectively. Analysis of variance showed that there is no any significant effect ($p>0.05$) on shape due to variety and treatment alone but significant effect ($p<0.05$) of their interaction. LSD showed that sample C64 and B64 were significantly superior to A64 and D64.

4.4.5 Effect of treatment and variety on overall acceptability (OA) of *Masyeura*

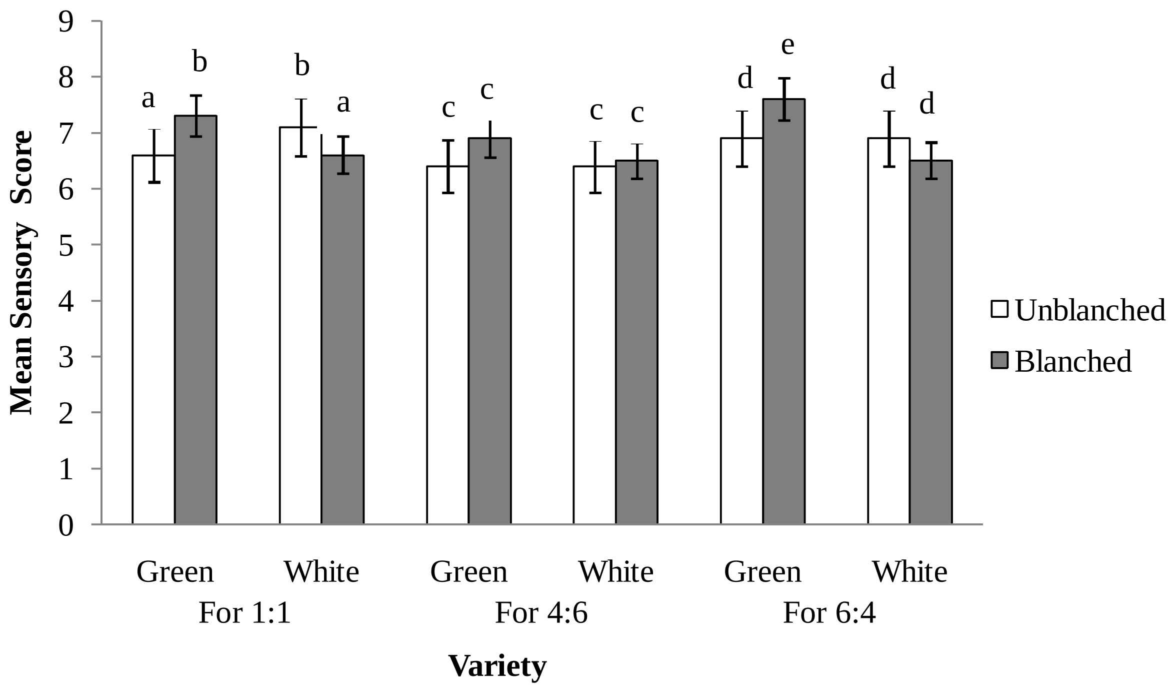


Fig 4.7 Average sensory score for OA with different treatments and varieties

Note: This graph consist combined plot for different proportion. The letter above bar denotes significant difference and is confined to each proportion separately. No comparison within proportion is done.

The average sensory score for overall acceptability was 6.6, 7.3, 7.1, and 6.6 for sample A11, C11, B11, and D11 respectively at mixing proportion of 1:1. Analysis of variance showed that there is no any significant effect ($p>0.05$) on overall acceptability due to variety and treatment but their interaction has significant effect ($p<0.05$). LSD showed that sample C11 is significantly superior to other sample at 95% level of confidence.

Similarly, the average sensory score for overall acceptability at proportion 4:6 was 6.4, 6.9, 6.4 and 6.5 for sample A46, C46, B46, and D46 respectively. Analysis of variance showed that there is no any significant effect ($p>0.05$) on overall acceptability due to variety and treatment but sample C46 has got the highest sensory score. This becomes clear from Fig 4.7.

Again, the average sensory score for overall acceptability for *Masyeura* at proportion 6:4 was 6.9, 7.6, 6.9, and 6.5 for sample A64, C64, B64, and D64 respectively. Analysis of variance showed that there is no any significant effect (p>0.05) on shape due to variety and treatment alone but significant effect (p<0.05) of their interaction. LSD showed that sample C64 was significantly superior to rest of the samples.

From above results we can conclude that the *Masyeura* prepared from blanched shreds of green chayote on each proportion with black gram dahl has impact positive impression on panelist. Thus, selected samples were then cooked and again subjected for sensory analysis.

4.5 Sensory analysis of cooked *Masyeura*

4.5.1 Comparison in between proportional ratio of Green blanched with control

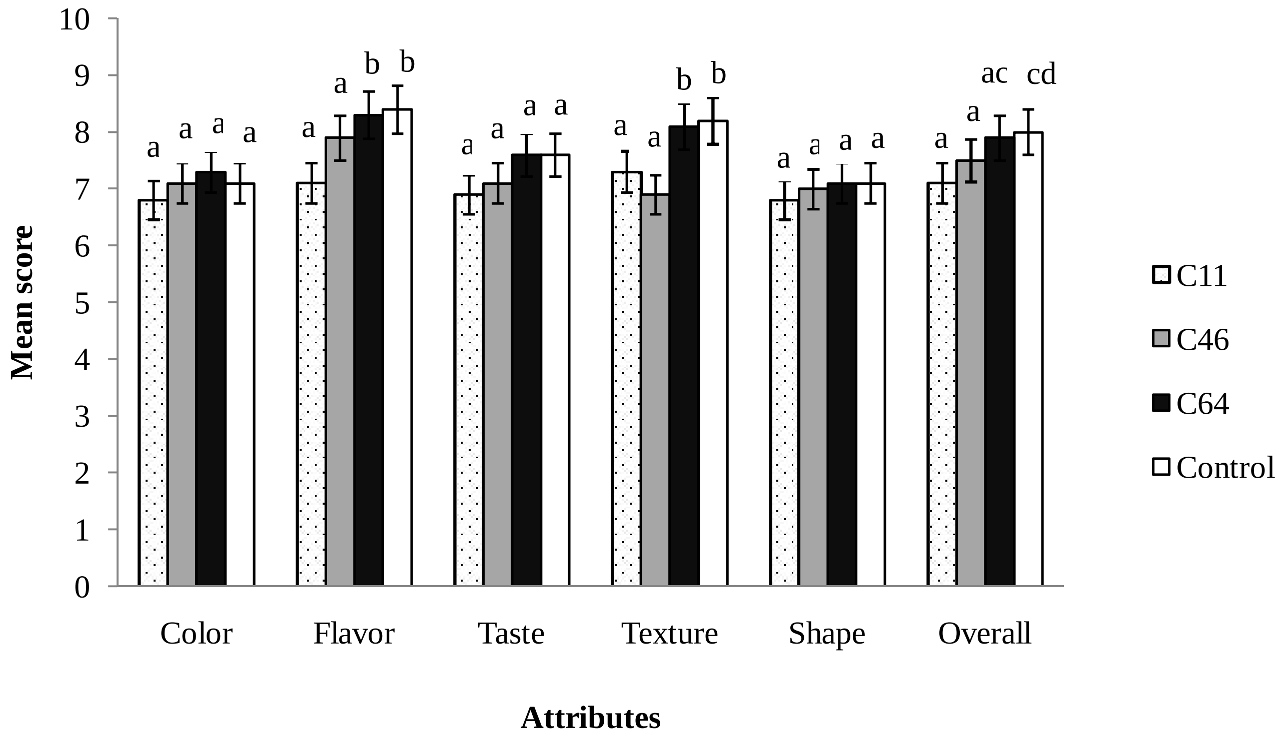


Fig 4.8 Average Sensory score for three different ratio of green blanched type.

Note: The different word above bar denotes the significant difference among samples.

4.5.1.1 Color

The average sensory score for color was 6.8, 7.1, 7.3 and 7.1 for sample C11, C46, C64 and control respectively. The mean score showed that C64 has highest score which can be seen clearly from Fig 4.8. The analysis of variance showed that in case of color, sample C11, C46, C64 and control showed no significant difference (p<0.05) with each other.

4.5.1.2 Flavor

The average sensory score for flavor was 7.1, 7.9, 8.3 and 8.4 for sample C11, C46, C64 and control respectively. Mean score showed that C64 has superiority to all but inferior to control. In case of flavor sample C11 was significantly different from C46, C64, and control but C46 was significant difference ($p<0.05$) from control and C64 but sample C64 and sample didn't differed significantly ($p>0.05$).

4.5.1.3 Taste

The average sensory score for taste was 6.9, 7.1, 7.6 and 7.6 for sample C11, C46, C64 and control respectively. In case of taste mean score showed C64 and control to be superior to all and ANOVA showed no significant difference with each other.

4.5.1.4 Texture

The average sensory score for texture was 7.3, 6.9, 8.1, and 8.2 for sample C11, C46, C64 and control respectively. In case of texture sample mean score showed C64 was superior to C11 and C46 but inferior to control. ANOVA showed that C11 and C46 was not significant difference ($p>0.05$) with each other but different to control and C64. C64 and control didn't show any significant difference with each other.

4.5.1.5 Shape

The average sensory score for shape was 6.8, 7, 7.1 and 7.1 for sample C11, C46, C64 and control respectively. Though sample C64 and control has achieved highest mean score in case of shape all samples showed insignificant difference to each other ($p>0.05$).

4.5.1.6 Overall acceptability

The average sensory score for overall acceptance was 7.1, 7.5, 7.9 and 8 for sample C11, C46, C64 and control respectively. The overall acceptability mean showed that product C64 is superior to C11 and C46 but inferior to control. C11 and C46 was significant different to C64 and control whereas C64 and control showed no any significant difference to each other. The superiority of C64 might be due to good flavor, and texture. Hence, from the statistical analysis the overall acceptability of product C64 was seen. This is supported by previous research that the *Masyeura* having higher proportion of dahl and lower proportion of vegetable comes superior. Thus the superior product was subjected for further analysis.

4.6 Analysis of *Masyeura* (product C64)

The chemical analysis of the best product (Product C64) found from sensory analysis was carried out. The result is tabulated in Table 4.2.

Table 4.4: Analysis of *Masyeura*

Parameters	Values
Moisture (%)	9.9 (0.15)
Protein (%)	20.1 (0.19)
Fat (%)	0.31 (0.52)
Ash (%)	3.2 (0.2)
Crude fiber (%)	4.6 (0.2)
Carbohydrate (%)	61.81 (0.73)
Ascorbic Acid (mg/100g)	6(0.19)
Energy (Kcal./100g)	341.23

The values are the means of triplicate samples and the values in the parenthesis are standard deviation.

4.5 Microbiological quality of product

Total Plate Count (TPC) and Yeast and Mold count of the product as received by the microbiological assay are shown in Table 4.5.

Table 4.5: Microbiological assay of the products

Parameters	Values (cfu/g)
TPC	$>6.85*10^2$
Yeast & Molds	148

Different colonies of yeast were found when grown in selected yeast and mold media i.e. MYGP Agar. The presence of mold was also found. The same result has been observed by Dahal *et al.* (2003) and Deo (2003) and reported the fermentation in *Masyeura* may be due to action of yeast. Whereas the result for total plate count was supported by Mukherjee *et al.* (1965) saying dehulled black gram harvours the lactic acid bacteria in large number which may play a major role in fermentation.

4.6 Changes during storage of *Masyeura*

The change during storage of *Masyeura* was studied for 4 weeks. The product was packed in HDPE and LDPE bags and stored at room temperature (25±3ºC). The moisture content and acidity of the product was evaluated from the date of manufacture up to 4 weeks.

4.6.1 Changes in Acidity

In general, the acidity is the indication of content of acidic mater in the product which signifies continuation of fermentation or not. The increment in acidity of the product was found increased with storage time and also depends on packaging material. After four weeks of storage, the acidity increment was not found significantly different. The acidity of the product was observed to be 0.7 at initial which reached 0.767 HDPE and 0.771 in LDPE within 4 weeks at 25±3ºC. The change pattern of acidity during storage time has been shown on Fig 4.7.

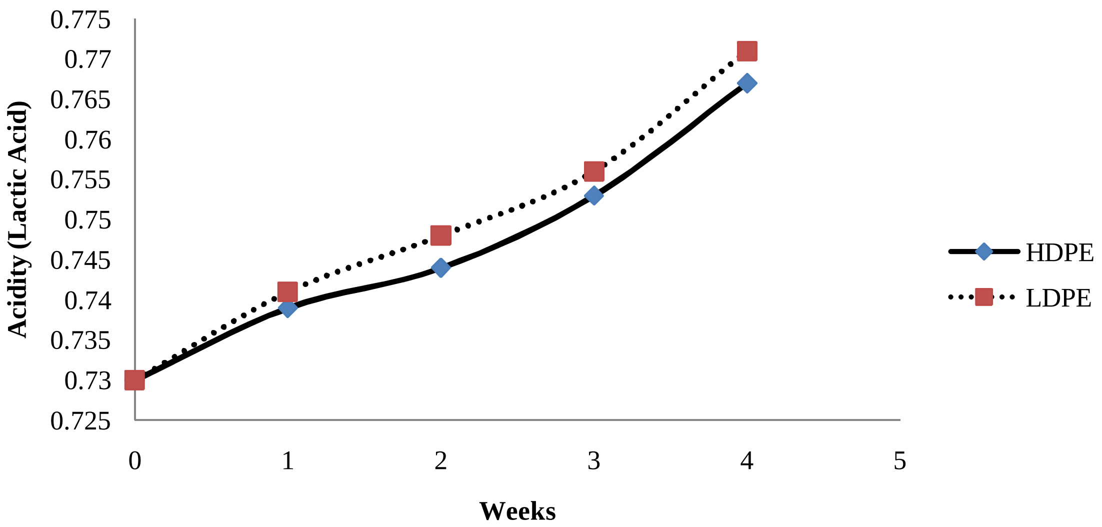


Fig 4.9 Changes in acidity during storage at 25±3ºC

From the result of statistical analysis (Appendix C), variation in packaging material had no significant effect on acidity but storage time had significant effect on acidity of product.

According to (Dahiya and Prabhu, 1977), acidity can be the subjective organoleptically appraisal of the taste and off flavor quality of food. Acidic taste is concerned with the changes that result from reaction of microbial resulting continuous breakdown of carbohydrate, i.e. fermentation reactions catalyzed by lactase from food or from microorganisms. The change in acidity of sample at 25±3°C could easily be evaluated by Fig. 4.7.

4.6.2 Changes in moisture

Moisture is a very sensitive indicator of dried product spoilage. Moisture determination therefore provides a means of predicting the risk of the development of off flavor and mold growth in product. After four weeks of storage, the moisture content increment was found minimum in HDPE while more increment of moisture obtained in LDPE.

The moisture content of the product was observed to be 9.9 at initial which reached 9.963 and 9.98 in HDPE and LDPE at 25°C respectively within 4 weeks. There was significant difference ($p<0.05$) with storage time and between two packaging material. The change in moisture content of the product is shown in Fig. 4.8.

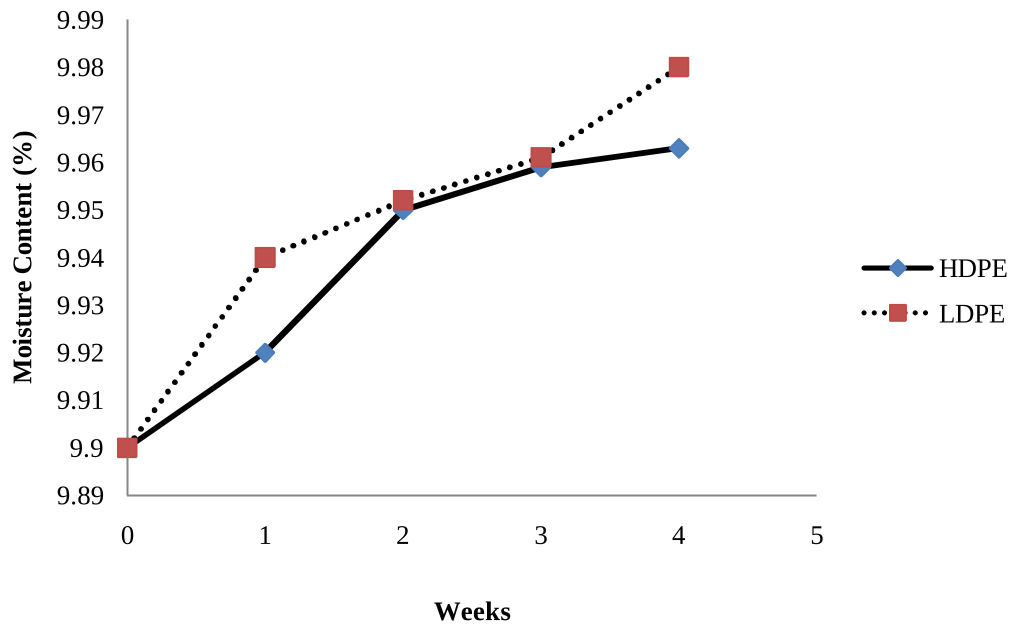


Fig 4.10 Changes in moisture content during storage at 25±3°C.

According to Kumar (2001), moisture content in dry products is very sensitive indications of the early stage of deterioration. This moisture contents softens the product and may provide the suitable condition for development of risk of mold. Moisture content is a critical component of material quality and essentially a function of quality control in most production cases. From biological research organizations, pharmaceutical manufacturers, to food producers and packers, moisture content control greatly influences the physical properties and product quality of nearly all substances and materials at all stages of processing and final product existence.

4.7 Rate of changes in the acidity and moisture during storage time

The result was observed that is increment of the values during storage time. The rate of increase in the acidity was calculated to be 0.0013 % per day in case of HDPE, while 0.00136 % per day in case of LDPE on study of one month.

Similarly, the rate of increase in the moisture was calculated to be 0.0021% per day in case of HDPE, while 0.0026% per day in case of LDPE.

4.8 Cost of Product

The cost of most preferred *Masyeura* (sample C64) is NRs. 18.04 per 100gm including overhead cost and profit of 10%. (Calculation is given in Appendix D).

Part V

Conclusion and Recommendation

5.1 Conclusions

From the above results and discussions, it was concluded that:

a. *Masyeura* can be prepared by using easily available raw materials; i.e., chayote, and black gram and the palatable product can be obtained. The food may be prepared using traditional techniques not requiring special equipment.
b. The optimization of blanching time were studied and found 85^{o}C for 3 minute for vegetable which has consequent effect on quality of product thus prepared.
c. From the sensory evaluation and statistical analysis of the product, formula which contains 60% part of black gram and 40% of green chayote's blanched shred (C64) was found most acceptable product.
d. From analysis of product (60-40), it was concluded that it provides considerable amount of nutrients providing 341 kcal energy per 100 g product.
e. The total cost of *Masyeura* was calculated and found to be NRs. 18.04 per 100g.
f. The sample packaged in two different packaging materials i.e. LDPE and HDPE at 25±3ºC temperature; HDPE was found superior to LDPE.
g. This type of product will play an important role for the utilization of underutilized crops and can be stated as good type of preservation technique for chayote.

5.2 Recommendations

This study can be further continued with the following recommendations before industrializing this product.

a. Evaluation of nutritional quality (e.g. PER, NPU, Digestibility etc) of the product.
b. Study of the amino acid profile composition of the prepared products.
c. Isolation and identification of the particular bacteria, yeast and mold responsible for the fermentation and the fermentation pattern in *Masyeura*.
d. Comparative study on sun dried and cabinet dried *Masyeura*.
e. Shelf life study of *Masyeura* could be studied using different packaging material.

Part VI

Summary

Nepal being a developing country and due to poor socio-economic condition, inadequate development of technology and their researches the status of Nepal has not been upgraded. Large number of situation and condition of here in Nepal has potential to upgrade the Nepalese status. Similarly, due to lack of proper facilities of market, preservation method yearly the different crops here in Nepal are under-utilized.

The present work is mainly focused on utilizing the underutilized vegetable chayote, value adding on it by preparation of *Masyeura* of chayote and black gram. The *Masyeura* is one of the traditional dried food products of Nepal. It has been known from the very beginning and is very difficult to trace its origin owing to the lack of any published work. The product is made from mixture of pulses and vegetables

Two different variety of chayote was taken. Blanching and un-blanching their shreds *Masyeura* were prepared on different proportional ratio with paste of black gram dahl, i.e. at ratio 1:1.4:6 and 6:4 of black gram paste and shreds of chayote. All the preparation process was followed as for the literature available.

The prepared products were first sensorially evaluated by means of 9 points Hedonic test, which was carried out by semi trained panelists including teachers, students and staffs of Central Campus of Technology.

Each panelist was provided 4 sample of each proportion and evaluating card. They were requested to score samples in order of performance for A, B, C and D (of all proportion) in different parameters. All scores were summed up and statistically analyzed.

In sensory scoring test of uncooked *Masyeura*, C11, C46 and C64 obtained higher score on each proportion. Than these three products were set for sensory analysis (cooked) and compared parallely with *Masyeura* made from colocasia and blackgram to find out the superior one. From statistical analysis of the sensory evaluation data, product C64 is significantly different ($P \leq 0.05$) and superior from other in regarding flavor, texture and overall acceptance. At the time of sensory evaluation, most of the panelist commented that all the products possessed flat shape. This may be due improper way of making lumps of

mixed paste. However, all the products were made by same process the variation of variety and proportion of raw materials may have made the product C64 different from other ones.

The chemical composition of selected product C64 was analyzed by following the standard procedure. Moisture content was found to be 9.9 %. Due to this low amount of moisture in food, microbial growth may not occur and the shelf life of the product would be more, if high moisture and air barrier packaging materials are use. The energy value was found to be 341.23 Kcal per 100 gm of product.

After finding chemical composition and quality attributes, *Masyeura* storability at room temperature (25±3^{o}C) condition was performed on HDPE (high density polyethylene) and LDPE (low density polyethylene). Storage stability was studied throughout the four weeks of period. Both the packaging material showed no significant difference in acidity ($p>0.05$) but there was significant difference in packaging material in case of moisture content of the product. Similarly, storage time also showed the significant effect on the acidity and moisture of product. From the result of change during storage time it was found that the rate of increase in the acidity was 0.0013 % per day in case of HDPE, while 0.00136 % per day in case of LDPE. Similarly, the rate of increase in the moisture was 0.0021% per day in case of HDPE, while 0.0026% per day in case of LDPE, which showed that HDPE was significantly superior to LDPE.

The average cost of the product was calculated. Actually costing of the product must include manufacturing cost and fixed cost. The most effective cost factors to be considered in manufacturing are raw materials, electricity, labor, packaging material and overhead costs. These costs vary with time and season. It was found that this type of product can be prepared at about NRs. 18.04 per 100g including overhead cost and profit of 10%.

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Appendices

Appendix-A

A.1 Sensory Analysis of *Masyeura* (uncooked) made from Chayote and Black gram

Name of Panelist: …………………………………….... Date: ……………………

Name of the product: ***Masyeura***

Type of Product: Legume based fermented food indigenous to Nepal

Dear Panelist, you are given 4 sample of *Masyeura* on each proportion of different varieties. Please conduct the sensory analysis based on the following parameter using the scale given.

Sample	Color	Flavor (Smell)	Shape	Texture	Overall acceptance
A11					
B11					
C11					
D11					
Sample	Color	Flavor (Smell)	Shape	Texture	Overall acceptance
A46					
B46					
C46					
D46					
Sample	Color	Flavor (Smell)	Shape	Texture	Overall acceptance
A64					
B64					
C64					
D64					

Like Extremely	9
Like Very Much	8
Like Moderately	7
Like Slightly	6
Neither Like nor dislike	5
Dislike Slightly	4
Dislike Moderately	3
Dislike Very Much	2
Dislike Extremely	1

Comment (if any)

.....…………………………………………………………

……………………………………………………………

……………………………………………………………

……………………………………………………………

……………………………………………………………

..................…………..

Signature

A.2. Sensory Evaluation Card

Sensory Analysis of *Masyeura* (cooked)

Name of Panelist: ……………………………….   Date: …………………

Name of the product: ***Masyeura***

Type of Product: An indigenous legume based fermented product

Dear Panelist, you are given 4 sample of *Masyeura*, please conduct the sensory analysis based on the following parameter using the table given

Sample	Color	Flavor	Taste	Texture	Overall acceptance
C11					
C46					
C64					
Control					

Like Extremely	9
Like Very much	8
Like Moderately	7
Like Slightly	6
Neither like nor dislike	5
Dislike Slightly	4
Dislike Moderately	3
Dislike very much	2
Dislike Extremely	1

Comment (if any)

………………………………………………………………………………..

……………………………………………………………………………………….....

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…………………..

Signature

Appendix-B

1. Sensory analysis of the product (For Proportion 1:1)

Table B.1.1: Two way ANOVA (no blocking) for color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	7.225	7.225	14.21	<.001
Treatment	1	0.225	0.225	0.44	0.51
Variety. Treatment	1	0.025	0.025	0.05	0.826
Residual	36	18.3	0.5083		
Total	39	25.775			

Since F pr. < 0.05, for factor variety there is no significant difference between the samples so LSD testing is not necessary.

Table B.1.2: LSD Table for color

Table	Variety	Treatment	Variety.Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.457	0.457	0.647

Table B.1.3: Two way ANOVA (no blocking) for flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.9	0.9	1.8	0.188
Treatment	1	0.1	0.1	0.2	0.657
Variety. Treatment	1	0.1	0.1	0.2	0.657
Residual	36	18	0.5		
Total	39	19.1			

Since F pr. > 0.05, there is no significant difference between the samples.

Table B.1.4: Two way ANOVA (no blocking) for Texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	1.6	1.6	2.62	0.114
Treatment	1	0.4	0.4	0.65	0.424
Variety. Treatment	1	0	0	0	1

Residual	36	22	0.6111
Total	39	24	

Since F pr. > 0.05, there is no significant difference between the samples.

Table B.1.5: Two way ANOVA (no blocking) for Shape

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.1	0.1	0.35	0.556
Treatment	1	0.9	0.9	3.18	0.083
Variety. Treatment	1	0.4	0.4	1.41	0.243
Residual	36	10.2	0.2833		
Total	39	11.6			

Since F pr. > 0.05, there is no significant difference between the samples for the variate shape.

Table B.1.6: Two way ANOVA (no blocking) for Overall Acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	1.6	1.6	2.8	0.103
Treatment	1	1.6	1.6	2.8	0.103
Variety. Treatment	1	8.1	8.1	14.16	<.001
Residual	36	20.6	0.5722		
Total	39	31.9			

Since F pr. < 0.05, between interaction of factors there is significant difference between the samples so LSD testing is necessary.

Table B.1.7: LSD table for overall acceptability

Table	Variety	Treatment	Variety.Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.485	0.485	0.686

2. Sensory analysis of the product (For Proportion 4:6)

Table B.2.1: Two way ANOVA (no blocking) for color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	4.9	4.9	8.73	0.005
Treatment	1	1.6	1.6	2.85	0.1
Variety. Treatment	1	0.9	0.9	1.6	0.213
Residual	36	20.2	0.5611		
Total	39	27.6			

Since F pr. < 0.05, for factor variety there is significant difference between the samples so LSD testing is necessary.

Table B.2.2: LSD for color

Table	Variety	Treatment	Variety. Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.48	0.48	0.679

Table B.2.3: Two way ANOVA (no blocking) for flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.225	0.225	0.31	0.582
Treatment	1	0.225	0.225	0.31	0.582
Variety. Treatment	1	0.225	0.225	0.31	0.582
Residual	36	26.3	0.7306		
Total	39	26.975			

Since F pr. > 0.05, there is no significant difference between the samples for the variate flavor.

Table B.2.4: Two way ANOVA (no blocking) for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.625	0.625	1.03	0.318
Treatment	1	2.025	2.025	3.33	0.076
Variety. Treatment	1	0.225	0.225	0.37	0.547
Residual	36	21.9	0.6083		
Total	39	24.775			

Since F pr. > 0.05, there is no significant difference between the samples.

Table B.2.5: Two way ANOVA (no blocking) for shape

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.9	0.9	2.61	0.115
Treatment	1	0.9	0.9	2.61	0.115
Variety. Treatment	1	0.9	0.9	2.61	0.115
Residual	36	12.4	0.3444		
Total	39	15.1			

Table B.2.6: Two way ANOVA (no blocking) for overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.9	0.9	1.34	0.255
Treatment	1	2.5	2.5	3.72	0.062
Variety. Treatment	1	0.4	0.4	0.6	0.446
Residual	36	24.2	0.6722		
Total	39	28			

Since F pr. > 0.05, there is no significant difference between the samples.

3. Sensory analysis of the product (For Proportion 6:4)

Table B.3.1: Two way ANOVA (no blocking) for color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	2.5	2.5	2.76	0.105
Treatment	1	0.4	0.4	0.44	0.511
Variety. Treatment	1	6.4	6.4	7.07	0.012
Residual	36	32.6	0.9056		
Total	39	41.9			

Since F pr. > 0.05, there is no significant difference between the samples.

Table B.3.2: Two way ANOVA (no blocking) for flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	3.025	3.025	4.76	0.036
Treatment	1	0.225	0.225	0.35	0.556
Variety. Treatment	1	0.625	0.625	0.98	0.328
Residual	36	22.9	0.6361		
Total	39	26.775			

Since F pr. < 0.05, for factor variety there is significant difference between the samples.

Table B.3.3: LSD table for flavor

Table	Variety	Treatment	Variety.Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.512	0.512	0.723
Total	39	26.775	

Table B.3.4: Two way ANOVA (no blocking) for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0.4	0.4	0.64	0.43
Treatment	1	0.9	0.9	1.43	0.239
Variety. Treatment	1	0.1	0.1	0.16	0.692
Residual	36	22.6	0.6278		
Total	39	24			

Since F pr. > 0.05, there is no significant difference between the samples for the variate texture.

Table B.3.5: Two way ANOVA (no blocking) for shape

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	0	0	0	1
Treatment	1	0	0	0	1
Variety. Treatment	1	6.4	6.4	14.77	<.001
Residual	36	15.6	0.4333		
Total	39	22			

Since F pr. <0.05, for interaction between factors there is significant difference between the samples for the variate shape so LSD testing is not necessary.

Table B.3.6: LSD table for shape

Table	Variety	Treatment	Variety.Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.422	0.422	0.597

Table B.3.7: Two way ANOVA (no blocking) for Overall Acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	1.6	1.6	2.46	0.125
Treatment	1	0	0	0	1
Variety. Treatment	1	4.9	4.9	7.54	0.009
Residual	36	23.4	0.65		

Total	39	29.9

Since F pr. < 0.05, there is significant difference between the samples for the variate over acceptability so LSD testing is necessary.

Table B.3.8: LSD table for Overall Acceptability

Table	Variety	Treatment	Variety.Treatment
rep.	20	20	10
d.f.	36	36	36
l.s.d.	0.517	0.517	0.731

4. Comparison in between proportional ratio of Green blanched with control

Table B.4.1: One way ANOVA (no blocking) for Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	1.275	0.425	0.87	0.463
Residual	36	17.5	0.4861		
Total	39	18.775			

Since F pr. > 0.05, there is no significant difference between the samples for the variate color so LSD testing is not necessary.

Table B.4.2: One way ANOVA (no blocking) for Flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	10.475	3.4917	7.71	<.001
Residual	36	16.3	0.4528		
Total	39	26.775			

Since F pr. < 0.05, there is significant difference between the samples for the variate flavor so LSD testing is necessary.

Table B.4.3: LSD for Flavor

Sample code	Mean score	LSD at 0.05	Mean difference	Remarks
C11	7.1	0.658	C46-C11 = 0.8	>LSD*
C46	7.9		C64-C46 = 0.4	<LSD
C64	8.3		C64-C11 = 1.2	>LSD*
Control	8.4		Control-C11 = 1.3	>LSD*
			Control-C46 = 0.5	<LSD
			Control-C64 = 0.1	<LSD

(* = Significantly Different)

Table B.4.4: One way ANOVA (no blocking) for Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	3.8	1.2667	3.12	0.18
Residual	36	14.6	0.4056		
Total	39	18.4			

Since F pr. > 0.05, there is no significant difference between the samples for the variate taste.

Table B.4.5: One way ANOVA (no blocking) for Texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	11.875	3.9583	7.31	<.001
Residual	36	19.5	0.5417		
Total	39	31.375			

Since F pr. < 0.05, there is significant difference between the samples for the variate texture so LSD testing is necessary.

Table B.4.6: LSD for Texture

Sample code	Mean score	LSD at 0.05	Mean difference	Remarks
C11	7.3	0.747	C11-C46 = 0.4	<LSD
C46	6.9		C64-C46 = 1.2	>LSD*
C64	8.1		C64-C11 = 0.8	>LSD*

Control	8.2		Control-C11 = 0.9	>LSD*
			Control-C46 = 1.3	>LSD*
			Control-C64 = 0.1	<LSD

(* = Significantly different)

Table B.4.7: One way ANOVA (no blocking) for Shape

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	0.6	0.2	0.47	0.707
Residual	36	15.4	0.4278		
Total	39	16			

Since F pr. > 0.05, there is no significant difference between the samples for the variate shape.

Table B.4.8: One way ANOVA (no blocking) for Overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Proportion	3	5.075	1.6917	4.95	0.006
Residual	36	12.3	0.3417		
Total	39	17.375			

Since F pr. < 0.05, there is significant difference between the samples for the variate overall acceptability so LSD testing is necessary.

Table B.4.9: LSD for Overall acceptability

Sample code	Mean score	LSD at 0.05	Mean difference	Remarks
C11	7.1	0.567	C46-C11 = 0.4	<LSD
C46	7.5		C64-C46 = 0.4	<LSD
C64	7.9		C64-C11 = 0.8	>LSD*
Control	8.0		Control-C11 = 0.9	>LSD*
			Control-C46 = 1.5	>LSD*
			Control-C64 = 0.1	<LSD

(* = Significantly different)

Appendix C

1. Changes during storage of the product

Table C.1.1: Two way ANOVA (no blocking) for acidity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Storage time	4	0.14263	0.03566	97.03	<.001
Packaging materials	1	0.00341	0.00341	9.29	0.156
Residual	24	0.00882	0.00037		
Total	29	0.15487			

Since, F pr. < 0.05, there is significant difference between the samples at different storage time and but no significantly different between two packaging material.

Table C.1.2: Two way ANOVA (no blocking) for moisture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Storage time	4	8.4057	2.1014	47.21	<.001
Packaging materials	1	1.50528	1.5052	33.82	<.001
Residual	24	1.06822	0.0445		
Total	29	10.9792			

Since F pr. < 0.05, there is significant difference between the samples at different storage time and between two packaging material.

Table C.1.3: Average acidity for sample packed in HDPE and LDPE.

Weeks	HDPE	LDPE
0	0.73	0.73
1	0.739	0.741

2	0.741	0.748
3	0.749	0.752
4	0.769	0.771

Table C.1.4: Average moisture content for sample packed in HDPE and LDPE

Weeks	HDPE	LDPE
0	9.9	9.9
1	9.92	9.94
2	9.95	9.952
3	9.959	9.961
4	9.963	9.98

Table C.1.5: One way ANOVA for rehydration ratio.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	11	0.55232	0.05021	1.7	0.134
Residual	24	0.70887	0.02954		
Total	35	1.26119			

Since F pr. > 0.05, there is no significant difference between the samples on variate rehydration ratio.

Table C.1.6: One way ANOVA for bulk density.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	11	0.072097	0.006554	6.88	<.001
Residual	24	0.022867	0.000953		
Total	35	0.094964			

Since F pr. <0.05, there is significant difference between the samples on bulk density.

Appendix-D

Table D.1: Result of physical analysis of prepared *Masyeura*.

Sample	Code	Average. wt. of single Ball (gm)	Rehydration Ratio	Bulk Density (gm/cm^3)
Green Un-Blanched 1:1	A11	1.7	2.98:1	0.8
Green Un-Blanched 4:6	A46	2.1	3.10:1	0.76
Green Un-Blanched 6:4	A64	1.8	3.05:1	0.83
White Un-Blanched 1:1	B11	2.1	3.01:1	0.72
White Un-Blanched 4:6	B46	1.9	3.32:1	0.71
White Un-Blanched 6:4	B64	1.9	3.26:1	0.81
Green Blanched 1:1	C11	1.8	3.29:1	0.69
Green Blanched 4:6	C46	1.9	3.02:1	0.72
Green Blanched 6:4	C64	1.8	3.11:1	0.73
White Blanched 1:1	D11	2	2.93:1	0.7
White Blanched 4:6	D46	1.7	2.98:1	0.71
White Blanched 6:4	D64	1.8	2.89:1	0.74

Table D.2: Cost calculation of the product (product C64).

Particulars	Cost (NRs/kg)	weight (gm)	Cost (NRs/100gm)
Black Gram	120	60	12
Chayote	20	40	2
Raw material Cost		100	14
Processing and labor Cost (10% of raw material cost)			1.4
Packaging cost			1
Profit (10%)			1.64
Grand Total Cost			18.04

Cost of raw materials varies with season.