INFLUENCE OF STORAGE ON THE QUALITY OF SELECTED PULSES

By

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DECLARATION

I hereby declare that this thesis entitled "Influence of storage on the quality of selected pulses" is a bonafide record of the research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Influence of storage on the quality of selected pulses" is a record of research work done independently by Mrs. Bhanu Lekha. T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

Since large number of people in India live below subsistence level, they depend mostly on few staple food crops like cereals, millets and pulses. As the per capita income is low, the other important dietary constituents are often missing in their diets. Under these conditions, availability of pulses is a determining factor of the quality of the diet in terms of it's protein content.

Total production of pulses in India is about 12.2 million tons produced in 23.3 million hectares. (Annonymous, 1991). National dietary surveys indicate that an average per consumption co-efficient unit of pulse intake in India is 32 g against the requirement of 40 g of pulses (Gopalan et al. 1991). Kerala diets also reveal a similar trend with 19 g of pulses.

Total pulses produced in the country is sufficient to meet the requirements of 9.92 percent of the populations. Another notable point in this context is that the existing poor storage condition of this crop with high temperature and relative humidity in the state results in loss of quality and quantity of the food crops.

Because of poor yields and low returns pulses are cultivated mostly for household consumption by the farmers and usually crops are held at the farm house level till the next harvest, for consumption and also for seed purposes. But information on post harvest losses of these crops is scanty. Considering the low availability of pulses, minimising post harvest losses is also imperative. To develop a strategy appropriate to every region, scientific data of the existing post harvest problem is also needed.

Hence the present study on "Influence of storage on quality of pulses" was planned with the following objectives

a) To assess the consumer level preference for various pulses

b) To assess the problems related to storage and marketing and

c) To assess the changes in selected pulses during farm level storage and market storage.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Leguminous plants belong to the family of Leguminosae and the seeds of leguminous plants are known as legumes or pulses. In this country, several varieties of pulses are cultivated with bengalgram accounting for a major fraction. Since foods of animal origin are expensive and not readily available, pulses are of considerable importance as a source of protein in Indian diets.

This chapter presents a review on :

1. Nutritional composition of pulses
2. Antinutritional factors in pulses
3. Qualitative losses in pulses during storage
4. Cooking characteristics of stored pulses

1. Nutritional composition of pulses

Pulse grains are considered more nutritive than the cereals or any other crops since they contain two to three times more protein than the cereal grains. These crops offer the most nutrients and are the most widely used component of Indian diet being within the reach of all sections of the society. In the world context India produces about 40 to 80 per cent of the global production of pulse crops (Chandra, 1984).

Deosthale (1982) reported that pulses are rich in protein, minerals and vitamins. Hence are important in cereal based diets.

Varietal variation in the proximate composition of pulses was reported in many studies. Rao et al. (1978) evaluated the chemical composition of six types of mung beans, and stated that they are rich sources of polysaccharides proteins and minerals. Echardallou et al. (1985) have reported that the pulses are rich sources of unavoidable carbohydrates, viz. raffinose, xylose, arabinose, galactose and unidentified sugars.

Swamy et al. (1992) had reported that the cotyledons of redgram was rich in starch and contained a water soluble polysacchride mainly of arabinose type. The intermediate fraction had less starch than in the cotyledon and was rich in free sugars. Arabinogalactan type polysaccharide and were characteristics of intermediate fraction and were gummy and hygroscopic in nature. the alkali in soluble residue in the intermediate fraction and was a complex of cellulose and noncellulose polysaccharides. The content of this fraction and also of the pectin was greater in different milling cultivar. The husk was rich in non starchy polysaccharides and contained varying amounts of arabinose and xylose in most of the fractions. Both glucoronic and galacturonic acid were present on the husk, where as the cotyledon and intermediate fraction contained galacturonic acid only.

Most of the legumes are used as dehusked and decorticated dals rather than as whole legumes.

Sha et al. (1988) had reported that the protein content of chickpea, lentil and Phaseolus radiatus varied from 20.42 to 24.53 %, the highest being found in lentil. The essential aminoacid content of these legumes ranged from 33.34 to 35.05 g/100g of protein.

A study conducted by Hebbel et al. (1976) had reported that some varieties of beans contained phenyl alanine (422 mg), histidine (140 mg) isoleucine (421mg), leucine (367 mg), lysine (509 mg), valine (287 mg), threonine (244 mg), methionine (55 mg) and tryptophan (46 mg) compared with FAO reference protein, the beans were reported to be deficient in methionine and tryptophan, but were rich in lysine.

Rao et al. (1979) had reported that the protein content of redgram, bengalgram, blackgram and greengram was found to be 22.7g per cent, 20.4g per cent, 27.1g per cent and 26.9g per cent. Redgram protein had a lower tryptophan content 0.5g/16gN, when compared to that of blackgram 1.0 greengram 1.1, and bengalgram 1.3g/16gN proteins. The methionine content of greengram was 1.0, redgram 1.2, bengalgram 1.4 and blackgram 1.4g/16gN. The lysine content of greengram was 5.4, bengalgram 5.7, redgram and blackgram 6.6g/16gN. Nicotinic acid content of these pulses ranged from 2.3 to 11.6mg/100g. Riboflavin content ranged from 0.18 to 0.24mg/100g and vitamin B_6 content ranged from 0.26 to 0.30mg/100g.

Charanjeet et al. (1988) had reported that the nutritional quality and acceptability of rice beans were comparable to other commonly consumed pulses. Singh (1989) had also reported that chickpea varieties evolved at ICRISAT contain the sulfur containing aminoacids such as methionine, cystine and lysine. Aswathi et al. (1992) studied the physico-chemical and nutritional qualities of 23 promising varieties of chickpeas. They had stated that some varieties exhibited higher concentration of tryptophan and methionine where as some varieties were superior in chemical score and biological value.

Sharma et al. (1992) had analysed the proximate composition of two advanced varieties of faba bean and reported that they are rich sources of proteins (28.65 and

29.22 g%), crude fibre (8.80 and 9.00 g%) and carbohydrate (56.52 g per cent), on dry matter basis.

Gaspen Ros _et_ _al_. (1992) had reported that the invitro protein digestibility of cowpeas as 70.7 per cent.

Different processing methods applied on pulses in general are winnowing, drying, decorting, milling, soaking, germinating and frying and these methods may have an effect on their nutritional composition.

Phillip _et_ _al_. (1988) had reported that the efficacy of decorticating cowpea improved by hydrating and then drying. Effects of drying temperature on functional and nutritional properties of cowpea meal were found to have no effect on the extraction rate.

2. Antinutritional factors in pulses

Legumes are also known to contain a number of antinutritional factors and toxic factors, some of which are thermolabile while others were heat stable. The thermolabile factors include trypsin inhibitors, haemaglutenins, goiterogens, saponins, alkaloids, phytates and cyanogenetic glucosides. Polyphenolic compounds like tannins and beta-N-

Oxalyl diamino propionic acid are reported to be heat stable category.

Phirke *et al*. (1982) reported that black phaseolus seeds, contain the highest concentration of polyphenols, followed by purple, reddish purple, brown and the white varieties. Shinde *et al*. (1991) have also reported that polyphenol content was maximum in red coloured varieties and minimum in white coloured varieties.

Phirke *et al*. (1982) had reported that dehulling of greengram decreased the polyphenol content by 60-70 per cent.

El Fahi *et al*. (1983) had reported that carbohydrate fraction of chickpea, cowpea and horsegram, cause flatulence while the husk and the derived carbohydrate fraction were inhibitory to gas formation by Chlostridium perferingens. Fake *et al*. (1983) have also reported that the endosperm and carbohydrate fraction of chickpea, cowpea and horsegram cause flatulence. Ogun *et al*. (1989) reported that dehulling of cowpea decreased stachyose and removed the tannin. Hot soaking is also reported to cause a significant reduction in stachyose and trypsin inhibitory activity.

Bernal *et al*. (1990) reported that the contents of phytate or its rate of hydrolysis are not the major contributor to the seed susceptability and induced hardening in different bean varieties. Khan et al. (1988) have also reported soaking, boiling, roasting and frying invariably result in the loss of phytic acid content of brown and white varieties of bengalgram. Loss of phytic acid in presoaked grams are reported to increase with resting time. The loss during the soaking and resting period of pre-soaked grams may be attributed to enzymic activity. Immature brown grams contain much less phytic acid than dried mature brown grams.

Reddy et al. (1985) and Bressani et al. (1983) had reported that the tannins are located mainly in the seed coat, the physical removal of them by either dehulling or milling and separating hulls may decrease the tannin content in beans and improved their nutritional quality.

Gaspen Ros et al. (1992) reported that heating decreased the original trypsin inhibitor activity by 81.7% after 5 minutes and 85.9% after 10 minutes. Dehulling alone is reported to increase the trypsin inhibitor activity as reported by Shinde et al. (1991). They had also reported that cooking of whole seeds and cotyledons reduced the trypsin inhibitor activity by 87-90 per cent. Poel et al. (1992) have also reported that effects of steam treatment on antinutritional factors on beans. The results indicate that steam treatment at 119°C for 5 to 10 minutes seem to be a good compromise in terms of inactivation of antinutritional factors.

Shinde et al. (1991) had reported that dehulling and cooking reduced the polyphenol content by 70 per cent and 40 per cent respectively.

Akinycle et al. (1991) had reported that in cowpea seeds after fermentation for 24 hours and soaking (4 hours) or dehulling treatments the decrease in flatulence properties are effective. Addition of chickpea husk (15 per cent) to a fermentable subsrate containing glucose or chickpea endosperm are reported to result in complete inhibition of gas production as reported by El Fahi et al., (1983).

Aflatoxin is a highly toxic substance produced in stored food materials by molds mainly by Aspergillus flavus and Aspergillus niger. Aflatoxin was not reported in stored grains, as studied by Rao et al. (1979), Rampal et al. (1984) and Gupta et al. (1988). Singh et al. (1990) reported that 38 different cultivars of pulses were screened to determine the varietal responses in respect of aflatoxin production. Greengram and soyabean were highly resistant against aflatoxin elaboration.

Ahamad (1993) has also reported that in blackgram aflatoxin contamination was not detected until 3-4 months of storage and depended on the storage system. Closed metal bins and restricted air exchange resulted in lower production of aflatoxin. Greater amount of aflatoxins were detected by Ahamad (1993) in samples stored in gunnybags and higher amounts were observed in gunnybag samples in the wet season. In this experiment Aspergillus flavus and Pencillium utrimum was observed during harvesting and their density was found to increase considerably in storage. Almost 70 per cent of Aspergillus flavus isolates were also found to be toxigenic.

Experiments conducted by Singh et al. (1990) on chickpea, green gram and lentil revealed that green gram was most susceptible to Aspergillus flavus infection and allowed maximum aflatoxin production followed by chickpea and lentil. They had further stated that tannic acid, ferulic acid and sodium benzoate reduced aflatoxin production in the infected seeds of greengram, while sodium chloride and sodium benzoate did not show fungitoxic effect.

Kovaes et al. (1991) has reported that irradiation reduced the number of microbes but had no effect on the biological values or the activities of trypsin inhibitor and lipoxygenase. Dielectric heating had no effect on microbes, but inactivated the trypsin inhibitor and lipoxygenase and increase the biological values of the soyabean.

3. Qualitative losses in pulses during storage

According to Ramzan et al. (1991) India produces about 12.65 million tonnes of different kinds of pulses annually and the post harvest handling and storage losses are estimated to be about 8.5 percent. Nearly 80 percent of the total loss of pulses is caused by insects, rodents and microorganisms in storage. Ramzan et al. (1991) found out that the post harvest handling and storage losses are estimated to be about 8.5%.

Bressani (1984) had conducted studies on storage and processing of common beans. The results revealed that storage and processing introduce chemical changes that affect the nutritional value of food. He had further revealed that improper storage and incorrect or excessive thermal processing are known to affect nutrient content in foods.

When compared with major other foods, pulses are more ssceptible for damage due to insects. Bressani (1984) had reported that bengalgram and blackgram lost about 18% of their protein quality because of insect infestation. The loss may be due to contamination from uric acid as well as by increase in fat, acidity and microbial contaminations.

Vimala *et al*. (1984) had reported that the periodical estimation of dhal yields of greengram, redgram, blackgram and bengalgram have revealed that as the period of storage and level of insects infestation increased, the yield of dhal from the four pulses decreased and the yield of broken seeds increased. Decrease in dhal yield was more in redgram (7.79 per cent) followed by greengram (6.98 per cent) bengalgram (3.04 per cent) and blackgram (2.67 per cent).

Farmers adopted various methods to prevent losses but they succeed only partially owing to the storage of grains in traditional storage structures. A survey was conducted by Thakre *et al*. (1988) in Jabalpur to ascertain the extent of losses of stored food commodities and storage practices followed by the farmers. As per the findings, nearly 5 per cent of total quantity of stored food grains lost during storage and majority of farmers were observed to use traditional storage structures like earthern pots and banda. Loss in viability and quality in the grains due to stick beating and threshing at greater speed were reported by Saini *et al*. (1980).

Many conventional storage practices adopted by farmers are found to give protection aganist insect attacks.

Daniel *et al*. (1977) had reported that insect infestation adversely affects the hygienic condition and overall nutritive value of greengram. Kernal damage was 52% in greengram, 56% in bengalgram and 49% in redgram. There was a marked reduction in the lysine and threonine contents of greengram (5.7 to 4.0 g/100g). The PER (Protein Efficiency Ratio) of uninfested greengram was 1.55 and this decreased to 1.01 with the infested sample.

Ushakumari *et al*. (1991) reported on dhal recovery from redgram grains treated with protectants like leaves, cowdung ash and mustard oil and stored for 4 months in tin containers and clay pots. The findings indicated that samples treated with mustard oil and dried neem leaves were not infested. Wolfson *et al*. (1991) reported on storing cowpeas, with ash to protect them against *C. maculatus* in a traditional storage method. It was found that a minimum ratio of 3 parts of ash to 4 parts of cowpeas prevented growth of *C. maculatus* and that a 3 cm layer of ash on top of stored seeds prevented infestation by adults.

Srivastava *et al.* (1992) had revealed that the infestation by pulse beetle as in stored blackgram seeds results not in quantitative loss but also qualitative losses such as reduction in seed viability. The mean number of insects per 100 g seeds were 283.3, 531.9, 922.5 and 1561.5 after 3, 6, 9 and 12 months of storage. Seed damage increased significantly between 0 to 3, 3 to 6, 6 to 9 and 9 to 12 months storage. The initial seed viability was 90.5 per cent. It decreased tremendously at 3 months and thereafter gradually but significantly at 3, 6, 9 and 12 months storage.

Halpin *et al.* (1987) had reported that in green peas after 3 months of storage, peroxidase and polyphenoloxidase activity decreased or remained constant. Lipoxygenase activity increased over storage, most noticably in the long time or low temperature blanch treatment. Sensory evaluation indicated gradual loss of quality due to poor flavour in the long time or low temperature blanch. Impact of better storage techniques may not be felt unless the storage losses are prevented. Annual availability of the pulses may be increased considerably by improved storage techniques.

Rajendraprasad et al. (1992) had reported significant increase in moisture content of cowpea and soybean during storage in the month of November.

Biochemical constituents of pulses such as reducing sugar, crude fibre, total carbohydrate and non reducing sugars may decrease with the advancement of storage period. Srivastava et al. (1988) had reported that the artificial infestation of Pigeonpea seeds stored in the mud bins resulted in such changes. Emefu et al. (1993) had also reported that the infested cowpea flour samples had lower protein and fat content than the uninfested samples.

Modget et al. (1993) had revealed that in bengalgram, redgram and greengram the crude protein content increased while total protein and methionine decreased, At the 60 per cent infestation level, contents of crude protein were 24 to 48 percent higher than the control, while protein and methionine were 32-41 and 31-58 per cent respectively and their values were lower than the control. They were significantly correlated with the level of infestation. They further reported that the B vitamin content decreased and mineral content increased with increasing infestation level.

Pests are responsible for considerable production loss. Various pulses cultivated are generally damaged by major pests. Khattak et al. (1991) had reported that in bengalgram, damage and weight loss were higher in the pulse beetle infested samples. Doharey (1989) had reported that the storage fungi are the major cause of damage of stored pulses. The deteriorations other than biochemical changes caused by storage fungi are reduction in germination, discolouration of grain, increase in heating time, processing quality of grain and production of mycotoxins as reported by Rao et al. (1980) Shehnaz and Thephillus (1975) and Swaminathan et al. (1981), While conducting similar type of studies, they had concluded that the uric acid content increased rapidly in stored pulses with the increased pulse beetle infestation during prolonged storage.

It is highly essential to draw the attention of the small farmers to bad hygiene, mould, insects and rodents, which farmers at present accept as inevitable during storage. Casewell (1978) and Bressani (1984) have stressed the importance of appropriate storage conditions and well controlled processing which have positive effects in retaining the original nutrient content of the food and improving the availability of specific nutrient and the overall quality of the product.

According to Casewell (1978) pest control can be effective through adequate hygiene, physical methods of control such as storing under ashes or coating with vegetable oil and chemical methods. He has recommended hermit storage for household storage and improved by fumigation products for trader's stored material so as to retain their quality status.

Moisture content plays an important role in the safe storage of food grains as stated by Gupta et al. (1980). Moisture may be gained or lost by the grain depending upon the atmospheric humidity. The study was carried out to determine the absorption of moisture by cereals, millets and pulses at 25°C and relative humidities ranging from 40-100%. They conclude that moisture level changed depending upon the atmospheric humidities.

Gupta et al. (1980) had further reported that the absorption of moisture was more, at higher relative humidities in the case of pulses than that of cereals and millets. The maximum moisture content was found in the order of blackgram, bengalgram and greengram during storage.

Rao et al. (1991) reported that the moisture content and temperature of the stored grain varied and were influenced with the changes in atmospheric temperature and relative humidity. Jain et al. (1992) reported that the cowpea seeds at 9 per cent or lower moisture content can be safely stored for 3 years, even at ambient conditions.

Storage strctures used, have an influence on the rate changes in the biochemical constituents of pulses. Pushpasree et al. (1988) reported that among the bags, plastic lined jute bag was found to give better protection than the tightly knit jute bag for storage.

Birewar et al. (1980) reported that an indoor type design of cavity wall bin of 0.75 Mt capacity was developed at Indian grain storage institute, Hapur for storage of grains at farmers level. Observations on storage bin of Hapur indicated that the structure is suitable for storage of food grains as well as for seeds, since it maintained grain temperature and moisture within a safe limit. The bin was found to be rat proof and free from insect damage.

Rao et al. (1990) had reported that the moisture content decreased in blackgram stored in jute gunnybag, nylon gunny bag, steel bin and plastic lined jute gunnybag, upto 120 days and the mositure content increased at 150 days due to changes in atmospheric temperature and relative humidity.

Rao et al. (1991) had conducted studies on two varieties of blackgram and were stored for 150 days. Moisture content of the two varieties ranged from 8 to 11.20 per cent and 8.10 to 12.70 per cent respectively for the whole period indicating that moisture was not influenced by the type of storage structures or the varieties.

Srivastava et al. (1990) reported that the natural convections in grain stores also produced moisture movement. The process is very low but the moisture content of the grain can change enough during the month of storage to influence the quality of the grain.

Katiyar et al. (1992) reported that the seeds of chickpea harvested at physiological and harvestable maturity were cleaned and dried to a moisture content of 8 to 8.5 per cent and stored under ambient conditions in the storage structure of gunnybags, pucca, earthern pots, tin containers and polythene bags for a period of nine months. The moisture content was found to be increased in all the containers.

According to Bressani (1984) storage with high temperature and relative humidity will result in staple foods with high moisture levels and a decrease in quality because of the maillard reaction and because of the growth of fungi that produced toxic compounds. According to Onesirosan (1986) temperature, moisture content and duration of storage affected the aesthetic qualities, incidence of internally-borne storage fungi and germination percentage.

Soluble peroxidase activity of blackgram and the effect of heat pretreatments and storage conditions on hardening and enzyme inactivation of the pulse was studied by Rivera _et al_. (1989). They had stated that a heat pretreatment of beans at moisture content not exceeding 13% failed to control hardening in gram subsequently stored at temperature of 27°C above and at a moisture level of 13%. Storage is reported to have a direct effect on the germination rate of the grains.

Onesirosan (1986) reported that variation in initial moisture contents had no deleterious effects on germination of winged bean seeds stored at 8^{o}C for 24 weeks.

In a storage study with blackgram, pulses stored in steel bin and nylon gunny bag recorded highest germination (Rao et al., 1991). Usha et al. (1990) reported that the cowpea seeds and horsegram seeds treated with malathion and stored in polythene bags and cloth bags were found to have good viability over a period of 8 months while Rao et al. (1991) reported that the blackgram stored in steel bin and nylon gunny bag recorded the highest germination percentage when compared to the pulses stored in jute bags and mud pots.

Halpin et al. (1987) had reported that in greengram the enzymes such as, peroxidase, polyphenoloxidase, lipoxygenase and catalase exhibited varying degrees of activity over the first 3 months in storage. The quality loss was also noticed due to this enzymatic changes as reported by Casewell (1978) that the common pests of stored grain legume include Callosobruchus bruchus, Lesioderma serriorne and Trogoderma granarium.

Doharey (1989) had reported that the stored pulses were attacked by various deteriorating agencies such as insects, rodents, birds and microorganisms. Ramzan (1991) stated that during storage the pulses are mainly damaged by three species of pulse beetles C. chinensis (L) C. analis (F) and C. maculatus (F). Ramzan et al. (1991) had also reported that during storage the pulses are damaged mainly by pulse beetles.

Ramdoss et al. (1987) reported that mostly the bengal gram varieties were susceptible to the attack of pulse beetle in storage. Kumari et al. (1991) had studies on the growth and development of Callosobruchus chinensis on five pulses viz. chickpea, pigeon pea, greengram, blackgram and peas. Growth index in gram, peas and urd were 1.89, 1.37 and 1.07 respectively. Arhar and moong grains unlike urd and peas were prone to the pest attack.

Storage fungi are reported to be major cause of damage of stored pulses, (Daharey, 1989).

Satyavir et al. (1989) studied the infestation of seeds and loss in weight of mothbean and cowpea seeds at 4 levels of initial infestation and the highest loss due to infestation reported in the study was 68, 90 per cent after six months storage. Srivastava et al. (1988) studied the composition of pigeonpea seeds for one year in wooden, steel and mud bins in relation to field borne infestation by bruchid. The highest increase in insect population was seen in mud bins followed by steel and wooden bin.

Insect infestation losses were observed to be higher in earthern pitchers and least in tin containers and polythene bags. Swarooparani et al. (1988) had reported that plastic bag was observed to be the best with regard to its efficiency in preventing infestation in pulses and its cost when compared to jute bag and plastic lined jute bag. Rao et al. (1991) had reported that two varieties of blackgram were stored in polythene lined jute gunnybag, jute gunnybag, nylon gunnybag and steel bin, for 150 days and seed borne fungi was also observed to be less in blackgram stored in jute gunnybag.

Ramzan et al. (1991) found out that the losses caused by C. Chinensis (L) in Kabligram was the maximum (75%) in earthern pitchers and the least in tin containers (20.5%).

In plastic containers and polythene bags, the damage was 30.5 and 52.5% respectively.

Krishna Jha *et al*. (1993) had reported that the moisture impermeable metal containers and laminated aluminium foil packs gave more protection to full fat soyflour under 38°C and 90 per cent RH. While jute and cotton bags were found to be unsuitable.

Covering pulses with 7 cm layers of sand or saw dust, wood ash or dung ash has been recommended against bruchids as stated by Ramzan *et al*. (1991).

Gupta *et al*. (1981) reported on an evaluation of the qualitative and quantitative losses in bengalgram caused by pulse beetle during six months storage and revealed an increase in moisture content, insect population, weevilled grain, weight loss, protein, fat, free fat, acidity, uric acid, total ash, acid in soluble ash, calcium and crude fibre. While viability, total sugars and starch had decreased.

Vimala *et al*. (1985) reported that greengram, redgram and blackgram were separately fumigated with EDB, sprayed with malathion 50 per cent and treated with tricalcium phosphate at 0.2 per cent level and stored in jute bags, metal bins and mud pots for 1 year.

Patel et al. (1990) reported the levels of fenuvalerate residues from pigeonpea grains as well as from the podshell. Three emulsion sprays (0.005%, 0.01%, 0.02%) and a dust formulation (0.4%) were applied 25 kg ha^{-1}. The levels in pigeonpea grains at harvest did not exceed the maximum residue limit of 1 ppm. However, more than 1 ppm of residues were found in the pod shells from all the treatments except 0.005% spray.

Different edible oils aganist insect attack are reported by Sujatha et al. (1985) and Ramzan et al. (1991). An indepth study undertaken by Pushpasree et al. (1988) on similar lines to find out the efficacy of four oils, namely coconut, gingelly, groundnut and safflower oils as prestorage treatments for greengram stored in two types of bags, viz. tightly knit and plastic lined jute bag.

Among the four oils used, safflower oil at 0.6 per cent level was found to be effective with insignificant level of infestation.

Doharey _et_ _al_. (1990) had reported that oils of groundnut, mustard, ricebean, safflower, sesamum, and were used at 0.10, 0.25. 0.50 and 1.10 per cent concentration to control _Callosobruchus_ _ohinensis_ and _Callosobruchus maculatus_ in greengram. Malathion 50 per cent EC was used at 0.00 % (10 ppm) level. Coconut, groundnut and mustard oils at 1.0 per cent concentration controlled the pest effectively. Other oils controlled the pests upto 6 months. All the edible oils were more effectively controlled the pests than malathion. Sunflower oil at all the concentration against _C_. _Chinensis_ and safflower oil against _C_. _maculatus_ were found less effective after 6 months of treatment.

Kiran kumari _et_ _al_. (1990) conducted an experiment under a typical godown condition with temperature 32.2 ± 4 per cent and relative humidity 70.3 per cent to evaluate the efficacy of mustard oil, linseed oil, till oil, groundnut oil and neem oil as grain protectant at 1% level against pulse beetle. All these vegetable oils tested, proved equally effective for reduction in the percentage of damaged grains by number as well as by weight.

Pereira (1990) assessed traditionally extracted groundnut oil, palm kernal oil and industrially extracted groundnut oil as protectants of cowpea and groundnuts against pulse beetle with oil treatment, the degree of ovicidal activity was higher on bambara groundnuts than on cowpea. Even after 90 days storage, a major part of the insecticidal activity was retained by the cowpea testa. At 8 ml Oil/Kg. cowpea seed gave good protections upto 3 months.

Single et al. (1990) had reported that least number of egg colony (34.3 eggs) occured on chickpea seeds treated with mustard oil at 5 ml/Kg. When compared to coconut oil, groundnut oil, sesame, soyabean and rapeseed oils. Chickpea treated with oil, suffered less seed damage than untreated seeds and it does not adversely affect seed germination.

Echendu (1991) reported that the surface application of cashewnut shell liquid was found to be superior to ginger and neem in reducing infestation by pulse beetles. The results of the viability test also revealed no adverse effects on seed viability as a result of the treatments.

Sree Ramah et al. (1992) had studied on freshly harvested seeds of cowpea stored in cloth bag and polythene bag for eight months after treating with malathion 5 per cent dust at 2g/Kg. and neem oils at 5 ml/Kg. alongwith an untreated control under the ambient conditions. The neem oil seed treatment gave 100 per cent protoction against Bruchid infestation, and maintained higher germination in both the containers at the end of storage period. In Malathion dust treatment, the Bruchid infestation was significant only after 6 months but the good seed content was to the extent of 82 per cent even after 8 months. In untreated control, the Bruchid infestation was noticed in the first month itself and at the second month end, the good seed content was reduced to 13 per cent and by eighth month it was almost zero. Though there was a gradual increase in insect count, kernal damage, weight loss, and uric acid content as the period of storage increased, in general greengram samples treated with oils showed better resistance to insect infestation than untreated samples. Among the four oils used safflower oil at 0.6 per cent level was found to be effective with insignificant level of infestation.

Sharma et al. (1992) had reported that the treatment of chickpea seeds with the edible oils of coconut, sesamum, rape seed and cotton seed of quantity 1 ml., 2ml and

4 ml/Kg, were found to be safe against the pulse beetles during 12 months of storage.

Ghosh _et_ _al_. (1980) reported that seed dressing of _Cicer_ _arietinum_ with powdered neem seed kernal at the rate of 1.5 part/100 part grain proved to be the more efficacious for the control of pulse beetles followed by chrysanthimum powder and sweet flag powder. Powdered neem seed kernal provided best result in respect of toxic effect, safety and economy, whereas other two products, though inferior than former, were also fairly effective. Reddy _et_ _al_. (1987) also reported on the efficacy of neem leaves, country borage leaves and rhizome of sweet flag in the form of dusts and benzene extracts, as pre-storage for greengram. The sweet flag applied as dusts and benzene extract offered best protection with reference to pulse beetle population, kernal damage, weight loss, nitrogen content and viability loss. Ushakumari _et_ _al_. (1991) reported that the cow dung ash treated samples showed 61.5 per cent damage due to insect infestation.

Pre-storage chemical fortification of seeds is a method to prolong their shelf life. Swarooparani _et_ _al_.

(1988) had reported that the 0.5 per cent tricalcium phosphate treatment was the best in protecting the pulses from infestation. Vanangamudi et al. (1986) studied on redgram, greengram and blackgram seeds for determining the effect of indole 3 butyric acid, in appropriate concentration, pelleting with peat-based rhizobium culture and dusting with thiram as 75 per cent. Wettable dust powder at 2 g/Kg. of seeds was found to retard the deterioration of seeds and to maintain their germinability for 48 months. Van Toai et al. (1986) reported that the effect of vitavax 200 seed treatment became significant only after 24 months of warehouse storage. Of the three storage and conditioned storage, the conditioned storage was found to be superior for maintaining seed quality followed by nitrogen gas storage and warehouse storage. According to Singh et al. (1979) even at the lowest concentration malathion exerted prophylatic action on pests to stored products. They had further suggested that this sample technique can replace fumigation for controlling infestation of stored grain.

Study conducted by Singh et al. (1979) indicated that DDT 100 ppm. DDT 200 ppm and Yardona 20 ppm were the most persistent chemicals used to grains meant for seed purpose. In this study, malathion and lindane were restricted to grains meant for seed purpose only. Taylor et al. (1980) reported that effectiveness of dilute dust formulations of pirimiphos methyl and permethrin on redgram and on Phaseolus radiatus as a protection against bruchids and observed that damage is much reduced and reinfestation is largely prevented. To ensure good control, minimum application rate of 5 mg./Kg. is recommended.

4. Cooking characteristics of the stored pulses

Cooking characteristics in general are found to be affected during storage. Hardness during cooking is considered to be a disadvantage found in stored pulses. Cooking time is reported to increase with the advance in storage period irrespectively (Vimala et al. 1985). Bressani (1984) has also reported that the poor storage will increase the hard to cook state and increase in storage period resulted in increase in cooking time.

Rozo et al. (1990) conducted a storage study with whole beans and reported that increase in hardness of cooked whole beans due to storage may probably be due to the synthesis of nitrogen containing compounds in the cell walls during adverse storage resulting in dissolution of the middle lamella during cooking.

Mafulekamm _et al_. (1990) also studied on the hardness of decorticated beans stored for 4 to 8 months. The findings revealed that hardness increased due to storage temperature.

Studies conducted by Bernal Lungo _et al_. (1990) threw light on the significance of phytate on the hardening of stored grains. The experiments revealed that Michigas cultivar, the most susceptible to hardening, showed higher initial content of phytate which decreased by 20.7% after 30 days of storage. In contrast, the cultivar, Ojode cabra was found less susceptible to hardening and presented a lower initial content of phytate and a marked drop of 66.1% in its level during the same period of storage time.

Liu _et al_. (1992) reported that the hard-to-cook state of cowpea seeds was experimentally induced after differential storage of seeds for 12 months. Water absorption following incubation increased with incubation temperature but aged seeds absorbes less water than control seeds.

In the same experiment influence of various temperature and relative humidities on hardening was ascertained. They had further stated that soaking in calcium chloride alone evoked a great increase in hardness whereas incubation slightly enhanced hardening. Rozo et al. (1990) reported that acid detergent residue lignin and cellulose contents of cotyledons in pulses did not change by cooking.

Bak et al. (1988) reported that the foliar application with gibberellic acid, and white wash, especially under saline conditions, improved the nutritive value of raw cowpea seeds by increasing total protein, soluble carbohydrate, total free aminoacid and invitro protein digestibility as well as reducing antinutritional factors like trypsin inhibitors and tannins. Bakr et al. (1992) found out that cooking time, volume and firmness of cooked cowpeas were not affected by foliar application of plants with gibberellic acid and cycocel. Salinization increased cooking time, decreased volume and firmness of cooked seeds.

Phirke et al. (1982) had reported that soaking the phaseolus seeds in water for 12 hours reduced the cooking time by about 60 per cent in the various types of seeds. Srivastava et al. (1988) had conducted studies on the effects of soaking seeds in different concentrations of sodium bicarbonate on leaching of various compounds and nutritional quality of pigeon pea seeds. Soaking in solutions of sodium bicarbonate caused leaching of sugars, protein and electrolytes from seeds to the soaking medium, decrease in starch and protein content in seeds and increase in amylose activity. The decrease in pectin and gum, and the increase in polygalacturonase and pectin methyl esterase were more when seeds were soaked in sodium bicarbonate solutions than in water.

Bakr et al. (1990) conducted studies on mung bean seed and he reported that soaking slightly increased protein content and reduced phytate and trypsin inhibitor content. Reduction were greater at 55^{o}C than at 22 -25^{o}C. Biosynthesis of protein, ascorbic acid and riboflavin and biodegradation of phytate and trypsin inhibitor were greater during germination at ambient than at lower temperature. Thiamine and aminoacid contents were less affected by germination temperature. The higher levels of ascorbic acid (47 mg/100g) riboflavin (10.035 mg/g) and thiamine (0.043 mg/g) were reached after 48 hours germination at 20^{o} C, 48 hours at ambient temperature and 72-96 hours at ambient temperature respectively.

Sharma et al. (1991) had reported that the faba bean varieties showed increased protein and starch digestibility due to soaking and cooking, but autoclaving for 25 minutes had maximum beneficial effect.

Sharma et al. (1992) had reported that soaked and dehulled seeds showed reduction in phytic acid (4 per cent) and saponin (26-29 per cent) and further autoclaving for 25 minutes resulted in maximum loss of antinutrients. Antinutrients concentration decreased during germination and lectin was found even after 48 hours of sprouting.

Bakr et al. (1992) had evaluated that soaking in water for 12 hours before cooking, decreased cooking time and firmness but increased volume of cooked seeds, whereas the effect of soaking in hot water was more pronounced. Rate of water inhibition during cooking of dry and soaked seeds was linear to cooking time. Soaked seeds in distilled water gave the highest weight at any time of cooking. More solids were leached out due to cooking in 2 per cent sodium chloride solution compared to cooking in plain water. Soaking in hot water before cooking retained more nutritional components. Soaking in hot water improved markedly the sensory properties particularly appearance, texture and colour.

A study conducted by Kailasapathy et al. (1986) on the effect of soaking of blackgram, greengram, cowpea, soyabean and winged bean on cooking quality revealed a reduction in cooking time. They had further suggested that soaking the seeds in sodium bicarbonate solution have a slight advantage over soaking in water or sodium chloride solution with regard to tenderness and palatability.

Akinyele et al. (1991) had reported that in cowpea verbacose decreased significantly due to the treatments like fermentation (24 hours), or soaking (4 hours) or dehulling. Stachyose decreased moderately in soaking (29.8 per cent) and dehulling (16.9 per cent), raffinose decreased significantly in dehulling (56 per cent), sucrose increased moderately in soaking (41.9 per cent) and dehulling (45.9 per oent) fructose increased in fermentation (105 per cent) and soaking (43 per cent) and glucose or galactose increased in fermentation (56.4 per cent) but decreased in both soaking (55 per cent) and dehulling (63.6 per cent).

Pushpamma et al. (1983) had reported that soaking roasting and simple drying were the pretreatments given to redgram, mungbean, urdbean and bengalgram before milling and dehusking. Considerable differences were noticed in yields of dehusked split grain and cooking quality between and within legumes in different methods of processing.

Charanjeet et al. (1988) had conducted studies on the cooking qualities of rice bean. He reported that the cooking time for rice bean was significantly higher than that of greengram but comparable to blackgram. Sensory evaluation of cooked pulses showed that overall acceptability of whole rice bean was comparable to that of greengram, blackgram and cowpea.

Phadye et al. (1979) reported that the protein fractions of blackgram were characterised for their aminoacid composition, isoelectric points and subunit composition.

Globulins which formed 81 per cent of the solublised proteins were devoid of sulfur containing amino acids. Phrike et al. (1982) studied about the various agents employed to solublise the bean proteins and had found that sodium hydroxide extracted the maximum protein. It was also observed that the bean proteins had least solubility at pH4. As reported by Pushpamma et al. (1983) the protein content of dhal is higher by 6-12 per cent than the whole grains in redgram and urdbean but less by 11 to 14 per cent in chickpea. Reduction in protein solubility, at a temperature greater than or equal to $90^{o}C$ was observed by Philip et al. (1988).

Poel et al. (1992) reported lysine was lost partially on heating. They further indicated that steam treatment at 119^{o} C for 5 to 10 minutes damaged protein as measured by total and available lysine.

Ziena et al. (1992) reported that almost all essential amino acids declined after cooking at temperature 100- 125^{o} C for 1 to 2 hours.

However the time required for cooking can be appreciably shortened by sprouting during which the thick outer coat bursts open and the grain becomes soft making it easier for the cooking water to penetrate the grain. Sprouting had a remarkable effect on increasing starch digestibility as reported by Sharma (1991).

Sprouting of pulses results in an increase in digestibility and decrease in cooking time. Legumes which are not easily digested are well tolerated after sprouting Obizoba (1992) studied on the effect of sprouting on nitrogenous constituents of pigeon pea seeds. After 48 hours of sprouting, there were increases in moisture, crude protein, ash, total nitrogen, true protein and total non-protein nitrogen but, after 96 hours of sprouting there were increase in moisture, crude protein and ash.

Obizoba (1992) reported the effect of sprouting on mineral composition of pigeonpea seeds and the results indicate that sprouting caused an increase in all mineral levels except phosphorus. A comparison among varying times revealed that sprouting for 48 hours offered greater advantage over 96 hours.

Ros et al. (1992) reported that ash was affected by the time of heating, changes occurred most rapidly during the first five minutes and more slowly thereafter. Fresh cowpea seeds were softened sufficiently for eating after 10 minutes at which time, pH increased from 6.5 to 6.75 . Philip et al. (1986) had reported that increase in drying temperature increased browning of the meal.

Pushpamma et al. (1983) reported on losses of calcium, iron and B group vitamins during roasting and simple drying. Philip et al. (1988) reported that increase in drying temperature reduced thiamine content.

MATERIALS AND METHODS

MATERIALS AND METHODS

A study on "Influence of different storage methods on quality changes in selected pulses" was conducted to assess

a. the consumer level preference for various pulses commonly stored by the farmers and godown owners

b. the problems related to storage and marketing and

c. the changes in selected pulses during farm level and market based storage .

Investigation carried out under the study was classified into four broad areas.

a. A field survey among selected fifty farmers engaged in pulse cultivation to collect information on the pulses grown, varietal preference for consumption and storage and marketing practices adopted by them with reference to commonly cultivated pulses.

b. A field survey among forty five selected personnel who are engaged in the maintenance of godowns that store pulses and other grains, to collect information on their preference for procurement and storage to understand the existing storage conditions in the godowns; and to study the problems faced by them while storing pulses on a large scale.

c. Detailed laboratory estimations on stored pulses, withdrawn from a godown at regular intervals to study qualitative changes and losses under bulk storage.

d. Detailed laboratory estimations at regular intervals on pulses stored by conventional methods, popularly adopted by farm households, to study the quality changes and extent of losses.

Sample selection

a. Selection of area for the study

From Thiruvananthapuram district three Krishi Bhavans were selected for the study in consultation with the district level officials of the Department of Agriculture. The Krishi Bhavans selected for the survey were Venganoor, Neyyattinkara and Balaramapuram. These Krishi Bhavans were selected because they had pulses as one of the major crops of the area. Moreover the co-operation of the officials was forth coming and were accessible. Discussions were held with the officials of the selected Krishi Bhavans to explain the objectives of the survey and to get the co-operation required in data collection from the farmers of their jurisdiction.

b. Selection of farmers

From the above three Krishi Bhavans fifty farmers were selected for the study by stratified random sampling technique. The main criterion for selection of farmers for the study was that they were regularly cultivating one or more commonly used pulses, and were storing these pulses for more than three months. Thus 26 farmers from Venganoor, 15 from Neyyattinkara and 9 from Balaramapuram were selected for the study.

c. Selection of godowns for the study

All the forty five godowns in Thiruvananthapuram district which were storing pulses on a wholesale basis, and which were established for more than 5 years were selected for the study.

Selection of tools and conduct of the study

Initially two schedules were formulated as detailed below :

a. Schedule to elicit information from the farm families on the types of pulse crops grown, storage practices adopted, problems faced by the farmers in storing pulses and varietal preference for consumption was structured suitably and pretested at the field level. The finalised schedule was used for the survey. The survey was conducted by interviewing the heads of the selected fifty farm households by the investigator.

b. Schedule to elicit details on the storage of the godown, information related to duration of storage, physical facilities available in the godowns and problems faced by the wholesale dealers in storing pulses in their godowns was suitably structured and pretested.

Interview method was used to collect the required information using the above questionnaire from the wholesale dealers who owned godowns.

From the above surveys the following details were gathered. Pulses like greengram, blackgram and cowpea were the most commonly cultivated pulses of the area. Containers like mudpots, gunnybags, aluminium tins and plastic containers were commonly used for storing the pulses and the pulses were stored for more than three months at a stretch by the farmers at their households. In the godowns the pulses like greengram blackgram, cowpea, redgram and bengalgram were commonly stored in gunnybags for more than one month by the wholesale dealers.

On the basis of the above results, detailed storage studies were conducted in the laboratory as detailed below :

Studies on farm level storage

For the farm level storage the methods adopted by the farmers, as revealed by the survey was employed in the laboratory. Thus pulses like greengram, blackgram and cowpea were procured and stored in mudpots, gunnybags, plastic bags and aluminium tins. The samples of 2 kgs each were stored in the above said containers for the purpose and were stored in the laboratory for a period of 12 months. The samples were withdrawn every month starting from the date of procurement to the twelth month, for detailed physical, chemical and microbiological and organoleptic analysis.

Studies on godown level storage

From the forty five godowns, one was selected at random for storing the pulses for detailed study. This godown, infact, was used as a field laboratory. As revealed by the earlier survey, pulses like greengram, blackgram, cowpea, redgram and bengalgram were selected for the study, immediately after procurement at the godown. The samples of 2 kgs each were stored in small gunnybags stitched for the purpose and were stored in the godown itself for a period of 12 months. Every month one gunnybag was withdrawn, starting from the procurement date to the twelfth month. The temperature and relative humidity of the godown, where the pulses were stored were also recorded. The samples were systematically labelled, coded and kept ready for analysis. The samples withdrawn every month were subjected to the following tests to assess their quality.

i) Physical analysis - was carried out to observe the losses due to the advancement of storage. Losses in constituent fractions - undamaged grains, damaged grains and foreign matter - were assessed using standard techniques. Percentage weight loss due to infestation and fungal damage in different periods of storage was calculated (Pushpamma and Chittamma Rao, 1981). Loss due to pest infection were also assessed.

ii) Microbial contamination - Qualitative examination of the samples for the presence of micro organism was carried out by Direct plate method. (James M. Jay, 1986)

Stored samples withdrawn once in 3 months from the laboratory and godown were subjected to the following tests -

i) Cooking quality

Cooking quality of the pulses were carried out to determine the changes in organoleptic qualities due to long period of storage. The cooking quality of the stored pulses were determined by cooking the pulses by commonly used household cooking methods. The methods used were :

1. cooking with excess water

2. Soaking the pulses for 3 hours in water and cooking with excess water

3. Steaming

4. Soaking the pulses for 3 hours in water and steaming.

After cooking the pulses the following parameters were ascertained by the method suggested by Adams (1978).

1. Cooking time
2. Water uptake
3. Volume expansion
4. Percent hydration coefficient

The above said parameters were conducted to study the changes in cooked pulses due to storage.

ii) Chemical analysis

Changes in moisture, nitrogen, non-protein-nitrogen, minerals and uric acid content of the stored samples were observed. So they were estimated using the standard techniques detailed below.

1. Mositure - Method of A.O.A.C. (1970)

2. Nitrogen - Microkjeldal method (Jackson, 1973)

3. Non-protein nitrogen - Method of Bhatly et al. (1973).

4. Minerals - Atomic Absorption spectrometer - Perkins Elmer 3030

5. Uric acid - Methods of Seligson (1963).

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

This chapter presents a comprehensive information on the consumer level preference for various pulses and problems faced by the farmers and personnel responsiblo for large scale storage of pulses. Data pertaining to quality changes in stored pulses are also included.

The above details were collected through

1. A survey conducted to elicit information on the pulse crops grown, storage practices adopted, and varietal preference for consumption among selected 50 farm families of Venganoor, Neyyattinkara and Athiyanoor Krishi Bhavans area by interview method using a suitably structured schedule.

2. A survey conducted to elicit information on the different large scale storage methods adopted for pulses and storage problems faced at godowns/warehouses by the owners.

3. Storage studies at the farm level and at godowns.

4.1. Details collected through the survey among 50 farmers are presented under:

1.1 Cultivation of different types of pulses.

1.2 Storage of pulses at the farm level.

1.3 Qualitative and quantitative changes during storage

1.1 Cultivation of different types of pulses

Blackgram, green garm, horsegram and cowpea were found to be the pulses commonly cultivated by the farm families. Details of different types of pulses cultivated and area of cultivation under each pulse are presented in Table 1.

Among the 50 farmers surveyed, 30 percent were in possession of 21 to 30 cents of land while 36 per cent had 31 to 40 cents. 41 to 50 and 51 to 60 cents of lands were possessed respectively by 14 percent and 8 percent of farmers surveyed. Only four to eight percent of farmers were found to possess 71 to 80 cents and 91 to 100 cents respectively.

Among the farmers surveyed, blackgram was cultivated by 28 percent of the farmers, greengram by 18

Table 1. Details of different types of pulses cultivated and area un
cultivation (in percentage)

Details of pulses	Area under cultivation (in cents)								
	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	To
Blackgram	4	–	–	–	–	–	–	–	4
Cowpea + Greengram	8	8	2	–	–	–	–	–	18
Horsegram + Greengram	2	2	–	–	–	–	–	–	4
Greengram + Blackgram	6	6	2	2	–	–	–	–	16
Horsegram + Greengraam + Blackgram	10	12	6	2	–	2	–	2	34
Cowpea + Blackgram + Greengram	–	8	4	4	–	–	–	–	16
Cowpea + Blackgram + Greengram + Horsegram	–	–	–	–	–	2	–	6	8
	30	36	14	8	–	4	–	8	10

percent, horse gram by 12 per cent and cowpea by 8 percent of the farmers. Only four percent of the farmers were cultivating blackgram alone and the area under cultivation was between 21 cents to 30 cents. Cowpea and blackgram were cultivated by 18 percent of the farmers and among them 8 percent were cultivating the pulses in 21 to 30 cents of land while another 8 percent of the farmers cultivated these crops in 31 to 40 cents. The remaining 2 percent of the farmers were in the habit of cultivating the two pulses under an area of 41 to 50 cents.

Horsegram and greengram were cultivated only by 4 percent of the farmers. 21 to 40 cents was the area used for legume cultivation by these farmers.

Six percent of the farmers reported that they were in the habit of cultivating greengram and blackgram in an area of 21 to 30 cents, another 6 percent of the farmers reported 31 to 40 cents as their pulse cultivating area. While 41 to 50 cents and 51 to 60 cents of cultivation area were reported by 2 percent of the farmers respectively. 34 percent of the farmers were found to cultivate horsegram, greengram, and blackgram, under an area of 21 to 30 cents and was reported by 10 percent of the farmers. The above pulses were cultivated by 12 percent of the farmers under an area of 31 to 40 cents, while 6 percent of the farmers reported that they were cultivating these pulses in an area of 41 to 50 cents, 51 to 60 cents (2 percent) and 71 to 80 cents (2 percent). Cowpea, blackgram and greengram were cultivated by 16 percent of the farmers under the area 31 to 40 cents (8 percent) and 41 to 50 cents (4 percent). Four types of pulses viz. cowpea, blackgram, greengram and horsegram were cultivated by 8 percent of the farmers and the area allocated for cultivation was 71 to 80 cents by 2 percent and 91 to 100 cents by 6 percent of the farmers.

Details pertaining to the preference of farmers for different pulses for cultivation are given in Table 2.

As revealed in Table, 84 percent of the farmers had first preference for blackgram for cultivation. Another 10 percent preferred this crop as a second choice. The order of preference as a first choice was blackgram (10 percent) followed by horsegram (6 percent), cowpea (6 percent) and greengram (4 percent). As a second choice 58 percent of the farmers preferred horsegram and 24 percent of the farmers

Table 2. Distribution of farmers based on their preference for cultivation of different pulses

Details of pulses	Details of farmers	
	First preference	Second preference
Blackgram	42(84)	5 (10)
Cowpea	3(6)	4 (8)
Horsegram	3(6)	29(58)
Greengram	2(4)	12(24)
Total	50(100)	50(100)

Number in parenthesis indicates percentage preferred greengram and only 8 percent of the farmers preferred cowpea.

Duration of cultivation had no influence in deciding the choice of a pulse crop as crop for cultivation. In this context though greengram, horsegram and cowpea could be harvested after 2 months they preferred blackgram on a duration of 2 1/2 months. The harvested pulses were stored by all the farmers at their households.

The major pre harvest loss of the produce during cultivation was mainly due to attack by insects, rodents and birds. Details pertaining to the loss of crops during cultivation are presented in Table 3.

As revealed in the table, the main loss of crops was due to insect attack (32 percent) while loss due to rodent attack was reported to be 20 percent. 22 percent of the farmers had reported the loss due to both insects and rodents. While losses due to rodents and birds and due to insects, birds and rodents were reported by 4 percent and 22 percent of farmers respectively.

Table 3. Loss of pulses during cultivation

Reasons	Details of farmers
Insects	16 (32)
Rodents	10 (20)
Birds	-- --
Insects rodents	11 (22)
Rodents birds	2 (4)
Insects, rodents, birds	11 (22)
Total	50 (100)

Number in parenthesis indicate percentage

Table 4. Distribution of farmers based on the annual yield of pulses from other farmers

Yield (in kg)	Details of farmers
10-20	12 (24)
20-30	12 (24)
30-40	5 (10)
40-50	4 (8)
50-60	3 (6)
60-70	3 (6)
70-80	1 (2)
80-90	1 (2)
Total	(82)

Number given in parenthesis indicates percentage

In every harvest, 24 percent of the farmers had obtained 10 to 20 kg of pulses. About 10 percent of farmers were found to have an yield of 31 to 40 kg at every harvest. Forty one to 50 kg by 6 percent of the farmers and 61 to 70 kg by another 6 percent of the farmers. An yield of 70 to 80 kg of pulses and 80 to 90 kg of pulses were obtained by 2 percent each of the farmers surveyed. The pulses were mostly produced for household consumption and stored till the next crop was harvested.

1.2 Storage at the farm level

As revealed in Table 5 pulses were generally stored at the farm as well as in the farmhouses. Eight percent of these families stored the pulses in the farm itself, while 92 percent stored the crops in their houses. Quantity of pulses stored at household level varied from pulse to pulse and also depended on the quantity produced, the level of consumption, family requirements for both consumption and seed purposes till the harvest of the subsequent crop and storage facilities available at the households. Large sized mudpots and gunny bags were found to be popularly used for storing pulses at the farm. In the houses, mudpots, gunny

Table 5. Conventional methods of pretreatments given to the pulses prior to storage

Pre treatments given	Storage containers used						
		At farm		At farm house			
	No. of farm families in percentage	Mud pot	Gunny bag	Mud pot	Gunny bag	Aluminum tins	Plastic Bag
Mixing with sand	28(56)	2(4)	–	21(42)	3(6)	1(2)	1(2)
Sundrying	19(38)	–	2(4)	10(20)	6(12)	1(2)	–
Mixing ash	3(6)	–	–	–	–	2(4)	1(2)
Total	50(100)	2(4)	2(4)	31(62)	9(18)	4(8)	2(4)

Numbers given in parenthesis indicates percentage bags, aluminium tins and plastic containers were used as storage containers by 62, 18, 8 and 4 percent of the farmers respectively.

Sun drying pulses prior to storage was a traditional custom followed by all the farmers. 82 percent of the farmers were in the habit of sundrying pulses for 6 hours before storage while sundrying for 2 hours was adopted by 18 percent of the farmers.

From the observations made at the storage sites, it was found that pretreatments were given prior to storage. Hence details of pre-treatments given were collected. Pulses stored at the farm houses were generally subjected to conventional pretreatments. Three of treatments were given conventionally prior to storage of pulses. They are (i) mixing the pulses with sand, (ii) mixing the pulses with ash, and (iii) Sundrying. According to variations in the storage containers, the type of pretreatments given also was found to differ. 4 percent of the farmers reported that the pulses stored in mudpots at the farm was mixed with sand while another 4 percent of the farmers were in the habit of sundrying the pulses which were stored in gunny bags. At the

Table 6. Modern methods of pretreatments given to the pulses prior to storage

	Distribution of the farm families (in per cent)			
Preatments	Greengram	Blackgram	Horsegram	Cowpea
For food				
Fungicide spraying	-	-	-	1(2)
Insecticide spraying	7(14)	5(10)	3(6)	3(2)
For the seeds				
Treatment with insecticide	5(10)	1(2)	2(4)	2(4)
For seeds as well as for foods				
No treatment	3(76)	44(88)	45(90)	44(88)
	50(100)	50(100)	50(100)	50(100)

Percentage of farm families given in parenthesis farm house the pulses were stored in mudpots, gunny bags, aluminium tins and plastic bags and were treated with sand by 42, 6, 2 and another 2 percent of the farmers respectively. 20 percent of the farmers reported that sundrying was given as a pretreatment for the pulses stored in mudpot while 12 percent of the farmers reported sundrying as a pretreatment for pulses stored in gunny bag. Sundrying as a pretreatment was given by 2 percent of the farmers for the pulses stored in aluminium tins. Only 6 percent of the farmers had reported mixing the pulses with ash as a pretreatment, especially for the pulses stored in aluminium tins and plastic bags.

Modern pretreatments given to the pulses before transportation to the storage place is given in Table 6.

Many of the farmers (76 percent to 90 percent) were not in the habit of applying modern pretreatments to all four types of pulses prior to storage. Pulses stored were used for two purposes one as food item and also as seed material. Very few farmers were found to treat pulses with insecticides, if the crop was to be used for table purposes. Insecticides were found to be used by 2 to 4 percent of the

Table 7. Usage of stored pulses by the farmers

Usage of pulses	Details of families
For consumption alone	10 (20)
For consumption and seed purposes	21 (42)
For consumption and for givng seeds as gifts	5 (10)
For consumption and for selling seed to the neighbours	4 (8)
For consumption, seed purpose and for marketing	10 (20)
Total	50(100)

Number given in parenthesis indicate percentage farmers while fungicide was used by 2 percent for cowpea alone prior to storage.

Details pertaining to usage of pulses are presented in Table 7.

Among the farmers surveyed, 20 percent of the farmers were storing the pulses only for household consumption while 42 percent of the farmers were storing the pulses for consumption and seed purposes. The pulses stored were used for giving gifts to neighbours as seeds and for consumption by 10 percent of the farmers, while 8 percent of the farmers besides using the crop in the diet, were in the habit of selling the same for seed purpose. The stored pulses were used for three major purpose viz. for consumption, seed purpose and also for marketing by the remaining 20 percent of the farmers surveyed.

Pulses (Whole grains) were stored as such or as processed dhal. Generally at periodical intervals, the whole grains were processed into dhal and stored separately for household use. According to variation in the duration of storage, and the form in which the pulses were stored (either

Table 8. Distribution of farm families based on the variatons in the storage methods of dhal

Methods of storage	Distribution Total	of farm families Duration of storage (in months)			
		3	6	9	12
Gunny bags	10 (20)	2(4)	8(16)	-	-
Mud pots	4 (8)	-	-	-	4(8)
Plastic bags	27 (54)	-	10(20)	4(8)	13(26)
Aluminium tins	9 (18)	-	2(4)	1(2)	6(12)
Total	50(100)	2(4)	20(40)	5(10)	23(46)

Number in parenthesis indicate percentage as whole grain or as dhal) the containers chosen for storage were found to differ. Details related to this aspect are presented in Table 8.

As revealed in the table, pulses were mainly stored in gunny bags and mud pots, while, plastic containers and aluminium tins were used by majority of the farmers to store split dhal. For the latter, gunny bags and mud pots were found to be less popular as containers.

Duration of storage of these processed pulses was also found to influence the type of containers used. For storage of short duration of less than 3 months, gunny bags were used. While for longer duration, plastic containers and tins were used. For storage of longer duration (one year) plastic containers were preferred by 26 percent of the farmers surveyed. Tins (12 percent) and mud pots (3 percent) were also found to be used for this purpose. Among the various storage containers, plastic containers were the most popular ones, followed by gunny bags, aluminium tins and mud pots.

1.3 Qualitative and Quantitative changes during storage

Farm level storage of longer duration is expected to cause quantitative and qualitative changes in pulses.

Information in this regard was collected and details are presented in Table 9.

Among the 50 farmers surveyed 62 percent were of the view that storage of longer duration will cause any change in the stored pulses. However 38 percent of the farmers had detected weight loss of the stored pulses. Quantitative changes in the form of weight loss in pulses was observed occasionally in samples stored in gunny bags by 14 percent of farmers and in plastic containers by 12 percent. In general, such changes in pulses were not observed by many of the farmers who had stored these food materials in gunny bags (22 percent), plastic containers (20 percent), aluminium tins (14 percent) and mud pots (6 percent). Qualitative changes noted in the stored raw pulses were changes in colour, taste and texture. Such changes were reported by 12, 70 and 6 percent of the farmers respectively. No qualitative changes were observed by 12 percent of the farmers.

As revealed in Table 10, six percent of the farmers reported an improvement in taste in the stored pulses, especially the ones stored in mud pots. But eight percent of the farmers complained that there was discolouration, and

Table 9. Quantitative and qualitative changes in the stored pulses

Loss in stored pulses	Details of farm families Storage containers used				
	Gunny bags	Mud pots	Plastic bags	Aluminium tins	Total
Quantitative loss					
Weight.loss	7(14)	2(4)	6(12)	4(8)	19(38)
No change	11(22)	3(6)	10(20)	7(14)	31(62)
Qualitative changes					
Colour	1(2)	2(4)	-	-	3(6)
Taste	7(14)	2(4)	5(10)	18(36)	35(70)
Texture	2(4)	-	-	1(2)	3(6)
No change	1(2)	3(6)	-	2(4)	6(12)

Number given in parenthesis indicate percentage.

hardness in pulses, stored for long periods in gunny bags, plastic bags and aluminium tins while cooking. Storage, was observed to induce discolouration, and inferior taste in pulses, irrespective of the type of storage containers (40 percent farmers). Another 6 percent of the farmers reported poor taste and of flavour when stored pulses were cooked. Hardness due to changes in texture, discolouration, inforior taste and smell were also observed by 12 percent of the farmers while 8 percent of the farmers did not observe any qualitative changes in similar situations.

Drying was reported to be one of the pretreatments adopted by all the farmers surveyed before storing pulses. Drying was done before storage and in between storage. Losses due to drying before storage and in between storage are detailed in Table 11. Major changes reported by drying before storage were weight loss and taste difference. Weight loss was reported by 8 percent of the farmers, while 4 percent of the farmers reported a difference in taste and another 4 percent of the farmers reported both weight loss as well as a change in taste. When compared to the losses due to drying prior to storage, quantity lost due to drying in between storage was higher, and was observed by 14 percent of

Table 10. Organoleptic changes in the stored pulses

Changes in stored pulses	Details of farmers				
	Storage containers				
	Gunny bags	Mud pot	Plastic Bag	Aluminium Tin	Total
Better taste	-	2(4)	-	1(2)	3(6)
Texture toughens & discolouration	2(4)	-	1(2)	1(2)	4(8)
Discolouration & inferior taste	5(10)	4(8)	6(12)	5(10)	20(40)
Taste lessened & change in smell	1(2)	-	1(2)	1(2)	3(6)
Texture toughens, discolouration, inferior taste and smell	1(2)	-	4(8)	1(2)	6(12)
No change	1(2)	2(4)	-	1(2)	4(8)

Numbers given in parenthes is indicate percentage the farmers. Quantitive loss was highest in pulses stored in plastic containers, followed by that stored in gunny bags, aluminium tins, and mud pots respectively. 26 percent of the farmers had reported taste difference due to drying the pulses in between storage periods. Taste difference was higher in pulses stored in plastic containers and aluminium tins followed by pulses stored in gunny bag and mud pot. These two defects viz. weight loss and change in taste were reported by 14 percent of the farmers. Reduction in quantity, change in colour and taste were observed in pulse samples stored in gunny bags, mud pots and aluminium tins. Taste difference and grain shrinkage as major changes due to sundrying were reported by 4 percent of the farmers. Such defects were not observed in samples, stored in plastic bags and mud pots. Changes in colour, taste and grain shrinkage were reported by 4 percent of the farmers who had observed the above changes only in samples stored in gunny bags and plastic bags. Eight percent of the farmers observed no change at all in pulse samples stored in mud pots and aluminium tins by 6 percent and 2 percent of the farmers respectively.

Table 11. Losses during drying pulses

Different types of losses	Distribution of farm families					
	Storage containers used					
	No storage	Gunny bags	Mud pot	Plastic Bag	Aluminium Tin	Total
Drying before storage						
Quantity difference	4(8)	-	-	-	-	4(8)
Taste difference	2(4)	-	-	-	-	2(4)
Quantity lost and taste difference	2(4)	-	-	-	-	2(4)
Drying in between storage						
Quantity loss	7(14)	2(4)	1(2)	3(6)	1(2)	14(28)
Taste difference	13(26)	3(6)	2(4)	4(8)	4(8)	26(52)
Quantity lost and taste difference	7(14)	1(2)	1(2)	2(4)	3(6)	14(28)
Quantity lost, colour change and taste difference	3(6)	1(2)	1(2)	-	1(2)	6(12)
Taste difference and grain shrinks	2(4)	1(2)	-	-	1(2)	4(8)
Colour change, taste difference and grain shrinks	2(4)	1(2)	-	1(2)	-	4(8)
No change	4(8)	-	3(6)	-	1(2)	8(16)

Numbers given in parenthesis indicate percentage.

Table 12. Location of godowns selected for the study

Locations	Details of godowns	
Trivandrum city	22	(49.0)
Neyyattinkara	5	(24.4)
Attingal	5	(11.1)
Nedumangad	7	(15.5)
Total	45	(100.0)

Numbers given in parenthesis indicate percentage.

Table 13. Area available in the godowns

Area of godowns (feet)	Details of godowns	
Less than 100	14	(31.0)
101 - 200	16	(35.6)
201 - 300	11	(24.6)
301 - 400	3	(6.7)
400 and above	1	(2.3)
Total	45	(100)

Numbers in parenthesis indicate percentage

4.2. Information on elicited the different large scale storage methods adopted for pulses and storage problems faced, by the owners of 45 godowns in Thiruvananthapuram district are presented under.

2.1. Details of godowns

As shown in Table 12 forty five godowns selected for the study were from Thiruvananthapuram city (49 per cent), Neyyattinkara (24.4 per cent), Attingal (11.1 per cent) and Nedumangad towns (15.5 per cent).

As detailed in Table 13 area available for storage in the different godowns ranged between 4 to 420 sq.ft. In the godowns surveyed (31.0 per cent) had an area of less than 100 sq. ft. While 35.6 per cent of the godowns had an area of 101-200 sq. feet and 24.6 per cent has an area of 201-300 sq. ft. There were 6.7 per cent of the godowns with an area of 301-400 sq.ft. Only 2.3 per cent of the godowns had an area above 400 sq.ft.

Ventilation facilities increased as the area of the godown enhanced (Table 14). Godowns with the area upto 80 sq.ft. had 2 to 3 windows. There were eighteen per cent of the godowns with 3 to 5 windows in an area of 80-100 sq.ft. while 5 to 7 windows were found in 35 per cent of the godowns

Table 14. Ventilation facilities in the godowns

Area (sq.ft.)	Number of windows 2-3	3-5	5-7	7-9	9-11
40-60	3(6.6)	-	-	-	-
60-80	3(6.6)	-	-	-	-
80-100	-	8(17.7)	-	-	-
100-120	-	-	4(9.0)	-	-
160-180	-	-	9(20.0)	-	-
180-200	-	-	3(6.6)	-	-
260-280	-	-	-	5(11.1)	-
280-300	-	-	-	6(13.3)	-
360-380	-	-	-	-	3(6.6)
400-420	-	-	-	-	1(2.2)

Numbers in parenthesis indicate percentage

with an area of 100-120 sq.ft. and 24.4 per cent of the godowns had 7 to 9 windows in an area of 260 to 300 sq.feet.

Bricks, cement and tiles were used for the construction of walls and floors (Table 15) in 89 per cent of the godowns, walls were constructed with tiles and the remaining 11 per cent were made with bricks. In 91 per cent of the godown, flooring was with cement while tiles were used for the same purpose in 9 per cent of the godowns. All the godowns had galvanised iron sheet roofings but none had cieling.

2.2. Storage of pulses at the godowns

The survey revealed that the pulses were procured from five states viz. Tamilnadu, Karnataka, Uttar Pradesh, Maharashtra and Madhya Pradesh (Table 16). Blackgram and redgram were procured from all the states. While green gram were received from Karnataka, Uttar Pradesh, Maharashtra and Madhya Pradesh.

55.5 per cent of the wholesale dealers were procuring the pulses once in a month, while 26.8 per cent procured them once in a fortnight (Table 17). Only 17.7 per cent of the wholesale dealers were procuring their goods once in 10 days. The pulses were transferred from the 5 states

Table 15. Building materials used for the godowns

Details of godowns	Tiles	Bricks	Cement	% No.
Walls	40(89)	5(11)	-	-
Floor	4(9)	-	41(91)	-
Roof without ceiling	-	-	-	(100)

Numbers in parenthesis indicate percentage

Table 16. Source of supply of pulses stored in the godowns

Pulses	Source of supply				
	Tamil Nadu	Karnataka	Maharashtra	Madhya Pradesh	Uttar Pradesh
Green gram	-	24 (53.3)	10 (22.2)	7 (15.5)	4 (8.9)
Black gram	10 (22.2)	15 (33.3)	13 (28.8)	-	7 (15.5)
Bengal gram	2 (4.4)	12 (27.0)	4 (8.9)	22 (48.9)	5 (11.1)
Red gram	13 (28.8)	4 (8.9)	21 (46.7)	5 (11.1)	2 (4.4)
Cowpea	15 (33.3)	25 (55.6)	5 (11.1)	-	-

Numbers in parenthesis indicate percentage

Table 17. Frequency in procurement of pulses

Frequency of transport	Details of godowns	
0-10 days	8	(17.7)
10-15 days	12	(26.8)
1 months	25	(55.5)
Total	45	(100)

Numbers in parenthesis indicate percentage

through train. Fifteen days were taken for transit from Karnataka and Andhra Pradesh, while it was reported that 20 days were needed to transport pulses from Maharashtra and Madhya Pradesh. Only one day was taken for transit from Tamil Nadu.

Gunnybags and plastic bags were the containers used for storing pulses in the godowns (Table 1.8). Duration of storage at godowns varied from 15 days to 6 months. Among the wholesale dealers surveyed 11.1 per cent of stored their pulses for 15 days, 17.7 per cent of the wholesale dealers for 1 to 2 months and 40 per cent of the wholesale dealers stored pulses for 3-4 months and for 5 to 6 months by 31.2 per cent of the wholesale dealers.

Pretreatment given before storage was spraying. A single lot of 200 sacks stored in 100 sq. feet area was said to be sprayed with 2 ounze of diethyl dichloro venyl phosphate (DDVP) dissolved in 5 litres of water. Beside this care was taken to keep the premises of the godowns clean by sweeping and then dusting with DDT.

Spraying and fumigation were the mode of application of insecticide. Malathion was used for spraying and aluminium phosphate for fumigation. Fumigation against insect was used as a part of integrated control system and according to the dealers, it did not give any residual protection. It was further mentioned that fumigation controlled rodents also. Anticoagulant baits such as warfarin was also used, for routine control of rats and rice. Acute poison was also used, if resistance to anticoagulants appeared in rat or mouse population.

Many of the personnel maintaining godowns had specific preference in the selection of pulses for storage in their godowns (Table 18).

First preference was given for greengram by 89 per cent of the wholesale dealers while the remaining 11 per cent gave only second preference for greengram. According to these personnel (11 per cent), their first choice was blackgram. Blackgram was preferred as second item by 85 per cent of the wholesale dealers and as third item by 4 per cent. Bengal gram was not generally preferred to be stored. This pulse was ranked as third, fourth and fifth by 24 per cent, 58 per cent and 18 per cent of the wholesale dealers respectively. Similarly red gram was preferred as second, third and fourth by 4 per cent, 85 per cent and 24 per cent of the wholesale dealers respectively. Among the various pulses, cowpea was the least preferred one. 82 per cent of the personnel gave fifth preference for cowpea and 18 percent as fourth preference. Factors which may affect the

Table 18. Preference for storing pulses in the godown

Pulses	Distribution of godowns				
Green gram	40(89)	5(11)	-	-	-
Black gram	5(11)	38(85)	2(4)	-	-
Bengal gram	-	-	11(24)	26(58)	8(18)
Red gram	-	2(4)	38(85)	11(24)	-
Cowpea	-	-	-	8(18)	37(82)
Total	45(100)	45(100)	45(100)	45(100)	45(100)

Numbers in parenthesis indicate percentage

development and activity of insects, mites and pests in pulses are temperature and relative humidity of the godown, nature and moisture content of the grains. Temperature of the godowns in general were found to be optimum (29°C to 31°) for the development of insect pests in the stored pulses.

Infected pulses were sold as cattle feed by 60.2 per cent and as manure by 10.8 per cent. Twentynine per cent of the wholesale dealers sold the same in subsidized rates to petty shop keepers (Table 19).

As viewed by the wholesale dealers, the type and condition of the pulse grains received, mainly decide the extent of insect attack which caused massive losses, while the contamination by microorganisms affected the grain quality. Insect fragments found in the infested grains were also found to affect the grain quality.

4.3. Storage studies at the farm level and godowns

Storage studies at the farm level and godowns were conducted with reference to

1. Quantitative tests conducted on stored pulses.
2. Qualitative tests conducted on stored pulses.
3. Cooking tests conducted on stored pulses.

Table 19. Ways of disposal of infected pulses

Ways of disposal	Details of godowns
As Cattle feed	7(16.0)
Sold at subsidised rate	13(29.0)
Used as manure	3(6.6)
Cattle feed and sold at subsidised rate	2(4.2)
Cattle feed and used as manure	18(40.0)
Sold at subsidised rate and used as manure	2(4.2)
Total	45(100)

Numbers in parenthesis indicate percentage

Quantitative tests were conducted to determine the influence of storage methods, storage containers and storago periods on the quality of different pulses stored for one year, Effects of two levels of storage were also tried viz, 'large scale storage' and 'farm level storage'. As perceived from the survey mentioned under 4.20, it was observed that in largescale storage the pulses were stored only in gunny bags where as in farm level storage the pulses were stored in gunny bags, plastic bags, mud pots, and aluminium tins. Based on the above inference, five types of pulses, namely, green gram, blackgram, cowpea, redgram and bengalgram were stored under large scale storage. While, three types of pulses such as, green gram, blackgram and cowpea were stored under farm level storage. The effect of storage was then assessed quantitatively and qualitatively.

4.3.1. Quantitative tests conducted on stored pulses

Quantitative tests were conducted every month and the quantitative tests included periodical recording of percent weight loss, quantitative loss, constituent fractions, pulses contaminated by fungal bacterial attacks in different pulses stored for one year.

Per cent weight loss of stored pulses due to insect infestation and fungal damage were worked out using the formula of Pushpamma and Chittamma Rao, (1981).

Per cent weight loss:-

$$L = W + M + G - 100/s\ (W_1 + M_1 + G_1)$$

where:

L = Per cent loss of weight.

W = Percentage by number of weevilled grain.

G = Percentage by number of germ eaten grain.

W_1 = Weight of weevilled grain.

M_1 = Weight of mouldy grain.

G_1 = Weight of germ eaten grain.

Table 20 presents the details regarding per cent weight loss of pulses. Under large scale storage for one year, weight loss has been maximum in blackgram in which the loss increased from 0.01 to 28.01 per cent, followed by red gram (0.03 to 12.79 per cent), cowpea (0.02 to 9.83 per cent), blackgram (0.02 to 9.68 per cent) and least in greengram (0.40 to 1.22 per cent). According to Shehnaz et al. (1977) weight loss due to insect infestation and fungal damage was not reported in fresh blackgram, while 23.60 per

Table 20, Effect of storage methods, containers and storage periods on percent weight loss in pulses

Storage methods	Containers	Pulses	Storage peorids (in months) 1	2	3	4	5	6	7	8	9	10	11	12
Large scale	Gunny bag	Greengram	0.40	0.41	0.40	0.55	0.74	0.93	0.96	0.99	0.58	0.16	0.72	1.22
		Blackgram	0.02	0.33	0.32	0.38	0.43	0.33	0.62	0.93	2.17	4.61	6.98	6.68
		Cowpea	0.02	0.27	0.28	0.21	0.27	0.81	0.98	1.07	2.49	4.77	7.28	9.83
		Marginal mean	0.14	0.34	0.33	0.38	0.48	0.69	0.85	0.99	1.75	3.18	4.99	6.91
		Red gram	0.03	0.23	0.21	0.39	0.33	0.17	1.61	2.02	4.63	7.32	10.11	12.79
		Bengalgram	0.01	0.13	0.36	0.51	0.69	2.32	3.49	5.92	6.82	7.66	17.32	28.01
Farm level	Gunny bag	Greengram	0.37	0.39	0.41	0.58	0.75	0.91	0.93	0.98	0.54	0.16	0.77	1.14
		Blackgram	0.36	0.33	0.35	0.36	0.48	0.40	0.73	0.95	2.68	4.37	6.48	9.41
		Cowpea	0.30	0.27	0.29	0.26	0.33	0.24	0.95	1.09	3.21	4.45	6.92	9.92
		Marginal mean	0.34	0.33	0.35	0.40	0.52	0.52	0.87	1.01	2.14	2.99	4.72	6.82
	Plastic bag	Greengram	0.40	0.41	0.45	0.61	0.73	0.94	0.90	0.86	0.58	0.04	0.59	1.54
		Blackgram	0.36	0.32	0.33	0.32	0.44	0.28	0.79	1.21	2.72	5.16	7.57	10.55
		Cowpea	0.30	0.26	0.26	0.22	0.19	0.08	0.99	1.46	3.58	5.36	7.43	10.19
		Marginal mean	0.34	0.29	0.31	0.37	0.38	0.51	0.87	0.98	1.84	2.86	4.89	6.30
	Mud pot	Greengram	0.38	0.38	0.41	0.58	0.35	0.85	0.89	0.95	0.42	0.24	0.78	1.02
		Blackgram	0.35	0.22	0.24	0.30	0.46	0.43	0.78	0.99	2.61	4.24	6.84	9.61
		Cowpea	0.30	0.27	0.28	0.24	0.34	0.26	0.96	1.01	2.49	4.10	7.06	8.72
		Marginal mean	0.34	0.29	0.31	0.37	0.38	0.51	0.87	0.98	1.84	2.86	4.89	6.30
	Aluminium tin	Greengram	0.35	0.37	0.40	0.53	0.33	0.86	0.87	0.94	0.51	0.31	0.69	0.90
		Blackgram	0.37	0.36	0.36	0.37	0.57	0.47	0.56	0.55	2.52	3.96	6.15	9.10
		Cowpea	0.30	0.28	0.31	0.27	0.38	0.30	0.72	0.62	2.48	3.90	7.01	8.68
		Marginal mean	0.34	0.34	1.07	0.39	0.43	0.54	0.72	0.70	1.84	2.72	4.62	6.62
	Marginal mean	Greengram	0.38	0.39	0.42	0.57	0.54	0.89	0.90	0.93	0.51	0.19	0.71	1.15
		Blackgram	0.48	0.31	0.32	0.34	0.49	0.40	0.71	0.93	2.63	4.43	6.76	9.67
		Cowpea	0.40	0.27	0.29	0.25	0.31	0.22	0.91	1.05	2.94	4.45	7.11	9.38

cent loss was reported on third month and 46.3 per cent at sixth month of storage. Gupta et al. (1981) had reported that in blackgram, weight loss of 55.3 per cent was observed due to prolonged period of storage.

Under farm level storage, weight loss was maximum in blackgram where the initial weight loss of 0.37 per cent increased to 9.10 per cent, followed by cowpea (0.30 to 8.68 per cent) and lowest in greengram (0.35 to 0.90 per cent) after 12 months of storage.

Increase in weight loss was noticed as period of storage increased. Weight loss was maximum after six months of storage in different pulses, stored under large scale as well as under farmlevel storage. According to Bressani (1984) the percentage weight loss increased as the period of storage increased.

Among the containers used for storing the pulses, weight loss was highest in pulses stored in plastic bag (0.35 to 7.34 per cent), followed by gunny bag (0.34 to 6.82 per cent), mud pot (6.30 per cent) and lowest in pulses stored in aluminium tin (6.22 per cent).

Weight loss due to infestation

Weight loss due to infestation in different containers during varying periods of storage was estimated by studying major constituent fractions of pulses viz. damaged grains and foreign matter.

Table 21 presents the particulars regarding the damaged fraction (in number and weight) of different types of pulses stored in different containers during the storage period of one year in large scale and farmlevel storage. There was a steady increase in the number and weight of this fraction in all the pulses stored in different containers.

Results indicated that there was variation in damaged fraction among different pulses. Under largescale storage, number of damaged grains were maximum in redgram, where the initial damaged grain of 48 increased to 715 after 12 months of storage. It was followed by blackgram (60 to 710 grains). In cowpea the initial number of damaged grain was 50 which was increased to 666 grains after 12 months of storage. In this context among the pulses greengram and bengalgram, were found to have less damage.

Table 21. Effect of storage methods, containers, and storage period on the constituents (number and weight) of pulses

Treatments			Storage periods (in months)																							
									Mean																	
Storage methods	Containers	Pulses	1 No.	1 Wt.	2 No.	2 Wt.	3 No.	3 Wt.	4 No.	4 Wt.	5 No.	5 Wt.	6 No.	6 Wt.	7 No.	7 Wt.	8 No.	8 Wt.	9 No.	9 Wt.	10 No.	10 Wt.	11 No.	11 Wt.	12 No.	12 Wt.
Large scale	Gunny bag	Greengram	47	2.5	58	2.6	69	2.9	94	3.9	118	5.9	140	7.9	188	10.39	248	13.7	320	15.8	391	19.2	465	21.5	645	28.9
		Blackgram	60	4.1	71	4.3	98	5.2	119	7.4	161	11.4	168	13.9	232	16.90	298	19.8	374	26.0	470	33.7	532	36.4	710	39.6
		Cowpea	50	1.0	66	4.1	78	4.8	99	6.7	127	9.3	160	12.4	212	15.9	274	19.2	359	25.8	430	33.5	487	35.7	666	38.7
		Marginal mean	52	3.53	65	3.67	82	4.3	104	6.0	129	5.86	156	11.4	211	14.4	273	17.66	351	22.5	430	28.8	495	31.2	674	35.73
		Red gram	48	4.1	72	4.6	85	5.4	106	7.6	139	11.7	168	14.1	238	17.5	303	20.6	379	27.1	480	36.2	535	40.9	715	44.2
		Bengalgram	26	6.0	39	7.0	65	10.2	79	12.4	102	15.5	134	18.9	177	23.3	222	26.0	283	36.8	358	45.8	420	49.5	526.	53.2
Farm level	Gunny bag	Greengram	38	2.3	53	2.5	64	2.7	80	3.7	114	5.7	130	7.4	187	10.09	238	13.4	314	15.4	384	18.8	456	24.4	632	28.6
		Blackgram	52	4.0	68	4.2	86	5.2	116	7.3	129	10.8	157	13.7	223	16.5	288	19.5	364	25.6	460	33.6	527	36.2	700	39.2
		Cowpea	46	3.9	59	4.0	73	4.7	98	6.5	124	9.2	142	12.0	204	15.3	270	19.0	347	25.6	417	33.2	483	34.3	661	38.5
		Marginal mean	45	3.4	60	3.6	74	4.2	98	5.83	122	8.56	143	11.0	205	2.45	265	17.3	348	22.2	421	28.2	489	31.6	664	35.4
	Plastic bag	Greengram	45	2.8	58	2.9	75	3.4	99	4.5	136	6.9	144	8.1	203	11.2	274	15.0	339	16.6	414	16.6	483	20.6	666	29.6
		Blackgram	55	4.2	74	4.4	106	5.9	120	7.8	151	12.0	173	14.3	248	17.3	313	20.9	389	27.1	487	27.1	543	37.2	751	40.7
		Cowpea	48	4.0	70	4.2	84	4.8	118	7.0	140	9.5	169	12.9	223	17.0	305	19.9	372	26.9	447	26.9	517	36.9	669	39.9
		Marginal mean	49	3.6	67	3.83	88	4.7	112	6.43	142	9.47	162	11.7	225	15.16	297	18.6	367	23.5	449	23.5	514	31.5	705	36.7

Treatments		Mean												Storage periods (in months)											
Storage Containers methods	Pulses	1		2		3		4		5		6		7		8		9		10		11		12	
		No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Mud pot	Greengram	34	2.3	54	2.4	61	2.7	76	3.7	112	5.6	127	7.2	180	10.0	226	13.2	306	15.2	381	15.2	448	24.3	628	28.4
	Blackgram	51	3.9	66	4.2	82	5.2	106	7.3	127	10.5	152	13.5	216	16.1	275	19.3	356	25.2	452	25.2	519	35.7	694	38.9
	Cowpea	43	3.9	60	4.0	68	4.6	90	6.5	116	9.2	140	12.0	195	14.6	260	18.5	334	24.9	410	24.9	478	34.9	647	38.4
	Marginal mean	44	3.4	60	3.53	70	4.16	90	5.83	118	8.43	139	10.9	197	13.5	254	17.0	332	21.7	414	21.7	482	33.7	656	35.2
Aluminium tin	Greengram	28	2.1	46	2.3	56	2.6	65	3.6	99	4.5	122	6.8	160	9.8	220	12.6	306	14.9	372	14.9	430	24.1	591	28.1
	Blackgram	37	3.8	60	4.1	69	4.8	95	7.0	120	10.4	145	13.2	205	15.8	270	18.9	351	24.7	441	24.7	512	35.4	679	38.6
	Cowpea	36	3.8	53	3.9	60	4.5	82	6.3	110	8.7	132	11.8	188	14.1	249	18.1	326	24.4	402	24.4	472	33.5	633	37.8
	Marginal mean	34	3.2	53	3.43	62	3.96	81	5.68	109	7.86	133	10.6	197	13.2	246	16.5	328	21.3	405	21.3	471	31.0	634	34.8
Marginal mean	Greengram	38	2.38	53	2.53	64	2.85	79	3.88	115	5.68	131	7.38	183	10.27	240	54.2	316	15.53	388	19.23	454	23.35	630	28.68
	Blackgram	49	3.98	67	3.80	86	11.33	109	7.35	132	10.93	157	13.68	223	16.42	287	27.88	365	25.65	460	33.77	425	36.13	706	39.35
	Cowpea	43	3.90	61	4.03	71	4.65	97	6.58	123	9.15	146	12.18	203	15.25	271	18.88	345	25.45	419	33.37	488	34.19	660	37.85
	CD for CxP	2.98	0.29	2.98	0.29	3.60	0.32	3.49	0.46	3.72	0.29	3.55	0.36	5.97	0.35	4.63	0.29	4.75	0.29	5.83	0.29	5.83	0.29	6.11	0.30
	CD for C	1.72	0.17	1.72	0.17	1.80	0.19	1.89	0.27	1.98	0.17	2.05	0.21	3.44	0.20	2.67	0.17	2.74	0.17	3.37	0.17	3.37	0.17	3.53	0.17
	CD for P	1.49	0.15	1.49	0.15	2.09	0.16	2.09	0.23	1.89	0.15	1.77	0.18	2.98	0.17	2.32	0.15	2.37	0.15	2.91	0.15	2.92	0.15	3.05	0.15

Weight of damaged fraction was highest in bengalgram (6.00 to 53.20g) after 12 months of storage, followed by redgram (4.10 to 44.20g), blackgram (4.10 to 39.60g), cowpea (4.00 to 38.70g) and lowest in greengram where the weight of damaged fraction increased from 2.5 to 28.00g. Variation in number and weight of damaged grains in different pulses is based on the rate of insect infestation which is influenced by the quality of pulses. Statistical analysis of the data revealed significant difference among the pulses stored.

Studies conducted by Srivastava et al. (1988) had reported that bengalgram had more insect infestation followed by blackgram and least incidence of insect infestation was noted in greengram Gupta et al. (1981) had also reported that greengram gave better shelf-life when compared with other pulses. Prolonged storage resulted in increased insect infestation and greengram was least damaged followed by blackgram and bengalgram as recorded by Srivastava et al. (1988).

Under farm level storage variation in the damaged fraction of different pulses were noted. Number and weight of damaged grains were highest in blackgram (number 49 to 706 grains and weight 3.98 to 39.35 g) followed by cowpea, in which, the initial number and weight of damaged grain of 43 increased to 660 and weight increased to 37.85g from 3.90g. Minimum increase was noted in greengram, where the number and weight of damaged grain was 38 to 630 grains and 2.38 to 28.68g respectively. Statistical analysis of the data revealed significant difference among the different pulses stored. Studies conducted by Gupta et al. (1984) had found that insect population, percent weevilisation and weight loss was more in blackgram (0 to 46.3 per cent) due to prolonged storage.

For comparing the two levels of storage, viz, largescale and farm level storage, pulses stored in gunny bags were taken into consideration. Proportion of damaged fraction under largescale storage was found to be higher than in the pulses stored under farmlevel storage. The marginal mean obtained for pulses stored under largescale storage varied from 52 to 674 (3.53 to 35.73g), while for the pulses stored under largescale storage, the number of damaged grains increased from 45 to 664 (3.4 to 35.4 g).

Increase in the damaged fraction both in largescale as well as in farm level storage, was profound after 6 months of storage. Under largescale storage, during the first six months, damage was observed to be less, the increase in damaged fraction of different pulses (both by number and weight) varied from 11 to 33 and 0.10 to 3.40 g. While, the increase of damaged fraction after sixth month to twelth month varied from 43 to 180 grains and 2.70 to 7.40 g.

Similar trend in damage was observed under farmlevel storage also. Average number and weight of damaged fraction of different pulses increased from 131 to 640 grains and weight 7.37 to 25.68 g after sixth month of storage to twelth months of storage. While, the increase in damaged fraction from first month to sixth month of storage was from 15 to 66 grains, and weight 0.1 to 3.1g for different pulses. Similar results were reported in studies conducted on pulses by Gupta et al. (1981) has revealed that insect population, weevilled grain and weight loss were greater in blackgram due to prolonged storage period. Reddy et al. (1987) had also found out that increase in weevilled grain, kernal damage and weight loss were observed in greengram with the advancement of storage time.

Among the containers used for storing the pulses, increase in damaged fraction was highest in the pulses stored in plastic bags where the initial 49 damaged grains increased to 705 grains and 3.6 g of damaged grains increased to 36.7g after 12 months of storage. Compared to plastic bags, gunny bags, mud pot and aluminium tins were ranked, on the basis of number and weight of damaged grains present after 12 months storage period. Statistical analysis of the data revealed significant differences among the containers.

In studies conducted on storage containers by Gupta et al. (1988) it was observed that mudbins, tightly knit jute bag and plastic lined jute bags were ranked as suitable containers for storing pulses. Srivastava et al. (1988) had reported that steel bins and aluminium bins are the ideal storage containers and the pulses will have less insect infestation.

Among the different combinations tried under large scale as well as under farmlevel storage, maximum damage was observed in blackgram stored in plastic bag and minimum in bengalgram stored in gunnybag, based on number of damaged grains. While maximum damage was observed in bengalgram

Table 22. Effect of storage methods, containers and storage period on the other fractions (number and weight) in pulses

Treatments			Storage periods (in months) Mean																							
Storage methods	Containers	Pulses	1		2		3		4		5		6		7		8		9		10		11		12	
			No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Large scale	Gunny bag	Greengram	52	6.0	50	6.0	70	6.5	87	8.1	98	7.9	129	9.0	92	8.5	81	8.2	79	9.7	113	10.5	108	9.1	99	9.4
		Blackgram	70	6.0	59	6.7	68	7.5	80	8.1	76	7.1	84	7.3	98	7.7	64	6.6	51	4.5	40	2.2	68	8.9	80	8.2
		Cowpea	39	3.8	58	6.3	62	6.4	67	7.2	69	6.1	72	6.7	79	6.6	54	5.7	36	3.9	39	3.2	36	4.4	82	7.4
		Marginal mean	53	5.27	56	6.33	66	6.8	78	7.8	81	7.03	95	7.67	90	7.6	66	6.8	55	6.03	64	5.3	71	7.47	87	8.33
		Red gram	59	6.3	67	6.6	80	7.5	102	10.1	118	10.0	123	10.7	106	9.9	98	9.3	80	8.1	46	3.3	59	3.9	75	6.4
		Bengalgram	38	5.1	31	5.0	42	8.9	53	11.1	91	10.4	88	9.9	93	10.3	102	10.4	50	4.8	41	3.7	52	5.0	67	6.7
Farm level	Gunny bag	Greengram	53	5.8	59	-5.7	61	6.4	80	8.1	106	8.0	102	8.9	90	8.7	80	8.3	82	9.7	91	9.4	90	8.6	83	9.0
		Blackgram	52	5.5	64	7.2	64	7.2	84	8.4	68	6.9	88	7.4	108	10.2	70	7.2	62	4.6	45	3.5	47	5.6	68	8.2
		Cowpea	46	5.5	60	6.2	64	7.1	62	6.7	57	5.9	63	6.5	83	6.9	48	5.4	38	3.9	44	3.2	48	5.4	73	7.2
		Marginal mean	50	5.6	61	6.37	63	6.9	75	7.73	77	6.93	84.3	7.6	94	8.6	66	6.97	60	6.07	60	5.37	62	6.53	75	8.13
	Plastic bag	Greengram	69	6.2	73	6.5	78	6.6	88	8.6	89	7.5	129	9.7	98	8.5	88	8.2	129	11.3	130	10.8	79	5.8	116	10.4
		Blackgram	86	7.2	83	8.7	79	8.7	102	9.6	92	8.1	105	9.5	102	9.9	82	8.0	64	5.8	38	3.9	83	7.2	102	9.1
		Cowpea	58	6.3	81	8.0	83	8.9	91	8.4	92	8.4	69	7.0	79	7.1	82	7.1	70	6.2	53	5.1	42	4.3	98	7.7

Treatments			Storage periods (in months) Mean																							
Storage methods	Containers	Pulses	1 No.	1 Wt.	2 No.	2 Wt.	3 No.	3 Wt.	4 No.	4 Wt.	5 No.	5 Wt.	6 No.	6 Wt.	7 No.	7 Wt.	8 No.	8 Wt.	9 No.	9 Wt.	10 No.	10 Wt.	11 No.	11 Wt.	12 No.	12 Wt.
		Marginal mean	54	6.57	79	7.7	80	8.07	94	9.07	91	8.0	101	8.73	93	8.5	84	7.77	87	7.77	74	6.6	68	5.77	105	9.07
	Mud pot	Greengram	50	5.7	58	6.1	58	6.3	75	7.8	90	7.6	103	9.1	81	8.3	91	8.6	88	9.9	64	6.8	82	8.3	78	8.7
		Blackgram	56	5.3	56	5.7	59	6.4	68	7.4	63	6.9	92	7.7	82	8.0	71	6.8	46	4.4	39	4.2	80	6.7	76	8.2
		Cowpea	40	5.2	51	6.5	60	6.6	61	6.6	55	5.1	54	6.2	76	7.1	49	5.6	48	4.3	58	6.9	40	3.5	70	7.2
		Marginal mean	48	5.4	55	6.1	59	6.43	68	7.3	69	6.53	83	7.67	79.0	7.8	70	7.0	61	6.2	54	5.97	67	6.17	75	8.03
	Aluminium tin	Greengram	43	5.4	49	5.6	52	5.8	68	7.0	69	8.0	76	8.5	70	8.0	93	8.5	91	10.0	69	6.3	73	8.0	70	8.5
		Blackgram	43	4.8	51	5.4	61	6.3	64	77.2	57	6.7	96	7.9	72	7.6	68	6.8	63	6.5	42	4.0	51	5.6	79	8.0
		Cowpea	39	4.4	46	5.9	57	6.4	54	6.5	57	5.1	48	5.6	83	7.3	56	5.7	45	5.2	40	4.1	46	4.4	62	7.3
		Marginal mean	42	4.87	49	5.63	57	6.17	57	6.9	61	6.6	73	7.3	75	7.63	72	7.0	66	7.23	50	4.8	57	6.0	70	8.0
	Marginal mean	Greengram	54	5.78	59	5.98	62	6.28	78	7.90	89	7.78	103	9.05	70	8.38	88	8.4	98	10.2	89	8.3	81	7.7	87	9.15
		Blackgram	59	5.70	64	6.75	66	7.15	79	8.15	70	7.15	95	8.12	91	8.92	73	17.2	59	5.3	41	3.9	65	6.38	81	18.5
		Cowpea	46	5.35	59	6.65	66	7.25	67	7.05	62	6.12	59	4.58	80	7.10	59	5.95	50	4.9	46	4.8	44	4.4	79	7.35
		CD for CxP	2.98	0.29	3.26	0.29	3.62	1.06	2.98	0.29	2.98	0.29	2.98	0.29	3.24	0.29	3.09	0.32	2.98	0.29	3.09	0.30	2.98	0.30	2.98	0.40
		CD for C	1.72	0.17	2.09	0.17	2.89	0.61	1.92	0.17	1.72	0.17	1.72	0.17	1.86	0.19	1.78	0.19	1.72	0.17	1.78	0.72	1.72	0.17	1.72	0.20
		CD for P	1.50	0.15	1.80	0.29	1.81	0.53	1.49	0.15	1.49	0.14	1.49	0.14	1.61	0.22	1.54	0.16	1.49	0.15	1.54	0.20	1.50	0.21	1.49	0.20

stored in gunny bag and minimum in greengram stored in aluminium tin, based on the weight of damaged grains. Statistical analysis of the data revealed significant difference among the above combinations tried.

Changes in proportion of foreign matter are due to changes in the quantity of rodent hair excreta and also the inorganic matter which is mostly influenced by the farm or household practices adopted in drying and cleaning of the stored grains. The grain was normally dried in the backyard periodically and cleaned. In such periodical drying there is always the possibility that sand, small stones and dust from the drying yard finds its way into the stored crops and increases the foreign matter. There is also a possibility that on the process of this periodical drying and cleaning the split grains, big stones and dust were manually removed such practices might have contributed to the changes in the proportion of foreign matter in the pulses and reflected in the values given under foreign matter (Tables 22).

The percentage of foreign matter was observed to vary among the pulses. There is no steady increase or decrease of grains both in terms of per cent by weight and per cent by number of foreign matter.

Fungal contamination

Qualitative examination of the samples for the presence of micro organisms, revealed that Aspergillus flavus was noticed in all the stored pulses. Studies conducted by Singh et al. (1990) found that Aspergillus flavus is the predominent fungi causing spoilage of stored pulses viz., greengram, chickpea and lentil.

Fungal contamination in the stored samples were found to increase with the advancement of storage period (Table 25). In pulses stored under largescale storage, fungal contamination was totally absent during the first month of storage where as from second to fifth month, the number of colonies increased and they were found within the range of one to four fungal colonies/petriplate. During sixth month of storage one to four colonies/petriplate were found in greengram, cowpea and redgram, whereas in blackgram and bengalgram five to nine fungal colones/petriplate were observed. In all the pulses, number of fungal colonies increased in a range of five to nine colonies/petriplate from seventh month of storage. While in blackgram and bengalgram during twelth month of storage, more than 10 fungal colonies/petriplate were observed. Studies conducted by

Table 23. Effect of different storage methods containers and storage periods on the fungal contamination of pulses

Storage level	Containers	Pulses	Period of storage (months)											
			1	2	3	4	5	6	7	8	9	10	11	12
Large scale	Gunny bag	Greengram	-	+	+	+	+	+	+	++	++	++	++	++
		Blackgram	-	+	+	+	+	++	++	++	++	++	++	++
		Cowpea	-	+	+	+	+	+	++	++	++	++	++	++
		Marginal mean	-	+	+	+	+	+	++	++	++	++	++	++
		Redgram	-	+	+	+	+	+	++	++	++	++	++	++
		Bengalgram	-	+	+	+	+	++	++	++	++	++	++	++
Farm level	Gunny bag	Greengram	-	+	+	+	+	+	+	++	++	++	++	++
		Blackgram	-	+	+	+	+	++	++	++	++	++	++	++
		Cowpea	-	+	+	+	+	+	++	++	++	++	++	++
		Marginal mean	-	+	+	+	+	+	++	++	++	++	++	++
	Plastic bag	Greengram	-	+	+	+	+	+	++	++	++	++	++	++
		Blackgram	-	+	+	+	++	++	++	++	++	++	++	++
		Cowpea	-	+	+	+	+	+	++	++	++	++	++	++
		Marginal mean	-	+	+	+	+	+	++	++	++	++	++	++
	Mud pot	Greengram	-	+	+	+	+	+	+	+	++	++	++	++
		Blackgram	-	+	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	+	+	+	+	+	+	++	++	++	++	++
		Marginal mean	-	+	+	+	+	+	+	++	++	++	++	++
	Aluminium tin	Greengram	-	-	-	+	+	+	+	+	++	++	++	++
		Blackgram	-	+	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	+	+	++	++	++	++
		Marginal mean	-	-	-	+	+	+	+	+	++	++	++	++

\- Fungi present
Fungi absent

\+ - One to four colonies/petriplate
++ - 5 to 9 colonies/petriplate
+++ - 10 or more colonies/petriplate

Doharey et al. 91989) had reported that prolonged period of storage enhanced microbial attack in pulses, also resulting in discolouration, deterioration of processing quality and Mycotoxin production.

Under farm level storage the pulses were stored in different containers, such as gunny bag, plastio bags, mud pots and aluminium tins. Increase in fungal colonies/petriplate was maximum in pulses stored in plastic bag, followed by gunny bag, mud pot and aluminium tin. In pulses stored in mud pot, one to four fungal colonies/petriplate were observed from second month to seventh month of storage. From eighth month onwards the colonies present were in the range of five to nine fungal colonies/petriplate were observed in pulses stored in aluminium tin. No fungal colonies were observed until third month of storage in pulses stored in aluminium tin.

Comparatively less number of fungal oolonies/petriplate were observed in pulses stored in aluminium tin. No fungal colonies were observed until third month of storage in pulses stored in aluminium tin.

One to four fungal oolonies/petriplate were observed from growth month to ninth month of storage and from ninth month it increased from five to nine fungal colonies/petriplate. Studies conducted by Rao et al. (1991) had reported that the blackgram stored in jute gunny bag recorded less incidence of seed borne fungi, when compared to blackgram stored in steel linen and nylon gunny bag. Ahmad (1993) had also reported that fungal populations were detected in blackgram stored for one year in gunny bags and airtight metal bins. The fungal attack was more in blackgram stored in gunny bags than in the airtight metal bins.

Bacterial contamination of pulses

Table 24 presents the details regarding the bacterial contaminations of pulses. Results indicate that bacterial contaminations increased with increase in storage period. In the pulses stored under large scale storage, bacterial contamination was not observed during first month of storage. During second and third month of storage, bacterial contamination was observed only in blackgram and bengal gram. During fourth month of storage one or more bacterial colonies/petriplate were observed in all the

Table 24. Effect of different storage methods, containers and storage period on the bacterial contamination of pulses

Storage level	Containers	Pulses	Period of storage (months) 1	2	3	4	5	6	7	8	9	10	11	12
Large scale	Gunny bag	Greengram	-	-	-	-	+	+	+	+	++	++	++	++
		Blackgram	-	+	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	+	++	++	++	++	++
		Marginal mean	-	-	-	+	+	+	+	++	++	++	++	++
		Redgram	-	-	-	+	+	+	+	++	++	++	++	++
		Bengalgram	-	+	+	+	+	+	++	++	++	++	++	++
Farm level	Gunny bag	Greengram	-	-	-	-	+	+	+	+	+	++	++	++
		Blackgram	-	+	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	+	++	++	++	++	++
		Marginal mean	-	-	-	+	+	+	+	++	++	++	++	++
	Plastic bag	Greengram	-	-	-	-	+	+	+	+	+	++	++	++
		Blackgram	-	+	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	++	++	++	++	++	++
		Marginal mean	-	-	-	+	+	+	++	++	++	++	++	++
	Mud pot	Greengram	-	-	-	-	+	+	+	+	+	++	++	++
		Blackgram	-	-	+	+	+	+	++	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	+	++	++	++	++	++
		Marginal mean	-	-	-	+	+	+	+	++	++	++	++	++
	Aluminium tin	Greengram	-	-	-	-	+	+	+	+	+	++	++	++
		Blackgram	-	-	-	+	+	+	+	++	++	++	++	++
		Cowpea	-	-	-	+	+	+	+	+	++++		++	++
		Marginal mean	-	-	-	+	+	+	+	+	++	++	++	++

\+ - Bacteria present
\- - Bacteria absent

\+ - One to four colonies/petriplate
++ - 5 to 9 colonies/petriplate
+++ - 10 or more colonies/petriplate

pulses, except in greengram. In all the pulses one or more bacterial colonies/petriplate were observed during fifth and sixth month of storage. Increase in number of bacterial colonies/ petriplate was maximum from eighth month onwards. It increased from 5 to 9 bacterial colonies/petriplate. Studies conducted by Srivastava et al. (1991) found that in greengram, blackgram and redgram microbial population increased due to long period of storage.

Under farm level storage, among the containers the pulses stored in plastic bag had maximum number of bacterial colonies followed by gunny bag, mud pot and aluminium tin. Bacterial containers was totally absent during first month of storage. On second month one or more oolonies/petriplate was observed in blackgram stored in gunny bag and plastic bag. During third month blackgram stored in gunny bag, plastic bag and mud pot had one or more bacterial colonies/petriplate. From fourth month to sixth month similar trend of one or more bacterial petriplate was observed in all the containers. From seventh month onwards, number of bacterial colonies/petriplate in blackgram and cowpea stored in plastic bag and gunny bag. From eighth month onwards, the number of bacterial colonies in the pulses stored in gunny bag and mud pot increased from five to nine colonies/petriplate in all the containers except in aluminium tin. Where the number of colonies increased from five to nine bacterial colonies/petriplate after ninth month of storage.

When the two levels of storage viz., 'large scale' and 'farm level' storage of pulses stored in gunny bag was observed. It was found out that in both cases the number of fungal colonies/petriplate and the number of bacterial colonies/petriplate increased with the advancement of storage (from 0 to more than 10 fungal and bacterial colonies/petriplate).

Quantitative loss estimates of pulses due to one year storage calculated using the formula:

$$\text{Quantitative loss} = \frac{A\,(a) + \frac{(A+B)}{2}\,(b-a) + \frac{(B+C)}{2}\,(c-b)}{A}$$

Where:

A = Quantity of greengram stored initially

a = Percentage weight loss due to insect infestation initially.

B = Balance left after 6 months storage.

b = Percentage weight loss due to infestation after 6 months of storage.

C = Balance left after 12 months storage.

c = Percentage weight loss due to insect infestation after 12 months of storage.

Table 25. Effect of storage method, containers and storage period on quantitative loss estimate of pulses.

Pulses	Large Scale Storage Gunny bag	Farm level storage				
		Gunny bag	Plastic bag	Mud Pot	Aluminium tin	Mean
Greengram	2.43	2.36	2.45	2.34	2.31	2.35
Blackgram	3.90	3.81	4.06	3.78	3.72	3.86
Cowpea	3.46	3.41	3.53	3.37	3.34	3.41
Redgram	3.70	—	—	—	—	—
Bengalgram	7.54	—	—	—	—	—

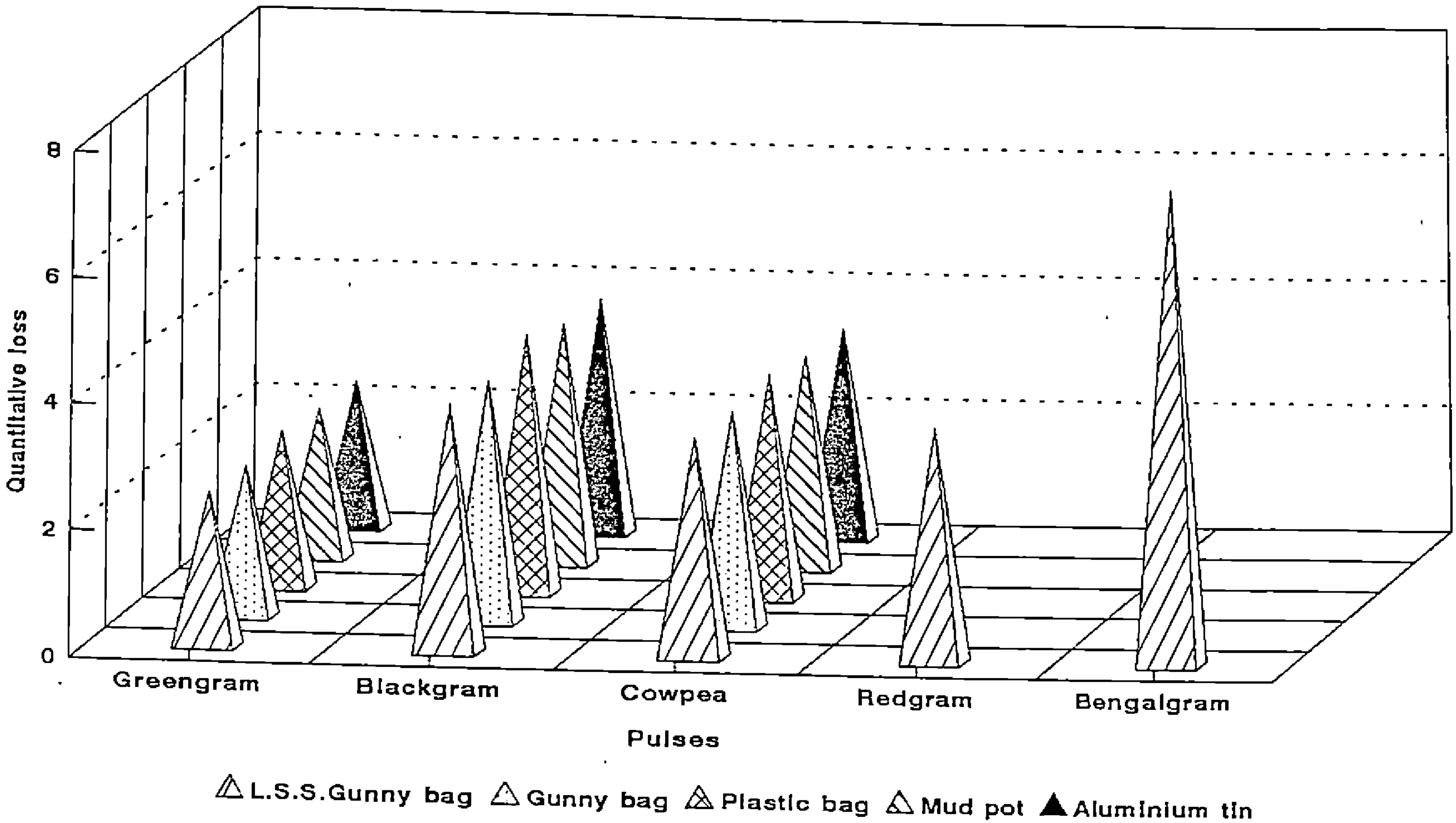

Fig. [redacted]1 Effect of storage methods, storage period and type of containers and pulses on the quantitative loss of pulses

Details are given in Table 25 and Fig. 1. Quantitative loss is between 2.31 and 7.54 percent. Mean values indicated that the loss was least in green gram followed by cowpea, blackgram in the largescale and farm level storage. Percent weight loss was higher in pulses stored under largescale storage when compared to farmlevel storage.

The percentage weight loss observed in all the pulses suggested that though no scientific pest control measures were adopted to prevent insect infestation in storage of pulses.

4.3.2. Qualitative tests conducted on stored pulses

Qualitative tests included determination of protein, moisture, non-protein nitrogen minerals ssuchas calcium and iron and uric acid of different stored pulsese once in three months for one year.

Moisture content of stored pulses

Increase in moisture level were observed in different types of pulses, stored in various containers and the results are presented in Table 26.

Table 26. Effect of storage methods, containers and type of pulses on the moisture content of pul at different storage period (percent)

Treatment				Storage periods (in months)							
				3		6		9		12	
Storage methods	Containers	Pulses	Fresh sample	Mean	Diffe-rence	Mean	Diffe-rence	Mean	Diffe-rence	Mean	Diffe rence
Large scale	Gunny bag	Greengram	10.4	10.98	0.58	11.45	0.47	12.68	1.23	14.19	1.51
		Blackgram	12.71	13.43	0.72	14.30	0.87	15.48	1.18	16.91	1.43
		Cowpea	13.62	14.27	0.65	15.43	1.16	16.36	0.93	17.81	1.45
		Marginal mean	12.24	12.89		13.73		14.84		16.30	
		Red gram	13.03	14.11	1.08	15.21	1.10	16.32	1.11	17.54	1.22
		Blackgram	2.24	10.90	1.66	11.88	0.98	11.24	1.36	14.35	1.11
Farm level	Gunny bag	Greengram	10.4	10.98	0.46	11.38	0.52	12.47	1.09	14.20	1.73
		Blackgram	12.71	13.60	0.89	14.15	0.55	15.45	1.30	16.95	1.50
		Cowpea	13.62	14.26	0.64	15.29	1.03	16.45	1.16	17.75	1.30
		Marginal mean	12.24	12.91		13.61		14.79		16.30	
	Plastic bag	Greengram	10.4	11.05	0.65	12.02	0.97	13.15	1.13	14.45	1.30
		Blackgram	12.71	13.82	1.11	14.46	0.85	15.92	1.47	17.70	1.78
		Cowpea	13.62	14.65	1.03	15.43	1.08	17.10	1.67	18.79	1.69
		Marginal mean	12.24	13.17		13.96		15.40		16.98	
	Mud pot	Greengram	10.4	11.05	0.65	11.62	0.57	13.03	1.39	14.42	1.41
		Blackgram	12.71	13.68	0.97	14.45	0.77	15.36	0.91	17.53	2.17
		Cowpea	13.62	14.48	0.68	15.51	1.03	16.51	1.00	18.15	1.65
		Marginal mean	12.24	13.23		13.86		14.96		16.70	
	Aluminium tin	Greengram	10.4	10.61	0.21	11.32	0.71	11.81	0.49	12.68	0.87
		Blackgram	12.71	13.43	0.72	14.11	0.68	15.36	1.25	16.28	0.92
		Cowpea	13.62	14.20	0.58	15.14	0.94	16.34	1.20	17.19	0.8
		Marginal mean	12.24	12.76		13.52		14.50		15.38	
	Marginal mean	Greengram	10.4	10.98	0.49	11.59	0.70	12.76	1.71	13.93	1.1
		Blackgram	12.71	13.63	0.92	14.29	0.60	15.60	1.31	17.11	1.5
		Cowpea	13.62	14.39	0.77	15.34	0.94	16.64	1.30	17.97	1.3

CD for storage periods	0.35			
CD for containers	1.75	0.21	0.073	0.093
CD for pulses	1.51	0.10	0.063	0.081
CD for container x pulses	1.51	0.20	0.130	0.162
CD for storage period x treatment	1.46			

Under large scale storage the increase in moisture content was highest in red gram, where the initial moisture content of 13.03 per cent increased to 17.54 per cent after 12 months of storage with an increase of 4.51 per cent. Next to red gram, moisture content was higher in blackgram, (from 12.71 to 116.91 per cent with an increase of 4.20 per cent). In stored cowpea the initial moisture content of 13.62 per cent increased to 17.81 per cent, and the increase was observed to be 4.19 percentage, comparatively moisture increase was less in green gram (3.79 per cent) and in bengal gram (3.45 per cent).

Maximum increase in moisture content among different pulses except for bengal gram, were noticed during the period between ninth and twelth month of storage. Increase in moisture level varied from 0.93 to 1.51 percentage. While in bengal gram the moisture level varied maximum during sixth and ninth month of storage where the moisture content ranged from 0.98 to 1.36 per cent. Steady increase in moisture content of pulses were observed as the storage period prolonged. Statistical analysis of the data revealed significant difference between storage periods.

Studies conducted by Daniel et al. (1977) reported that in green gram, bengal gram and red gram, moisture content increased due to prolonged storage period. Swaroopa rani et al. (1988) had reported that the moisture content of untreated samples increased with an increase in the level of insect infestation.

Under farm level storage the increase in moisture content was lowest in green gram, where the initial moisture content of 10.4 per cent increased to 13.93 percentage, and the increase was found to be 3.53 per cent, followed by cowpea, where the increase was 4.35 per cent after 12 months of storage. In blackgram, the increase was highest where the initial moisture level of 12.71 per cent increased to 17.11 percent where the increase was 4.4 per cent. Statistical analysis of the data revealed significant difference among different pulses.

Studies conducted by Gupta et al. (1980) had found that increase in moisture level was maximum in blackgram, followed by bengal gram and green gram. Srivastava (1992) had also reported that in green gram the initial moisture content of 11.40 per cent increased to 14.01, 14.75, 15.18

and 15.68 per cent respectively during third, sixth, ninth and twelth months of storage.

Maximum increase in moisture content was noticed during the period between sixth and ninth months of storage. The increase ranged from 0.60 to 1.31 per cent. Increase was maximum in blackgram (0.60 to 1.31 per cent), followed by cowpea (0.95 to 1.30 percentage) and least in green gram (0.70 to 1.17 per cent). Studies conducted by Gupta et al. (1980) revealed that the absorption of moisture was more at higher relative humidity in case of pulses.

Among the different containers used for storing the pulses, increase in moisture content was maximum in pulses stored in plastic bag where the increase was from 12.24 to 16.98 per cent and the increase was 4.74 per cent followed by mud pot where the initial moisture content of 12.24 increased to 16.70 per cent with an increase of 4.5 per cent. In gunny bag the increase was found to be 4.06 per cent and the increase was least in pulses stored in aluminium tin where the initial moisture level of 12.24 increased to 15.38 per cent. Statistical analysis of the data indicated that variation was significant only at third month of storage.

Katiyar *et al*. (1992) had observed similar result and they had reported that maximum increase in moisture content was observed in pulses stored in gunny bags, when compared to mud pots, polythene bags and tin containers.

Among the combinations tried under large scale as well as farm level storage, maximum increase was observed in blackgram stored in plastic bag where the initial value of 12.71 per cent increased to 17.70 per cent and minimum increase was observed in green gram stored in aluminium tin. The increase was from 10.4 to 12.68 per cent. Statistical analysis of the data revealed significant difference at 5 per cent level.

When comparing the two levels of storage, viz. 'large scale' and 'farmlevel' storage, the increase in moisture content of pulses stored under large scale was higher than the farmlevel storage. The increase of moisture content was from 12.24 per cent to 16.60 per cent. (4.36 per cent increase) and 12.24 to 16.30 per cent (4.06 per cent increase) for large scale and farmlevel storage respectively.

Moisture content of pulses stored at largescale and farmlevel storage ranged between 9.40 to 13.62 per cent.

There was a slight increase in moisture content of different grams stored for 12 months (2.20 to 4.99 per cent). The changes in moisture content could have been due to the changes in atmospheric temperature and relative humidity or due to insect infestation and a combination of all these factors.

Protein content of stored pulses

Changes in protein content due to prolonged storage are presented in Table 27. In largescale storage, there was a decrease in protein content of pulses. Variation in protein decrease was noted among the different pulses. Under large scale storage, the decrease in protein was least in greengram with an initial protein content of 23.20 g percent decreased to 18.40 g percent after 12 months of storage. The loss in protein content, after one year, was found to be 4.80 g percent in green gram, followed by cowpea, in which the decrease was from 22.80 g percent to 17.79 g percent with a loss of 5.01 g percent. In redgram the initial protein content was 22.30 g percent and it reduced to 17.10 g percent with a protein loss of 5.20 g percent. Red gram was followed by bengal gram, where the loss was found to be 6.10 g percent. Maximum loss in protein content was noted in

Table 27. Effect of storage methods, containers and type of pulses on the protein content of pulses at different storage period (g/100g)

Treatments				Storage periods (in months)							
				3		6		9		12	
Storage methods	Containers	Pulses	Fresh sample	Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
Large scale	Gunny bag	Greengram	23.3	22.05	1.15	20.82	1.23	19.75	1.07	18.40	1.35
		Blackgram	23.50	21.58	1.92	19.42	2.16	18.20	1.22	16.93	1.27
		Cowpea	22.80	22.05	0.75	19.95	2.10	18.75	1.20	17.79	0.96
		Marginal mean	23.16	21.89		20.06		18.90		17.71	
		Red gram	22.30	21.00	1.30	19.60	1.400	18.20	1.40	17.10	1.10
		Blackgram	22.6	21.01	1.59	19.10	1.918	17.70	1.406	16.50	1.20
Farm level	Gunny bag	Greengram	23.20	22.40	0.80	21.72	0.68	20.68	1.04	18.92	1.76
		Blackgram	23.50	21.82	1.68	19.97	1.85	18.50	1.42	17.49	1.01
		Cowpea	22.80	22.00	0.80	20.80	1.20	18.98	1.82	18.07	0.91
		Marginal mean	23.16	22.05	1.11	20.80	1.25	18.84	1.96	18.16	0.68
	Plastic bag	Greengram	23.2	21.90	1.30	20.80	1.10	19.40	1.40	18.37	1.03
		Blackgram	23.50	21.29	2.21	19.62	1.675	117.65	1.97	16.90	0.75
		Cowpea	22.80	22.39	0.41	21.10	1.29	19.75	1.35	118.19	1.56
		Marginal mean	23.16	21.86	1.30	20.50	1.36	18.93	1.57	17.82	1.11
	Mud pot	Greengram	23.2	22.35	0.85	21.37	0.98	20.14	1.23	19.00	1.14
		Blackgram	23.50	21.62	1.88	20.67	0.95	18.75	1.92	17.41	1.34
		Cowpea	22.80	22.22	0.58	20.95	1.27	19.40	1.55	18.33	1.07
		Marginal mean	23.16	22.06	1.10	20.99	1.07	19.43	1.56	18.24	1.19
	Aluminium tin	Greengram	23.20	22.42	0.78	21.60	0.82	20.25	1.35	19.20	1.05
		Blackgram	23.50	21.95	1.55	20.65	1.30	18.80	1.85	17.90	0.90
		Cowpea	22.80	22.32	0.48	20.95	1.37	19.35	1.60	18.55	0.80
		Marginal mean	23.16	22.23	0.93	21.06	1.17	19.46	1.60	18.55	0.91
	Marginal mean	Greengram	23.2	22.27	0.93	21.38	0.89	19.96	1.42	18.87	1.09
		Blackgram	23.50	21.67	1.83	20.22	1.45	18.42	1.80	17.43	0.99
		Cowpea	22.80	22.23	0.57	20.95	1.28	19.37	1.58	18.28	1.09

CD for storage periods	0.15			
CD for containers	0.48	0.42	0.37	0.26
CD for pulses	0.41	0.36	0.33	0.22
CD for container x pulses	0.82	0.72	0.67	0.45
CD for storage period x treatment	0.52			

blackgram where the initial protein content of 23.50 g percent was reduced to 16.93 g percent with a loss of 6.57 g percent. Variation in protein content of different pulses, before and after storage, were found to be statistically significant at one percent level. Studies conducted by Vimala et al. (1986) had reported that decrease in nitrogen level was noticed in green gram, black gram and bengal gram. The loss was least in green gram, followed by blackgram and bengal gram.

Maximum decrease in protein content in different pulses were noticed during the period between third and sixth months of storage. The loss in protein content of different pulses at periodical interval of 3 months varied from 0.75 g percent to 2.16 g percent. Protein loss was maximum in blackgram and cowpea. Rate of protein loss was found to be higher in all the pulses except greengram, where the loss it was higher only after one year storage. The Statistical analysis of the data revealed that there is significant difference in the protein content of the pulses at different intervals in storage periods.

Under farm level storage also, protein loss was lowest in greengram, from the initial value of 23.2g percent to 18.87g percent, after 12 months of storage, with a loss of 4.33 g percent. Green gram was followed by cowpea where the protein content decreased from 22.80 to 18.28g percent with a loss of 4.52 g percent. In blackgram the decrease in protein content was higher than the above two pulses from an initial value of 23.50g percent to 17.43g percent, with a loss of 6.07g percent. Similar trend was observed at large scale storage also. Changes in protein content of different pulses, before and after storage, were found to be statistically significant at one per cent level.

Maximum decrease in protein content among different pulses were noticed during the period between sixth month and ninth month of storage. The loss in protein content of different pulses varied from 0.89 to 1.8g percent. Maximum variation in protein content was observed in blackgram, the loss ranged from 1.45 to 1.8g percent followed by cowpea, where the loss was from 1.28 to 1.58 g percent and for green gram the loss in protein content ranged 0.89 to 1.42g percent at sixth and ninth month of storage respectively. Studies conducted by Daniel et al. (1977) had reported that the prolonged storage decreased the nitrogen level in different pulses. In these studies after 4 months of storage the change was significant. Bressani *et al*. (1984) had also reported that with the advancement of storage time, loss in protein quality of greengram was noticed. The statistical analysis of the data revealed that there was significant difference in the protein content of different pulses between the large scale and farm level storage periods.

During storage, variation in protein content among pulses stored in different containers was noted. Maximum variation was noted among the pulses stored in plastic bags. Where the protein content decreased from 23.16g percent to 17.82g percent, after 12 months of storage and the loss in protein content was 5.34 g percent followed by the pulses stored in gunny bag, where the initial protein content of 23.16 g percent decreased to 18.16 g percent after 12 months of storage. The loss in protein content of pulses stored in gunny bag was found to be 5.0g percent. In the pulses stored in mudpot the protein content was found to decrease from 23.16 g percent to 18.24 g percent. Protein loss was least for pulses stored in aluminium tin and in this container the initial protein content of 23.16 g percent was reduced to 18.55 g percent with a loss of 4.16 g percent of protein. Statistical analysis of the data further revealed significant difference among the pulses stored in different containers.

Among the different combinations tried under large scale as well as farm level storage, maximum variation was observed in blackgram stored in plastic bag under farm level storage, where the initial protein content of 23.5 g percent decreased to 16.90g percent after 12 months of storage and the loss was found to be 6.6g percent. In his studies Gupta (1984) had also reported that in blackgram, the protein loss was highest during the sixth month of storage. In greengram stored in aluminium tin, under farm level storage, minimum change was observed where the protein content decreased from 23.2g percent to 18.87 g percent and the loss was found to be 4.0g percent. Studies conducted by Pushpasree et al. (1988) reported that there was a gradual decrease in protein content of greengram as the period of storage increased. Statistical analysis of the data revealed that there is significant difference among the different combinations tried.

For comparing the two levels of storage viz., large scale and farmlevel storage, the values obtained for pulses stored in gunny bags under the above levels of storage were taken into consideration. The loss in protein content of pulses were higher in pulses stored under large scale storage (5.45g percent marginal mean) after 12 months of storage while, it was lower in pulses stored under farmlevel storage with a protein loss of 5.0 g percent (marginal mean) during the same storage period.

Non-protein-nitrogen

Non-protein-nitrogen level of pulses were found to be influenced by storage methods, containers, length of storage period and type of pulses stored. Details are presented in Table 28.

In large scale storage there was increase in non-protein-nitrogen content of pulses. Variation in non-protein-nitrogen content was noted among the different pulses. Under large scale storage the increase in non-protein nitrogen content was minimum in cowpea as 167.8mg/100g, from 448mg to 615.8mg/100g after 12 months of storage. While in redgram it was 168.8mg (from 448mg to 616.8mg/100g). the increase in bengalgram was slightly higher as 171.7mg/100g; followed by greengram, where the increase was found to be 176.8mg/100g. Maximum increase was observed in blackgram, where the initial non-protein-nitrogen content of different pulses before and after storage was found to be statistically significant.

Table 28. Effect of storage level, containers and type of pulses on the non-protein-nitrogen content mg) of pulses at different storage period.

Treatment				Storage period (in months)							
				3		6		9		12	
Storage level	Containers	Pulses	Fresh sample	Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
Large scale	Gunny bag	Greengram	(428)	470.40	(42.40)	492.80	(22.40)	537.60	(44.80)	604.80	(67.20)
		Blackgram	454)	504.00	50.00)	532.00	28.00)	602.40	70.40)	649.80	47.40)
		Cowpea	(448)	476.40	(28.40)	506.80	(30.40)	551.60	(44.80)	615.80	(64.20)
		Marginal mean	433.3	483.60		510.53		563.86		623.46	
		Red gram	(448)	482.00	(34.00)	504.00	(22.00)	543.20	(39.20)	616.80	(73.60)
		Bengalgram	(482)	509.60	(27.60)	526.00	(16.40)	589.20	(63.20)	653.70	(64.50)
Farm level	Gunny bag	Greengram	(428)	464.80	(36.80)	492.80	(28.00)	537.60	(44.80)	595.20	(57.60)
		Blackgram	(454)	492.80	(38.80)	526.00	(33.20)	594.00	(68.00)	634.20	(40.20)
		Cowpea	(448)	470.80	(22.80)	504.00	(33.20)	548.80	(44.80)	606.00	(57.20)
		Marginal mean	443.3	476.13		507.60		559.47		611.80	
	Plastic bag	Greengram	(428)	476.00	(48.00)	498.40	(22.40)	543.20	(44.80)	610.40	(67.20)
		Blackgram	(454)	500.80	(46.80)	537.60	(36.80)	599.60	(62.00)	642.90	(43.30)
		Cowpea	(448)	482.00	(34.00)	509.60	(27.60)	554.40	(44.80)	620.60	(66.20)
		Marginal mean	443.3	486.20		515.20		565.73		624.60	
	Mud pot	Greengram	(428)	459.20	(31.20)	487.20	(28.00)	532.00	(44.80)	590.20	(48.20)
		Blackgram	(454)	496.00	(42.00)	520.80	(24.80)	571.20	(50.40)	632.60	(61.40)
		Cowpea	(448)	470.80	(22.80)	501.20	(30.40)	543.20	(42.00)	605.50	(62.30)
		Marginal mean	443.3	475.00		503.10					
	Aluminium tin	Greengram	(428)	453.60	(25.60)	4487.2	(33.60)	526.40	(39.20)	583.60	(57.20)
		Blackgram	(454)	493.20	(39.20)	509.60	(16.40)	565.60	(56.00)	628.60	(63.00)
		Cowpea	(448)	465.90	(17.90)	498.40	(32.50)	537.20	(38.80)	599.10	(61.90)
		Marginal mean	443.3	470.70		498.40		543.07		603.70	
	Marginal mean	Greengram		463.40		491.40	(28.00)	551.10	(59.70)	597.85	(43.75)
		Blackgram		495.70		523.50	(27.80)	582.60	(59.10)	634.57	(60.97)
		Cowpea		472.20		503.30	(31.10)	545.90	(42.60)	607.80	(62.10)

CD for storage periods	2.41			
CD for containers	7.00	7.26	6.61	8.20
CD for pulses	6.00	6.32	6.43	7.03
CD for container x pulses	12.06	13.83	14.13	13.29
CD for storage period x treatment	9.94			

Figures in paranthesis indicate increase in non-protein-nitrogen content (mg/100g)

Maximum increase in non-protein content among different pulses were noticed during ninth and twelth month except in the case of blackgram and bengal gram, where maximum increase was between sixth and ninth month of storage. For blackgram the increase was between 28.00 to 70.40mg/100g and for bengal gram it was between 16.40 to 63.20mg/100g. Between ninth and twelth month the increase in non-protein-nitrogen level varied from 39.20 to 73.60mg/100g for different pulses. In greengram the increase was from 44.80 to 64.20 mg and in redgram the increase was from 39.20 to 73.60mg/100g between ninth and twelth month respectively. Statistical analysis of the data reveled significant difference among the storage periods. Studies conducted by Gupta et al. (1981) had reported that the storage of pulses increased the non-protein-nitrogen level in pulses. Darewicz et al. (1992) revealed that storage and drying methods increased non-protein-nitrogen level in pulses.

Under farmlevel storage the increase in non-protein-nitrogen content was highest in blackgram, where the initial level of 454 mg increased to 634.57mg/100g with an increase of 180.57mg. Blackgram was followed by greengram with an increase was observed in cowpea where the initial content of 448 mg of non-protein-nitrogen was increased to 599.10 mg and the increase was found to be 159.8mg/100g. Statistical analysis of the data revealed significant difference in the increase of non-protein-nitrogen among the pulses.

The results of farmlevel storage revealed that increase in non-protein-nitrogen was maximum in blackgram and minimum in greengram, the loss was found to be between ninth and twelth month, except in blackgram, stored in gunnybag and plastic bag. In blackgram the increase was maximum between sixth and ninth month of storage. In greengram the increase was from 551.10 mg to 594.85mg/100g and in cowpea non-protein-nitrogen content increased from 42.60 to 62.10mg/100g between ninth and twelth month of storage respectively. In blackgram the increase was from 27.80 to 59.10mg/100g on sixth and ninth month of storage respectively.

Changes in non-protein-nitrogen content among different pulses, stored in different containers was noted. Maximum increase was noted in pulses stored in plastic bags. Where the non-protein-nitrogen level increased from 443.30mg/100g to 624.6mg/100g with an increase of 181.30 mg after 12 months of storage, followed by the pulses stored in gunny bag, where the increase was 168.5mg/100g. The increase in non-protein-nitrogen level of pulses stored in mud pot was 166.10 mg where the initial level of 443.3 mg was increased to 609.43mg/100g. Minimum increase was noted in the pulses stored in aluminium tin where the initial non-protein-nitrogen content of 443.30 mg was increased to 603.70mg/100g, and the increase was found to be 160.4mg/100g. Statistical analysis of the data on non-protein-nitrogen content of pulses stored in different containers revealed that the variation was significant at one per cent level.

Among the different combinations tried under large scale as well as farm level storage, maximum variation was observed in blackgram stored under large scale storage, where the initial non-protein-nitrogen level of 454.00 mg increased to 649.8 mg and the increase was found to be 195.8mg/100g. Minimum change was observed in cowpea stored in aluminium tin with an increase of 151.10mg/100g where the initial non-protein-nitrogen level of 448.00mg/100g increased to 500.10mg/100g. Statistical treatment of the data on non-protein-nitrogen content revealed that there is significant difference among the combinations tried.

Among the two levels of storage viz. 'large soale' and 'farm level' storage, the increase in non-protein-nitrogen content of pulses stored under large soale storage were higher than that of pulses stored in farm level storage. The increase was found to be 180.16mg/100g and 168.5mg/100g for large scale and farm level storage respectively after 12 months of storage.

The results of non-protein-nitrogen content of pulses stored under large scale and farmlevel storage revealed that there was increase in non-protein-nitrogen level of different pulses. The increase was maximum in blackgram and minimum in cowpea. The increase was highest between ninth and twelth month of storage. Under largescale storage, gunny bag was used for storing the pulses, while under farm level storage, four types of containers were used for storing the pulses viz., gunnybag, plastic bag, mudpot and aluminium tin. Among the containers, both under large scale as well as farm level storage, increase in non-protein-nitrogen content was highest in pulses stored in plastic bag and lowest in aluminium tin. And among combinations tried under large scale as well as farm level storage, increase in non-protein-nitrogen level was maximum in blackgram stored in gunny bag under largescale storage and minimum in cowpea stored in aluminium tin under farmlevel storage.

Mineral content of stored pulses

Decrease in calcium content were observed in different types of pulses. Stored in various containers and the results are presented in Table 29.

Under large scale storage the decrease in calcium content was minimum in cowpea and redgram, where the initial calcium content of 74 decreased to 27 mg/100g/ and 71 to 24 mg/100g in.g. The rate of decrease was more in greengram, (61 mg/100g) blackgram (62 mg/100g) and bengal gram (77 mg/100g). Studies conducted by Srivastava et al. (1992) had reported decrease in mineral content of pulses due to long period of storage.

Decrease in calcium content was maximum between sixth and ninth month of storage except in blackgram and cowpea, where, the decrease in calcium content was maximum between third and sixth month of storage. Statistical analysis of the data revealed significant difference among the storage periods.

Table 29. Effect of storage methods, containers and types of pulses on the calcium content (Mg/100g) of pulses at different storage periods

Storage level	Containers	Pulses	Fresh sample	Storage Periods (in months) 3 Mean	3 Difference	6 Mean	6 Difference	9 Mean	9 Difference	12 Mean	12 Difference
Large scale	Gunny bag	Greengram	124	116	8	99	17	74	25	63	11
		Blackgram	151	140	11	119	21	102	17	89	13
		Cowpea	74	66	8	48	18	36	12	27	9
		Marginal mean	116.3	107.3	9	88.6	18.7	70.67	17.9	59.67	11
		Redgram	71	60	11	51	9	37	14	24	13
		Bengalgram	202	189	13	172	17	148	24	125	23
Farm level storage	Gunny bag	Greengram	124	116	8	101	15	77	24	64	13
		Blackgram	151	141	10	122	19	105	17	92	13
		Cowpea	74	69	11	50	19	38	12	30	8
		Marginal mean	116.3	108.6	7.7	91	17.6	73.3	17.7	62	11.3
	Plastic bag	Greengram	124	114	10	98	16	70	28	6	9
		Blackgram	151	136	15	120	16	101	19	85	16
		Cowpea	74	66	8	48	18	36	12	25	11
		Marginal mean	116.3	105.3	11.0	88.7	16.6	69	19.7	57	12
	Mud pot	Greengram	124	118	6	104	14	79	25	67	12
		Blackgram	151	141	10	125	116	109	16	92	17
		Cowpea	74	69	5	52	17	41	11	33	8
		Marginal mean	116.3	109.3	7.0	93.7	15.6	76.3	17.4	64	12.3
	Aluminium tin	Greengram	124	120	4	107	13	83	24	71	12
		Blackgram	151	144	7	128	16	112	116	97	15
		Cowpea	74	70	4	55	15	44	11	37	7
		Marginal mean	116.3	111.3	5.0	96.7	14.6	79.7	17	68	11.7
	Marginal mean	Greengram	124	117	14.5	102.5	25.25	77.25	11.45	65.8	--
		Blackgram	151	140.5	16.5	124	17.25	106.75	15.3	91.5	--
		Cowpea	74	68.5	17.2	51.3	11.5	39.80	8.5	31.3	--
CD Values				0.98		1.29		1.31		1.04	

Under farm level storage, decrease in calcium content was maximum in blackgram, where the initial calcium level of 151 mg/100g decreased to 91.5 mg/100g followed by greengram (124 mg/100g to 65.8 mg/100g), the decrease in calcium content was minimum in cowpea (74 mg/100g to 31.3 mg/100g). Significant difference in the calcium content among the pulses.

Decrease in calcium content was maximum between sixth and ninth month of storage except in the case of cowpea, where the decrease was maximum between third and sixth month of storage.

Among the containers used for storing the pulses, decrease in calcium content was maximum in the pulses stored in plastic bag (59.3 mg/100g) followed by gunny bag, (54.3 mg/100g) mud pot (52.3 mg/100g) and lastly aluminium tin(48.3 mg/100g). Statistical analysis of the data revealed significant differences among the containers at 5 percent level.

Among the combinations tried under large scale as well as in farm level storage, decrease in calcium content was maximum in bengal gram stored in gunny bag under large scale storage and minimum in cowpea stored in aluminium tin under farmlevel storage.

When the two levels of storage viz, large scale as well as farmlevel storage were compared, the pulses stored under farmlevel storage gave better results than the pulses stored under large scale storage. Statistical analysis of the data revealed significant difference at 5 percent level among the two levels of storage.

Decrease in iron content was noticed in the stored pulses. The details pertaining to this are presented in Table 3D.

Under large scale storage decrease in iron content was minimum in redgram. Where the initial iron content of 2.63 mg/100g decreased to 0.91 mg/100g, followed by greengram (4.31 mg/100g to 2.42 mg/100g), blackgram (3.74 mg/100g to 1.62 mg/100g), bengal gram (4.61 mg/100g to 2.63 mg/100g) and lastly cowpea (8.5 mg/100g to 5.27 mg/100g). Statistical analysis of the data revealed significant differences among the pulses stored under large scale storage.

Table 3D. Effect of storage methods, containers and types of pulses on the iron content (Mg/100g) of pulses at different storage periods

Storage level	Containers	Pulses	Fresh sample	Storage Periods (in months)							
				3		6		9		12	
				Mean	Diffe-rence	Mean	Diffe-rence	Mean	Diffe-rence	Mean	Diffe-rence
Large scale storage	Gunny bag	Greengram	4.31	3.91	0.40	3.16	0.75	2.74	0.44	2.42	0.30
		Blackgram	3.74	3.32	0.42	2.60	0.72	2.16	0.44	1.62	0.54
		Cowpea	8.5	7.70	0.82	7.12	0.58	6.32	0.80	5.27	1.05
		Marginal mean	5.52	4.98	0.54	4.29	0.69	3.73	0.56	3.10	0.63
		Redgram	2.63	2.30	0.33	1.53	0.77	1.13	0.40	0.91	0.22
		Bengalgram	4.61	4.11	0.50	3.62	0.52	3.02	0.60	2.36	0.66
Farm level storage	Gunny bag	Greengram	4.31	3.90	0.41	3.30	0.60	2.71	0.59	2.41	0.30
		Blackgram	3.74	3.43	0.31	2.71	0.72	2.33	0.50	1.70	0.53
		Cowpea	8.5	7.92	0.58	7.34	0.58	6.54	0.80	5.53	1.01
		Marginal mean	5.52	5.08	0.44	4.45	0.63	3.83	0.62	3.20	0.63
	Plastic bag	Greengram	4.31	3.70	0.61	3.14	0.56	2.46	0.68	2.26	0.20
		Blackgram	3.74	3.26	0.48	2.56	0.70	1.94	0.62	1.65	0.29
		Cowpea	8.5	7.76	0.74	7.02	0.74	66.07	0.95	5.12	0.95
		Marginal mean	5.52	4.91	0.61	4.24	0.67	3.49	0.75	3.01	0.48
	Mud pot	Greengram	4.31	4.10	0.21	3.51	0.59	2.81	0.70	2.53	0.28
		Blackgram	3.74	3.42	0.32	2.84	0.58	2.32	0.52	1.76	0.56
		Cowpea	8.5	7.80	0.70	7.51	0.29	6.12	1.39	5.62	0.50
		Marginal mean	5.52	5.11	0.41	4.62	0.49	3.75	0.87	3.30	0.45
	Aluminium tin	Greengram	4.31	4.22	0.09	3.86	3.36	3.00	20.86	2.55	0.45
		Blackgram	3.74	3.56	0.18	2.85	0.71	2.41	0.44	1.86	0.55
		Cowpea	8.5	7.81	0.69	7.53	0.28	6.82	0.70	5.92	0.91
		Marginal mean	5.52	5.11	0.411	4.75	0.36	4.08	0.667	3.44	0.64
	Marginal mean	Greengram	--	3.64	0.19	3.45	0.70	2.75	0.31	2.44	--
		Blackgram	--	3.42	0.68	2.74	0.51	2.23	0.49	1.70	--
		Cowpea	--	7.82	0.47	7.35	0.96	6.39	0.84	5.55	--

Decrease in iron content was maximum between sixth and ninth month of storage except in the oase of cowpea where the decrease was maximum between third and sixth month of storage. Statistical analysis of the data revealed significant difference at 5 percent level. Studies conducted by Gupta (1988) had reported that storage period has profound effect on the mineral content of pulses.

Under farmlevel storage decrease in iron content was minimum in greengram, where the initial iron content of 4.31 mg/100g decreased to 2.44 mg/100g, followed by blaokgram (3.74 mg/100g to 1.86 mg/100g) and lastly cowpea (8.5 mg/100g to 5.92 mg/100g). Decrease in the iron content was maximum between sixth and ninth month of storage except in blackgram where the deorease in iron content was maximum between third and sixth month of storage. Statistical analysis of the data revealed significant difference among the storage periods.

Among the containers used for storing the pulses, decrease in iron content was minimum in the pulses stored in aluminium tin (5.52 mg/100g to 3.44 mg/100g), followed by mud pot (5.52 mg/100g to 3.30 mg/100g), gunny bag (5.52 mg/100g to 3.01 mg/100g) and lastly plastic bag (5.52 mg/100g to 3.20

mg/100g). Statistical analysis of the data revealed significant difference at 1 per cent level.

Among the combinations tried under large scale as well as farmlevel storage, decrease in iron content was maximum in cowpea stored in Gunny bag under large scale storage (8.5 mg/100g to 5.27 mg/100g) and minimum in greengram stored in aluminium tin (4.31 mg/100g to 2.53 mg/100g).

Among the two levels of storage, decrease in iron content was maximum in the pulses stored under large scale storage (5.52 mg/100g to 3.10 mg/100g) than the pulses stored in farmlevel storage (5.52 mg/100g to 3.20 mg/100g). Statistical analysis of the data revealed significant difference among the two levels of storage.

Uric acid

Uric acid content of pulses may increase during storage due to insect infestation and due to the presence of insect excreta: Details pertaining to the uric acid content of stored pulses are presented in Table 31.

Table 31. Effect of storage level containers and type of pulses on the uric acid (mg/100g) of pulses at different storage period

Treatment			Storage period (in months)								
				3		6		9		12	
Storage level	Containers	Pulses	Fresh sample	Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
Large scale	Gunny bag	Greengram	0	1.35		3.26	1.91	7.93	4.67	12.25	4.31
		Blackgram	0	8.87		16.02	7.15	21.61	5.59	29.65	8.03
		Cowpea	0	1.96		5.63	3.67	9.77	4.13	13.90	4.13
		Marginal mean	0	4.06		8.30		13.10		18.60	
		Red gram	0	1.53		3.86	2.33	8.53	4.66	13.86	5.33
		Blackgram	0	2.35		6.93	3.58	12.46	5.52	20.19	7.72
Farm level	Gunny bag	Greengram	0	1.28		3.21	1.93	7.86	4.64	12.14	4.28
		Blackgram	0	8.80		15.98	7.17	21.56	5.58	29.62	8.05
		Cowpea	0	1.93		5.56	3.63	9.70	4.13	13.94	4.23
		Marginal mean	0	4.00		8.25		13.04		18.56	
	Plastic bag	Greengram	0	1.38		3.28	1.89	7.94	4.65	12.29	4.35
		Blackgram	0	8.89		16.04	7.15	21.63	5.59	29.68	8.04
		Cowpea	0	1.98		5.64	3.65	9.79	4164.	14.09	4.30
		Marginal mean	0	4.08		8.32		13.12		18.70	
	Mud pot	Greengram	0	1.25		3.19	1.93	7.81	4.62	12.07	4.26
		Blackgram	0	8.79		15.96	7.17	21.55	5.58	29.61	8.06
		Cowpea	0	1.92		5.54	3.62	9.62	4.08	13.82	4.14
		Marginal mean	0	4.00		8.23		12.99		18.51	
	Aluminium tin	Greengram	0	1.23		3.17	1.93	7.80	4.6330	12.04	4.24
		Blackgram	0	8.83		15.95	7.07	21.53	5.5860	29.60	8.06
		Cowpea	0	1.90		5.51	3.61	9.50	3.9850	13.80	4.29
		Marginal mean	0	4.00		8.21		12.94		18.50	
	Marginal mean	Greengram	0	1.28		3.21		7.85		12.14	
		Blackgram	0	8.84		15.98		21.57		29.60	
		Cowpea	0	1.93		5.56		9.65		13.91	

CD for storage periods	6.70			
CD for containers	0.21	0.29	0.51	0
CD for pulses	0.18	0.25	0.44	0
CD for container x pulses	0.36	0.51	0.88	0
CD for storage period x treatment				

In this study, an increase in the uric acid content was observed due to prolonged storage. This again varied with level of storage, and containers used for storage. There were individual variations among different pulses also.

Under large scale storage, variation in uric acid content of different types of pulses were noted in the study under report. Increase in uric acid content was minimum in green gram, where the uric acid content increased from 1.35 g to 12.25 g/100g after 12 months of storage with an increase of 10.89 g/100g followed by cowpea (11.93 g increase), red gram (12.32 g), bengal gram (17.83 g increase), and maximum increase was noted in blackgram where the uric acid increased from 8.87 mg to 29.65 g/100g after 12 months of storage and the increase was found to be 20.78 g/100g. Statistical analysis of the data revealed significant variation at one percent level.

Studies conducted by Daniel _et al_. (1977) had revealed that after 4 months of storage, uric acid content increased in green gram (2.03 g/100g), bengal gram (2.13 g/100g) and red gram (2.05 g/100g). Gupta _et al_. (1981) had also reported increase in uric acid content of bengal gram (23.20g/ 100g) after 6 months of storage.

Maximum variation in uric acid content was observed between ninth and twelth month of storage except in the case of green gram, where the increase was maximum between sixth and ninth month of storage, the increase in uric acid content ranged from 1.91 to 4.67 g/100g between sixth and ninth month of storage respectively. The increase in uric acid content of pulses varied from 4.13 to 8.03g/100g between ninth and twelth month of storage. In the studies conducted by Rao _et al_. (1985), prolonged storage of pulses were reported to have a direct effect on uric acid content.

Under farm level storage, variation in uric acid content of different pulses were noted. Increase in uric acid content was maximum in black gram, where the uric acid content increased from 8.84 to 29.60 g/100g, with an increase of 20.72 g/100g, followed by cowpea where the increase was from 1.93 to 13.91 g/100g and minimum increase was noted in green gram, and the increase was from 1.28 to 12.14 g/100g with an increase of 10.80g/100g.

Variation in uric acid content of different pulses between storage period was noted. Maximum increase was noted between ninth and twelth month of storage, except in the case of green gram, where the increase in uric acid content was maximum between sixth and ninth month of storage and the increase varied from 3.21 to 7.85 g/100g of uric acid. Studies conducted by Gupta et al. (1988) had reported that storage period had effect on the uric acid content of stored green gram.

In black gram and cowpea maximum increase was (from 7.85 to 12.14 g/100g) observed during ninth and twelth month of storage and for cowpea, 9.65 to 13.91g/100g during ninth and twelth month of storage.

Among the storage containers used, increase in uric acid content was maximum in pulses stored in plastic bags (14.62 g/100g) followed by samples in gunny bag (14.57 g/100g), mud pot (14.51 g/100g), aluminium tin (14.49 g/100g) after 12 months of storage. Statistical analysis of the data, reflected significant difference in uric acid content among pulses stored in different containers at one per cent level. Similar results were observed by Gupta et al. (1988) in their studies on untreated samples of pulses stored in tightly knit jute bag.

Among the different combinations tried under large scale and farm level storage, increase in uric acid content was maximum in black gram stored in plastic bag under farm level storage, where the uric acid level increased to 29.68 g/100g and increase was least in green gram stored in aluminium tin under farm level storage, in which the increase in uric acid level was 12.04 g/100g.

Among the two levels of storage, pulses stored in gunny bag under large scale storage has higher uric acid content than the pulses stored in gunny bag under the farm level storage. Marginal mean obtained for different pulses stored under large scale storage was within the range of 4.06 to 18.60 g/100g. While for different pulses stored under farm level storage has minimum increase in uric acid content, where the marginal mean obtained for different pulses was within the range of 4.00 to 18.57 g/100g.

Table 39. Qualitative loss (Percent) of pulses due to farm level and large scale storages

Treatments	Storage period						
	3rd month	difference	6th month	difference	9th month	difference	12th month
S_1	0.22	(0.51)	0.73	(0.60)	1.33	(0.69)	2.02
S_2C_1	0.20	(0.42)	0.62	(0.62)	1.24	(0.67)	1.86
S_2C_2	0.26	(0.47)	0.73	(0.75)	1.48	(0.66)	2.14
S_2C_3	0.19	(0.34)	0.53	(0.65)	1.18	(0.56)	1.74
S_2C_4	0.16	(0.29)	0.47	(0.58)	0.99	(0.56)	1.55

S_1 = Large scale storage

S_2 = Farm level storage

C_1 = Gunny bag

C_2 = Plastic bag

C_3 = Mud pot

C_4 = Aluminium tin

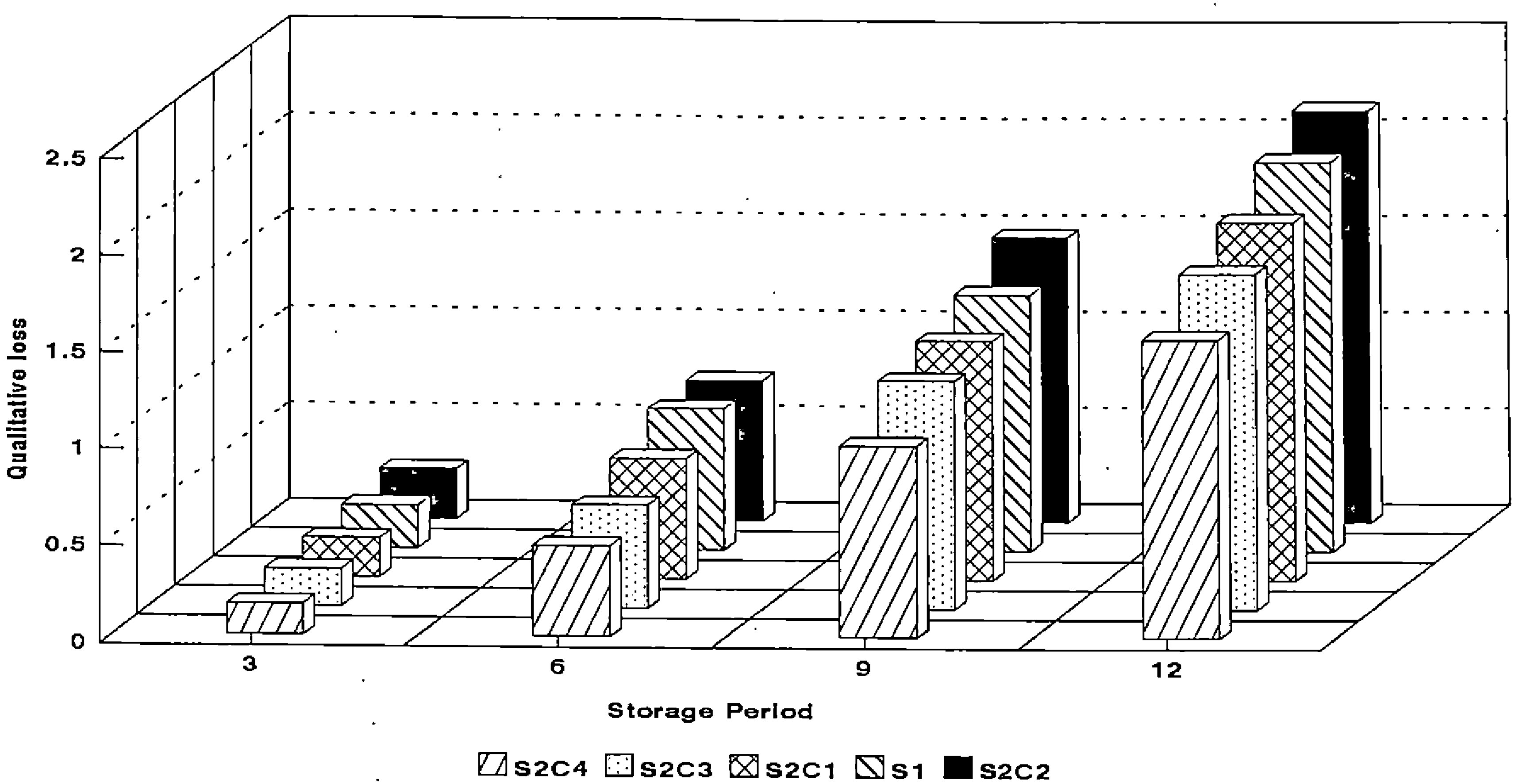

Fig. 2 Effect of storage methods, storage period and type of containers and pulses on the qualitative loss of pulses

S1 - Large scale storage, S2 - Farm level storage, C1 - Gunny bag, C2 - Plastic bag, C3 - Mud pot, C4 - Aluminium tin

Qualitative loss estimate was calculated by using the formula :

Qualitative loss =

$$\frac{\text{Initial protein value} - P_3}{P_3} + \frac{\text{Initial Ca} - Ca_3}{Ca_3} + \frac{\text{Initial Fe} - Fe_3}{Fe_3}$$

where P_3 = Protein value at 3rd month

Ca_3 = Calcium value at 3rd month

Fe_3 = Iron value at 3rd month

Qualitative loss was estimated in 3rd, 6th, 9th and 12th month to record the increase with the advancement of storage period. Table 3a and Fig. 2. present the details regarding the qualitative loss estimate. In the pulses stored under large scale storage, the qualitative loss increased from 0.22 to 2.02 per cent after 12 months of storage.

Under farmlevel storage, among the containers used for storing the pulses, qualitative loss was maximum in the pulses stored in plastic bag (0.26 to 2.14 per cent) followed by gunny bag (0.20 to 1.86 per cent), mud pot (0.19 to 1.74 per cent), and minimum in the pulses stored in aluminium tin (0.16 to 1.55 per cent).

Among the pulses stored under large scale as well as under farm level storage qualitative loss was was maximum between sixth and ninth month of storage.

Among the two levels of storage viz., 'large scale' and 'farm level' storage increase in qualitative loss was higher in the pulses stored in large scale storage than in the pulses stored under farm level storage..

4.3.3. Cooking tests conducted on stored pulses

Various aspects studied to find out the effect of different methods of storage and duration of storage on the cooking qualities of pulses were :

1. Time and water required to complete cooking of pulses.

2. Per cent increase in volume and weight of pulses after cooking

3. Per cent hydration coefficient

Various methods were used to cook the pulses. Methods applied for cooking were cooking with excess water, soaking for 3 hours and cooking with excess water, steaming and soaking for 3 hours and steaming.

Variation in cooking time, water uptake, volume expansion, and hydration coefficient were observed. The pulses were cooked with excess water and the details are presented in Table 33.

Dry as well as pulses soaked for 3 hours and then cooked with excess water. The time taken for cooking different pulses either dry or soaked increased with the advancement of the storage duration from 25.50 to 53.00 minutes for the dried pulses and 24.00 to 52.20 minutes for the soaked pulses.

Under farmlevel storage 3 types of pulses were stored viz., greengram, blackgram and cowpea. The marginal mean obtained for the pulses stored under farm level storage increased from the initial value of 25.50 to 52.00 minutes for the dried pulses and 24.00 to 50.40 minutes for the soaked pulses.

Among the different pulses stored under large scale as well as farm level storage, maximum time was taken to cook by bengalgram, followed by blackgram, redgram, cowpea and lastly greengram. Statistical analysis of the data revealed significant variation in the cooking time among different pulses. Studied conducted by Vimala et al. (1986) had revealed that greengram took least time and blackgram the highest time for cooking.

Irrespective of storage methods, and containers (except in gunny bag) cooking time was maximum for all the pulses between third and sixth month of storage. Statistical analysis of the data revealed significant difference in the cooking time of pulses in different storage periods. In prolonged storage, presence of storage fungi might have caused a deteriorative effect and increased the cooking time. Results on these lines are reported by Dobarey et al. (1988).

Maximum time for cooking was taken for pulses stored in plastic bag, followed by mudpot, gunny bag and lastly aluminium tin. Statistical analysis of the data also revealed significant difference in the cooking time for pulses stored in different containers.

Water uptake is the utilization of water for cooking pulses. Water uptake of pulses increased as the storage period increased. Maximum increase in water uptake was observed in pulses stored in large scale storage when compared to farm level storage.

Among the pulses stored, increase in water uptake was minimum in cowpea followed by greengram, blackgram redgram and lastly bengalgram. Statistical analysis of the data revealed significant difference on the water uptake among different pulses. Similar results on stored pulses were reported by Vimala et al. (1986).

Among the containers used for storing the pulses maximum increase in water uptake was observed in pulses stored in plastic bag followed by gunny bag, mud pot and lastly in aluminium tin. Statistical analysis of the data revealed significant difference among the pulses stored in different containers.

Maximum variation in water uptake was observed between ninth and twelth month of storage in all the pulses. Statistical analysis of the data revealed significant difference on the water uptake of pulses among storage periods.

Volume expansion of pulses decreased as the storage period increased. Among the two levels of storage, decrease in volume expansion was higher in the store pulses under large scale storage. Volume expansion of different pulses under large scale storage decreased from the initial value of

Table 33. Effect of storage methods, containers and types of pulses on the cooking qualities of different pulses at different storage periods

Marginal mean for	Cooking with excess water: Cooking time				Water uptake				Volume expansion				Hydration Coefficient			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
Large scale storage	30	41.2	44.3	53	152.3	161	175.3	203	7.17	6.25	5.0	4.17	6.54	7.0	7.47	8.57
Farmlevel storage	29.8	40.5	43.8	52	169.5	157	170	192	7.67	6.5	5.42	4.33	6.0	6.26	6.87	7.67
Greengram	26	38.2	42.8	50.3	134	141	160	184	6.75	5.9	5.0	4.69	5.43	5.66	6.5	7.36
Blackgram	35	46	50.4	63	165	168	182	209	7.37	6.0	4.94	4.19	6.6	6.73	7.3	8.0
Cowpea	27.1	38.4	46	54	154	158	170	193	8.4	7.24	5.9	4.3	6.1	6.3	6.9	7.7
Gunnybag	31.0	40.5	44	55	150	157	170	192	7.67	6.5	5.4	4.3	6.0	6.26	6.9	7.7
Plasticbag	32.3	44.3	51	65	154	159	175	200	6.8	5.7	4.7	3.9	6.2	6.4	6.9	7.96
Mudpot	28	40	48.5	55	150	156	170	192	7.5	6.5	5.3	4.7	6.1	6.3	6.9	7.6
Alluminium tin	26.4	39	42	50	147	152	166	188	8.0	6.9	5.8	5.1	5.4	6.0	6.8	7.3
Redgram	32	46	52	57	173	179	191	225	8.5	7.5	6.5	5.8	6.9	7.12	7.7	8.9
Bengalgram	62	73	81	89	188	191	203	240	10	8.8	7.5	6.0	7.5	7.7	8.2	9.6
CD for containers	3.5	3.26	4.1	2.7	2.6	3.1	2.8	3.7	1.44	1.0	0.9	1.7	0.9	0.82	0.8	1.85
Pulses	2.63	1.91	2.3	1.6	1.5	1.8	1.6	2.14	0.66	0.8	0.6	0.5	1.1	0.82	0.71	0.53
Containers	2.22	1.3	2.02	1.4	1.3	1.5	1.4	1.84	0.6	0.7	0.5	0.4	0.93	0.73	0.65	0.50
Fresh values for Greengram		25.0				126.5				7.82				5.12		
Blackgram		26.5				149.5				8.21				6.05		
Cowpea		25.0				138				9.30				5.86		
Redgram		27.0				163				9.35				6.57		
Bengalgran		49.5				172				11.95				7.25		

Marginal mean for	Soaking for 3 hours and cooking with excess water: Cooking time				Water uptake				Volume expansion				Hydration Coefficient			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
Large scale storage	28.2	39	43	52	146	161	177	201	8.92	7.67	6.33	4.8	6.3	6.9	7.4	8.5
Farmlevel storage	27.7	37	42	50	145	152	172	189	8.89	8.0	6.83	5.33	5.8	6.1	6.8	7.6
Greengram	21.1	34	40	47	129	138	163	181	8.13	7.5	5.9	4.9	5.2	5.5	6.4	7.3
Blackgram	31.6	42	49	63	159	164	185	207	9.13	7.8	6.62	5.4	6.4	6.54	7.3	7.9
Cowpea	26	37	44	51.5	147	155	173	190	9.0	8.3	6.9	5.4	5.9	6.2	6.8	7.7
Gunnybag	28	37	42	52	145	152	172	189	8.83	8.0	6.8	5.33	5.8	6.1	6.8	7.6
Plasticbag	30	42	50	63	148	155	178	197	8.0	7	5.7	4.33	5.9	6.2	7.8	7.9
Mudpot	27	36	46	54	145	153	174	187	8.5	7.83	6.3	5.5	5.8	6.1	6.8	7.6
Alluminium tin	24	35	40	48	143	149	170	186	9.7	8.5	7.0	6.16	5.7	6.0	6.7	7.44
Redgram	33	45	51	55	168	176	194	224	10.2	8.5	7.0	6.8	6.7	7.02	7.6	8.9
Bengalgram	60	71	81	88	181	190	206	238	12	10.5	8.5	7.5	7.2	7.6	8.1	9.5
CD for containers	3.38	2.26	3.2	2.0	2.6	1.98	2.23	1.33	1.14	1.14	1.2	1.62	0.86	0.76	0.71	
Pulses	1.07	1.94	1.3	1.9	1.2	1.5	1.4	1.28	1.70	0.66	0.66	0.7	1.02	0.80	0.63	0.50
Containers	0.9	1.68	1.13	1.6	1.0	1.3	0.98	1.11	0.66	0.57	0.57	0.6	0.86	0.68	0.53	0.59
Fresh values for Greengram		21.5				121				8.85				4.96		
Blackgram		25.5				145.5				9.78				6.02		
Cowpea		25				134.5				10.10				5.58		
Redgram		26.5				158				11.55				6.39		
Bengalgran		48.5				169				13.15				6.95		

8.44 to 4.17 ml (dry pulses) and 9.58 to 2.01ml (soaked pulses) after 12 months of storage. While, for the pulses stored under farm level storage the initial value of 8.44 decreased to 4.33 ml (dry pulses) and 9.53 to 5.33 ml (soaked pulses) after 12 months of storage.

Among the different pulses stored, maximum decrease in volume expansion was observed in bengalgram followed by cowpea, blackgram, redgram and lastly greengram after 12 months of storage. Statistical analysis of the data revealed significant difference in volume expansion among the dry and soaked pulses. Vimala _et al_. (1986) had also reported that storage duration of greengram, blackgram, redgram and bengalgram is inversely proportional to the increase of weight and volume of cooked pulses.

Among the containers used for storing the pulses, maximum reduction in volume expansion was noticed in pulses stored in plastic bag followed by gunnybag, mudpot and aluminium tin. Statistical analysis of the data revealed significant difference among the container, used for storing the pulses.

Hydration coefficient of pulses increased as the storage period increased. Hydration coefficient was higher in the pulses stored in largescale storage than in the pulses stored in farm level storage. Under large scale storage the initial hydration coefficient value of 5.68 increased to 8.57 (dry pulses) and 5.52 to 8.50 per cent after 12 months of storage. While the hydration coefficient of pulses stored under farm level storage varied from 5.68 to 7.67 per cent (dry pulses) and 5.52 to 7.60 per cent (soaked pulses) after 12 months of storage.

Among the pulses stored increase in hydration coefficient was maximum in bengalgram, followed by redgram, greengram, blackgram and cowpea. Statistical analysis of the data revealed significant difference for hydration coefficient among the stored pulses.

Among the containers used for storing the pulses, increase in hydration coefficient was maximum in the dry and soaked pulses stored in plastic bags followed by gunny bag mud pot and aluminium tin after 12 months of storage. Statistical analysis of the data revealed significant difference among the containers.

Among the storage periods, increase in hydration coefficient was maximum during ninth and twelth month of storage. Statistical analysis of the data revealed significant difference among storage periods.

Table 34 presents the details regarding cooking time water uptake, volume expansion and hydration coefficient of steamed pulses (dry as well as soaked).

Time taken for cooking different pulses increased with the advancement of storage period. Increase in time taken for cooking was maximum in the pulses stored under large scale storage.

Cooking time was highest for bengal gram followed by blackgram, cowpea, redgram and lastly in greengram after 12 months of storage. Statistical analysis of the data revealed significant difference in the cooking time among the dry and soaked pulses. Studies conducted by Bressni et al. (1984) has reported that cooking time is directly influenced by storage period. Vimala et al. (1985) had reported similar findings on stored greengram redgram and blackgram.

Table 34. Effect of storage methods, containers and types of pulses on the cooking qualities of different pulses at different storage periods

Marginal mean for	Steaming: Cooking time				Water uptake				Volume expansion				Hydration Coefficient				Soaking for 3 hours and steaming: Cooking time				Water uptake				Volume expansion				Hydration Coefficient			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
Large scale storage	29.0	42.8	47	55	154	165	176	203	7.3	6.6	5.3	4.2	6.63	7.04	7.5	8.6	30.2	41	44	55	147	161	178	202	9.1	7.5	6.6	4.93	6.3	9.9	7.4	8.60
Farmlevel storage	31.5	42.2	45	54	151	157	171	194	7.6	6.58	5.7	4.7	6.02	6.3	6.9	7.8	30	39	43	52	145	152	173	193	9.2	8.3	7.1	5.7	5.8	6.1	6.9	7.7
Greengram	28	38	43	51	135	142	161	186	7.6	5.2	5.3	4.8	5.4	5.7	6.6	7.4	26	36	40	48	130	139	164	183	8.4	8.0	6.2	5.3	5.2	5.6	6.4	7.3
Blackgram	35	48	53	66	160	169	182	204	8.62	6.3	5.3	4.4	6.6	6.7	7.4	8.04	34	45	50	64	156	164	186	199	9.4	8.3	6.9	6.12	6.4	6.6	7.3	7.9
Cowpea	28.3	39	46	55	153	158	171	194	7.43	7.5	5.8	4.8	6.1	6.3	7.0	7.8	27	37	44	51.6	148	156	175	192	9.4	8.6	7.4	5.5	5.9	6.2	6.8	7.7
Gunnybag	31.5	42.2	45	56	151	157	171	194	7.7	6.6	5.7	4.7	6.02	6.3	6.9	7.8	30	39	43	52	145	152	173	191	9.2	8.3	7.1	5.7	5.8	6.1	6.9	7.7
Plasticbag	33.3	45	52	65	156	160	176	200	7.2	6.0	4.8	4.3	6.23	6.4	7.2	8.0	32	43	51	63	149	156	179	199	8.3	7.5	6.2	4.8	6.1	6.2	7.0	7.95
Mudpot	29	40.5	49	56	151	157	171	192	7.7	6.8	5.7	4.8	5.94	6.3	7.0	7.6	28	40	47	54	147	154	175	187	8.8	8.5	6.6	5.3	5.9	6.2	6.9	7.5
Alluminium tin	27.3	38.5	42	52	149	152	167	190	8.8	7.3	5.7	5.1	5.92	6.1	6.9	7.6	26	36	40	48	144	150	172	187	10	8.8	7.5	6.6	5.8	6.0	6.7	7.5
Redgram	33.5	48	55	58	175	180	191	225	8.8	8.0	6.8	6.0	7.0	7.2	7.8	9.0	33	46	52	56	168	177	194	225	10.5	9.0	7.5	6.0	6.7	7.1	7.6	9.0
Bengalgram	64	74	84	90	190	195	203	241	10.3	9.0	7.8	5.8	7.6	7.8	8.3	9.6	61	70	81	88	181	190	207	239	12.3	10.8	8.5	8.0	7.2	7.6	8.1	9.5
CD for containers	2.4	2.6	2.48	2.26	1.36	1.81	1.2	1.91	1.12	0.91	1.42	1.02	1.5	0.93	0.8	0.76	2.32	3.39	3.05	3.4	1.61	1.3	1.14	1.77	1.04	0.97	1.53	1.26	1.46	0.9	0.76	0.63
Pulses	1.4	1.5	1.43	1.3	0.78	1.04	0.69	1.10	0.72	0.67	0.9	0.70	1.02	0.8	0.73	0.53	1.33	1.95	1.76	1.97	0.93	0.75	0.66	1.02	0.6	0.56	0.9	0.73	0.96	0.76	0.70	0.5
Containers	1.2	1.3	1.24	1.13	0.68	0.91	0.60	0.96	0.66	0.51	0.8	0.55	0.86	0.7	0.60	0.46	1.16	1.69	1.52	1.7	1.81	0.65	0.57	0.89	0.5	0.49	0.77	0.63	0.81	0.58	0.54	0.43
Fesh values for Greengram	26.5				128				8.65				5.05				25.5				120				8.95				4.52			
Blackgram	29.0				151.5				9.05				6.00				28.0				147				9.80				5.89			
Cowpea	26.0				139.5				9.07				5.72				25.5				134				9.75				5.39			
Redgram	29.5				165				9.25				6.39				28.0				159.5				9.98				6.15			
Bengalgram	51.0				173				11.85				7.15				50.0				167.5				12.15				6.75			

Among the containers used, cooking time was maximum for the pulses stored in plastic bag followed by mudpot, gunny bag and aluminium tin. Statistical analysis of the data revealed significant difference among the pulses stored in different containers at one per cent level.

Cooking time was maximum between third and sixth month of storage for pulses like greengram, cowpea and redgram while blackgram and bengalgram gave similar results between first and third month of storage respectively. Cooking time was maximum between third and sixth month for pulses stored in gunny bag, mud pot and aluminium tin and in the pulses stored in plastic bag. Maximum increase in time taken for cooking was noticed during ninth and twelth month of storage. Statistical analysis of the data revealed significant difference in cooking time in different pulses.

Water uptake of pulses increased as the storage period enhanced. Water uptake was maximum in the pulses stored under largescale storage, when compared to farm level storage. The water uptake of dry pulses stored under large scale storage increased from 140.00 to 203.00ml after 12 months of storage. While, the water uptake of pulses stored under farmlevel storage was 140.00 which increased to 193.50ml. The water uptake of soaked pulses stored under large scale storage increased from 134.00 to 202.00ml, while for the pulses stored under farm level storage, the increase was from 134.00 to 191.00 ml after 12 months of storage. The increase in water uptake of dry pulses were more than the soaked pulses.

Among the containers used for storing the pulses, water uptake was maximum in pulses stored in plastic bag. In the dry pulses the initial water uptake of 140.00 ml increased to 200 ml. While in soaked pulses the initial water of 134.00ml increased to 199.00ml after 12 months of storage. In gunny bag, mud pot and aluminium tin similar trend in in water uptake was noticed.

Water uptake was observed to be maximum between ninth and twelth month of storage, in the two levels of storage, and different types of pulses. Statistical analysis of the data revealed significant difference among storage periods in this context. Studies conducted by Liu et al.. (1992) had observed similar results in stored cowpea.

Volume expansion of pulses found to be decreased during storage. Decrease in volume expansion was higher in pulses stored under largescale storage.

Among the pulses stored, bengalgram had the lowest volume expansion followed by blackgram, cowpea, greengram and redgram. Decrease in volume expansion of dry bengalgram was from 11.85 to 5.80 ml and in soaked bengal gram it was from 12.15 to 8.00 ml. For blackgram it was 9.05 to 4.43ml (dry blackgram) while in soaked blackgram volume expansion decreased from 9.80 to 6.93 ml. In dry cowpea volume expansion of soaked cowpea was from 9.75 to 5.50 ml. For greengram it was 18.65 to 4.81 ml for dry greengram and 8.95 to 5.25 ml for soaked greengram. In case of redgram, where the initial volume expansion of 9.25 ml was found to decrease to 6.00 ml in dry redgram and from 9.98 to 6.00ml in soaked redgram after 12 months of storage.

Among the different containers used for storing the pulses, volume expansion was lowest in pulses stored in plastic bag, followed by gunny bag, mud pot and aluminium tin. Statistical analysis of the data revealed significant difference among the pulses except on sixth month of storage.

Data on volume expansion was not uniform for different pulses stored in various containers and during storage interval.

Hydration coefficient of pulses increased due to storage. Hydration coefficient was highest for pulses stored in largescale storage. Hydration coefficient was maximum in redgram followed by bengalgram, cowpea and in greengram. Similar trend in increase in Hydration coefficient was observed in dry as well as soaked pulses. Statistical analysis of the data revealed significant difference in hydration coefficient among the stored pulses.

Among the containers hydration coefficient was maximum in the pulses stored in plastic bag followed by gunny bag, mudpot and aluminium tin.

Since pulses continue to occupy an important place in the Indian diets, efforts should be made to improve their availability, consumer acceptance nutritional quality and post harvest operations. Impact of increased agricultural production of pulses may not be felt unless the storage losses are prevented by better methods.

At present pulses are primarily used as supplementary sources of staple foods like cereals. Pulses will continue to occupy an important place in the Indian diets and efforts should be made to improve their availability consumer acceptance and nutritional quality.

Impact of increased agricultural production of pulses may not be felt unless the storage losses are prevented by better methods.

SUMMARY

Preharvest loss of pulse crops as surveyed by farmers were caused by insects, rodents and birds. In every harvest, 10 to 90kg of pulses were harvested by the farmers.

The pulses were sundried for 2 to 6 hours before storage by all the farmers. Many farmers (56 percent) were in the habit of mixing the sundrying pulses with sand prior to storage major changes reported due to drying were quantity loss and taste difference. Only 8 percent of the farm families had separate storage structures for storing pulses at farm. Mud pot was mainly used as a storage container.

Pulses were used as food item and also as seed material. In the seed material fungicide and insecticide (36 percent) were applied before storage.

Whole grains were mainly stored in gunnybags (20 percent) and mud pots (8 percent) while, plastic containers (54 percent) and aluminium tins (18 percent) were used to store split dhal for long duration. For short duration storage, gunny bags were used for storing the processed pulses.

Qualitative and qantitative changes in stored pulses as reported by farmers were weight loss (38 percent), colour change (12 percent), taste changes (70 percent), texture change (12 percent). Discolouration and inferior taste were reported more in the pulses stored in plastic containers (12 percent) and least in mud pot (8 percent).

A survey to elicit information on the different large scale storage methods adopted for storing pulses and storage problems faced, was conducted among the owners of 45 godowns in Thiruvananthapuram District.

Areas available for each godown were ranging from 40 to 420 sq.ft. 71.1 percent of the respondents were in the habit of storing greengram, blackgram, bengalgram, redgram and cowpea.

Air circulation and light facilities increased as the area of the godown enhanced. Tiles (89 percent) bricks (11 percent), and cement (91 percent) were used as construction material for the godowns. (Walls 89 percent and floor 9 percent).

Pulses were procured once in a month from five neighbouring states viz, Tamilnadu, Karnataka, Uttar Pradesh, Maharashtra and Madhya Pradesh.

Pretreatments given before storage were spraying DDVP, sweeping and dusting DDT.

Preference of the respondents for storing pulses were in the order of greengram (89 percent), blackgram (85 percent), red gram (85 percent), bengal gram (58 percent) and cowpea (82 percent).

The infected pulses were sold as cattle feed and as manure (40 percent) or sold at subsidered rates for human consumption.

Laboratory studies were conducted to ascertain losses due to farm level and large scale storage. These tests comprised quantitative and qualitative ones.

Quantitative tests included periodical recording of percent weight loss, constituent fractions, pulses contaminated by fungal and bacterial attacks in different pulses stored for one year.

Per cent weight loss of pulses has been found to be increased due to the advancement of storage. Under largescale storage for one year, weight loss has been maximum in bengalgram, followed by redgram, cowpea, blackgram, and least in greengram. Under farm level storage for one year, percent weight loss was maximum in blackgram followed by cowpea, and greengram. A comparison of the two levels of storage revealed that increase in percent loss was highest in pulses stored under largescale storage. Increase in weight loss was maximum after six months of storage in the two levels of storage.

Among the containers used for storing the pulses, percent weight loss has been maximum in the pulses stored in plastic bag followed by gunny bag, mud pot and aluminium tin.

Damaged fraction (number and weight) of pulses increased as the storage period increased. Under largescale storage, number of damaged grain was maximum in redgram, followed by blackgram, cowpea, greengram and lastly bengal gram. Where as increase in weight of damaged fraction was highest in bengal gram followed by redgram, blackgram, cowpea and lowest in greengram. Under farm level storage the number and weight of damaged fraction was highest in blackgram, followed by cowpea and minimum increase was noted in greengram. Damaged fraction was found to be highest in largescale storage. Increase in damaged fraction, both in large scale as well as farmlevel storage was profound after 6 months of storage. Among the containers used for storing the pulses damaged fraction was highest in the pulses stored in plastic bag followed by gunny bag, mud pot and aluminium tin.

Qualitative examination of the samples for the presence of Micro organisms, revealed that Aspergillus flavus was noticed in all the stored pulses. Fungal contamination in the stored samples were found to increase with the advancement of storage period. Contamination was higher in largescale storage. Fungal contamination was maximum in blackgram and bengal gram followed by greengram, cowpea and redgram. In farmlevel storage fungal colonies were maximum in blackgram followed by cowpea and greengram. Bacterial contamination in stored pulses were also found to increase with the duration of storage. Bacterial colonies were maximum in bengalgram and blackgram followed by redgram, cowpea and greengram.

Fungal colonies and bacterial colonies were maximum in the pulses stored in plastic bag, followed by gunny bag, mud pot and aluminium tin.

In all combinations protein loss was least in greengram and highest in blackgram. Increase in moisture, non-protein-nitrogen and uric acid content was noticed due to prolong storage period. In stored pulses the protein content decreased where as moisture, non-protein-nitrogen and uric acid content increased after 12 months of storage.

Under farmlevel storage, the pulse like greengram, blackgram and cowpea were stored in four types of containers, viz, gunny bag, plastic bag, mud pot and aluminium tin. Decrease in protein content and increase in moisture, non-protein-nitrogen, and uric acid content was highest in pulses stored in plastic bag, followed by gunny bag, mud pot and aluminium tin.

Variation in cooking time water uptake, volume expansion and percent hydration coefficient were observed in soaked and unsoaked pulses. Under large scale storage, in all the pulses during cooking , an increase in cooking time, water uptake and percent hydration coefficient and decrease in volume expansion were noticed. In greengram the increase in cooking time, percent coefficient and water uptake was least, followed by cowpea, redgram, blackgram and highest in bengalgram. Decrease in volume expansion was lowest in greengram followed by redgram, blackgram, cowpea and highest in bengal gram in the dried as well as soaked pulses.

In pulses stored at farm level, maximum increase in cooking time, water uptake and percent hydration coefficients were observed in blackgram, followed by cowpea and greengram. And under farm level storage decrease in volume expansion was maximum in cowpea, followed by blackgram and greengram in the dried as well as in soaked pulses.

Compared to pulses stored at farm level storage pulses in large scale storage, took comparatively more time for cooking, with a higher water uptake and percent hydration coefficient and with a lower volume expansion.

Among the containers used for storing the pulses, increase in cooking time, water uptake, percent hydration coefficient and decrease in volume expansion was maximum in the pulses stored in plastic bag followed by gunny bag, mud pot and aluminium tin.

The results proved that among the two levels of storage, pulses stored under farm level storage gives better results than the pulses stored under large scale storage and amonth the containers, the pulses stored in aluminium tin was proved to be the better than the other storage containers.

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Appendix No. 1

A schedule to elicit information on the pulse crops grown, varietal preference for consumption and storage practices adopted among selected farm families.

1. Name and address of the farmer

2. The family size

   2 adults + 2 children

   2 adults + 3 children

   2 adults + 4 children

   2 adults + 5-6 children

   2 adults + 7 and above

3. Details of pulses cultivated and area under cultivation

   1. Cowpea
   2. Horsegram
   3. Blackgram
   4. Cowpea

4. Duration of cultivation of each crop

   1. 0 - 15 days
   2. 0 - 30 days

3. 0 - 45 days

4. 0 - 60 days

5. 0 - 75 days

6. 0 - 90 days

5. Pretreatments given to the crops after harvesting and before transporting to the storage place

1. Insecticide spraying
2. Fungicide spraying
3. Seed treatment with fungicide before storage
4. Seed treatment with insecticide before storage

6. Yield particulars of each pulse crop (kg/year)

7. Size of the farm hosehold

8. Facilities available for transporting pulse seed

1. Bullock carts
2. Head loads
3. By tractor
4. Using bicycle

9. Quantity of pulses stored

10. **Type of containers used for storage of pulses**

1. Mud pots
2. Gunny bags
3. Airtight aluminium tins
4. Plastic containers
5. Wooden containers

11. **Common pre-treatments given to the grain prior to storage**

1. Fumigation
2. Spraying insecticide
3. Spraying fungicide
4. Mixing the seeds with sand
5. Mixing the seeds with neem leaves
6. Sundrying

12. **Detail of chemicals used for the pretreatments**

1. Aluminium phosphide
2. Nuvan
3. DDVP
4. Malathion
5. Any other

13. Detail of sundrying hours

14. Storage of dhals after treatments

    1. Gunny bags
    2. Mudpots
    3. Plastic containers
    4. Aluminium tins

15. Treatments given during storage

16. Types of pulses stored for longer duration and period of storage

17. Quantitative and qualitative changes in pulses due to long period of storage

18. Changes in the organoleptic qualities after a long period of storage

19. Particulars related to the usage of pulse grains produced in the farm

    1. Used by the family
    2. Given as gifts.
    3. Sold to the neighbours
    4. Seed purpose
    5. Taken to the market

20. Farmers preference for various pulses

1. First preference
2. Second preference
3. Third preference

21. Detail of losses during drying

22. Causes for loss of stored grains

Appendix No.2

A schedule to elicit information on the different large scale storage methods, adopted for pulses and storage problems faced at godowns / warehouses by the agriculturists.

1. Name and address of the Wholesale dealer

2. Location of godowns selected for the study

3. Structure of the godowns

4. Details of godowns

4.1. Size of the godowns

4.2. Number of windows and doors

4.3. Light facilities

4.4. Air circulation facilities

5. Construction materials used for building godown/warehouse

5.1. Walls

5.2. Floor

5.3. Roof with ceiling

5.4. Roof without ceiling

6. Details of pulses stored

6.1. Type of pulses

6.2. Form of storage

6.3. Source of supply

6.4. Frequency of transport

6.5. Days taken for transit

7. Preference for storing different pulses

7.1. First preference

7.2. Second preference

7.3. Third preference

8. Pretreatments given before storage

9. Method of storage

9.1. Type of containers used for storing the pulses

9.2. Duration of storage

10. Protection measures taken during storage

11. Steps taken to remove the infected pulses

INFLUENCE OF STORAGE ON THE QUALITY OF SELECTED PULSES

By

Bhanu Lekha. T

ABSTRACT OF THE THESIS
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ABSTRACT

Blackgram, greengram, horsegram and cowpea were the pulses commonly cultivated in Kerala. Area under cultivation was in the range of 21 cents to 1 acre and 10 to 90 kg of pulses were harvested every time. Pre harvest loss of crops were mainly due to insect attack. Conventional methods of pretreatments such as sundrying and sand mixing were administered. Prior to storage, for seed material, fungicide and insecticide were also used. Quantitative, qualitative and organoleptic changes, such as weight loss, colour change, texture change, inferior taste and discolouration due to storage were reported by the farmers.

Forty five godowns were selected for the large scale storage study. Space facilities of the godown decided the number of pulses stored and duration of storage. Every month pulses were procured from Tamilnadu, Karnataka, Uttar Pradesh, Maharashtra and Madhya Pradesh. Prior to storage, pretreatments such as sparying DDVP, sweeping and dusting DDT were administered. Infected pulses were sold as cattle feed and as manure or sold at subsidredrate for human consumption.

Decrease in protein content, and volume expansion in all the pulses stored under large scale as well as farm

level storage were noticed. While increase in no-protein-nitrogen, uric acid, moisture, cooking time, water uptake, percent hydration coefficient, damaged fraction, percent weight loss fungal contamination and bacterial contamination were observed in all the pulses irrespective of storage containers, storage period and level of storage.