EFFECT OF PROCESSING ON THE MINERAL STATUS OF SELECTED PULSES

by

Seji Kochappan.N

THESIS

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.Department of Home Science, College of Agriculture

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DECLARATION

I hereby declare that this thesis entitled " ***Effect of Processing on the Mineral Status of Selected Pulses*** *" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.*

Vellayani
Date

Seji Kochappan .N

CERTIFICATE

*Certified that this thesis entitled " **Effect of Processing on the Mineral Status of Selected Pulses**" is a record of research work done independently by Miss. **Seji Kochappan. N** 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.*

Vellayani
Date :

Dr. (Mrs.) L. Prema
Chairman, Advisory Committee
Professor and Head
Department of Home Science
College of Agriculture.

Approved by :

Chairman

Dr. (Mrs.) L. Prema

Members

Dr. (Smt.) Mary Ukkuru.P

Dr. M. Achuthan Nair 17/X/95

Dr. N. Saifudeen

External Examiner. 17/10/95

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Seji Kochappan .N

CONTENTS

Page No :

LIST OF TABLES

LIST OF FIGURES

APPENDIX

Introduction

INTRODUCTION

Food legumes or grain legumes commonly known as pulses, occupy an important position in meeting the daily food needs of the people in developing countries. India is the largest producer of food legumes in the world and the percapita consumption of grain legumes in India ranges between 14 and 114 g (Parpia, 1972).

Significance of legumes in Indian diets lies in their ability to improve the nutritional quality of predominantly cereal based diets of large segments of population. In Indian diets, pulses are reported to be the major suppliers of minerals. Recent development in the field of nutrition research has been stressing the significance of trace minerals in the vulnerable stages of life.

Pulses are rich sources of certain antinutritional factors which may hinder the physiological utilisation of minerals. In the present experiment, an attempt is made to ascertain the influence of different processing and cooking treatments on various minerals trace elements amd antinutritional factors present in two pulses popularly consumed in Kerala, viz. blackgram and greengram.

Review of Literature

REVIEW OF LITERATURE

In this chapter, earlier studies on effect of processing on the mineral status of pulses are reviewed under

2.1 Minerals in pulses

2.2 Antinutritional factors in pulses.

2.3 Effect of processing and cooking treatments on minerals in pulses.

2.4 Effect of processing and cooking treatments on antinutritional factors in pulses.

Pulses are essential adjuncts in the Indian dietary. Different pulses are used for specific food preparations because of their peculiar culinary properties and flavour/aroma attributes. Green legumes commonly known as pulses, occupy an important position in meeting the mineral needs of the people in developing countries like India. The main importance of pulses in Indian diets lie in their ability to improve the nutritional quality of predominantly cereal based diets of large segments of the population.

Average essential minerals in pulses per consumption unit are reported to be 12.48 mg per cent of Ca, 21.84 mg per cent of P and 0.78 mg per cent of Fe (Ranganathan 1954). Sood et al. (1982) carried out a study of mineral composition of nine mung varieties. In these varieties calcium and iron were reported to range from 88 to 198 mg and 3.7 to 8.8 mg, by dry weight respectively. Haytowitz and Mathew (1986) had studied the mineral composition of eight pulse grains viz. mung bean, blackgram, cowpea, drybean, chickpea, pigeonpea lentil and soyabean. In these pulses calcium was in the range of 51 mg to 277 mg/100g, Fe 5.23 to 15.70 mg, Mg 115 to 250mg, P 166 to 704 mg, Zn 2.68 to 4.89 mg, Cu 0.659 to 1.658 mg and Mn 1.021 to 2.517 mg.

Kapoor and Gupta (1979) studied the distribution of nutrients in anatomical parts of soyabean. The proportion of seed coat, cotyledon and embryo in the whole seed was in the range from 8.04 to 8.34 per cent, 89.20 to 89.64 per cent and 2.10 to 2.24 per cent respectively. The nutrient composition of anatomical parts of soyabean seed revealed that cotyledons contributes mainly to the nutrients of the whole seed in respect to its mineral content varying from 84 to 88 per cent of the total mineral content of the whole seed. While seed coat and embryo hardly contributed to the food value except that the seedcoat contributes to 34.37 per cent of calcium.

Rao et al., (1988) reported that different varieties of mung bean differed significantly in their seed size, cooking time was found to reduce Ca, Mg, P, Fe and Zn. Singh et al., (1986) reported the calcium and iron content of whole seed of pigeon pea as 276.00 mg and 6.70 mg respectively.

Sharma and Salil (1992) studied the chemical composition and physico chemical properties of faba bean. In this experiment, the ash content of the legume was found to be in the range of 2.90 to 3.43 per cent on dry matter basis. Neerja and Hira (1993) also reported faba beans as a good source of minerals namely clacium, phosphorus and zinc. Ca and P contents of raw faba bean were found to be 180 and 424 mg/100 g dry matter respectively.

Adeyeye et al., (1994) studied the nutritional composition of three different coloured (reddish brown with black patches, light brown and black with yellow brown patches) African yam bean. Whole seeds and their cotyledons were identified and processed into meal. Average ash content of the seed in (Whole grain) meal was 2.60 per cent while the corresponding cotyledons were found to contain less ash (2.25 per cent). Whole seed meal processed from the bean was also reported to be rich in K (625.43 mg/10g) and P (206.35 mg/100g).

Chemical analysis and nutritional assessment of the less known pulses, like Vigna accoritifolia and Vigna vexillata were observed to be rich sources of minerals like Ca (356 and 324) Mg (259.89 and 189.41) Fe (20.32 and 15.14) Zn (7.49 and 4.79) and Mn (3.2 and 3.8 mg) in 100 g of pulse respecively (Sidduraja et al. (1994).

2.2 Antinutritional factors in pulses

Eventhough pulses in general are richer in minerals, these food crops have not become very popular because of the presence of certain antinutritional factors. According to Liener, (1962), few fators are thermo labile while others are heat stable Trypsin inhibitors, phyto haemagglutenins, anti vitamin factors, metal binding factors, goitrogens, lathyrogens and phytic acid are listed as heat labile factors while cynogens, alkaloids saponins and tannin (polyphenols) are accepted as heat stable ones.

Reddy *et al*. (1982), report phytic acid as one of the antinutrients in dry beans which serve as the main phosphorus reservoir since it accounts up to 80 per cent of the total phosphorus in common beans and occur as a complex with mono and divalent cations in discrete regions of the bean.

Reddy and Pierson (1987) found that most of the phytic acid in common beans are located in the cotyledons and not in the seed coat.

Khan *et al*. (1988) has reported that the phytic acid contents of brown bengal gram is more than that of white variety. Beal and Mehta (1985) reported that among different pulses largest proportion of phytate (91.1 per cent) was present in the garfield pea cotyledon.

Liener (1989) has reported the legume contain appreciable levels of tannins which may be broadly defined as polyphenolic substances. The tannin content of legumes ranges from 2000 mg./100g in faba beans to 45 mg/100g for soy beans. As reported by Elias et al., (1979) heat stable tannins in plant foods are concentrated mainly in the seed coat, where they are positively correlated with the colour of the seed coat.

Phirke and Jadhav (1982) reported that blackgram seeds contain the highest concentrations of polyphenol followed by purple, reddish purple, brown and the white varieties of bengalgram. Shinde et al., (1991) have also reported that polyphenol content was maximum in red coloured varieties and minimum in white coloured varieties of bengalgram.

Chang et al., (1994) analysed tannins of 3 cultivars of cowpea at three maturity stages. Cultivars differed in testa darkening which increased during maturation and darker testa was found to have greater tannin concentration. 96 per cent of the tannins in the cowpea was observed to present in testa. Grinding in 20 mesh was also found to reduce tannin (Chang et al., 1994).

Deshpande et al., (1982) has reported on the negative nutritional effect of the tannins. The major effect is to cause growth depression by decreasing the digestibility of protein and carbohydrates. This is most likely the consequences of the interaction of tannins with either protein or starch to form enzyme resistant substrates. Interaction with the enzymes themselves is also reported to cause an interference with the digestibiltiy of these substrates. Other antinutritional effects that have been attributed to the tannins include damage to the intestinal mucosa (Mitjawila et al., (1977) and the inherent toxicity is found to be caused by tannin metabolites absorbed from intestine (Hagerman and Butler. (1991).

Bressani et al.,(1983) have reported that binding of tannins to lysine of bean proteins may decrease lysine availability . Tannins also have been reported to interfere with the absorption of Fe (Garcia et al.,(1990). Tannins are observed to interfere with the absorption of glucose (Welch et al. , 1989) and vitamin B 12 (Carrena et al.,1989).

Nehad and Moneam (1990) reported tannin content in the hulls of different raw and cooked faba bean cultivars ranged from 1.20-4.40 and 0.39 0.93 g of catechin equivalent/g of hull respectively.

Bressani et al., (1983) studied the partition of polyphenols in beans during cooking. About 60, 67 and 37 per cent of total polyphenols of the raw beans were retained in black, white and red coloured beans respectively upon cooking.

The cooked water was also found to contain less than 20 per cent of the total phenols. Bressani _et al_. hypothesized that part of the polyphenolic compounds remain free and part become bound to other organic compounds and proteins in beans during cooking. The bound of polyphenolics may make the proteins less susceptible to enzymatic hydrolysis in the digestive tract, increasing faecal nitrogen output and thus decreasing protein digestibility. Free polyphenols are also found to influence protein digestibility indirectly by inhibiting the digestive enzymes.

The interaction of phyticacid with minerals is considered to be one of the primary factors limiting the nutritive value of legume proteins. Sathe and Krishnamurthy (1981) and Davis and Nightingale (1975) have shown phytates to be inhibitory to Fe absorption, where as others were found to have no effect. Vaintraul and Bulmaga (1991) have reported that phytate strongly interacted with the basic residues of protein. As a consequence of this, through non selective binding to proteins, phytate was found to inhibit the action of a number of enzymes important in digestion, including pepsin and trypsin (Singh and Krikorian, 1982) and alpha amylase (Deshpande and Cheriyan, 1984 and Thompson and Yoon, 1984).

Pulses are consumed as whole grain as such after cooking or after soaking, germination and fermentation. The crude fibre content of the whole grain of food legumes is higher in pulses than in cereals but the dehulled product dal which is predominantly consumed contains less fibre.

Kochar and Sharma (1991) reported the per cent concentration of total dietary fibre as neutral detergent fibre in whole legumes ranged from 12.50 to 12.83. Chemical composition of neutral detergent fibre showed that grains which are eaten with outer seedcoat or with fibrous constitution have high content of cellulose while those without outer seed coat of seed have low fibrous constitution and a high content of hemicellulose.

Goonerathne et al.,(1994) reported the fibre content of mungbean flour and black gram flour as 12.20 and 14.20 per cent respectively. Jyothi and Reddy (1981) reported the crude fibre of pigeon pea mature seed as 6.60 per cent and dhal 1.20 per cent. Hardalore and Sleh (1984) studied the chemical characteristics of 24 cultivars of Kabuli type of chickpea grown in Sudan. Crude fibre for these cultivars were found in the range of 4 to 4.9/100 gm. Adeyeye et al., (1994) studied the nutritional composition of 3 different coloured African yam bean. Whole seeds and their cotyledons were identified and processed into meal. Average fibre content of the seed (whole grain) meal were 6.00 per cent while the corresponding cotylendon contained 2.07 per cent fibre.

2.3 Effect of processing and cooking treatments on minerals

Pulses are consumed in a variety of ways such as cooked whole, germinated, fermented, dehusked and split, puffed, parched, roasted or ground wet or dry.

Use of food legumes in the form of dal is most common practice in India and over 75 per cent of total legumes produced in the country is converted into the decorticated and split products. The processing influenced the mineral profile of the pulses.

Obizoba (1992) studied the efect of sprouting on the mineral composition of pigeon pea seeds. After 16 hours of sprouting, there were increases in the percentage of ash. He found that sprouting increased all the minerals except phosphorus. He further observed that sprouting for 46 hours offered greater advantage over 96 hours of germination. Phytate, P, Fe, Mg and Cu content were not altered by germination and soaking prior to germination caused about 25 per cent loss in Cu.

Ionisable Fe content is observed to increase due to soaking in water and increased continuously with increasing period of germination. While soluble zn content was lowered by 25 per cent after over night water soaking but later germination resulted in a progressive increase. Removal of tannin could be a factor responsible for the observed increase in available Fe and Zn. Deosthale (1982) have also reported that during soaking and germination several enzyme systems become active and bring about profound changes in the minerals of the pulses.

Phytic acid levels in pulses may be manipulated by soaking the grams. Since such treatments may promote or inhibit development of phytase and consequently hydrolysis of phytic acid to inorganic P. Alternatively phytic acid and other ions may simply diffuse out of the grain and their reduction may subsequently influence the cooking quality of pulses.

There are certain groups of phenolic compounds that bind minerals in such a way that availability of nutrients are strongly inhibited. Reports on NIN (1979) indicate that analysis of whole grain and dhal carried out showed that the whole grain had consierably higher amounts of tannin as compared to dhal. Tannin present in the seed coat was responsible for the lower levels of ionisable iron in the whole grain.

There is a strong relationship betwen cooking quality and the phytic acid content. It is hypothecised that the beneficial effect of phytic acid on the cooking quality of pulses was probably due to phytic acid chelating Ca^{2+} and Mg^{2+} thus preventing their binding to pectin to form Ca^{2+} and Mg^{2+} pectates. If this hypothesis is correct, phytic acid may be largely, not entirely, responsible for variations observed in the cooking quality of pulses (Bhatty et al.,1983 and 1984 and Bhatty and Slinkard 1989).

Lombardi and Lange, (1965) investigated the effect of dehulling and autoclaving on invitro Fe, Zn, and Ca dialysability of two varieties of kidney bean. Dehulling reduced calcium content of kidney bean by 67 and 71 per cent in mottled and white bean respectively. Reduction in Fe and Zn content were also observed to be less. Dehulling was associated with a 36 per cent decrease in Fe dialysibility in both bean variety and with an increase of 59.0 and 76.50 per cent in Ca dialysibility of mottled and white kidney bean respectively ($P > 0.05$).

Baker and Gawish (1991) reported cooking in water containing NaCl (2%) after soaking in hot water for 12 hours showed the highest content of ash. Ikemfuna and Obizoba (1989) studied the effects of germination, dehulling and cooking on the nutritive value of cowpea flour supplemented with rice. The study was conducted in 20 adult rats. Calcium intake was influenced by treatments. Whether whole or dehulled, germination increased calcium intake. The lowest phosphorus intake of rats showed that dehulling alone seriously reduced phosphorus and magnesium intake. But dehulling and germination were found to improve magnesium retention. The study further revealed that cooking improved magnesium retention more than other process of germination.

Stella et al., (1992) have stated that copwea cooked in water became hard by the separate addition of similar concentrations of certain salts. The beans were also cooked in hard tap water and in distilled water before and after soaking in water. Hard water was found to cause a significant decrease in softness, led to reduced water absorption and also decreased solid loss in the cooked products, but it was also found to increase the cooking time and discolouration of the bean. Hard water was also found to increase the mineral content significantly.

Neerja and Charanjeet (1993) have studied the effect of various treatments on nutritional quality of faba beans. Pressure cooked roasted, sprouted, dehusked and raw faba beans were analysed for minerals and antinutritional factors. In this study sprouting and dehusking resulted in significant loss of calcium, while roasting and pressure cooking resulted in a significant loss of P. Reduction in P content was observed to be due to leaching of minerals in cooking water.

Singh *et al.*,(1989) reported that dehulling usually removes the germ along with husk, thus important mineral nutrients such as calcium, iron and zinc are also reported to be lost.

Attia *et al.*,(1994) studied the properties of whole dry seeds of chick peas before and after cooking and before and after decortification. Decortification is found to cause considerable losses in Ca, Zn, Mn, K and ash content. Significant and marked losses were found to be in the range of 6.30 to 50.60.

Studies by Mehta *et al.*,(1993) revealed that the Fe content of rice bean was 3.60 mg/100g as compared to 5.60 mg/100g in mung bean. The values for zinc were about the same in both legumes which were least affected by cooking and sprouting. Sprouting was found to increase the ionizable iron in both the legumes.

2.4 Effect of processing and cooking treatments on antinutritional factors

Definite information on the presence of the toxic and antinutritional principles in nutritionally valuable food legumes is required to help identify food processing methods that can minimise or completely eliminate the toxic effect before food legume are consumed. In this respect many of the household practices of processing food legumes are of considerable importance.

Seed coat of pulses are composed mainly of complex non digestible polysacchardes like cellulose and also contains some pigments and tannins. Except roughage, the seed coat has no nutritional significance.

Bressani *et al.*, (1983) and (1983), Deshpande and Salunkhe (1982) and Reddy *et al.*, (1985) had reported that the tannins are located mainly in the seed coat of the pulses and the physical removal of the constitutents can be attained by dehulling or milling. They studied the effect of pressure cooking, roasting, sprouting and dehusking the raw faba beans on antinutritional factors and found that the dehusked beans had the lowest tannin content (0.63 per cent).

Deshpande and Cheriyan (1984) reported reduction in tannin content of several pulses by soaking in different solutions. Bressani *et al.*, (1983) had also reported that soaking beans in sodium bicarbonate or mixed salt solutions removed tannins from common beans more effectively than does soaking in water. During soaking tannin is expected to diffuse in to the cotyledon endosperm and bind with the proteins during soaking.

Subhalakshmi *et al.*, (1976) and Rao and Deosthale (1982) have shown that by soaking in water for 24 hours about 24 per cent of tannin is lost from greengram. By germinating for 24-28 hours, 20-25 per cent of tannin is lost from greengram as reported by Rao and Deosthale (1982).

Rao and Prabhavati (1982) attributed the loss of tannins in beans during germination to the presence of polyphenol oxidase and to enzymatic hydrolysis. Some loss of tannins during germination may also be expected by this leaching into the water.

Nehad and Moneam (1990) reported presoaking prior to cooking removed most of the tannin from the coloured hulls. The percentage decrease in tannin of all tested samples ranged from 64.76 to 78.88 with an average of 74.17 per cent and it was statistically significant.

Different soaking treatments were reproted to result in 13-30 per cent loss of tannin (Sangle et al. (1993). As per the findings of this experiment 14 per cent of tannins were reduced by dehulling Dehulling process significantly reduced tannin content to mean value of 0.223 from 0.258 in the whole seeds. Among different treatments roasting had maximally reduced the tannin content (50.72 per cent loss). Soaking in brine solution also had better effect in lowering the tannin content 27.42 per cent.

Chang et al., (1994) reported that heating in water reduced tannin in whole cowpea (38-76 per cent), cotyledon (53-50 per cent) and testa (66 - 75 per cent). Most tannins occured in the testa, and hence dehulling was found to eliminate up to 96 per cent of the tannins. Heating of the seeds in water for 30 minutes was found to remove 38-76 per cent of tannins depending on the cultivar and maturity.

Attia et al., (1994) studied the effect of cooking and decortication on antinutritional factors. Decortication was observed to cause considerable losses in dietary fibre components and polyphenols.

El Fahi et al., (1983) reported that carbohydrate fraction of chickpea, cowpea and horsegram cause flatulence while the husk and the derived carbohydrate fraction were inhibitory to gas formation. These carbohydrate fractions are mainly pentosans. Ogun et al., (1989) reported that dehulling of cowpea decreased stachyose and removed tannin. Hot soaking was also reported to cause a significant reduction in stachyose and trypsin inhibitor activity. Akincyle and Akinlosote (1991) had reported that in cowpea seeds after fermentation for 24 hours and soaking (4 hours) or dehulling treatments were effective in decreasing the flatulence properties. Phirke et al. (1982) had also reported that dehulling of greengram decreased the polyphenol content by 60 to 70 per cent.

Neerja and Hira (1994) reported pressure cooking resulted in a maximum loss of phenolic compounds (66%) followed by sprouting (38%) dehulling (29%) and roasting (27%). All these treatments resulted in a significant loss of tannins. Salunkhe (1982) reported that soaking followed by germination considerably reduce the activity of trypsin inhibitors in pigeon pea. Dehulling alone increased the trypsin inhibitor activity, while cooking of whole seed and cotyledons reduced the trypsin inhibitor activity by 87-90 per cent. Ros and Collins (1992) reported that heating decreased the original trypsin inhibitor activity by 81.70 per cent after 5 minutes and 85.90 per cent after 10 minutes.

Vidal et al., (1990) studied the effect of different processing on neutral detergent fibre and detergent fibre cellulose and lignin content of legumes. Chick peas, kidney beans and lentil were soaked and cooked stimulating home processing. Decrease in values of fibre was more pronounced in pressure cooked chick peas and kidney beans when cooking liquid was removed. In lentils with cooking liquid embedded, no difference between processes was observed. When legume meal was used as food supplement, amounts of dietary fibre components on a dry weight basis, increased for chickpeas and beans while the semicellulose of beans and lentils decreased.

Goonerathne et al.,(1994) reported that cooking and processing of legume seeds resulted in significant degradation of fibre.

Sathe and Salunkhe (1984) reported among the processing methods, germination and fermentation appeared to be quite effective in decreasing phytate concentration where as soaking and cooking were found to remove 50-80 per cent or more of the endogenous phytate in beanseeds. Salunkhe et al.,(1982) reported that phytic acid forms insoluble compound with essential minerals such as Ca, Fe, Mg and Zn. Germination can reduce or eliminate appreciable amout of phytic acid in Pigeon pea, thus improving the bioavailability of minerals.

Beal and Mehta (1985) studied the effect of zinc and phytate distribution in peas. Influence of heat treatment and germination, pH substrate and phosphorus on pea phytate and phytase were studied. Cooking peas by two different methods resulted in 13 per cent phytate reduction. Peas incubated for 6 to 5 hour from 25-80°C yielded maximum phytate loss. Germination was found to decrease phytase activity. Ologhoba and Fetuga (1984) studied the distribution of phosphorus and phytate in Nigerean varieties of legumes like cowpea, lima beans and soyabeans and some effect of processing, germination and soaking were most effective in decreasing phytate contents while cooking and autoclaving only slightly altered total phosphorus and phytate contents in all the varieties. Germination increased organic P contents, but affected the highest percentage loss in residual organic P. Soyabean contained considerable amounts of phytate anion. Despite reduction through processing, phytate contents still exceeded the amount present in all varieties of raw lima beans.

Chang (1967), Singh and Sidih, (1979) have reported the presence of enzyme phytase in legumes. During germination of legumes the phytase activity is reported to increase with concomitant decrease of phytate (Eskin and Wiebe, 1983, Beal and Mehta, 1985).

Ziena et al., (1992) studied the effect of cooking temperature and cooking time on phytic acid and reported that retention of phytic acid in cooked beans was significantly lower than that in cooked bean liquor mixtures. Loss of phytic acid due to leaching was much higher for easy to cook beans than for hard to cook ones.

Khan et al., (1985) studied the effect of processing on the phytic acid content of brown and white varieties of bengal gram. Soaking, boiling, roasting and frying invariably resulted in the loss of phytic acid. Loss of phytic acid in the presoaked grains increased with resting time. The loss during the soaking and resting period of presoaked grains might be attributed to the enzymatic activity. Immature brown grains contained much less phytic acid than dried mature brown grams, but the loss of phytic acid on boiling and roasting was greater in the former than in the latter. Soaking of white grains in sodium bicarbonate solution reduced the loss of phytic acid on soaking and heat treatments.

Attia *et al.*,(1994) reported that significant changes in phytic acid and trypsin inhibitory activity were observed due to cooking and decortication. Significant and marked losses in antinutritional factor content were found to occur upon cooking the seeds. Percentage losses in phytic acid, and trypsin inhibitory activities were in the range 24 to 34.5, 58.7 to 62.2 and 53.6 to 59.9 per cent respectively.

Sangle *et al.*, (1993) reported that autoclaving and roasting resulted in 90.27 and 70.42 per cent loss in the trypsin inhibitor activity of soyabean respectively. Igbedioh *et al.* (1994) reported that soaking, soaking and dehulling and boiling, roasting, autoclaving and germination reduced phytic acid in the legumes to various extent. Boiling had the greatest effect on phytic acid levels in pigeon pea with a reduction of 53 per cent.

Sattar *et al.*,(1990) studied the effect of irradiation (.25 - 1 cm) and soaking (3 - 12 L) in tap and distilled water at ambient conditions (25-30°C) and 50°C on phytate contents. Phytate content significantly decreased with increased soaking time and irradiation dose. Rate of phytate removal was generally greater during soaking at 50°C than at ambient temperature. Phytate loss was greater on soaking in distilled water than on soaking in tap water. Irradiation doses decreased original phytate content from 210.0 mg/100g to 182.5 - 102.5 mg/100g. Soaking in tap water or distilled water for 12 hours reduced phytate to 78.9 to 109.5 mg/100g and 73.7 to 87.5 mg/100g respectively. Combination treatments resulted in greater destruction of phytate. Maximum destruction of phytate content (from 212 to 37.5 mg/100g) occured on soaking in distilled water at 50°C with irradiation at 1 kgy.

Yousefs et al., (1989) studied the effect of micro wave heating and gamma irradiation on phytate and phospholipid contents of soyabean. Inorganic phosphorus was significantly increased while, phytate and phospholipids were significantly decreased when soybean seeds was microwave heated for 9 minutes or more. Further more gamma irradiation treatment of 20 KGy or more significantly increased inorganic phosphorus and decreased phytate and phospholipids in the beans. The study showed that the increase of inorganic phosphorus was mainly due to the decomposition of phytic acid and phosphates of inositol.

Materials and Methods

MATERIALS AND METHODS

The study "Effect of processing on the mineral status of selected pulses" is an assessment of the influence of different processing techniques on the mineral status of selected pulses. Role of antinutritional factors present in the pulses on the immobilisation of minerals was also ascertained.

3.1 Pulses procured

Pulses selected for the present study were greengram (Pusa 91-92) and blackgram (Co_4), procured from the Rice Research Station, Kayamkulam.

3.2 Processing Methods Administered

Fresh pulses collected were cleaned. Foreign matters and damaged seeds were removed manually. Each pulse sample was washed initially to remove surface contamination and dried at 60°-70° C.

Different processing methods listed below were administered on the two pulse varieties.

3.2.1 Drying - (P_2)

3.2.2 Germinating - (P_3)

3.2.3 Pretreatment for loosening - (P_4)

3.2.4 Splitting and dehusking - (P_5)

Five portions of the pulses samples (500 g each) were taken for the processing undertaken. These samples were kept in a well ventilated and moisture free place.

3.2.1 **Drying**: The pulses were dried for six hours in the direct sunlight and stored in tins.

3.2.2 **Germinating**: Dried pulses were washed in water and soaked for 12 hours. The soaked pulses were sprouted following the procedure recommended by Rajalakshmi (1974). This was carried out on the day previous to the conduct of laboratory estimation.

3.2.3 Pre-treatment for loosening:

Pretreatment for loosening consists soaking of the pulses in water for different durations. In this experiment dried pulses were soaked in water for 7 hours and sundried for 16 to 17 hours in direct sun. The process of dehusking involves ~~the~~ loosening the husk which is achieved by prolonged sundrying after water application. The dried pulses were winnowed for 3 to 4 minutes. During this process the seed coat was separated and removed by winnowing.

3.2.4 Splitting and Dehusking

Dehusking involves removal of the fibrous seed coat that tightly envelopes the kernel and splitting the cotyledons. Dehulling improve cooking quality, digestibility and appearance.

Milling unit that is manually operated (Chakki - comprising two small grinding stones) was used for splitting. Six hours dried pulses were split in a stone chakki for 3 to 4 minutes and dehusked in a stone grinder for 1 minute. Dehusked pulses were winnowed for the removal of husk.

3.3 Cooking methods administered

Cooking methods administered were

3.3.1 Cooking by boiling method

3.3.2 Soaking for 3 hours and cooking by boiling method

3.3.3 Steaming

3.3.4 Soaking for 3 hours and steaming

3.3.5 Steam cooking under pressure

3.3.6 Roasting

3.3.7 Frying

3.3.8 Cooking in micro oven

On the basis of the different processing and cooking treatments administered, there were 40 groups in each pulse sample as detailed below:

P_1 C_1	P_2 C_1	P_3 C_1	P_4 C_1	P_5 C_1
P_1 C_2	P_2 C_2	P_3 C_2	P_4 C_2	P_5 C_2
P_1 C_3	P_2 C_3	P_3 C_3	P_4 C_3	P_5 C_3
P_1 C_4	P_2 C_4	P_3 C_4	P_4 C_4	P_5 C_4
P_1 C_5	P_2 C_5	P_3 C_5	P_4 C_5	P_5 C_5
P_1 C_6	P_2 C_6	P_3 C_6	P_4 C_6	P_5 C_6
P_1 C_7	P_2 C_7	P_3 C_7	P_4 C_7	P_5 C_7
P_1 C_8	P_2 C_8	P_3 C_8	P_4 C_8	P_5 C_8

Design - Completely randomised block design

- P_1 - Fresh samples
- P_2 - Drying
- P_3 - Germinating
- P_4 - Loosening
- P_5 - Splitting and dehusking
- C_1 - Boiling
- C_2 - Boiling after 3 hrs. soaking
- C_3 - Steaming
- C_4 - Steaming after 3 hours soaking
- C_5 - Cooking under pressure
- C_6 - Roasting
- C_7 - Frying
- C_8 - Cooking in a micro oven

For the above cooking treatments, aliquots of 2.5 g. each of the sample (from the 4 processed samples and 1 fresh sample) were weighed out into 40 small beakers. Similar batches were presented for analysis of minerals, trace elements and anti nutritional constituents. All the samples from various treatments were dried at 60 to 70°C and then powdered before analysis.

For germinating pulses, 2.5 g. were soaked in 15 ml. of distilled water. Excess water was discarded and grains were washed twice with distilled water. The samples (8 samples) were allowed to germinate in sterile petridishes containing moist filter paper for a period of 24 hours.

3.4 Analysis of minerals and Anti nutritional factors

Minerals and anti nutritional factors were estimated in the processed and cooked pulse samples (80 samples) as detailed below:

3.4.1 Estimation of minerals

Minerals such as calcium, magnesium, iron, copper, zinc and manganese were estimated by wet digestion of sample using tri acid mixture under AAS - PE 3030 (Jackson (1973).

Phosphorus was estimated by wet digestion with tri acid mixture and measuring the yellow colour of Vanedo molybdate reagent at 410 mm in spectronic 2000 (Jackson (1973).

3.4.2 Estimation of Anti nutritional factors

Anti nutritional factors such as fibre, phytic acid and tannin were estimated.

Fibre content of the samples were estimated by the method recommended by Jackson (1973).

Phytic acid content of the cooked pulse samples were estimated by the method recommended by Wheeler and Ferrel (1971) Phytin is extracted with Trichloroacetic acid and precipitated as ferric salt. The iron content of precipitate is determined colorimetrically.

Tannin: Tannins were estimated by Folin Dennis method, based on the non stoichio metric oxidation of the molecules containing a phenolic hydroxyl group. The tannin content of the sample was measured as tannic acid equivalents from the standard graph.

3.5 Statistical analysis of data

Statistical analysis of different processing techniques and cooking treatments on mineral status and anti nutritional factors of pulses were tested using analysis of variance for completely randomised block design.

Results and Discussion

Results and Discussion

RESULTS AND DISCUSSION

The study entitled "Effect of processing on the mineral status of selected pulses", presents a comprehensive information on the influence of various processing and cooking treatments on the mineral status of two pulses viz., blackgram (CO_4) and greengram (Pusa 91-92). The study also presents information on the effect of different processing and cooking treatments on antinutritional factors like fibre, phytic acid and tannin present in these two pulses. The role of antinutritional factors on the immobilisation of minerals in these foods were also ascertained.

The results of the study are presented here under.

4.1 Concentration of minerals in fresh blackgram and greengram.

4.2 Influence of different processing techniques on the mineral status of fresh pulses.

4.3 Influence of cooking treatments on the mineral status of fresh and processed pulses.

4.4 Concentration of antinutritional factors like fibre, phytic acid and tannin in fresh blackgram and greengram.

4.5 Influence of processing and cooking treatments on the antinutritional factors viz., fibre, phytic acid and tannin.

4.6 Association between minerals and antinutritional factors in pulses.

4.1 Concentration of minerals in fresh blackgram and greengram (Table 1)

Pulses are moderate sources of minerals. Total mineral content of pulses, in general, ranges from 3 to 4.5 g/100g (ICMR 1987). Major minerals present in the pulses are P, Ca, Fe, Mg, Mn, Zn and Cu.

A comparison with the standard data on minerals available from NIN (1991) revealed that minerals such as P, Ca, Mg and Zn were found in higher concentrations in the two pulses studied. Similar trend was observed in the case of Mn and Fe in blackgram while Cu was found to be lower in blackgram. Minerals like Fe and Mn were lower in greengram when compared to the available standard data, while Cu was higher in greengram analysed. Blackgram was found to be richer in P, Ca, Mn and Zn, while Cu was in higher concentration in greengram. Rao and Deosthale (1982) had reported that pulses contain relatively high amounts of inorganic nutrients such as Ca, P, Fe and Cu.

Variation in the mineral concentration may be due to the varietal differences and fertiliser applications. Narasimha and Desikachar (1978) reported a large variation in the Ca (118

Table 1 Mineral profile in fresh blackgram and greengram

Pulses	Constituents (mg/100g)				Constituents (ug/g)		
	P	Ca	Fe	Mg	Mn	Zn	Ca
Blackgram	445 ± 20.50 (-4.60)	310 ± 38.00 (12.20)	3.95 ± 0.29 (7.30)	215 ± 9.90 (4.60)	2.90 ± 0.20 (68.00)	50 ± 1.45 (29.00)	1.20 ± 0.13 (10.00)
ICMR*	385 ± 0.00	164 ± 0.00	3.80 ± 0.00	130 ± 0.00	0.96 ± 0.00	30 ± 0.00	0.93 ± 0.00
Greengram	420 ± 31.50 (7.50)	230 ± 11.60 (5.00)	3.95 ± 0.11 (2.78)	205 ± 7.50 (3.60)	1.80 ± 0.09 (5.00)	39.3± 0.14 (3.50)	2.20 ± 0.10 (4.50)
ICMR*	326 ± 0.00	124 ± 0.00	4.50 ± 0.00	127 ± 0.00	2.47 ± 0.00	30 ± 0.00	0.00 ± 0.39

Figures in paranthesis indicate per cent coefficient variation
ICMR

to 198 mg/100g) and Mg (76 to 152 mg/100g) contents of the cotyledons of 10 pigeon pea cultivars and as reported by them, mineral contents of cooked samples were positively correlated with the cooking time of the cotyledons.

As stated by Shobhana et al. (1976), the mineral composition of pigeon pea, chick pea, urd bean and mungbean showed little variation among the pulses. In this study the Ca content of pigeon pea seed was higher than that of chickpea, urd bean and mung bean, but the reverse was true for their Fe content.

As stated by Satna et al. (1979), in pulses the major form for the storage P is found in combination with phytic acid, which is the major fraction of total P constituting 43.10 to 47.50 per cent followed by nucleic acid P (18.10 to 18.50 per cent) phospholipid P (16.50 to 17.6 per cent) and inorganic P (6.4 to 7.3 per cent).

Geervani et al. (1980) had found that Ca content of legume are quite variable ranging from 80 to 100 mg per cent. Whole grains are to be good sources of Ca as the husk provides about 70 per cent of the fresh total grain Ca. They had further stated that Fe content in legumes vary ranging from 5-10 mg.

4.2 Influence of different processing techniques on mineral status of fresh pulses (Tables 2 and 3, Figures 1 and 2 and Appendix I

Loss of minerals and trace elements as a result of the processing techniques, varied for different elements.

A comparison of P content in fresh and other processed blackgram depicts significant variation in P_3, P_4 and P_5 samples. While in the case of greengram, similar trend was observed between P_4 and P_5 and P_5 and P_2.

Among the processed blackgram, variation in P content of P_2 with P_4 and P_5 were found to be significant. The highest P content was observed in fresh pulses. The decrease in P was appreciable in all the processing methods viz. P_2, P_3, P_4 and P_5.

Statistical treatment of the data revealed that among the processed pulse samples, variation in the P content of greengram samples when dried (P_2), germinated (P_3) and outer husk loosened (P_4) were found to be significant.

P content of blackgram when pretreated, split and dehusked are reported to be maximum because of P concentration in cotyledon (Prabhavati and Rao, 1979). Ologhobo and Fetuga (1984) studied the distribution of P in Nigerian varieties of legumes like cowpea, lentil beans and soybeans after processing. As per this study germination was reported to increase inorganic P

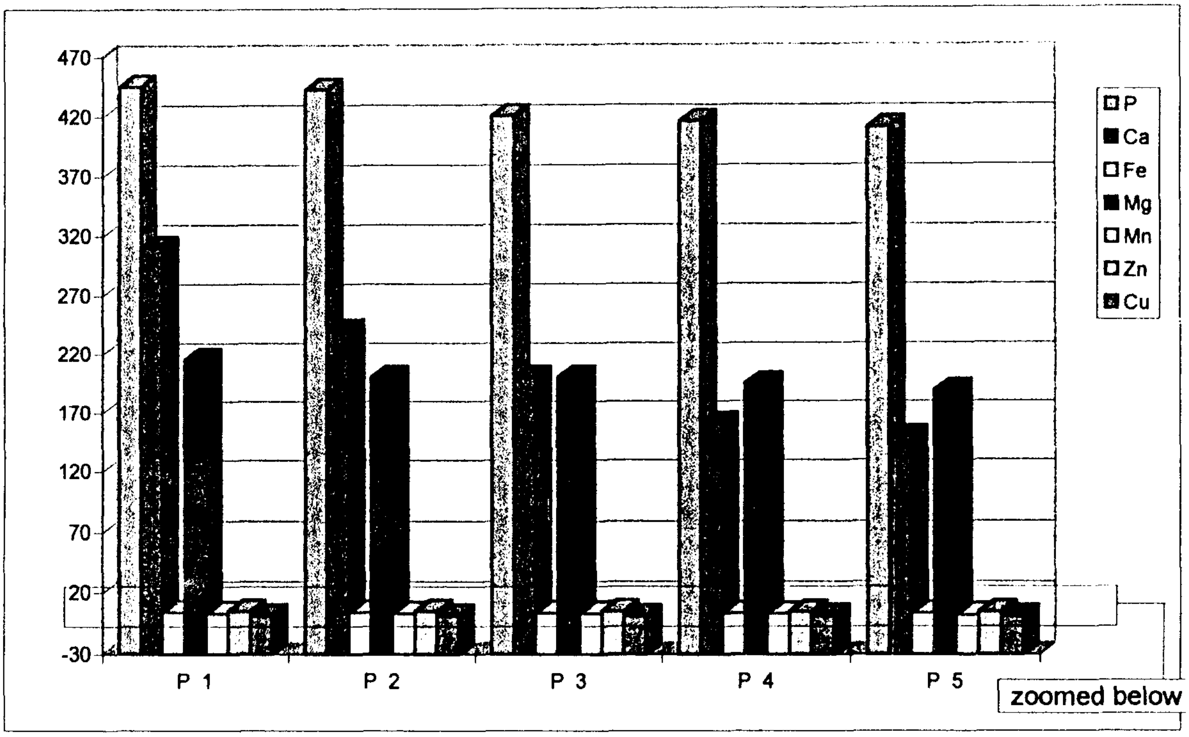
Table 2 Effect of processing techniques on mineral profile of fresh blackgram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	
P1	445.00 ± 205.00 (4.60)	310.00 ± 38.00 (12.20)	3.95 ± 0.29 (7.30)	215.00 ± 9.90 (4.60)	2.90 ± 0.20 (68.00)	5.00 ± 1.45 (29.00)	1
P2	442.00 ± 14.00 (3.00)	240.00 ± 28.00 (11.60)	3.95 ± 1.00 (25.00)	200.00 ± 11.60 (5.00)	2.90 ± 0.60 (20.00)	4.90 ± 0.49 (10.00)	1.
P3	420.00 ± 15.70 (3.70)	200.00 ± 27.20 (13.60)	3.55 ± 0.25 (7.00)	200.00 ± 12.00 (6.00)	2.90 ± 0.90 (31.00)	4.73 ± 1.76 (37.00)	0.
P4	415.00 ± 21.70 (5.20)	160.00 ± 26.40 (16.00)	3.40 ± 0.09 (2.60)	194.50 ± 4.90 (2.50)	2.60 ± 1.70 (6.00)	4.31 ± 0.97 (22.00)	0.
P5	410.00 ± 27.0 (6.50)	149.00 ± 31.00 (20.00)	3.35 ± 0.12 (3.58)	189.00 ± 17.00 (8.00)	1.90 ± 0.16 (8.00)	4.20 ± 0.71 (16.00)	0.
SE	8.06	3.10	0.15	1.21	0.09	0.06	
CD	24.31	8.91	0.1595	3.94	0.2587	0.1595	

P	P1	P2	P3	P4	P5
Ca	P1	P2	P3	P4	P5
Fe	P1	P2	P3	P4	P5
Mg	P1	P2	P3	P4	P5
Zn	P1	P2	P3	P4	P5
Cu	P1	P2	P3	P4	P5

Fig--1

INFLUENCE OF DIFFERENT PROCESSING TECHNIQUES ON MINERAL & TRACE ELEMENT COMPOSITION OF FRESH BLACKGRAM



Y-SCALE (0 TO 5) ZOOMED PICTURE

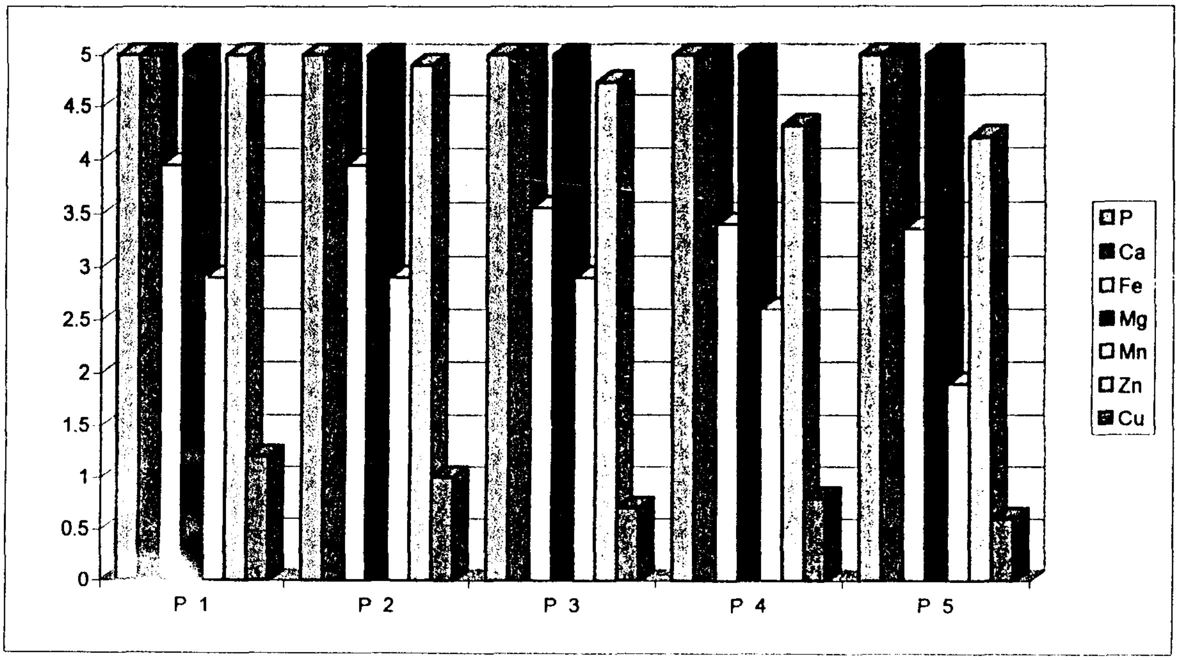


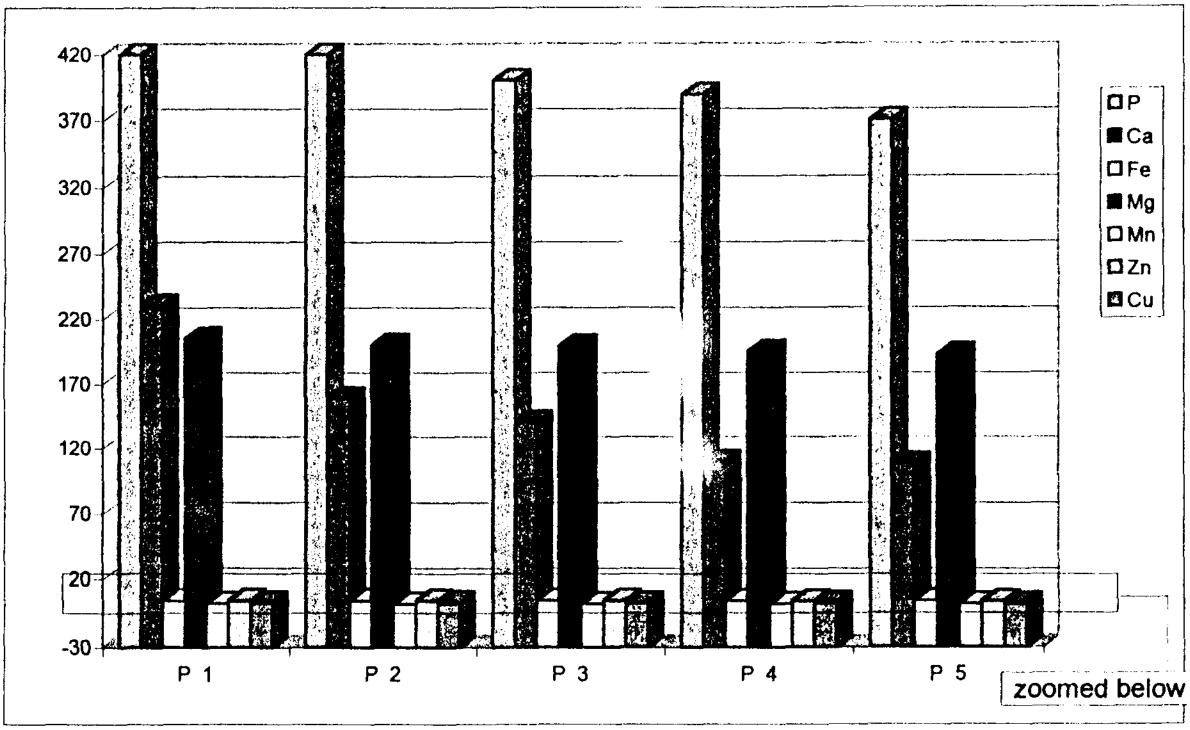
Table 3 Effect of processing techniques on mineral profile of fresh blackgram

Processing techniques	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P1	420.00 ± 31.50 (7.50)	230.00 ± 11.60 (5.01)	3.95 ± 0.11 (2.78)	205.00 ± 7.50 (3.60)	1.08 ± 0.09 (5.00)	0.93 ± 0.14 (3.50)	2.20 ± 0.1 (4.50)
P2	420.00 ± 25.00 (5.90)	159.00 ± 7.90 (4.90)	3.95 ± 0.13 (3.00)	200.00 ± 16.40 (8.20)	1.40 ± 0.06 (4.20)	3.80 ± 0.90 (2.30)	2.00 ± 0.2 (10.20)
P3	400.00 ± 20.00 (5.00)	140.00 ± 4.00 (10.00)	3.75 ± 0.08 (2.13)	199.00 ± 18.40 (9.20)	1.40 ± 0.10 (7.00)	3.60 ± 0.08 (2.20)	1.80 ± 0.3 (0.20)
P4	389.00 ± 8.00 (2.05)	110.00 ± 8.50 (7.00)	3.75 ± 0.09 (2.40)	195.00 ± 0.00 (0.76)	1.30 ± 0.06 (4.60)	3.29 ± 0.08 (0.24)	1.70 ± 0.2 (15.00)
P5	370.00 ± 9.30 (2.50)	108.00 ± 8.00 (7.00)	3.65 ± 0.09 (2.40)	192.50 ± 03.10 (1.60)	1.20 ± 0.25 (20.80)	3.14 ± 0.08 (2.50)	1.30 ± 0.17 (13.00)
SE	8.06	2.96	0.05	1.31	0.09	0.05	0.0
CD	24.31	8.91	0.1595	3.94	0.2587	0.1595	

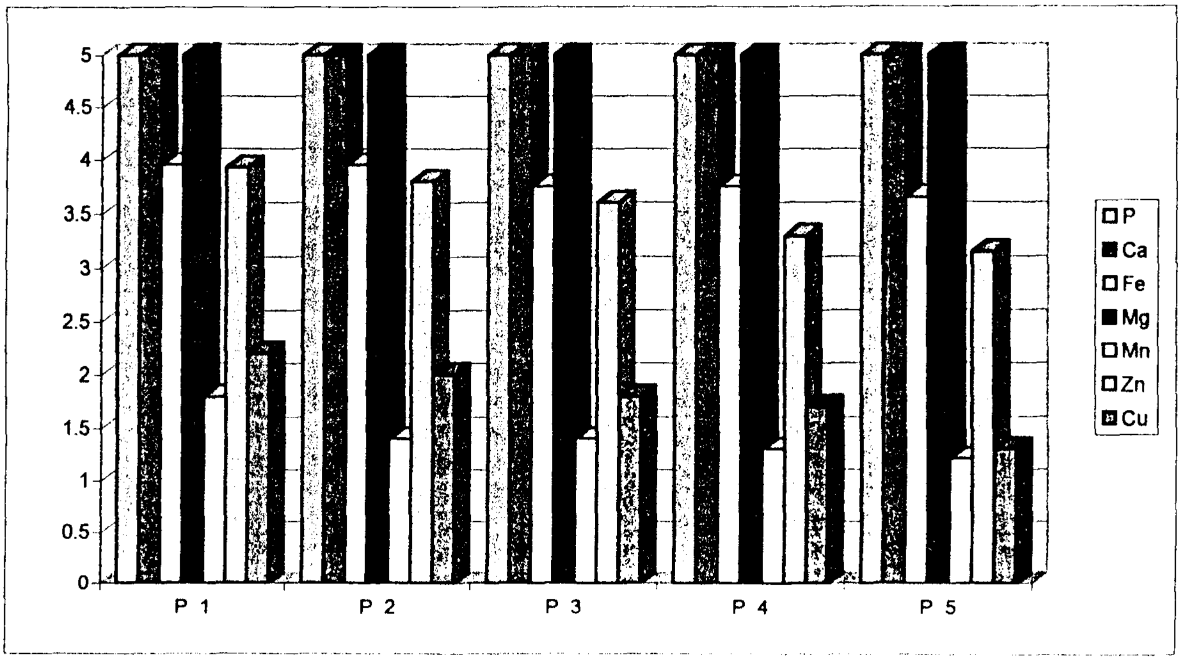
P	P1	P2	P3	P4	P5
Ca	P1	P2	P3	P4	P5
Fe	P1	P2	P3	P4	P5
Mg	P1	P2	P3	P4	P5
Zn	P1	P2	P3	P4	P5
Cu	P1	P2	P3	P4	P5

Fig--3

INFLUENCE OF DIFFERENT PROCESSING TECHNIQUES ON MINERAL & TRACE ELEMENT COMPOSITION OF FRESH GREENGRAM



Y-SCALE (0 TO 5) ZOOMED PICTURE



contents and affect the highest percentage loss in residual organic P.

Rao and Deosthale (1983) studied the effect of germination on mineral composition of pulses and stated that dehusking did not result in significant nutrient losses. Germination did not affect the mineral composition of the pulses.

A comparison of Ca content in fresh and other processed blackgram samples depicted a significant variation among all the processed samples and fresh samples.

The highest Ca content was observed in the fresh blackgram samples followed by P_2, P_3, P_4 and P_5. Higher Ca concentration in dried blackgram may be due to the variation in moisture. However, this variation was significant. Statistical treatment of the data revealed that among the processed pulse sample, variation in the Ca content of greengram samples of P_2, P_3 and P_4 were found to be significant. Among the processed greengram samples variation in the Ca content of P_2 with P_3, P_3 with P_4 and P_3 with P_5 were significant. However, variation of P_4 with P_5 was not significant. Probably in germinated pulses the trigerring action of several enzyme system has favoured the availability of Ca during the active process of germination. The lowest Ca content was observed in P_5 greengram samples. Removal of Ca from the outer layers of the grain during the above processing may be responsible for their loss.

Among the processed pulse samples variation in Ca content of blackgram in P_4 and P_5, is found to be statistically significant. During germination, the enzyme system of the grain becomes more active and this results in increased nutrient concentration. Variation in Ca in germinated (P_3), loosened (P_4), and dehusked (P_5) blackgram was found to be statistically significant. The Ca decrease in P_2 (dried) and P_3 (germinated) were marginal, while Ca decrease in P_4 and P_5 were appreciable. When compared to the other processing methods germination has been reported to increase Ca content in the study. Sprouting caused increase in all the mineral levels except for P (Obizoba, 1992).

A comparison of Fe content in fresh and other processed blackgram depicts significant variation except dried blackgram since no variation is found among fresh and dried blackgram samples. Among the processed blackgram samples significant variation in Fe content was found among P_3, P_4 and P_5 when compared with P_2 (dried) blackgram sample. A comparison of Fe content in fresh and other processed greengram depicted a significant variation among the treatments except between P1 and P_2.

Among the processed greengram samples variation in the Fe content of P_2 with P_3, P_4 and P_5 and variation of P_3 with P_4

and P_5 were also statistically significant. Similar results were observed in the case of P_4 and P_5. As remarked by Singh et al. (1989) dehulling usually remove the germ along with husk, thus important mineral nutrient such as Ca and Fe are lost by dehulling. While availability of Fe is reported to be 2 to 4 times more in dal as compared to whole grain in a study of Prabhavati and Narasimha Rao, (1979).

As revealed in the table, significant variation among processed blackgram was noted for Mg content. Comparison of Mg content of fresh sample with other processed blackgram samples were significant. Among the blackgram samples highest Mg content was observed in the fresh blackgram. Among the processed blackgram samples variations in Mg content of P_2 with P_4 and P_5, were found to be significant. The variations among P_3, P_4 and P_5 and P_4 and P_5 were also significant. A comparison of Mg content of fresh greengram and processed greengram samples depicted a significant variation except among the treatments between P_2 and P_3 and P_3 and P_5. Germination is reported to increase Mg retention (Ikemfuna, 1989) while sprouting is reported to increase all mineral levels except P (Obizoba, 1992).

Mn content of processed blackgram showed a significant variation. A comparison of the fresh samples with processed blackgram depicted a significant variation. Similar increase in

Mn content in this processed pulse may be mainly because of the variation in moisture.

Among the processed blackgram samples, variations in Mn content of P_2 with P_4 and P_5 were found to be significant. Observation among P_3 with P_4 and P_5 also revealed statistically significant variation. However, no significant variation was observed between P_2 and P_3.

Comparison of Mn content in the fresh greengram with other processed samples showed significant variations while no significant variation in Mn content among processed greengram samples are noted. Statistical treatment of the data revealed significant variation among fresh and processed blackgram samples except P_2 (dried).

Among processed blackgram samples significant variation was noted among P_2 with P_3, P_4 and P_5. Variations among P_3 with P_4 and P_5 were also found to be significant. However, no significant variation was observed between P_4 and P_5.

In greengram, Zn concentration in both fresh and processed samples showed a significant variation except with P_2 (dried). Among the processed samples significant variation was observed between P_4 and P_5.

As revealed in the Table 2, comparison of Cu content in fresh and other processed blackgram depicted no significant

Prabhavati and Rao, (1979) have reported that P loss of blackgram when pretreated, splitted and dehusked were minimum because of P concentration in cotyledon. Rao and Deosthale (1983) have reported that germinated seeds of all the pulses were relatively poor in the mineral content as compared to ungerminated dry seeds.

In blackgram as well as in greengram, significant loss of Ca and Mg was observed in dried pulses when compared with fresh samples, while for P, Fe, Mn, Zn and Cu no significant loss was observed in dried samples. Variation in mineral levels during drying may be due to the variation in moisture level. Significant loss of Ca, Fe, Mg, Mn and Zn was observed in splitted and dehusked blackgram and of P, Ca, Mg, Zn and Cu in greengram when compared with germinated samples. Singh et al. (1989) reported that dehulling usually removes the germ along with husk, thus important mineral nutrients such as Ca, Fe and Zn are lost.

Germinated samples showed significant retention of Ca, Mg, Mn and Zn when compared with sample which were pretreated to remove the outer husk. Similar observations were made in greengram related to minerals like Ca, Mg and Zn. Deosthale (1982) reported that during soaking and germination, several enzyme systems become active and bring about profound changes in variation between P_1 and P_2, P_2 and P_4, P_3 and P_4 and P_4 and P_5, while significant variation was observed between P_2 and P_3. Comparison of Cu content in fresh greengram with other processed greengram samples depicted significant variation except between P_1 and P_2. Variation in Cu content of P_2 sample with P_4 and P_5, P_3 with P_5 and P_4 with P_5 were statistically significant, while no significant variation was observed between P_3 and P_4.

Neerja and Hira. (1993) studied the effect of various treatments on nutritional quality of faba beans and found statistically significant decrease in Cu content upon different treatments. As stated by these authors, this might be due to leaching effect during cooking.

Rao and Deosthale (1983) had reported significant decrease in Cu contents during germination in blackgram and greengram. Considerable loss in Cu content was reported during the overnight soaking of blackgram (44 per cent) and greengram (27 per cent). Similar observation has been made in the present study.

Processing techniques as a whole were found to reduce all the minerals of fresh pulses. (Figures 1 and 2). Among different processing techniques applied on blackgram and greengram, minimum mineral loss was observed for drying followed by 'germination', 'loosening outer husk' and 'splitting and dehusking'.

the nutritive value of the pulses. The seed coat is reported to contribute more than 70 per cent of Ca in grain (Satna et al. (1979), Singh et al. (1984) and Attia et al. (1994) have reported that decortication caused considerable losses in Ca, Zn and Mn.

Significant loss of Ca, Fe, Zn and Cu was observed in germinated samples on comparison with dried sample in blackgram, while in greengram significant loss in germinated sample was observed for Ca and Zn on comparison with dried samples. Neerja and Hira (1993) reported that sprouting and dehusking resulted in significant loss of Ca. Rao and Deosthale (1983) reported that germination resulted in mineral loss. Nutrient losses occurred during overnight soaking in water and per cent losses in Cu content in blackgram was 44, greengram 27 and Fe about 22 in both. During soaking the seed coat gets disrupted and the cotyledons of the grains are exposed. Loss in total P content occurred during overnight soaking.

In greengram significant variation in P, Ca, Fe and Mg was not observed between loosened and splitted dehusked samples, but for Zn and Cu significant variation was observed between P_4 and P_5. While in blackgram significant variation between P_4 and P_5 was observed for Ca, Mg and Cu and for P, Fe, Mn and Zn, no significant variation was observed between P_4 and P_5 samples. The variation between outer husk loosened and splitted and dehusked sample may be due to removal of germ along with the husk during dehusking. Singh et al. (1989) reported that as dehulling usually removes the germ along with the husk, important mineral nutrients such as Ca, Fe and Zn are lost.

4.3.1 Influence of cooking treatments on the mineral status of fresh pulses (Tables 4 and 5 and Appendix II)

All the cooking treatments were found to reduce the P content of fresh blackgram and greengram significantly.

Among cooked samples, both in greengram and blackgram, significant retention of P was observed in unsoaked samples when compared with soaked samples. In both the pulses variation in P content between boiled and steamed samples was not significant, either in soaked or unsoaked.

Comparison of P_1C_5 (pressure cooked) sample with boiled and steamed blackgram samples revealed significant retention of P in P_1C_5 with soaked and cooked samples (P_1C_2 and P_1C_3) while significant loss was observed with unsoaked samples (P_1C_1 and P_1C_3). In greengram, no significant loss was observed in P_1C_5 with P_1C_1 and P_1C_3, while significant retention was noted in P_1C_5 with soaked samples (P_1C_4 and P_1C_4) as in the case of blackgram. Among P_1C_6 (roasted), P_1C_7 (fried) and micro oven cooked (P_1C_8) samples of blackgram and greengram, significant variation in P content was observed.

Table 4 Effect of cooking treatments on mineral profile of fresh blackgram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P1	445.00 ± 20.50 (20.50)	310.00 ± 38.00 (12.20)	3.95 ± 0.29 (7.30)	215.00 ± 9.90 (4.60)	2.90 ± 0.20 (6.80)	50.00 ± 1.45 (2.80)	1.20 ± 0.13 (10.80)
P1C2	120.00 ± 3.80 (3.10)	112.00 ± 3.00 (2.60)	2.70 ± 0.90 (3.30)	152.00 ± 0.89 (5.80)	1.10 ± 0.01 (0.90)	28.00 ± 2.00 (7.10)	0.60 ± 0.06 (3.30)
P1C2	100.00 ± 2.60 (2.60)	96.00 ± 2.80 (2.90)	2.30 ± 0.10 (4.30)	178.00 ± 9.10 (5.10)	0.90 ± 0.08 (2.80)	20.00 ± 1.80 (9.10)	0.30 ± 0.01 (3.30)
P1C3	123.00 ± 3.90 (3.10)	110.00 ± 4.80 (4.30)	2.71 ± 0.05 (1.80)	142.00 ± 7.80 (5.40)	0.80 ± 0.01 (0.25)	32.00 ± 2.10 (6.50)	0.80 ± 0.02 (2.50)
P1C4	101.00 ± 5.80 (5.70)	95.00 ± 3.90 (4.10)	2.33 ± 0.03 (1.20)	153.00 ± 4.50 (2.90)	0.70 ± 0.01 (1.40)	20.00 ± 2.10 (10.40)	0.50 ± 0.02 (4.00)
P1C5	110.00 ± 7.00 (6.30)	97.00 ± 2.00 (2.00)	2.40 ± 0.03 (1.20)	150.00 ± 5.10 (3.40)	0.60 ± 0.06 (10.0)	30.00 ± 1.80 (6.00)	0.50 ± 0.01 (8.00)
P1C6	97.00 ± 2.90 (2.90)	80.00 ± 8.00 (0.10)	2.40 ± 0.09 (3.70)	160.00 ± 5.30 (3.30)	0.70 ± 0.09 (12.80)	29.00 ± 0.90 (3.10)	0.50 ± 0.01 (8.00)
P1C7	89.00 ± 5.00 (5.60)	60.00 ± 2.70 (4.50)	2.50 ± 0.10 (4.00)	155.00 ± 4.80 (3.00)	0.80 ± 0.09 (11.25)	26.00 ± 1.30 (5.00)	0.70 ± 0.00 (0.00)
P1C8	90.00 ± 3.10 (3.40)	63.00 ± 4.50 (7.10)	2.70 ± 0.09 (3.30)	165.00 ± 9.10 (5.50)	0.60 ± 0.08 (13.30)	24.00 ± 1.50 (6.25)	0.80 ± 0.01 (5.00)
CD	8.17	13.95	0.47	36.00	0.00	8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P1	P1C3	P1C1	P1C5	P1C4	P1C2	P1C6	P1C8	P1C7
Ca	P1	P1C1	P1C3	P1C5	P1C2	P1C4	P1C6	P1C8	P1C7
Fe	P1	P1C3	P1C1	P1C8	P1C7	P1C5	P1C6	P1C4	P1C2
Mg	P1	P1C2	P1C8	P1C6	P1C7	P1C4	P1C1	P1C5	P1C3
Mn	P1	P1C1	P1C2	P1C3	P1C7	P1C4	P1C6	P1C5	P1C8
Zn	P1	P1C3	P1C5	P1C6	P1C2	P1C7	P1C8	P1C2	P1C4
Cu	P1	P1C3	P1C8	P1C7	P1C1	P1C4	P1C5	P1C6	P1C2

Table 5 Effect of cooking treatments on mineral profile of fresh greengram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P1	420.00 ± 03.50 (7.50)	230.00 ± 11.60 (0.0)	3.95 ± 0.11 (2.70)	205.00 ± 07.50 (3.60)	1.80 ± 0.09 (5.00)	39.30 ± 1.40 (3.50)	2.10 ± 0.10 (4.70)
P1C1	123.00 ± 03.80 (3.08)	71.00 ± 04.00 (5.60)	2.95 ± 0.10 (3.30)	138.00 ± 03.80 (2.70)	0.80 ± 0.08 (10.00)	27.00 ± 2.10 (7.70)	1.10 ± 0.09 (8.10)
P1C2	111.00 ± 05.00 (4.50)	52.00 ± 03.20 (6.15)	2.45 ± 0.20 (8.10)	151.00 ± 11.50 (7.60)	0.90 ± 0.01 (1.10)	19.00 ± 3.10 (16.30)	0.80 ± 0.06 (6.80)
P1C3	126.00 ± 04.90 (6.20)	81.00 ± 05.10 (6.20)	2.80 ± 0.09 (3.20)	123.00 ± 03.90 (3.10)	1.10 ± 0.09 (8.10)	39.00 ± 2.70 (9.30)	0.90 ± 0.04 (4.40)
P1C4	113.00 ± 06.90 (6.10)	63.00 ± 04.00 (6.30)	2.45 ± 0.08 (3.20)	142.00 ± 07.60 (5.30)	0.40 ± 0.02 (5.00)	18.00 ± 2.10 (11.6)	0.60 ± 0.02 (3.30)
P1C5	122.00 ± 10.00 (8.20)	51.00 ± 00.60 (1.10)	2.70 ± 0.01 (3.30)	130.00 ± 06.10 (4.60)	0.70 ± 0.03 (4.20)	28.00 ± 1.80 (6.40)	1.10 ± 0.09 (8.10)
P1C6	94.00 ± 03.70 (3.90)	41.00 ± 02.50 (6.00)	2.50 ± 0.12 (4.80)	140.00 ± 07.50 (5.30)	1.30 ± 0.06 (4.60)	27.00 ± 1.40 (5.10)	0.80 ± 0.02 (2.50)
P1C7	88.00 ± 08.10 (9.20)	48.00 ± 01.50 (3.10)	2.70 ± 0.08 (2.90)	121.00 ± 00.72 (5.90)	9.00 ± 7.20 (1.10)	26.00 ± 0.90 (3.40)	0.90 ± 0.03 (3.30)
P1C8	92.00 ± 03.40 (3.60)	52.00 ± 04.10 (7.80)	2.70 ± 0.09 (3.30)	142.00 ± 03.90 (2.70)	0.60 ± 0.04 (6.60)	31.00 ± 0.50 (1.60)	0.90 ± 0.03 (4.40)
CD	8.17	13.95	0.47	36	0	8	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P1	P1C3	P1C1	P1C5	P1C4	P1C2	P1C6	P1C8	P1C7
Ca	P1	P1C1	P1C3	P1C4	P1C2	P1C8	P1C5	P1C7	P1C6
Fe	P1	P1C1	P1C3	P1C5	P1C7	P1C8	P1C6	P1C2	P1C4
Mg	P1	P1C2	P1C4	P1C8	P1C6	P1C1	P1C5	P1C3	P1C7
Mn	P1	P1C6	P1C3	P1C2	P1C7	P1C1	P1C5	P1C8	P1C4
Zn	P1	P1C8	P1C3	P1C5	P1C1	P1C6	P1C7	P1C2	P1C4
Cu	P1	P1C1	P1C5	P1C3	P1C7	P1C8	P1C2	P1C6	P1C4

A comparison of samples cooked in water media with other samples such as roasted, fried and micro oven cooked samples, revealed significant retention of P in samples cooked in water media in both the pulses. However, between P_1C_6 and soaked samples in blackgram no significant variation in P content was observed.

Comparison of Ca content in fresh samples with cooked samples depicted significant reduction in cooked samples. Among samples cooked in water media, in blackgram as well as in greengram no significant variation in Ca was observed between steamed (P_1C_3, P_1C_4) and boiled (P_1C_1, P_1C_2) samples, either soaked or unsoaked. While significant loss of Ca was observed in soaked samples when compared with unsoaked samples in the two pulses. Comparison of P_1C_5 (pressure cooked) with boiled and steamed samples, revealed significant loss of Ca in P_1C_5 with P_1C_1 (boiled) and P_1C_3 (steamed) while no significant variation in Ca in soaked blackgram and greengram (P_1C_2 and P_1C_4 in P_1C_5) were observed. Among P_1C_6 (roasted), P_1C_7 (fried) and P_1C_8 (cooked in micro oven) no significant variation in Ca loss was observed in greengram, while significant retention of Ca was observed in P_1C_6 in blackgram among P_1C_6 (roasted) P_1C_7 (fried) and P_1C_8 (micro oven cooked) samples. Comparison of these samples (P_1C_6, P_1C_7 and P_1C_8) with samples cooked in water media revealed significant retention of Ca in samples cooked in water media (P_1C_1, P_1C_2, P_1C_3, P_1C_4 and P_1C_5) in blackgram while in greengram significant retention was noted only in P_1C_1 and P_1C_3 (unsoaked samples). Significant retention of Ca was also observed in P_1C_4 in greengram on comparison with P_1C_6 and P_1C_7 with P_1C_5 no significant variation in Ca loss was observed in P_1C_6, P_1C_7 and P_1C_8.

Comparison of Fe content in fresh pulses (P_1) with other cooked samples (C_1 to C_8) depicted a significant loss of Fe in cooked samples in blackgram and greengram. Loss of Fe in soaked samples (P_1C_2, P_2C_4) of blackgram and greengram was noted, when compared with unsoaked boiled (P_1C_1) and steamed (P_1C_3) samples. Statistical treatment of the data revealed that loss of Fe was significant only in P_1C_2 in greengram. Comparison of pressure cooked samples (P_1C_5), with boiled (P_1C_1, P_1C_2) and steamed (P_1C_3, P_1C_4) samples revealed. No significant variation was observed in Fe loss in both the samples.

Among roasted (P_1C_6), fried (P_1C_7) and micro oven cooked (P_1C_8) samples of blackgram and greengram, no significant variation in Fe retention was observed. Comparison of these samples with samples cooked in water media also revealed no significant variation in both the pulses.

Among samples cooked, significant loss of Mg was observed on comparison with the fresh samples of blackgram and greengram. Among cooked samples, no significant variation in Mg was observed both in blackgram and greengram. In greengram and blackgram, minimum loss of Mg was observed in soaked and boiled samples (P_1C_1) and maximum loss was observed in P_1C_1 in blackgram and in P_1C_7 in greengram.

Reduction of Mn in cooked samples was observed when compared with the fresh sample. Statistical treatment of the data revealed that there is no significant loss in Mn in cooked samples. Among cooked samples, highest loss of Mn was observed in blackgram samples cooked under pressure (P_1C_5) and cooked in micro oven, while in greengram maximum loss was observed in soaked and steamed sample (P_1C_1). No statistically significant variation in Mn was observed among cooked samples.

Comparison of Zn in fresh greengram and blackgram with cooked samples depicted significant variation. Significant loss of Zn was observed in cooked samples in both the pulses. Among samples cooked in water media, significant retention of Zn was observed in P_1C_1, P_1C_3 and P_1C_5 on comparison with P_1C_2 and P_1C_4 in blackgram and greengram. Among roasted (P_1C_6), fried (P_1C_7 and micro oven cooked (P_1C_8) samples of blackgram and greengram, no significant variation in Zn was noted. Comparison of these samples with samples cooked in micro oven revealed significant retention of Zn in soaked samples (P_1C_2 and P_1C_4) while no significant variation in Zn retention was observed with other samples (P_1C_1, P_1C_3 and P_1C_5) of the two pulses.

Significant loss of Cu was observed in cooked samples on comparison with fresh samples in blackgram and greengram. Among cooked samples, significant loss of Cu was observed in soaked samples (P_1C_2, P_1C_4) in both the pulses when compared with unsoaked samples (P_1C_1, P_1C_3). In blackgram significant variation in Cu loss was observed in sample cooked under pressure (P_1C_5) when compared with P_1C_1 and P_1C_3, while in greengram no significant variation in Cu was observed in P_1C_5. But among roasted (P_1C_6), fried (P_1C_7) and micro oven cooked sample (P_1C_8), significant variation in Cu loss was observed between P_1C_6 and P_1C_8 in blackgram while no such observation was made in greengram. Comparison among the samples such as P_1C_1, P_1C_2, P_1C_3, P_1C_4 and P_1C_5, revealed significant variation in Cu loss between P_1C_6 and P_1C_3, P_1C_2 and P_1C_7 and P_1C_4 and P_1C_8 in blackgram. In greengram significant variation was observed between P_1C_4 and P_1C_7, P_1C_4 and P_1C_8.

All the cooking treatments were found to reduce the mineral content of fresh pulse samples. Rao and Deosthale (1983) reported that cooking of raw pulse samples resulted in significant loss of Cu (44%), Fe (29%) and Mg (23%).

Table 6 Effect of cooking treatments on mineral profile of dried blackgram

Processing techniques	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P1	442.00 ± 14.00 (3.00)	240.00 ± 28.00 (11.60)	3.95 ± 0.10 (2.50)	200.00 ± 11.60 (5.00)	2.90 ± 0.16 (5.50)	49.00 ± 0.49 (10.00)	1.00 ± 0.09 (9.00)
P2C1	90.00 ± 20.10 (2.00)	89.00 ± 02.40 (2.00)	2.80 ± 0.14 (5.00)	158.00 ± 02.50 (175.00)	0.50 ± 0.01 (2.00)	24.00 ± 3.10 (12.00)	0.40 ± 0.01 (2.00)
P2C2	192.00 ± 03.16 (1.00)	105.00 ± 05.00 (4.00)	2.50 ± 0.14 (5.60)	175.00 ± 05.00 (2.80)	0.70 ± 0.10 (14.00)	17.00 ± 2.10 (12.00)	0.30 ± 0.01 (3.00)
P2C3	94.00 ± 02.40 (2.00)	63.50 ± 03.20 (5.00)	2.75 ± 0.14 (5.00)	140.00 ± 06.00 (4.20)	0.40 ± 0.03 (7.00)	14.00 ± 1.00 (7.00)	0.60 ± 0.10 (16.00)
P2C4	100.00 ± 03.10 (3.00)	78.50 ± 01.90 (2.00)	2.50 ± 0.20 (8.00)	160.00 ± 05.00 (3.10)	0.40 ± 0.03 (7.00)	13.00 ± 2.00 (6.00)	0.50 ± 0.02 (4.00)
P2C5	109.00 ± 04.20 (3.00)	84.00 ± 02.10 (2.00)	2.35 ± 0.10 (4.20)	151.00 ± 02.10 (1.30)	0.60 ± 0.03 (5.00)	45.00 ± 2.40 (5.00)	0.50 ± 0.03 (6.00)
P2C6	58.00 ± 02.10 (3.00)	113.50 ± 03.20 (2.00)	2.65 ± 1.12 (4.50)	170.00 ± 02.50 (1.40)	0.30 ± 0.01 (3.00)	22.00 ± 2.10 (9.00)	0.10 ± 0.05 (50.00)
P2C7	70.00 ± 02.30 (3.00)	52.00 ± 01.90 (3.60)	2.65 ± 0.21 (7.10)	165.00 ± 02.50 (1.50)	0.40 ± 0.01 (2.00)	15.00 ± 0.50 (3.00)	0.70 ± 0.07 (10.00)
P2C8	94.00 ± 01.08 (1.00)	54.40 ± 02.00 (9.00)	2.65 ± 0.31 (11.00)	155.00 ± 03.00 (1.90)	0.40 ± 0.20 (5.00)	31.00 ± 1.20 (3.00)	0.60 ± 0.06 (6.00)
CD	8.17	13.95	0.47	36	0	8	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P2	P2C2	P2C5	P2C4	P2C3	P2C8	P2C1	P2C7	P2C6
Ca	P2	P2C6	P2C2	P2C1	P2C5	P2C4	P2C3	P2C8	P2C7
Fe	P2	P2C1	P2C3	P2C6	P2C7	P2C8	P2C2	P2C4	P2C5
Mg	P2	P2C2	P2C6	P2C7	P2C4	P2C1	P2C8	P2C5	P2C3
Mn	P2	P2C2	P2C5	P2C1	P2C3	P2C4	P2C7	P2C8	P2C6
Zn	P2	P2C5	P2C8	P2C1	P2C6	P2C2	P2C7	P2C3	P2C4
Cu	P2	P2C7	P2C3	P2C8	P2C4	P2C5	P2C1	P2C2	P2C6

Table 7 Effect of cooking treatments on mineral profile of dried greengram

Processing techniques	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P2	420.00 ± 2.50 (7.50)	159.00 ± 7.90 (4.90)	3.95 ± 0.13 (3.00)	200.00 ± 16.40 (8.20)	1.40 ± 0.06 (4.20)	38.00 ± 0.09 (2.30)	2.00 ± 0.25 (12.00)
P2C1	65.00 ± 7.00 (11.00)	48.00 ± 2.80 (5.00)	2.95 ± 0.04 (1.00)	132.00 ± 04.00 (3.00)	0.40 ± 0.02 (5.00)	22.00 ± 1.50 (5.00)	1.10 ± 0.01 (9.00)
P2C2	83.30 ± 5.40 (6.00)	50.50 ± 1.60 (2.00)	2.45 ± 0.30 (11.00)	161.00 ± 03.00 (1.80)	0.70 ± 0.01 (1.00)	15.00 ± 2.10 (14.00)	0.90 ± 0.01 (1.00)
P2C3	70.00 ± 4.90 (7.00)	29.50 ± 3.10 (10.00)	2.70 ± 0.10 (3.00)	120.00 ± 03.20 (2.60)	0.60 ± 0.09 (15.00)	14.00 ± 1.30 (9.00)	0.90 ± 0.10 (14.00)
P2C4	80.00 ± 3.00 (3.00)	30.00 ± 4.30 (14.00)	2.30 ± 0.40 (17.00)	165.00 ± 01.90 (11.00)	0.50 ± 0.06 (12.00)	15.00 ± 2.10 (14.00)	0.70 ± 0.01 (1.00)
P2C5	49.00 ± 2.90 (5.00)	48.50 ± 2.90 (5.00)	2.70 ± 0.14 (5.00)	130.00 ± 05.00 (3.80)	0.80 ± 0.01 (1.00)	29.00 ± 1.90 (6.00)	1.30 ± 0.10 (7.00)
P2C6	78.50 ± 3.20 (4.00)	49.50 ± 4.50 (9.00)	2.50 ± 0.24 (9.00)	162.00 ± 02.00 (1.20)	0.80 ± 0.02 (2.00)	22.00 ± 2.10 (9.00)	0.80 ± 0.09 (11.00)
P2C7	55.00 ± 4.20 (7.00)	36.00 ± 6.20 (17.00)	2.75 ± 0.60 (21.00)	115.00 ± 04.00 (3.40)	0.70 ± 0.11 (15.00)	15.00 ± 0.31 (20.00)	0.80 ± 0.02 (2.00)
P2C8	51.00 ± 8.18 (15.00)	37.00 ± 4.90 (13.00)	2.45 ± 0.04 (9.00)	174.00 ± 04.00 (2.20)	0.20 ± 0.02 (10.00)	14.00 ± 1.20 (8.0)	0.10 ±0.01 (10.00)
CD	8.17	13.95	0.47	36.00	0	8	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P2	P2C2	P2C4	P2C6	P2C3	P2C1	P2C7	P2C8	P2C5
Ca	P2	P2C2	P2C6	P2C5	P2C1	P2C8	P2C7	P2C4	P2C3
Fe	P2	P2C1	P2C7	P2C3	P2C5	P2C6	P2C8	P2C2	P2C4
Mg	P2	P2C8	P2C4	P2C6	P2C2	P2C1	P2C5	P2C3	P2C7
Mn	P2	P2C5	P2C6	P2C2	P2C7	P2C3	P2C4	P2C1	P2C8
Zn	P2	P2C5	P2C1	P2C6	P2C2	P2C4	P2C7	P2C3	P2C8
Cu	P2	P2C5	P2C1	P2C2	P2C3	P2C6	P2C7	P2C4	P2C8

Minimum loss of all minerals was observed in unsoaked and cooked samples in blackgram (Fig. 3 and 4). While in greengram maximum retention of Mg was observed in soaked and boil sample, Fe Mn in fried sample and Zn micro oven cooked sample.

Significant retention of P, Ca, Fe, Zn and Cu was observed in unsoaked and cooked samples in both pulses. No significant variation in mineral content between fried roasted and micro oven cooked sample was observed in greengram. While in blackgram for Ca, significant variation between fried and roasted sample was observed.

Maximum loss of mineral in roasted, micro oven cooked sample and soaked and cooked samples. No significant variation in Mn retention was depicted by different cooking treatments in both pulses.

4.3.2 Influence of cooking treatments on the mineral status of dried pulse samples (Tables 6 and 7 and Appendix II)

A comparison of P content in blackgram samples treated by different cooking methods, depicted significant variation. There was consistent decrease of P in different cooked samples.

Between boiled and steamed blackgram samples variation in P loss was not significant. But variation in P content of soaked samples of blackgram (P_2C_2 and P_2C_4), but P loss was found to be significantly greater in steamed (P_2C_4) samples indicating the effect of steaming on P loss in pulses. Significant variation was observed between P_2C_1 and P_2C_2 also indicating the effect of soaking prior to boiling on P loss. While no significant variation in P loss was observed between P_2C_1 and P_2C_4. P reduction in samples P_2C_1 and P_2C_4 might be due to leaching of minerals in cooking water. Similar observations of P leaching in cooking media were reported by Mieners et al. (1976).

Among cooked samples P loss was minimum in P_2C_2 followed by samples cooked under pressure (P_2C_5) which had significant variation in P loss with all other cooked samples. While variation between P_2C_2 and P_2C_5 was statistically significant. Significant variation was observed in P retention of roasted pulses (P_2C_6) when compared to fried samples (P_2C_7) and pulses cooked in micro oven (P_2C_8). P retension in P_2C_7 was also significantly higher in comparison with P_2C_8. Comparison of P loss in roasted blackgram (P_2C_6) with boiled and steamed blackgram samples which were soaked and unsoaked showed significant variation in P loss. Similar variation was observed between fried blackgram (P_2C_7) with all the samples cooked in the medium of water by boiling and steaming (P_2C_1, P_2C_2, P_2C_3 and P_2C_4).

Variation in P loss in P_2C_8 with P_2C_3 with P_2C_1 and P_2C_3 samples did not show significant variation but with P_2C_2 the variation was significant. P loss from pulses cooked in micro oven (P_2C_8) was significantly lower when compared to roasted pulses (P_2C_6).

As in the case of blackgram significant variation was noted between the cooked greengram samples when a comparison of boiled and steamed greengram (P_2C_1 with P_2C_3 and P_2C_2 with P_2C_4) was made. Significant variation was observed between soaked and unsoaked greengram samples when boiled and steamed (P_1C_1 with P_2C_2 and P_2C_3 with P_2C_4). Similar observations were made in the case of blackgram also. Maximum loss of P was observed in greengram when cooked under pressure (P_2C_5) followed by samples cooked in micro oven (P_2C_8). Variation in P, content of P_2C_6 with P_2C_7 and P_2C_8 was statistically significant while unlike blackgram no significant variation in P loss was observed between P_2C_7 and P_2C_8 in greengram. Significantly greater loss of P was observed in greengram when compared to boiled and steamed samples.

Comparison of P content of greengram samples cooked under pressure with boiled and steamed (P_2C_1, P_2C_2, P_2C_3 and P_2C_4) samples showed significant variation. Similar observations were noted between fried (P_2C_7) and boiled and steamed greengram

(P_2C_1, P_2C_2, P_2C_3 and P_2C_4), while comparison in P content of P_2C_4 (steamed samples) showed significant variation only with P_2C_1 and P_2C_3 (unsoaked samples) which were treated in similar manner. Similar findings were observed in the case of blackgram also. Neerja et al. (1993) have also reported that roasting of pulses resulted in a significant loss of P.

Comparison of Ca content in dried and cooked blackgram depicted significant variation. Significant loss of Ca in cooked samples was observed. Similar observation was made in greengram also. As revealed in the Table 6, highest Ca retention among cooked blackgram samples was noted for P_2C_6 (roasted sample) followed in the order of P_2C_2, P_2C_1, P_2C_5, P_2C_4, P_2C_3, P_2C_8 and P_2C_7 while in the greengram, maximum retention was found in P_2C_2 samples in the order of P_2C_6, P_2C_5, P_2C_1, P_2C_8, P_2C_7, P_2C_4 and P_2C_3.

Between boiled and steamed blackgram sample (P_2C_1 with P_2C_3 and P_2C_2 with P_2C_4) significant variation was observed in Ca loss due to soaking. Similar variation was also observed between soaked and unsoaked blackgram samples in Ca content. P_2C_5 (Pressure cooked samples) showed significant retention in Ca content in blackgram when compared with all other cooked samples except P_2C_4. Samples cooked in micro oven (P_2C_8) also showed retention of Ca with all other cooked samples except P_2C_2 (soaked and boiled). No significant variation was observed between P_2C_7 and P_2C_8. Comparison of P_2C_7 and P_2C_8 with samples cooked in the media of water depicted significant retention of Ca except in the case of soaked and steamed sample (P_2C_3).

Comparison of Ca content in the dried greengram samples after cooking showed significant Ca retention irrespective of soaked or unsoaked samples and between boiled and steamed samples (P_2C_1 with P_2C_3, P_2C_2 with P_2C_4) while no significant variation in Ca was observed between soaked and unsoaked greengram (P_2C_1 with P_2C_2, P_2C_3 with P_2C_4).

Among cooked greengram no significant variation in Ca retension was observed between P_2C_5 (pressure cooked) and other cooked samples like P_2C_1 and P_2C_2 while statistically significant variation was observed with P_2C_3 and P_2C_4. Similarly variations in Ca content of P_2C_5 with P_2C_6, P_2C_7 and P_2C_8 were not statistically significant when the media of cooking were different. However, significant variation in Ca retention was observed between P_2C_6 (roasted) with P_2C_7 (fried) and P_2C_8 cooked in micro oven. Between P_2C_7 and P_2C_8 no significant variation in Ca loss in greengram was noted. Comparison of Ca content in P_2C_6 (roasted) with boiled and steamed samples depicted significant variation in Ca loss with steamed (P_2C_3 and P_2C_4)

greengram samples probably because of the variation in the media of cooking. Similarly P_2C_7 (fried greengram) showed significant variation with (P_2C_1, P_2C_2) (boiled greengram) but not with P_2C_3 and P_2C_4 (steamed greengram samples). Similar observations were also made when P_2C_8 was compared with boiled and steamed greengram.

Variation in Fe loss between dried samples and cooked samples was statistically significant both in blackgram and greengram. A comparison of samples cooked in the media of water revealed that there was no significant variation in Fe content of samples boiled or steamed with or without soaking (P_2C_1 and P_2C_3, P_2C_2 and P_2C_4). Maximum loss of Fe in blackgram was observed in P_2C_5, when cooked under pressure. Statistical treatment of the data revealed no significant variation in Fe content between blackgram samples cooked in different media. A significant reduction in Fe content of the beans was also observed on pressure cooking by Singh and Banerjee (1953).

Among cooked samples, in greengram, maximum Fe loss was observed for P_2C_4 (soaked and steamed). Similar observations was made for greengram also. However, statistically significant variation in Fe retention was not observed among samples cooked in different media except P_2C_1 and P_2C_4 in the case of greengram.

Rao and Deosthale (1983) had reported significant decrease in Fe content in pulses during cooking.

Comparison of Mg content of dried blackgram with other cooked samples depicted significant variation in Mg loss except in the case of boiled (P_2C_1) roasted (P_2C_6) and fried (P_2C_7) samples. Loss of Mg content in all the cooked samples were noted when compared with dried samples, both in greengram and blackgram.

Comparison of Mg loss in boiled and steamed samples (P_2C_1 and P_2C_2, P_2C_3 and P_2C_4) revealed that there was no statistically significant variations in blackgram. Similarly no significant variation was observed between soaked and unsoaked blackgram samples (P_2C_1 and P_2C_2, P_2C_3 and P_2C_4). Among cooked samples in blackgram, no significant variation in Mg retention was observed between pressure cooked sample (P_2C_5) and others. Variations in Mg loss in blackgram between P_2C_6 (roasted) and other samples viz cooked in the medium of water (P_2C_1, P_2C_2, P_2C_3, P_2C_4) or oil (P_2C_7)) or by means of micro oven (P_2C_8) depicted no significant variation. In the blackgram samples no significant variation was noted between fried (P_2C_7) and other cooked samples. Similarly blackgram samples cooked in micro oven (P_2C_8) with other cooked samples did not vary in Mg retention. In the blackgram, highest Mg retention was observed in P_2C_2

(soaked and boiled) while in greengram highest Mg retention was observed in P_2C_8 (micro oven cooked samples). In the case of greengram no significant variation in Mg loss was observed between boiled and steamed samples while Mg loss between soaked and unsoaked greengram was significantly varying in steamed samples but not in boiled samples. Mg loss in greengram cooked under pressure (P_2C_5) did not show significant variation with other samples cooked in the same medium like boiled, steamed, roasted or fried samples except with P_2C_8 (micro oven cooked greengram). Roasted greengram (P_2C_6) had significant Mg loss when compared to boiled and steamed samples. Significant variation in Mg loss was also observed between P_2C_6 (roasted) and P_2C_7 (fried) samples of greengram. Between fried sample (P_2C_7) and sample cooked in microoven (P_2C_8) also, significant variation in Mg loss was observed in greengram. A comparison of P_2C_7 (fried) with boiled and steamed samples revealed significant variation when compared to soaked (P_2C_2 and P_2C_4) greengram. In the case of blackgram no such observations were made.

Mn content of dried blackgram was 2.9 while in greengram it was 1.4. When cooked,there was considerable loss in Mn content both in blackgram and greengram and might be due to leaching effect during cooking. Statistical analysis of the data revealed variations in Mg loss among cooked samples were not significant. Similar observations were also made in the case of greengram among cooked samples in their Mn loss. In blackgram Mn retention was highest in P_2C_5 (soaked and boiled) while in greengram highest Mn retention was observed in P_2C_5 (Pressure cooked samples) and P_2C_6 (roasted).

No statistically significant variation was observed among samples, soaked and unsoaked, either boiled or steamed in Mn loss. Similarly between boiled and steamed samples, both in greengram and blackgram, no significant variation was noted for Mn. Similar observations were also made between samples cooked in water media and samples cooked in other media both in blackgram and greengram.

Comparison of Zn content in dried blackgram with other cooked blackgram sample depicted significant variation except P_2C_5 (pressure cooking). All the cooking treatments reduced the levels of Zn in both greengram and blackgram. Among cooked samples in blackgram highest Zn content was observed in P_2C_5 (pressure cooked) sample followed by P_2C_8 (micro oven cooked) and P_2C_1 (boiled). In greengram, as in the case of blackgram highest Zn content was observed for P_2C_5 (pressure cooked sample). Among boiled and steamed blackgram sample, significant variation in Zn loss was noted for boiled (P_2C_1) and steamed samples (P_2C_3). While no significant variation was noted between similarly treated samples (P_2C_2 and P_2C_4) after soaking for three hours. In greengram no significant variation in Zn loss was observed between boiled and stemed (P_2C_1 and P_2C_2, P_2C_3 and P_2C_4) greengram and soaked and unsoaked greengram (P_2C_1 and P_2C_2, P_2C_3 and P_2C_4) samples.

Pressure cooked blackgram sample showed significant variation in Zn content compared with all other cooked samples. Greengram samples cooked under pressure P_2C_5 significantly varied from all other cooked sampels except P_2C_1 (boiled) and P_2C_6 (roasted) samples.

Comparison of roasted blackgram (P_2C_6) with boiled and steamed blackgram samples showed significant variation with steamed (P_2C_3 and P_2C_4) samples. No significant variation was observed in Zn loss between roasted (P_2C_6) and fried (P_2C_7) blackgram samples while variation in Zn loss between roasted (P_2C_6) and micro oven cooked (P_2C_8) blackgram samples was statistically significant. However, variation in Zn loss between roasted (P_2C_7) and micro oven cooked (P_2C_8) greengram samples was not significant statistically. Roasted greengram (P_2C_6) did not show significant variation with other cooked samples. Fried blackgram with boiled and steamed samples did not show any significant variation except boiled blackgram sample (P_2C_1). Variation among P_2C_7 and P_2C_8 was also statistically significant.

Variation in Zn loss between fried greengram and other cooked greengram samples was not statistically significant. Similarly micro oven cooked greengram sample did not show significant variation with other cooked sample except boiled sample P_2C_1. However significant decrease in Zn loss during cooking was reported by Rao and Deosthale (1983) and Singh and Banerjee (1953).

Reduction in Cu content were observed during cooking in blackgram as well as in greengram. In blackgram comparison of Cu content in dried sample (P_2) with cooked sample depicted significant variation.

Among boiled and steamed samples, no significant variation was noted between boiled (P_2C_1) and steamed (P_2C_3) and also between soaked (P_2C_1 and P_2C_3) and unsoaked (P_2C_2 and P_2C_4) samples. No significant variation was observed among pressure cooked(P_2C_5)sample with boiled (P_2C_1 and P_2C_2) and steamed (P_2C_3 and P_2C_4) blackgram samples.

Significant variation in Cu loss of samples cooked under pressure (P_2C_5) with roasted (P_2C_6) blackgram was noted, however with fried (P_2C_7) and micro oven cooked samples (P_2C_8) the variation was not significant. Cu content of P_2C_6 (roasted) blackgram sample was very low which showed significant variation with all other cooked blackgram samples. Variation in Cu loss between fried blackgram (P_2C_7) and micro oven cooked (P_2C_8) samples was not statistically significant. Comparison of Cu content in dried greengram and cooked greengram depicted significant variation.

Among boiled and steamed greengram samples no significant variation in Cu loss was noted between boiled and steamed samples and also between soaked and unsoaked samples. Comparison of pressure cooked greengram (P_2C_5) which had the highest Cu content among cooked samples, with boiled and steamed samples, showed significant variation except with P_2C_1.

Significant variation in Cu loss among roasted greengram (P_2C_6), fried (P_2C_7) and micro oven cooked (P_2C_8) was also noted with greengram samples cooked under pressure P_2C_5. No variation was observed between fried (P_2C_7) and roasted (P_2C_6) greengram samples. Comparison of roasted greengram (P_2C_6) and fried greengram (P_2C_7) with boiled and steamed samples revealed variation in Cu loss, however, the variation was not significant while, with P_2C_1 the variation was significant.

Sample cooked under micro oven has the minimum Cu content which significantly varied from all other cooked greengram.

All the cooking treatments were found to reduce the mineral contents of the dried pulse samples such as P, Ca, Fe, Mg, Mn, Zn and Cu. Rao and Deosthale (1983) reported that cooking of raw pulse grains resulted in significant loss of Cu (44%), Fe (29%) and Mg (23%), while in greengram loss of Fe was 23 per cent and that of Cu 30 per cent.

Minimum loss of all minerals were observed for the samples cooked in water media except Ca in blackgram and Mg in greengram. Boiling and cooking under pressure were found to retain minerals like P, Ca, Mg, Mn, Zn and Cu more than other cooking techniques such as steaming, roasting, frying and cooking in micro oven. Significant reduction in Fe content of the beans during pressure cooking was reported by Singh and Banerjee (1953).

Significant retention of P in greengram and blackgram was observed in soaked and boiled samples. Boiling, cooking under pressure and roasting were found to retain Ca better than other cooking methods. Neerja and Hira (1993), had reported that roasting and pressure cooking resulted in a significant loss of P compared to boiled samples, while for Ca no such observations was made.

Retention of Fe was more observed in unsoaked and boiled samples. For both the pulses, roasting, frying and micro

Table 8 Effect of cooking treatments on mineral profile of germinated blackgram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P3	420.00 ± 15.70 (3.70)	200.00 ± 27.20 (13.60)	3.55 ± 0.25 (7.00)	200.00 ± 12.00 (6.00)	2.90 ± 1.90 (6.50)	47.30 ± 1.76 (3.70)	0.70 ± 0.10 (1.40)
P3C1	115.00 ± 10.00 (8.00)	79.00 ± 01.40 (1.70)	2.85 ± 0.05 (1.00)	230.00 ± 01.30 (5.60)	0.80 ± 0.02 (2.00)	31.00 ± 1.50 (4.00)	0.60 ± 0.01 (1.00)
P3C2	284.00 ± 08.90 (3.10)	124.50 ± 02.50 (2.00)	2.40 ± 0.10 (4.00)	194.00 ± 11.00 (5.60)	0.40 ± 0.01 (2.00)	21.00 ± 0.30 (1.00)	0.40 ± 0.01 (7.00)
P3C3	100.00 ± 09.20 (4.20)	66.50 ± 03.00 (4.00)	2.70 ± 0.17 (6.00)	245.00 ± 03.40 (0.00)	0.60 ± 0.04 (6.00)	33.10 ± 1.40 (4.00)	0.40 ± 0.10 (7.00)
P3C4	214.00 ± 05.10 (5.10)	82.50 ± 03.20 (5.00)	2.20 ± 0.14 (6.00)	214.00 ± 10.10 (4.60)	0.60 ± 0.03 (5.00)	31.00 ±12.50 (4.00)	0.50 ± 0.01 (2.00)
P3C5	155.49 ± 68.00 (3.00)	68.60 ± 01.30 (3.00)	2.48 ± 0.12 (5.00)	248.00 ± 12.00 (4.80)	1.20 ± 0.01 (7.00)	31.90 ± 1.50 (4.00)	0.60 ± 0.04 (5.00)
P3C6	80.50 ± 06.30 (7.80)	107.00 ± 00.50 (4.60)	2.55 ± 1.54 (5.00)	196.00 ± 07.10 (3.60)	0.80 ± 0.01 (3.00)	28.30 ± 1.90 (6.00)	0.50 ± 0.01 (2.00)
P3C7	91.00 ± 04.10 (4.00)	51.00 ± 01.20 (2.30)	2.55 ± 0.14 (5.40)	203.00 ± 11.00 (5.40)	0.40 ± 0.00 (0.00)	17.20 ± 1.00 (5.00)	0.40 ± 0.02 (5.00)
P3C8	56.00 ± 02.50 (4.40)	71.50 ± 02.70 (3.70)	2.75 ± 1.50 (5.40)	116.00 ± 02.00 (1.70)	0.40 ± 0.01 (2.00)	10.00 ± 0.39 (8.00)	0.40 ± 0.02 (5.00)
CD	8.17	13.95	0.47	36.00	0.00	8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P3	P3C4	P3C5	P3C1	P3C3	P3C7	P3C6	P3C7	P3C8
Ca	P3	P3C2	P3C6	P3C4	P3C1	P3C8	P3C5	P3C3	P3C7
Fe	P3	P3C1	P3C8	P3C3	P3C5	P3C6	P3C7	P3C2	P3C4
Mg	P3	P3C3	P3C1	P3C4	P3C7	P3C3	P3C6	P3C2	P3C8
Mn	P3	P3C5	P3C1	P3C6	P3C3	P3C4	P3C3	P3C7	P3C8
Zn	P3	P3C3	P3C1	P3C4	P3C5	P3C6	P3C2	P3C7	P3C8
Cu	P3	P3C1	P3C5	P3C4	P3C4	P3C2	P3C3	P3C7	P3C8

Table 9 Effect of cooking treatments on mineral profile of germinated greengram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P3	400.00 ± 20.00 (5.00)	140.00 ± 14.00 (10.00)	3.75 ± 0.80 (2.13)	199.00 ± 08.40 (9.20)	1.40 ± 0.10 (7.00)	36.00 ± 0.80 (2.20)	1.80 ± 0.07 (3.80)
P3C1	70.00 ± 03.10 (7.70)	35.50 ± 01.30 (3.00)	2.70 ± 0.09 (3.00)	245.00 ± 10.00 (4.00)	1.20 ± 0.10 (8.30)	30.00 ± 0.34 (1.10)	1.20 ± 0.10 (8.10)
P3C2	144.50 ± 03.20 (7.90)	42.00 ± 03.10 (7.00)	2.75 ± 0.14 (5.20)	105.00 ± 04.90 (4.60)	0.60 ± 0.01 (1.60)	15.00 ± 1.10 (7.10)	1.40 ± 0.08 (5.10)
P3C3	50.50 ± 04.60 (9.00)	26.00 ± 01.20 (4.20)	2.45 ± 0.10 (4.00)	221.00 ± 11.00 (4.90)	0.70 ± 0.01 (1.20)	25.00 ± 2.10 (8.00)	1.00 ± 0.01 (1.00)
P3C4	103.00 ± 13.00 (12.00)	25.00 ± 03.20 (12.00)	2.25 ± 0.20 (8.00)	181.00 ± 01.30 (7.10)	0.60 ± 0.00 (0.00)	26.00 ± 3.40 (1.30)	1.10 ± 0.01 (1.00)
P3C5	70.00 ± 05.10 (7.30)	39.00 ± 03.60 (9.10)	2.65 ± 0.30 (11.00)	149.00 ± 03.10 (2.10)	0.30 ± 0.01 (3.00)	30.00 ± 2.10 (7.00)	0.90 ± 0.02 (2.20)
P3C6	75.00 ± 8.10 (11.00)	42.50 ± 02.70 (6.20)	2.45 ± 0.10 (4.10)	158.00 ± 02.80 (1.70)	0.40 ± 0.02 (5.00)	23.00 ± 0.70 (3.20)	0.60 ± 0.03 (5.00)
P3C7	71.00 ± 04.20 (5.40)	34.50 ± 01.90 (5.20)	2.45 ± 0.08 (3.20)	149.00 ± 02.70 (1.80)	0.20 ± 0.01 (0.50)	24.00 ± 1.40 (5.00)	0.60 ± 0.03 (5.00)
P3C8	40.00 ± 06.80 (7.00)	32.00 ± 02.10 (6.00)	2.72 ± 0.13 (4.70)	196.00 ± 04.30 (2.10)	0.90 ± 0.01 (11.00)	25.00 ± 2.10 (8.40)	0.90 ± 0.01 (1.00)
CD	8.17	13.95	0.47	36.00	0.00	8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P3	P3C2	P3C4	P3C6	P3C7	P3C1	P3C5	P3C3	P3C8
Ca	P3	P3C6	P3C2	P3C5	P3C1	P3C7	P3C8	P3C3	P3C4
Fe	P3	P3C2	P3C8	P3C1	P3C5	P3C3	P3C6	P3C7	P3C4
Mg	P3	P3C1	P3C3	P3C8	P3C4	P3C6	P3C5	P3C7	P3C2
Mn	P3	P3C1	P3C8	P3C3	P3C2	P3C4	P264	P3C5	P3C8
Zn	P3	P3C1	P3C5	P3C4	P3C3	P3C8	P3C7	P3C6	P3C2
Cu	P3	P3C2	P3C1	P3C4	P3C3	P3C5	P3C8	P3C6	P3C7

oven cooking did not exhibit significant variation in Fe and Mn retention.

Maximum loss of Mn, Zn and Cu in greengram were observed in samples cooked in micro oven and maximum retention was observed in samples cooked under pressure, while in blackgram maximum loss of Mn and Cu were observed in roasted samples and Zn in steamed samples. No significant variation in Mn retention was depicted by different cooking treatments in greengram and blackgram. Cooking under pressure was observed to have significant Zn retention in both the pulses. No significant retention of Cu was observed among the samples cooked in water media.

4.3.3 Influence of cooking treatments on germinated samples of pulses (Table 8 and 9) and Appendix II

On line with the findings of Rao and Deosthale (1983) mineral losses during cooking of both raw and germinated greengram and blackgram were significant.

Cooking treatments as a whole was found to reduce the P content in germinated blackgram as well as in germinated greengram. A comparison of P loss in germinated blackgram before and after cooking showed significant variation among different cooking treatments. Maximum loss of P was observed in P_3C_8 (micro oven cooked) followed by P_3C_6, P_3C_7, P_3C_1, P_3C_5, P_3C_3 and P_3C_2.

Statistical treatment of the data revealed significant difference in retention of P among P_3C_2 and P_3C_4. When compared to unsoaked sample (P_3C_1) P loss was significant in soaked samples. Comparison of P loss in P_3C_5 with all other cooked samples depicted significant variation. Similarly comparison of P_3C_6, P_3C_7 and P_3C_8 with all other cooked blackgram depicted significant variation. Variation in P in roasted P_3C_6, when compared to P_3C_7, P_3C_8, P_3C_7 and P_3C_8 was also found to be statistically significant.

Variations in P content in germinated greengram, uncooked and cooked, were found to be statistically significant. Maximum loss of P was observed in P_3C_8 (micro oven cooked) followed by P_3C_3 (steamed greengram).

Among boiled and steamed blackgram samples significant variation was noted between boiled and steamed greengram samples irrespective of soaked or unsoaked. Similarly significant retention of P was noted in P_3C_2 (soaked and boiled) and P_3C_4 (soaked and steamed) when compared to P_3C_1 (boiled) and P_3C_3 (steamed) respectively. Comparison of P content in P_3C_5 with other cooked samples depicted significant variation except with P_3C_1, P_3C_5 and P_3C_7. While no variation was noted between P_3C_6 (roasted greengram) and P_3C_7 (fried greengram).

Significant loss of P content in P_3C_8 was observed when compared with all other cooked samples. Comparison of roasted

(P_3C_6) and fried greengram (P_3C_1) with boiled and steamed sampl showed significant variation in P retention except with P_3 (boiled greengram samples).

Comparison of Ca loss in germinated and cook blackgram after germination, depicted significant variatio Significant loss of Ca in cooked samples was also observe Similar observations were made in greengram also.

As revealed in the Table 8, highest Ca retention amo cooked samples in blackgram was noted for P_3C_2 followed by P_3C P_3C_1, P_3C_8, P_3C_5, P_3C_3, P_3C_4 and P_3C_7. Between boiled a steamed blackgram samples (P_2C_1 with P_2C_1 and P_2C_3 with (P_3C significant variation in Ca loss was observed, due to soakin Similar variation was also observed between soaked and unsoak blackgram samples in Ca loss. Significant loss of Ca content w observed in P_2C_5 when compared with that of boiled and steam blackgram samples except P_2C_1 and P_2C_4. Variation in Ca loss P_2C_5 was significant when compared with P_2C_6 (roasted) P_2 (fried) and P_2C_8 (micro oven cooked).

Significant retention of Ca was observed in P_2C_6 wh compared with boiled and steamed blackgram (P_2C_1, P_2C_2, P_2C_3 a P_2C_4). Similar observations were made, when P_3C_5 was compar with P_3C_7 and P_3C_8. Between P_3C_7 (fried) and P_3C_8 (micro ov cooked) significant variation in Ca loss was noted in blackgra

Comparison of P_3C_7 with boiled and steamed samples depicted significant variation in Ca loss except in P_3C_3 and when cooked P_3C_8 was compared with boiled and steamed blackgram no significant variation in Ca loss was observed except with P_3C_2.

Comparison of Ca in germinated greengram samples with cooked greengram showed significant variation. Minimum loss of Ca was observed in P_3C_4 followed by P_3C_3. Between boiled and steamed samples significant variation was noted between P_3C_2 and P_3C_4 (soaked samples) but Ca loss between P_3C_1 and P_3C_3 was not significant. Ca loss between soaked and unsoaked sample was not significant (P_3C_2 and P_3C_4). Among cooked greengram, no significant variation was noted between P_3C_5 and boiled samples (P_3C_1 and P_3C_2) in Ca loss. Variation in Ca loss of these samples when compared with steamed samples, was also significant. Comparison of P_3C_5 with P_3C_6 (roasted) P_3C_4 (fried) and P_3C_8 (Micro oven cooked) did not show any significant retention of Ca in greengram. Similar observation was made when P_3C_4 was compared with P_3C_1 and P_3C_2. However, significant variation was not observed in P_3C_6 when compared with P_3C_3 and P_3C_4. Comparison of P_3C_7 and P_3C_8 with boiled and steamed samples did not show any significant variation in Ca loss.

Variation in Fe loss of dried samples, cooked and uncooked depicted statistically significant variation both in blackgram and greengram. Among blackgram samples cooked in water medium no significant variation in Fe loss was noted in soaked samples (P_3C_3 and P_3C_4). Maximum loss of Fe was observed in P_3C_4 (soaked and steamed). No variation in Fe content was noted between P_3C_6 and P_3C_7. When both were compared with P_3C_1 and P_3C_2 (boiled), P_3C_3, P_3C_4 and P_3C_5 (steamed and pressure cooked samples), no significant variation in Fe loss was noted in blackgram, similar results were observed in P_3C_8 (micro oven cooked). A comparison between P_3C_8 with boiled and steamed blackgram showed significant variation between P_3C_8 and P_3C_4.

In greengram samples cooked in water, significant variation in Fe loss was noted in soaked samples of (P_3C_2 and P_3C_4). Maximum loss of Fe was observed in P_3C_4 (soaked and steamed). No significant variation in Fe content was noted between P_3C_6 and P_3C_7 and when both were compared with boiled steamed and pressure cooked samples and with samples cooked in micro oven (P_3C_8). Similarly germinated greengram cooked in micro oven when compared with boiled and steamed samples revealed significant variation in Fe loss.

Mg content of both germinated greengram and blackgram were found to be improved by some of the cooking treatments. Comparison of Mg content of P_3 with cooked samples showed no statistically significant variation except in P_3C_3, and P_3C_8.

Among blackgram samples cooked in water medium, no significant variation was noted betweensoaked and unsoaked samples (P_3C_1 versus P_3C_3 and P_3C_2 and P_3C_4). Among cooked blackgram no significant variation was observed in Mg content in P_3C_5 (Pressure cooked) when compared to boiled and steamed blackgram. When compared with P_3C_6 (roasted), P_3C_7 (fried) and P_3C_8 (micro oven cooked blackgram) significant retention of Mg was observed in P_3C_5.

Comparison of P_3C_6 with P_3C_7 did not show any significant variation in Mg in blackgram but with P_3C_8 significant Mg retention was observed. Among cooked samples, maximum loss of Mg was observed in P_3C_8 which showed significant reduction when compared with other cooked blackgram samples.

Comparison of Mg loss in germinated greengram with cooked samples depicted significant variation in cooked sample except with P_3C_3, P_3C_4 and P_3C_8. Among cooked samples, maximum loss of Mg was observed in P_3C_2 which showed significant reduction when compared to P_3C_4. No significant variation in Mg loss was observed between P_3C_1 and P_3C_3 greengram samples.

Comparison of P_3C_5 (pressure cooked) with boiled and steamed blackgram samples showed significant loss except with P_3C_4 (soaked and steamed). No significant reduction was observed when P_3C_3 (pressure cooked) was compared with P_3C_6 (roasted) and

P_3C_7 (fried) samples of blackgram. Between P_3C_5 and P_3C_8 (micro oven cooked) significant variation was observed in Mg loss.

Comparison of samples of P_3C_6 and P_3C_7 with Black gram samples cooked in water media, statistically significant variation in Mg loss was observed in P_3C_1, P_3C_2 and P_3C_3. Variation in Mg loss in P_3C_8 (micro oven cooked), when compared to boiled and steamed blackgram samples (P_3C_1 and P_3C_2) was significant.

Mn content in cooked and germinated sample was found to be less than that of uncooked, germinated samples. But statistical treatment of data revealed no significant variation in Mn content in both greengram and blackgram among cooked samples.

Zn concentration of germinated pulses were found to be reduced by cooked treatment in both blackgram and greengram.

Among boiled and steamed blackgram samples significant variation was noted between P_3C_2 (soaked and boiled) and P_3C_4 (soaked and steamed). Variation in Zn loss was noted in soaked and boiled sample when compared with P_3C_1 (unsoaked and boiled). However, no such loss of Zn was found when the soaked sample was steam cooked.

P_3C_5 (pressure cooked) showed a significant retention of Zn, only with P_3C_2 (boiled sample) when compared with boiled and steamed blackgram samples. Significant retention of Zn in P_3C_5 was noted when compared with P_3C_7 (fried) and P_3C_8 (micro oven cooked). Maximum loss of Zn in blackgram was observed in the sample cooked by micro oven. In fact loss in micro oven cooked sample was significant when compared with other cooked blackgram samples except P_3C_7 (fried). Loss in Zn in P_3C_6 (roasted) showed no significant variation except P_3C_2 when compared with blackgram samples cooked in water medium while in fried blackgram (P_3C_7) Zn loss was significantly varying when compared to samples cooked in water media.

In greengram samples loss of Zn content was not significant in cooked samples when compared with germinated sample except in P_3C_2 (soaked and boiled) in which Zn loss was maximum. Between boiled and steamed greengram significant variation was noted between P_3C_2 (soaked and boiled) and P_3C_4 (soaked and steamed). However no such variation was found between the two unsoaked samples on which the same cooking techniques were administered. Between soaked and unsoaked samples significant retention of Zn was observed in P_3C_6 (boiled), when compared with P_3C_2 (soaked and boiled) while no such variation was observed in steamed samples.

Variation in Zn retention in greengram was significant in P_3C_5 (pressure cooked) only with P_3C_2 (soaked and boiled) when compared to boiled and steamed samples. Similarly no significant retention in Zn content was observed in P_3C_3 (pressure cooked) when compared with P_3C_1 (roasted), P_3C_7 (fried) and P_3C_8 (micro oven cooked) greengram samples.

P_3C_6, P_3C_7 and P_3C_8 were compared with samples cooked in water media and statistically significant variation in Zn loss were not depicted by these samples except with P_3C_2 (soaked and boiled). Statistically significant variation was not observed in Zn loss in P_3C_6 with P_3C_7 (fried) and P_3C_8 (micro oven cooked). Similar observations were made when a comparison between P_3C_7 and P_3C_8 was made.

Loss of Cu content in cooked blackgram and greengram observed on comparison with germinated uncooked pulses. Loss of Cu in blackgram was significant in all the cooked sample except in P_3C_1 (boiled), P_3C_4 (soaked and boiled), P_3C_5 (pressure cooked) and P_3C_6 (roasted). Among samples cooked in water media no statistically significant variation in Cu loss was observed.

Similar results could be observed among roasted (P_3C_6), fried (P_3C_7) and micro oven cooked (P_3C_8) blackgram samples. However as when these sample were compared with the blackgram samples cooked in water media, statistically significant variations were not observed.

Among cooked samples loss of Cu was significant in P_3C_4 when compared with P_3C_2 but not in P_3C_3 with P_3C_1.

No significant loss in Cu was observed between soaked and unsoaked greengram samples.

P_3C_3 showed significant loss in Ca when compared with boiled (P_3C_1, P_3C_2) greengram. However, with steamed (P_3C_2 and P_3C_4) samples, significant variation were not found. When P_3C_5 (pressure cooked) was compared with P_3C_6 and P_3C_7 significant retention in Cu was observed in P_3C_5 but with P_3C_8 no significant variation was observed in this regard. Similarly variation between P_3C_6 (roasted) and P_3C_7 (fried) no variation was noted in Cu loss.

Samples like P_3C_6 and P_3C_7 when compared with the samples cooked in water media significant loss of Cu was observed. P_3C_8 also showed significant loss when compared with boiled samples in Cu content in greengram.

All the cooking treatments reduced the mineral concentration of germinated blackgram and greengram, except Mg which was higher in blackgram samples cooked under pressure and boiled greengram (sample). Cooking losses of nutrients of germinated greengram and blackgram were 5-15 per cent, over and above the losses observed during germination (Rao and Deosthale, 1983).

Among cooking methods, boiling by absorption method was found to have minimum loss of minerals, except Mg for which the minimum loss was observed for steamed samples in greengram and blackgram. This may be due to absorption during steaming and prevention of leaching out of minerals through water.

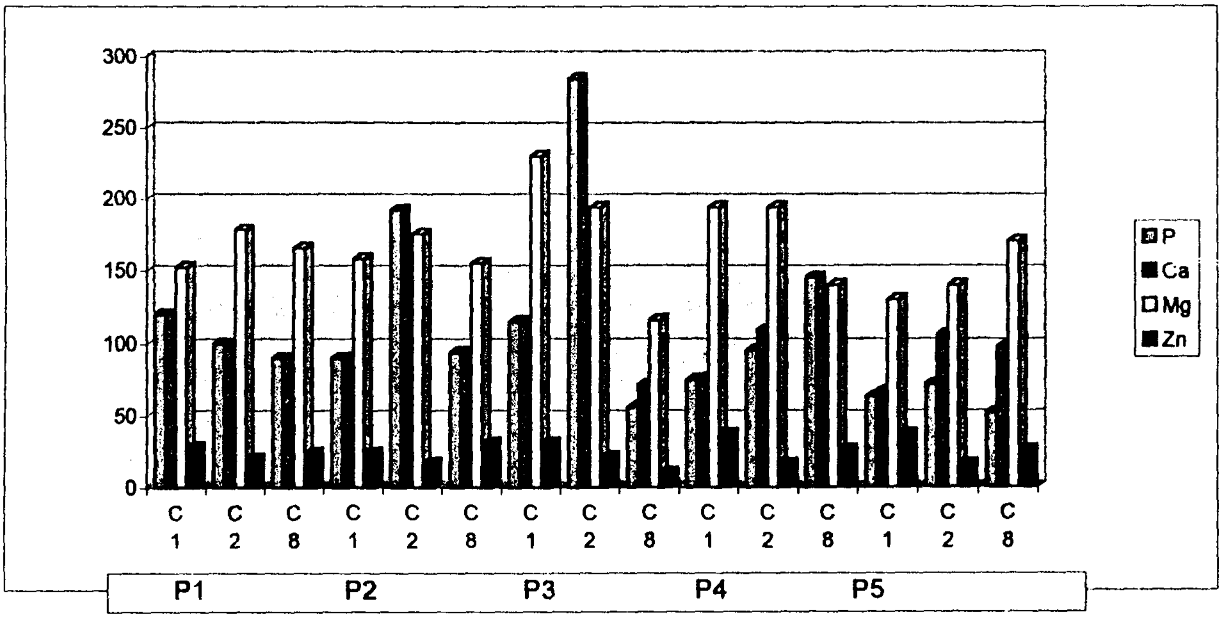
Soaking greengram and blackgram for three hours in water and cooking helped significantly to retain P when compared to other cooking methods, while soaking and steaming reduced Ca and Fe significantly, in both the pulses. Similarly, in greengram, soaked samples either boiled or steamed and fried samples, showed maximum loss of minerals such as Ca, Fe, Mg, Mn, Zn and Cu. This may be due to the leaching of minerals in water during soaking. Rao and Deosthale (1983) have also reported that seed coat of greengram and blackgram gets disrupted during soaking and the cotyledons of the grains are exposed and loss of total P occurred during overnight soaking.

Maximum loss of minerals such as P, Mg, Mn, Zn and Cu were observed in micro oven cooked blackgram samples while cooking in water media retained maximum amount of Mg, Mn, Zn and Cu in both the pulses (Figure 3 & 4).

Significant variation in P, Ca and Zn level was observed between roasted and fried samples in blackgram, while no such variation was observed in greengram.

Fig. 3

EFFECT OF SELECTED COOKING TREATMENTS ON MINARAL STATUS OF FRESH &PROCESSED BLACKGRAM



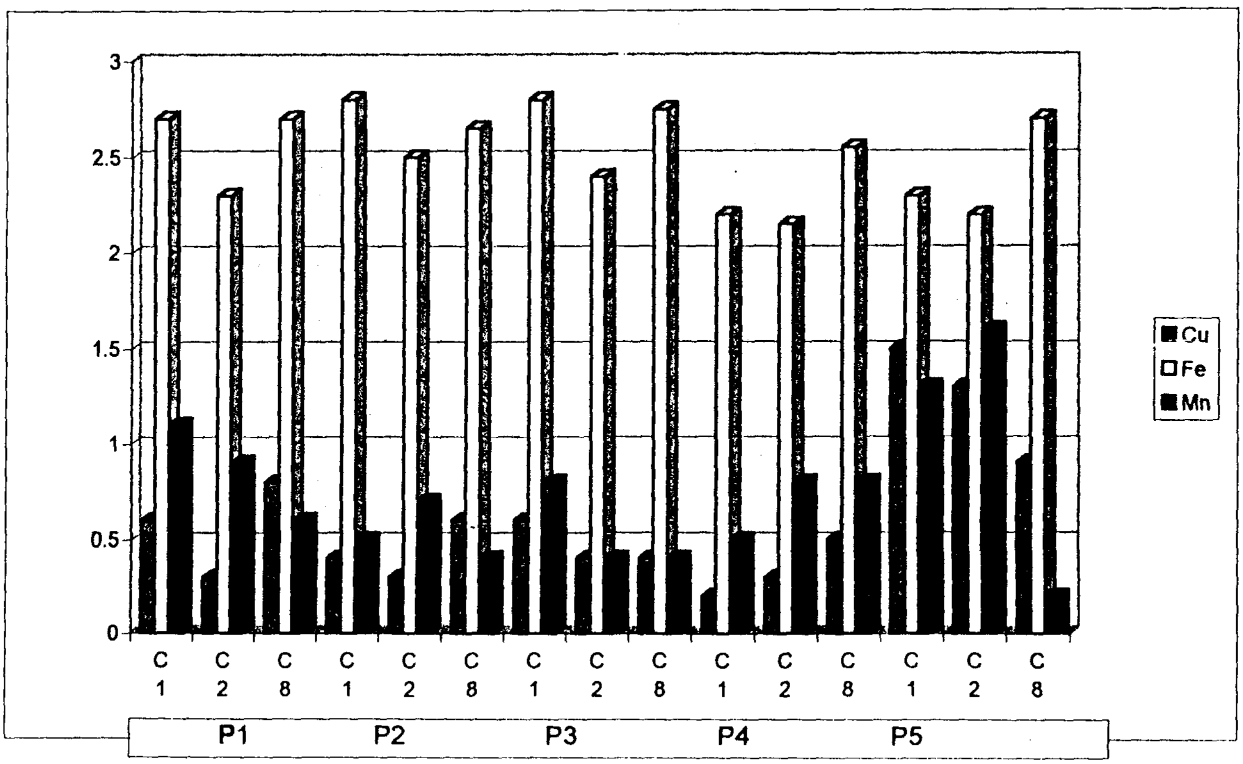
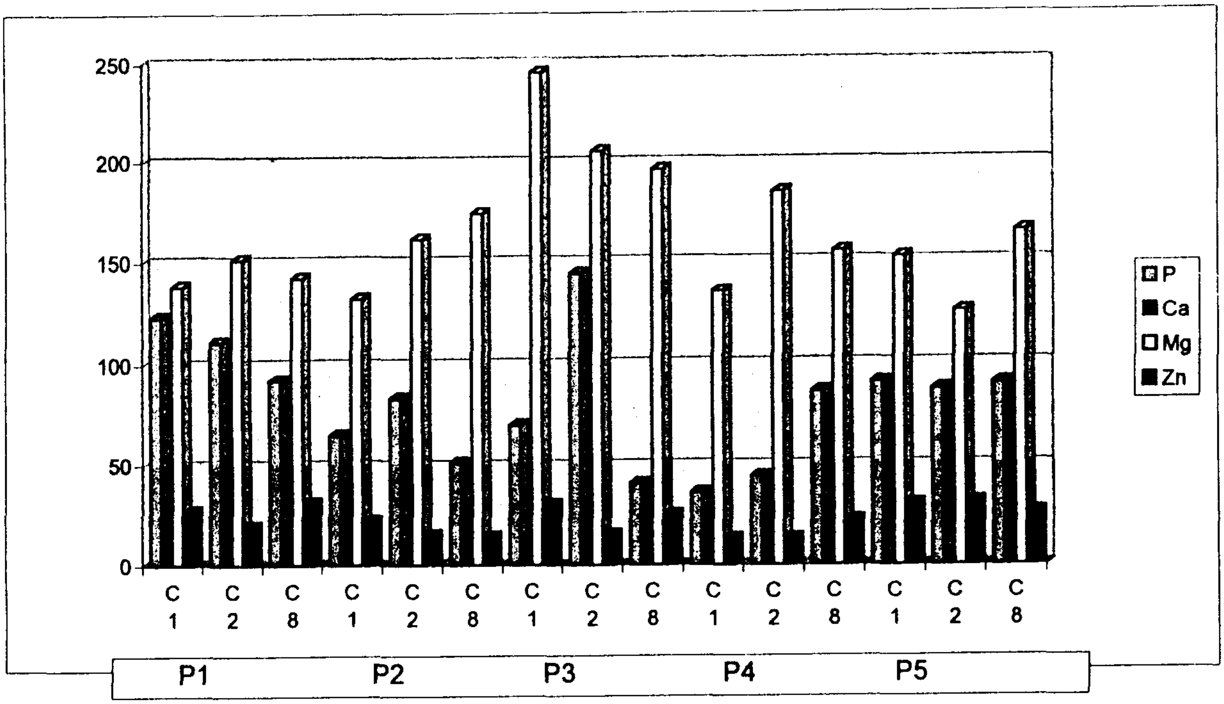
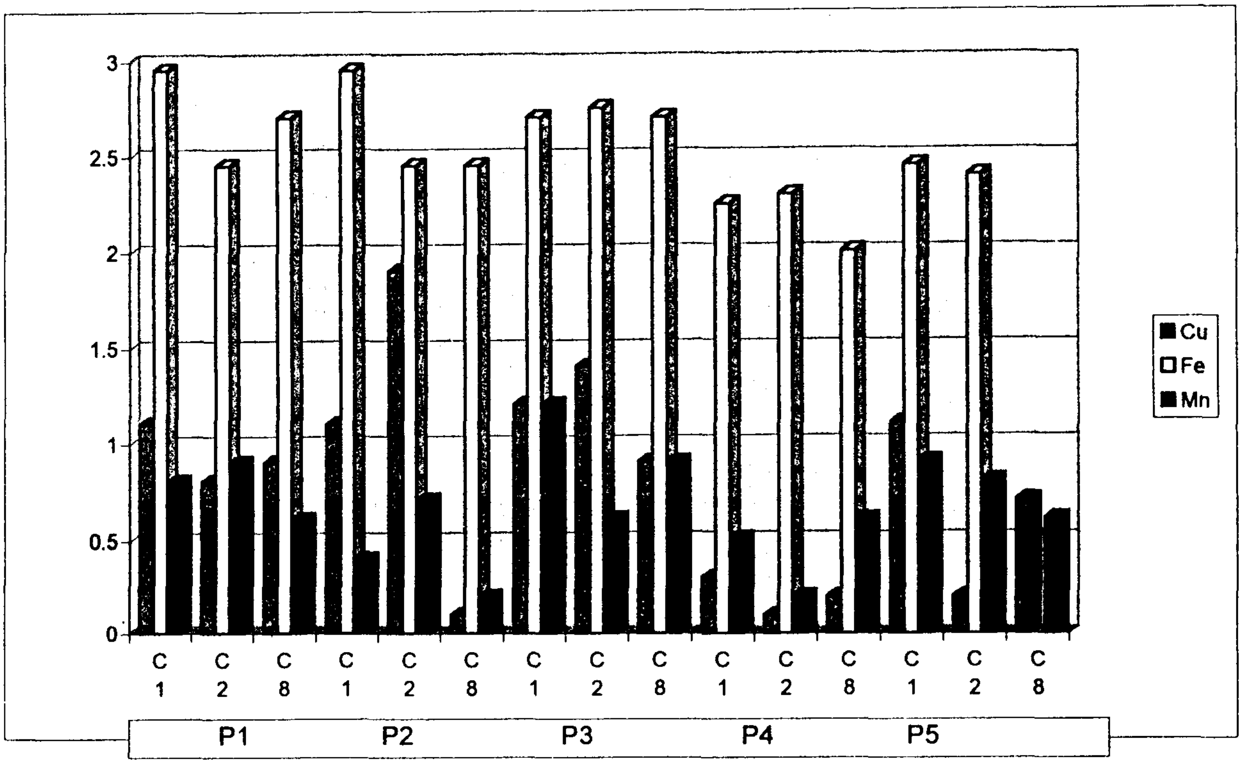


Fig. 4

EFFECT OF SELECTED COOKING TREATMENTS ON MINERAL STATUS OF FRESH & PROCESSED GREENGRAM





4.3.4 Influence of cooking treatments on the mineral profile of pulses pretreated for loosening the outer husk (Table 10 and 11 and Appendix II)

P content in cooked pulses were found to be reduced when compared to the raw samples in greengram and blackgram. Variations in the mineral content of these two samples (cooked and uncooked) were found to be statistically significant. Among cooked samples significant variation in P loss was observed between boiled and steamed blackgram samples (P_4C_1 with P_4C_3 and P_4C_2 with P_4C_4). Significant retention of P in soaked samples were also observed when compared with unsoaked samples.

Among cooked samples minimum loss of P was observed in P_4C_5 (pressure cooked) the variation which was significant with all other cooked samples of greengram. Among P_2C_6 (roasted greengram) P_2C_7 (fried) and P_2C_8 (micro oven cooked) of greengram samples, significant retention of P content in P_4C_6 and P_4C_7 were noted when compared with P_4C_8. While no significant variation in P loss were noted between P_4C_6 and P_4C_7. Comparison of P_4C_6 and P_4C_7 with greengram samples cooked in water media depicted significant variation. Similar observations were also made for P_4C_8, when compared with greengram cooked in water media in their P loss.

Table 10 Effect of cooking treatments on mineral profile of loosened blackgram

Cooking treatments	Mg/100g					ug/g	
	P	Ca	Fe	Mg	Mn	Zn	Cu
P4	415.00 ± 21.70 (5.20)	160.00 ± 26.00 (1.30)	3.40 ± 0.09 (2.60)	194.50 ± 4.90 (2.50)	2.60 ± 0.17 (6.50)	43.10 ± 0.97 (2.30)	0.70 ± 0.12 (17.10)
P4C1	75.00 ± 05.00 (6.00)	76.00 ± 03.00 (3.90)	2.25 ± 0.07 (3.10)	194.30 ± 3.00 (1.50)	0.50 ± 0.00 (0.00)	37.10 ± 0.40 (10.80)	0.20 ± 0.00 (0.00)
P4C2	95.00 ± 03.00 (3.10)	109.50 ± 03.50 (3.10)	2.15 ± 0.15 (2.30)	194.00 ± 3.00 (1.50)	0.80 ± 0.01 (1.20)	16.05 ± 0.05 (0.30)	0.30 ± 0.10 (7.70)
P4C3	45.00 ± 03.00 (6.60)	47.00 ± 00.20 (4.20)	2.55 ± 0.16 (6.20)	156.00 ± 5.00 (3.20)	0.70 ± 0.10 (14.00)	12.20 ± 0.15 (1.20)	0.70 ± 0.01 (1.40)
P4C4	55.50 ± 02.00 (3.60)	50.50 ± 01.00 (1.90)	2.25 ± 0.08 (3.50)	170.00 ± 4.00 (2.30)	0.71 ± 0.10 (14.00)	27.10 ± 0.10 (10.40)	0.40 ± 0.00 (0.00)
P4C5	88.00 ± 03.00 (3.40)	58.50 ± 01.00 (1.60)	2.55 ± 0.05 (1.90)	135.00 ± 7.00 (5.10)	1.10 ± 0.10 (9.00)	18.30 ± 0.10 (0.50)	0.60 ± 0.10 (16.60)
P4C6	71.00 ± 01.00 (1.40)	71.00 ± 02.50 (3.50)	2.55 ± 0.05 (1.90)	156.00 ± 9.00 (5.70)	0.80 ± 0.10 (1.20)	24.10 ± 0.15 (0.60)	0.40 ± 0.10 (7.10)
P4C7	88.20 ± 04.00 (2.20)	46.00 ± 03.50 (7.60)	2.25 ± 0.15 (6.60)	139.00 ± 6.00 (4.30)	1.00 ± 0.10 (10.00)	34.30 ± 1.00 (2.90)	0.70 ± 1.07 (0.00)
P4C8	145.00 ± 6.00 (4.10)	50.50 ± 01.50 (2.90)	2.55 ± 0.05 (1.90)	140.00 ± 4.00 (2.60)	0.80 ± 0.10 (12.50)	26.10 ± 0.15 (0.60)	0.50 ± 0.00 (0.00)
CD	8.17	13.95	0.47	36.00		8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P4	P4C8	P4C2	P4C5	P4C7	P4C1	P4C6	P4C4	P4C3
Ca	P4	P4C2	P4C1	P4C6	P4C5	P4C4	P4C8	P4C3	P4C7
Fe	P4	P4C3	P4C5	P4C6	P4C8	P4C1	P4C4	P4C7	P4C2
Mg	P4	P4C1	P4C2	P4C4	P4C3	P4C6	P4C8	P4C7	P4C5
Mn	P4	P4C5	P4C7	P4C2	P4C6	P4C8	P4C3	P4C4	P4C1
Zn	P4	P4C1	P4C7	P4C4	P4C8	P4C6	P4C5	P4C2	P4C3
Cu	P4	P4C3	P4C7	P4C5	P4C8	P4C4	P4C6	P4C2	P4C1

Table 11 Effect of cooking treatments on mineral profile of loosend greengram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P4	389.00 ± 8.00 (2.00)	110.00 ± 8.50 (7.70)	3.75 ± 0.09 (2.40)	195.00 ± 1.50 (7.60)	1.30 ± 0.06 (4.60)	33.00 ± 0.08 (2.40)	1.70 ± 0.07 (3.80)
P4C1	36.00 ± 0.50 (11.00)	27.50 ± 0.50 (1.00)	2.25 ± 0.05 (2.20)	135.00 ± 5.00 (3.70)	0.50 ± 0.10 (20.00)	13.00 ± 1.00 (7.60)	0.30 ± 0.00 (0.00)
P4C2	44.00 ± 0.70 (2.00)	34.50 ± 1.50 (4.00)	2.30 ± 0.60 (2.60)	185.00 ± 6.10 (3.20)	0.20 ± 0.01 (5.00)	13.00 ± 0.50 (3.80)	0.10 ± 0.01 (10.00)
P4C3	50.00 ± 0.50 (1.00)	34.50 ± 0.60 (1.00)	2.40 ± 0.10 (4.10)	160.00 ± 8.00 (5.00)	0.50 ± 0.03 (6.00)	29.10 ± 0.10 (0.34)	0.70 ± 0.10 (14.00)
P4C4	57.50 ± 0.50 (1.00)	33.50 ± 0.50 (1.00)	2.05 ± 0.05 (2.40)	190.00 ±10.00 (5.20)	0.90 ± 0.02 (2.00)	32.90 ± 1.00 (3.00)	0.80 ± 0.05 (6.00)
P4C5	105.00 ± 3.50 (3.00)	37.50 ± 1.00 (2.00)	2.40 ± 0.10 (4.10)	149.00 ± 3.00 (2.00)	0.50 ± 0.02 (4.00)	27.00 ± 2.10 (7.00)	1.20 ± 0.10 (8.00)
P4C6	93.00 ± 1.50 (1.00)	37.50 ± 0.50 (1.00)	1.95 ± 0.05 (2.50)	123.00 ± 4.00 (3.20)	0.80 ± 0.01 (1.20)	28.00 ± 0.50 (1.70)	0.40 ± 0.01 (2.50)
P4C7	95.00 ± 2.10 (2.00)	29.50 ± 1.50 (5.00)	2.10 ± 0.05 (2.30)	170.00 ± 8.00 (4.70)	0.60 ± 0.01 (1.60)	28.00 ± 1.00 (3.50)	0.70 ± 0.10 (14.00)
P4C8	80.00 ± 3.00 (3.00)	39.50 ± 1.50 (3.70)	2.00 ± 0.05 (2.50)	155.00 ± 6.00 (3.80)	0.60 ± 0.01 (1.60)	22.00 ± 1.50 (6.80)	0.20 ± 0.00 (0.00)
CD	8.17	13.95	0.47	36.00		8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P4	P4C5	P4C7	P4C6	P4C8	P4C4	P4C3	P4C2	P4C1
Ca	P4	P4C8	P4C5	P4C6	P4C2	P4C3	P4C4	P4C7	P4C1
Fe	P4	P4C3	P4C5	P4C2	P4C1	P4C7	P4C8	P4C4	P4C6
Mg	P4	P4C4	P4C2	P4C7	P4C3	P4C8	P4C5	P4C1	P4C6
Mn	P4	P4C4	P4C6	P4C7	P4C8	P4C3	P4C5	P4C1	P4C2
Zn	P4	P4C4	P4C3	P4C6	P4C7	P4C5	P4C8	P4C1	P4C2
Cu	P4	P4C5	P4C4	P4C3	P4C6	P4C7	P4C1	P4C8	P4C2

Comparison of Ca in cooked samples with uncooked pulses which were partly dehusked depicted significant loss both in blackgram and greengram. In greengram among cooked samples, no significant variation was noted between boiled and steamed samples (P_4C_1, P_4C_2, P_4C_3 and P_4C_4).

No significant variation in Ca loss was also observed in P_4C_5 and P_4C_6 when these two samples were compared with boiled and steamed greengram samples.

Similar observations were also made with P_4C_7 and P_4C_8 on comparison with P_4C_5 and P_4C_6. No significant retention of Ca was observed in P_4C_7 and P_4C_8 when compared with samples cooked in water media. No statistically significant variation in Ca retention was observed between P_4C_7 and P_4C_8.

In blackgram, among cooked samples, retention of Ca was significant in boiled samples (P_4C_1 and P_4C_2) when compared with steamed samples (P_4C_3 and P_4C_4). Between soaked and unsoaked blackgram samples, significant variation in Ca loss was noted between P_4C_1 and P_4C_2 while variation in Ca loss was not significant between P_4C_3 and P_4C_4. Significant loss of Ca was observed in P_4C_5 when compared with boiled blackgram samples (P_4C_1 and P_4C_2). But with steamed samples (P_3C_3 and P_3C_4) variation in Ca loss was not significant.

In blackgram, significant retention of Ca was observed in P_4C_6 when compared with P_4C_7 and P_4C_8. While no such significant variation was noted between P_4C_7 and P_4C_8. Comparison of variation in Ca content of P_4C_6 with boiled and steamed samples depicted significant variation except with P_4C_1. P_4C_7 and P_4C_8 depicted significant loss of Ca content when compared with boiled samples, (P_4C_1 and P_4C_2) of blackgram however, with steamed samples (P_4C_3 and P_4C_4) the variation was not significant.

Fe content in blackgram and greengram was reduced by all the cooking treatments. Statistical treatment of the data revealed significant loss of Fe in blackgram and greengram by cooking treatments when compared to outer husk loosened pulses.

In blackgram, among cooking treatments, no significant variation in loss of Fe was observed. Fe in P_4C_5 (samples cooked under pressure) when compared with boiled and steamed blackgram samples, no significant retention in Fe content was observed. Maximum loss of Fe among cooked samples in blackgram was observed in P_4C_2. Statistically significant variation was not observed in P_4C_6 with sample cooked in water media as well as with P_4C_7 and P_4C_8 samples.

Comparison of P_4C_7 and P_4C_8 with samples cooked in water media also depicted no significant variation, in P_4C_7 and P_4C_8.

In the case of greengram, among samples cooked in water media, no significant variation in Fe retention was observed.

Among P_4C_6 (roasted), P_4C_7 (fried) and P_4C_8 (micro oven cooked) greengram samples no statistically significant retention of Fe was observed. Comparison of P_4C_6, P_4C_7 and P_4C_8 with samples cooked in water media depicted no significant variation in Fe loss.

The Mg content of loosened pulses (P_3) was found to be retained in certain cooking methods. In blackgram, comparison of Mg content in loosened pulses with cooked pulse samples showed significant retention only with P_4C_5, P_4C_7 and P_4C_8.

Among cooked blackgram, no significant retention in Mg was observed between boiled and steamed samples. Similar observations were also made between soaked and unsoaked pulses irrespective of the cooking techniques applied.

Maximum loss of Mg was observed in P_4C_5 which showed significant loss when compared with boiled and steamed samples (P_4C_1, P_4C_2 and P_4C_3) except with P_4C_4.

Among samples cooked in other media no significant variation in Mg loss was observed.

Comparison of P_4C_6, P_4C_7 and P_4C_8 with samples cooked in water media revealed, significant loss of Mg in P_4C_1, P_4C_2 and P_4C_3.

Among cooked samples of greengram no significant retention of Mg was observed between boiled and steamed samples (P_4C_1 with P_4C_3 and P_4C_2 with P_4C_4). Between soaked and unsoaked samples significant retention was observed in P_4C_2 with P_4C_1, while no such significant variation was observed in P_4C_4. Comparison of P_4C_5 with boiled and steamed greengram samples significant reduction in Mg was depicted with soaked samples (P_4C_2 and P_4C_4). Maximum loss of Mg among cooked samples was observed in P_4C_6 and the loss was significant when compared with samples cooked in water media except P_4C_1 and P_4C_5. When compared with P_4C_7 (fried) and P_4C_8 (micro oven cooked) significant loss of Mg was observed in P_4C_7. The loss of Mg content in P_4C_8 was not significant when compared to P_4C_7. With samples cooked in water media no significant retention of Mg was observed in P_4C_7. Similar observation was also made in P_4C_8 when compared with samples cooked in water media.

Mn loss from loosened greengram and blackgram was observed on comparison with the same sample after cooking. In blackgram the Mn loss was minimum in P_4C_1 and in P_4C_2 in greengram. While the statistical treatment of the data revealed no significant variation in Mn content among cooked samples in blackgram as well as in greengram.

The concentration of Zn in both the pulses was found to be reduced by the cooking treatments. In blackgram loss of Zn in cooked samples is significant when compared with P_3 (loosened pulses) except in the case of P_4C_1 (boiled).

Among cooked samples in blackgram, significant retention of Zn was observed in P_4C_1 and P_4C_4 among boiled and steamed samples. When compared with boiled and steamed samples of blackgram loss of Zn in P_4C_5 was significantly high when compared to P_4C_1 and P_4C_4. Among P_4C_6 (roasted), P_4C_7 (fried) and P_4C_8 (microoven cooked) samples significant retention of Zn was observed in P_4C_7 when compared to P_4C_6 and P_4C_8. A comparison of the samples cooked in water media revealed significant retention of Zn in P_4C_7 except with P_4C_4. Loss of Zn in blackgram in P_4C_8 was significant with that of samples cooked in water media except in the case of P_4C_4 and P_4C_5. In greengram among cooked samples significant retention of Zn was noted in steamed samples when compared with boiled greengram (P_4C_1 with P_4C_3 and P_4C_2 with P_4C_4) while variation in Zn loss was not significant between soaked and unsoaked samples. When compared with boiled and steamed samples, retention of Zn in P_4C_5 was significant with boiled greengram (P_4C_1 and P_4C_2) samples. Variations within samples like P_4C_6, P_4C_7 and P_4C_8 were not found to be significant. Among P_4C_6 (roasted), P_4C_7 (fried) and P_4C_8 (micro oven cooked) greengram samples also, no significant variation in Zn content was noted.

When samples cooked in water media were compared, Mg retention was significantly higher in P_4C_1 and P_4C_3 than in P_4C_2 and P_4C_4 respectively.

Cu concentration among cooked samples in greengram as well as in blackgram were found to be decreased when compared with P_4 (loosened pulses). Among cooked samples in blackgram, loss of Cu was significant in P_4C_1, among steamed samples. In this respect no significant variation was noted between soaked and unsoaked samples. Variation in Cu loss of P_4C_5 and boiled and steamed samples was not significant except in the case of P_4C_1.

Among P_4C_6 (roasted), P_4C_7 (fried) and P_4C_8 (cooked in micro oven) samples, no significant variation was noted. Comparison of these samples with samples cooked in water media depicted no significant variation in Cu content in blackgram.

In greengram maximum loss of Cu was observed in P_4C_2 and P_4C_8. Significant retention of Cu in loosened raw pulses was observed when compared with cooked samples. Among cooked samples significant retention of Cu was observed in steamed (P_4C_3 and P_4C_4) greengram on comparison with boiled samples. But variation was not significant between soaked and unsoaked samples. P_4C_5 (pressure cooked) retained the maximum amount of Cu among cooked samples in which the retention was significant when compared with all other cooked greengram samples. Among

Between boiled and steamed samples significant variation in P, Ca and Zn was observed in blackgram and P and Zn in greengram. In greengram maximum loss of P, Ca, Mn, Zn and Cu was observed in boiled samples, while in blackgram loss of Fe, Zn and Cu was observed in boiled samples. This may be due to the leaching of solids in water during cooking.

4.3.5 Influence of cooking treatments on mineral profile of splitted and dehusked pulses (Tables 10 and 11)

P content in split and dehusked samples of blackgram and greengram were found to be reduced by all the cooking treatments applied.

In blackgram, comparison of P in P_5 with the P in all other cooked samples depicted significant variation.

Among samples cooked in water media , significant retention of P was observed in P_5C_4, when compared to other boiled and steamed samples. Between soaked and unsoaked samples, significant variation in P loss was noted both in boiled and steamed samples (P_5C_1 with P_5C_2 and P_5C_3 with P_5C_4).

P_5C_5 when compared with boiled and steamed samples, variation in P content was found to be significant with P_5C_4. Significant retention of P was observed in P_5C_5 when compared with P_5C_7 (fried blackgram) and P_5C_8 (micro oven cooked)

When samples cooked in water media were compared, Mg retention was significantly higher in P_4C_1 and P_4C_3 than in P_4C_2 and P_4C_4 respectively.

Cu concentration among cooked samples in greengram as well as in blackgram were found to be decreased when compared with P_4 (loosened pulses). Among cooked samples in blackgram, loss of Cu was significant in P_4C_1, among steamed samples. In this respect no significant variation was noted between soaked and unsoaked samples. Variation in Cu loss of P_4C_5 and boiled and steamed samples was not significant except in the case of P_4C_1.

Among P_4C_6 (roasted), P_4C_7 (fried) and P_4C_8 (cooked in micro oven) samples, no significant variation was noted. Comparison of these samples with samples cooked in water media depicted no significant variation in Cu content in blackgram.

In greengram maximum loss of Cu was observed in P_4C_2 and P_4C_8. Significant retention of Cu in loosened raw pulses was observed when compared with cooked samples. Among cooked samples significant retention of Cu was observed in steamed (P_4C_3 and P_4C_4) greengram on comparison with boiled samples. But variation was not significant between soaked and unsoaked samples. P_4C_5 (pressure cooked) retained the maximum amount of Cu among cooked samples in which the retention was significant when compared with all other cooked greengram samples. Among

P_4C_6, P_4C_7 and P_4C_8 significant variation was noted between P_4C_7 and P_4C_8. Variation in loss of Cu in greengram sample P_4C_6 with steamed sample were found to be significant Cu loss in P_4C_7 was also significant with boiled sample (P_4C_1 and P_4C_2). Cu loss in P_4C_8 was significant when compared to all the other cooked samples except boiled greengram samples.

All the cooking treatments were found to reduce all the mineral contents of loosened blackgram and greengram. Attia et al., (1994) reported that decortication and cooking of pulses resulted in considerable losses of Ca, Zn, Mn, K and ash contents. Among outer husk removed pulses, minimum loss of minerals such as Fe, Mg, Mn, Zn and Cu was found due to cooking in water media.

In blackgram significant retention of P was observed in soaked samples, compared to unsoaked samples, while in greengram no such observations were made. However, soaked sample of greengram as well as blackgram significantly retained Mg. In both pulses no significant variation among samples cooked in water media was observed for the Fe and Mn content.

Among cooked blackgram samples, no significant variation in Fe, Mg, Mn and Cu was observed between roasted, fried and micro oven cooked samples, while in greengram such observations were made for Ca, Fe, Mn and Zn.

Between boiled and steamed samples significant variation in P, Ca and Zn was observed in blackgram and P and Zn in greengram. In greengram maximum loss of P, Ca, Mn, Zn and Cu was observed in boiled samples, while in blackgram loss of Fe, Zn and Cu was observed in boiled samples. This may be due to the leaching of solids in water during cooking.

4.3.5 Influence of cooking treatments on mineral profile of splitted and dehusked pulses (Tables 10 and 11)

P content in split and dehusked samples of blackgram and greengram were found to be reduced by all the cooking treatments applied.

In blackgram, comparison of P in P_5 with the P in all other cooked samples depicted significant variation.

Among samples cooked in water media , significant retention of P was observed in P_5C_4, when compared to other boiled and steamed samples. Between soaked and unsoaked samples, significant variation in P loss was noted both in boiled and steamed samples (P_5C_1 with P_5C_2 and P_5C_3 with P_5C_4).

P_5C_5 when compared with boiled and steamed samples, variation in P content was found to be significant with P_5C_4. Significant retention of P was observed in P_5C_5 when compared with P_5C_7 (fried blackgram) and P_5C_8 (micro oven cooked)

Table 12 Effect of cooking treatments on mineral profile of split and dehusked blackgram

Cooking treatments	Mg/100g				ug/g		
	P	Ca	Fe	Mg	Mn	Zn	Cu
P5	410.00 ± 27.00 (6.50)	149.00 ± 3.10 (5.40)	3.35 ± 0.12 (3.58)	189.00 ± 17.00 (8.00)	1.90 ± 0.16 (8.00)	42.00 ± 1.00 (16.00)	0.60 ± 0.12 (20.00)
P5C1	63.00 ± 03.00 (4.80)	67.00 ± 3.00 (4.50)	2.34 ± 0.10 (4.30)	130.00 ± 04.00 (3.10)	1.30 ± 0.10 (7.70)	37.00 ± 2.50 (6.80)	1.50 ± 0.01 (2.00)
P5C2	72.00 ± 02.00 (2.80)	106.50 ± 5.00 (4.70)	2.25 ± 0.15 (6.70)	140.00 ± 05.00 (3.60)	1.00 ± 0.11 (11.00)	16.00 ± 2.00 (12.50)	1.30 ± 0.10 (7.70)
P5C3	64.50 ± 01.50 (2.80)	46.50 ± 1.50 (3.20)	2.20 ± 0.15 (6.80)	130.00 ± 03.00 (2.30)	0.90 ± 0.09 (10.0)	12.00 ± 1.00 (8.30)	1.20 ± 0.10 (8.30)
P5C4	92.50 ± 03.20 (3.50)	60.00 ± 3.00 (5.00)	2.45 ± 0.20 (8.20)	140.00 ± 02.50 (1.80)	0.70 ± 0.02 (2.90)	27.00 ± 2.00 (7.40)	1.50 ± 0.10 (6.70)
P5C5	17.50 ± 01.40 (1.90)	89.50 ± 2.50 (2.80)	2.35 ± 0.15 (6.40)	200.00 ± 05.50 (2.75)	1.50 ± 0.20 (13.30)	18.00 ± 1.50 (8.30)	0.80 ± 0.10 (12.50)
P5C6	71.50 ± 03.40 (4.80)	110.00 ± 5.00 (4.50)	2.15 ± 0.10 (4.00)	225.00 ± 05.50 (2.40)	0.90 ± 0.01 (1.10)	24.00 ± 1.20 (5.00)	1.30 ± 0.01 (7.70)
P5C7	44.50 ± 02.50 (5.60)	100.00 ± 5.50 (5.50)	2.40 ± 0.10 (4.20)	189.00 ± 05.50 (2.90)	0.90 ± 0.02 (2.20)	34.00 ± 2.00 (5.80)	1.10 ± 0.10 (9.09)
P5C8	52.00 ± 02.10 (4.03)	98.50 ± 1.50 (55.60)	2.70 ± 0.15 (5.60)	170.00 ± 03.00 (1.80)	0.20 ± 0.10 (5.00)	26.00 ± 2.00 (7.70)	0.90 ± 0.10 (11.10)
CD	8.17	13.95	0.47	36.00		8.00	0.30

Figures in paranthesis indicate per cent coefficient variation

P	P5	P5C4	P5C2	P5C6	P5C5	P5C3	P5C1	P5C8	P5C7
Ca	P5	P5C6	P5C2	P5C7	P5C8	P5C5	P5C1	P5C4	P5C3
Fe	P5	P5C8	P5C6	P5C4	P5C1	P5C7	P5C5	P5C2	P5C3
Mg	P5	P5C6	P5C5	P5C7	P5C8	P5C2	P5C4	P5C1	P5C3
Mn	P5	P5C5	P5C1	P5C2	P5C3	P5C6	P5C7	P5C4	P5C2
Zn	P5	P5C1	P5C7	P5C4	P5C8	P5C6	P5C5	P5C2	P5C3
Cu	P5	P5C1	P5C4	P5C2	P5C6	P5C3	P5C7	P5C8	P5C5

blackgram samples. With P_5C_6 no significant variation in P was noted. Significant loss of P was noted in P_5C_6 when compared to P_5C_4 among steamed and boiled samples. Comparison of P_5C_7 and P_5C_8 with samples cooked in water media, revealed significant variation in P loss.

In greengram among boiled and steamed samples, variation in loss of P content was noted between P_5C_2 and P_5C_4. But no such variation was observed between P_5C_1 and P_5C_3. Between soaked and unsoaked samples, retention in P content was significantly higher in P_5C_3 when compared to P_5C_4.

The loss of P among cooked samples was minimum in P_5C_5 followed by P_5C_6. Both these samples showed significant retention of P, on comparison with all other cooked samples except P_5C_6 with P_5C_4, while no significant variation was noted between P_5C_5 and P_5C_6.

Between P_5C_7 (fried) and P_5C_8 (micro oven cooked), no significant variation in P content was noted in greengram. Similarly no significant retention in P was noted in P_5C_7 and P_5C_8 when compared with P_5C_1, P_5C_2 and P_5C_3, but significant loss was observed with P_5C_4 in greengram.

Ca content of split and dehusked samples of greengram and blackgram were found to reduce when the samples were cooked.

Statistical treatment of the data revealed significant loss of Ca in cooked samples of blackgram.

Comparison between boiled and steamed samples of blackgram depicted significant variation in Ca loss between P_5C_1 and P_5C_3 and P_5C_2 and P_5C_4.

Between soaked and unsoaked samples also, statistically significant variation in the Ca content was noted in boiled and steamed blackgram.

Comparison of variation in loss of Ca in P_5C_5 with samples such as boiled, steamed and roasted, fried and micro oven cooked blackgram, depicted significant variation.

Minimum loss of P among cooked samples was noted in P_5C_6 followed by P_5C_2 and P_5C_7.

Significant variation in Ca was noted between P_5C_6 and P_5C_7, while variation in Ca loss between P_5C_7 and P_5C_8 was not statistically significant. When these two samples were compared with samples cooked in water media significant retention was observed with P_5C_1, P_5C_3 and P_5C_4.

In greengram among boiled and steamed samples, variation in loss of Ca was not significant while the variation in Ca loss between soaked and unsoaked samples was significant in steamed (P_5C_3 and P_5C_4) greengram samples.

Comparison of Ca content in P_5C_5 with boiled and steamed samples revealed that significant variation was found with P_5C_3.

Among P_5C_6 (roasted greengram), P_5C_7 (fried greengram) and P_5C_8 (micro oven cooked greengram) significant variation in Ca content was noted in P_5C_6 with P_5C_7 and P_5C_8. The variation of Ca loss in P_5C_7 and P_5C_8 was not statistically significant.

Comparison of Ca retention in P_5C_6 with P_5C_1 and P_5C_2 with P_5C_3 was significant among samples cooked in water media. Variation in Ca loss was significant in P_5C_7 and P_5C_8 only when compared with P_5C_7 and P_5C_6 among samples cooking in water media in greeengram.

Among split and dehusked pulses loss of Fe was found to be significant when cooked. In greengram among cooked samples, no significant variation in Fe retention was observed between boiled and steamed blackgram. Similar observation was also noted between P_5C_1 and P_5C_2, and P_5C_3 and P_5C_4 (soaked and unsoaked samples). Comparison of Fe content in the splitted and dehusked samples in cooked and uncooked form showed significant loss of Fe and due to cooking.

Statistical treatment of the data revealed significant variation in Fe loss between (P_5) fresh and cooked samples, both in greengram and blackgram. In blackgram among cooked samples, no significant retention of Fe was observed in samples cooked in water media, between boiled and steamed samples, and also between soaked and unsoaked samples.

Among blackgram samples of P_5C_6, P_5C_7 and P_5C_8, no significant variation in Fe retention was observed. When these three samples were compared with the samples cooked in water, significant variation in retention of Fe was observed in P_5C_8 alone with P_5C_3.

Similar observations were made in greengram. No significant variation in Fe retention was observed among cooked samples. When compared to greengram samples such as P_5C_1, P_5C_2, P_5C_3 and P_5C_4, loss of Fe was significant in P_5C_5 and P_5C_6 except between P_5C_6 and P_5C_4. On comparison with P_5C_7 (fried) and P_5C_8 (micro oven cooked greengram) significant variation in Fe loss was observed in P_5C_5 but not in P_5C_6.

Retention of Fe in P_5C_7 and P_5C_8 was also not significantly varying when compared with boiled (P_5C_1, P_5C_2) and steamed (P_5C_3, P_5C_4) greengram samples.

Mg content in split and dehusked samples of pulses have improved in two cooking treatments. In all other cases reduction in Mg content was observed.

In blackgram among cooked samples no significant retention of Mg was observed among boiled and steamed samples (P_5C_1 with P_5C_3 and P_5C_2 with P_5C_4). Similarly between soaked and unsoaked samples, no significant variation in Mg loss was observed.

In P_5C_5 (cooked under pressure) blackgram sample, increase in Mg content was observed though statistically not significant. When compared with boiled and steamed samples. (P_5C_1, P_5C_2, P_5C_3 and P_5C_4) significant increase in Mg content was observed. Comparison of P_5C_5 with P_5C_6, P_5C_7 and P_5C_8 revealed no statistically significant variation in blackgram. While significant variation in Mg loss was observed when a comparison of P_5C_6 with P_5C_7 and P_5C_8 was made. Similarly a comparion P_5C_6 and P_5C_7 revealed significant variation in retention of Mg when compared with P_5C_1, P_5C_2, P_5C_3 and P_5C_4. While P_5C_8 was found to show significant variation in loss of Mg with unsoaked boiled and steamed samples (P_5C_1 and P_5C_3).

In greengram significant variation in Mg was noted in cooked samples except in roasted, fried and micro oven cooked greengram.

Among cooked samples no significant retention of Mg was noted between boiled and steamed greengram samples (P_5C_1 with P_5C_3 and P_5C_2 with P_5C_4) and between soaked and unsoaked samples (P_5C_1 with P_5C_2 and P_5C_3 with P_5C_4).

Among boiled and steamed samples of greengram only with P_5C_1 variation in Mg in P_5C_5 was found significant. Comparison of P_5C_5 with P_5C_6, P_5C_7 and P_5C_8, revealed, variation in Mg retention was significant.

Among P_5C_6 (roasted), P_5C_7 (fried) and P_5C_8 (micro oven cooked), greengram samples, significant variation in Mg retention was noted between P_5C_6 with P_5C_7 and also with P_5C_8. While variation in Mg retention between P_5C_7 (fried) and P_5C_8 (micro oven cooked) was also as significant in greengram.

Comparison of Mg retention in P_5C_6 with all other cooked samples was found to be statistically significant.

A comparison of fried (P_5C_7) and micro oven cooked (P_5C_8) greengram with samples cooked in water media, revealed significant variation with P_5C_2 and P_5C_4.

Mn content in cooked samples of blackgram and greengram was found to be reduced, when compared to split and dehusked samples. Statistical treatment of the data revealed no significant retention of Mn between P_5 and cooked samples and also among cooked samples both in blackgram and greengram.

Zn concentration of split and dehusked samples was reduced by all the cooking treatments in greengram and blackgram.

Statistical treatment of the data revealed that among cooked samples of blackgram, significant retention of Zn was observed between boiled and steamed samples (P_5C_1 with P_5C_3 and P_5C_2 with P_5C_4). Between soaked and unsoaked samples (P_5C_1 with P_5C_2 and P_5C_3 with P_5C_4) also variation in Zn loss was significant.

Significant retention of Zn was observed in P_5C_5 with P_5C_1 and P_5C_4 among boiled and steamed samples. With P_5C_6, P_5C_7 and P_5C_8, significant Zn retention was observed with P_5C_7 and P_5C_8.

Among P_5C_6, P_5C_7 and P_5C_8 significant variation was noted between P_5C_6 with P_5C_7 and P_5C_7 with P_5C_8. Comparison of P_5C_6 with samples cooked in water media, revealed significant Zn retention in P_5C_1, P_5C_2 and P_5C_3. Comparison of P_5C_7 with samples cooked in water media depicted significant variation alone with P_5C_2 and when P_5C_8 was compared with samples cooked in water media significant variation in Zn retention was noted with P_5C_1, P_5C_2 and P_5C_3. In greengram, comparison of Zn content in P_5 with cooked samples of P_5 depicted significant variation only in P_5C_7.

Among cooked samples, between boiled and steamed samples significant variation in Zn retention was noted between P_5C_2 and P_5C_4. P_5C_5 when compared with boiled and steamed samples was found to have significant variation in Zn retention only with P_5C_4.

Among P_5C_6 (roated), P_5C_7 (fried) and P_5C_8 (micro oven cooked) greengram samples, significant variation in Zn retention was observed.

On comparison of P_5C_6 with samples cooked in water media, no significant variation in Zn retention was observed in greengram. While between P_5C_7 and boiled samples significant variation in Zn content was observed.

No significant retention of Zn was observed in P_5C_8 when compared with samples cooked in water media.

Cu concentration in split and dehusked samples of blackgram was improved by all the cooking treatments except boiling, while in greengram all the treatments reduced the Cu content.

In blackgram, comparison of Cu content in split and dehusked samples with cooked samples showed significant Zn retention except in P_5C_5.

Among cooked samples, between boiled and steamed samples significant retention in Cu was noted between P_5C_1 and P_5C_3. Between soaked and unsoaked samples, significant variation in Cu was noted between P_5C_3 and P_5C_4.

Blackgram sample cooked under pressure (P_5C_5) was found to show significant retention of Cu when compared with all other cooked samples except P_5C_8.

Among roasted, fried and micro oven cooked samples, significant retention of Cu was observed between P_5C_6 and P_5C_8. When these three blackgram samples were compared with samples cooked in water media, significant variation was observed between P_5C_6 with P_5C_3, P_5C_7 with P_5C_1 and also with P_5C_4 and P_5C_8 when compared with all samples cooked in water media.

In greengram comparison of cooked samples with P_5 showed significant variation with all other samples except with P_5C_1 and P_5C_5.

Among samples cooked in water media, between boiled and steamed samples significant retention was noted in P_5C_1 with P_5C_3. Between soaked and unsoaked samples significant retention of Cu was noted between P_5C_1 and P_5C_2.

Comparison of P_5C_5 with boiled and steamed samples revealed significant variation in all the samples except P_5C_1. Among roasted, fried and micro oven cooked, significant retention was observed in P_5C_6. Significant retention in Cu was also observed between P_5C_6 and P_5C_8.

When P_5C_6 and P_5C_7 were compared with samples cooked in water media, significant variation in Cu retention was noted in all the samples except in P_5C_1. While significant retention in P_5C_8 was observed with all the samples cooked in water media.

All cooking treatments reduced the mineral contents in blackgram and greengram except Mg and Cu which was found to be increased in some cooked samples. Attia et al., (1994) reported that decortication and cooking of pulses resulted in desirable losses of Ca, Zn, Mn and ash contents.

In greengram and blackgram no significant variation of P, Ca, Fe, Mg, Mn and Cu retention was observed between fried and micro oven cooked samples. Maximum loss of P in both pulses was observed in fried samples and roasting retained Ca and Mg significantly when compared to other cooking treatments. Singh et al., (1989) reported that cooking resulted in significant loss of minerals.

Among boiled and steamed samples no significant variation in Fe, Mn and Mg was observed in greengram and blackgram. Ca in greengram also showed significant variation but not in blackgram. Maximum loss of P in both the pulses was observed in fried sample.

In blackgram maximum loss of Ca, Fe and Mg was observed in steamed sample while in greengram loss of Ca was observed in steamed sample and Fe and Mg in sample cooked under pressure.

4.4 Concentration of fibre, phytic acid and tannin in pulses (Table 14)

Antinutritional factors like fibre, phytic acid and tannin were estimated in the fresh pulses. Fibre content of blackgram was found to be slightly higher than that of greengram.

Phytic acid is one of the antinutrients in dry beans and serve as the main P reservoir. It accounts for upto 80 per cent of the total P in common beans and occur as a complex with mono and divalent cations in discrete region of the bean. (Reddy et al. 1982). Phytic acid concentration of blackgram was found to be higher than that of greengram.

As reported by Vaintraul and Bulmaga (1991) and Singh and Krikorian (1982) phytate strongly interacts with the basic residues of protein. As a consequence of this non selective binding of proteins, phytates has been shown to inhibit the action of a number of enzyme important in digesion, including pepsin, trypsin etc.

The negative effects of tannin is to cause growth depression by deccreasing the digestibility of protein and carbohydrate (Deshpande et al. 1992) and damaged to intestinal mucosa (Mitjawila et al. 1977). In greengram tannin concentration was lower than that of blackgram. Dark colour of the seed coat is due to high tannin concentration.

Table 14 Concentration of antinutritional factors in fresh blackgram and greengram

Pulses	Fibre (%)	Phytic acid mg/100	Tannin mg/100g
Blackgramm	2.20 ± 0.10 (4.50)	234.8 ± 15.40 (6.50)	3.55 ± 0.45 (12.60)
Greengram	1.98 ± 0.18 (9.00)	195.5 ± 5.70 (2.9)	2.50 ± 0.09 (3.60)

Table 13 Effect of cooking treatment on mineral profile of split and dehusked greengram

	mg/100g				µg/gm		
Treatment	P	Ca	Fe	Mg	Mn	Zn	Cu
P5	370.00 ± 98.00 (2.50)	108.00 ± 8.00 (7.40)	3.65 ± 0.09 (2.40)	192.50 ± 3.15 (1.60)	1.20 ± 0.15 (12.00)	314.00 ± 0.08 (0.25)	1.30 ± 0.17 (13.00)
P5C1	90.50 ± 2.00 (7.70)	40.00 ± 0.40 (10.00)	2.45 ± 0.15 (6.10)	152.00 ± 2.00 (1.30)	0.90 ± 0.00 (0.0)	30.00 ± 1.00 (3.30)	1.10 ± 0.10 (9.00)
P5C2	87.00 ± 3.00 (3.40)	45.00 ± 0.50 (1.00)	2.40 ± 0.10 (4.10)	125.00 ± 5.00 (4.00)	0.80 ± 0.01 (1.20)	31.00 ± 0.50 (1.60)	0.20 ± 0.00 (0.00)
P5C3	90.00 ± 6.00 (6.60)	32.50 ± 0.60 (1.80)	2.40 ± 0.50 (2.00)	133.00 ± 3.00 (2.20)	0.80 ± 0.01 (1.20)	24.00 ± 1.50 (6.00)	0.40 ± 0.05 (12.50)
P5C4	104.00 ± 45.00 (4.30)	49.00 ± 0.60 (1.20)	2.10 ± 0.10 (4.70)	110.00 ± 3.00 (2.70)	0.70 ± 0.00 (0.00)	21.00 ± 1.10 (5.20)	0.40 ± 0.01 (2.50)
P5C5	115.00 ± 10.00 (8.60)	51.00 ± 0.51 (1.00)	1.55 ± 0.10 (6.40)	105.00 ± 2.50 (2.30)	0.90 ± 0.10 (1.10)	30.00 ± 1.40 (4.20)	1.10 ± 0.05 (4.54)
P5C6	110.00 ± 9.00 (8.10)	61.00 ± 1.00 (1.60)	1.75 ± 0.05 (2.80)	210.00 ± 8.00 (3.80)	0.90 ± 0.10 (1.10)	25.00 ± 9.00 (8.80)	1.00 ± 0.01 (1.00)
P5C7	85.50 ± 3.50 (4.00)	33.00 ± 0.10 (3.00)	2.10 ± 0.10 (4.70)	165.00 ± 7.00 (4.20)	0.60 ± 0.00 (1.60)	19.00 ± 1.00 (5.20)	0.90 ± 0.01 (1.10)
P5C8	90.00 ± 6.00 (6.60)	34.00 ± 1.00 (2.90)	2.05 ± 0.05 (2.40)	165.00 ± 4.00 (2.40)	0.60 ± 0.03 (5.00)	26.00 ± 1.50 (5.70)	0.70 ± 0.03 (4.30)
SE	2.89	4.93	0.17	0.13	0	3.00	1.01
CD	8.17	13.95	0.47	36.00	0	8.00	0.30

P	P5	P5C5	P5C6	P5C4	P5C1	P5C3	P5C8	P5C2	P5C7
Ca	P5	P5C6	P5C5	P5C4	P5C2	P5C1	P5C8	P5C7	P5C3
Fe	P5	P5C1	P5C2	P5C3	P5C4	P5C7	P5C8	P5C6	P5C5
Mg	P5C6	P5	P5C7	P5C8	P5C1	P5C3	P5C2	P5C4	P5C5
Mn	P5	P5C1	P5C5	P5C6	P5C2	P5C3	P5C4	P5C7	P5C8
Zn	P5	P5C2	P5C1	P5C5	P5C8	P5C6	P5C3	P5C4	P5C7
Cu	P5	P5C1	P5C5	P5C6	P5C3	P5C7	P5C8	P5C4	P5C2

4.5.1 Effect of processing on antinutritional factors in pulses (Tables 15 and 16, Figure 5 and 6 and Appendix I)

Antinutritional factors such as fibre, phytic acid and tannin were determined in fresh and processed samples of blackgram and greengram. Influence of different processing techniques on the removal of antinutritional factors were varying from one another.

A comparison of fibre content in fresh and other processed blackgram depicted significant variation in P_4 and P_5. Similar observations were also made in greengram for the fibre contents. Among the processed pulses no significant variation in fibre was noted among P_1, P_2 and P_3 in both the pulses. Significant loss of fibre content was observed in P_4 and P_5 in greengram and blackgram.

Statistical treatment of the data revealed that no significant variation in fibre between P_4 and P_5 in greengram and blackgram. While in, P_4 and P_5, significant variation in fibre loss, was observed due to different processing techniques (P_1, P_2 and P_3) in greengram and blackgram.

Comparison of phytic acid in fresh blackgram and processed blackgram depicted significant variation in processed blackgram (P_3, P_4 and P_5). In the case of greengram significant variation was noted in P_3 and P_4.

Table 15 Effect of processing on antinutritional factors in fresh blackgram

Processing techniques	Fibre (%)	Phytic acid mg/100	Tannin mg/100g
P1	2.20 ± 0.10 (4.50)	234.80 ± 15.40 (6.50)	3.55 ± 0.45 (12.60)
P2	2.20 ± 0.10 (4.70)	231.50 ± 10.30 (4.40)	3.35 ± 0.25 (7.40)
P3	2.30 ± 0.02 (8.60)	164.20 ± 4.40 (2.60)	2.50 ± 0.11 (4.40)
P4	0.67 ± 0.09 (13.40)	195.40 ± 5.30 (2.70)	1.65 ± 0.90 (5.45)
P5	0.59 ± 0.08 (13.50)	196.20 ± 3.90 (1.90)	1.35 ± 0.50 (3.70)
CD	0.49	17.87	0.79

Fibre	P3	P1	P2	P4	P5
Phytin	P1	P2	P5	P4	P3
Tannin	P1	P2	P3	P4	P5

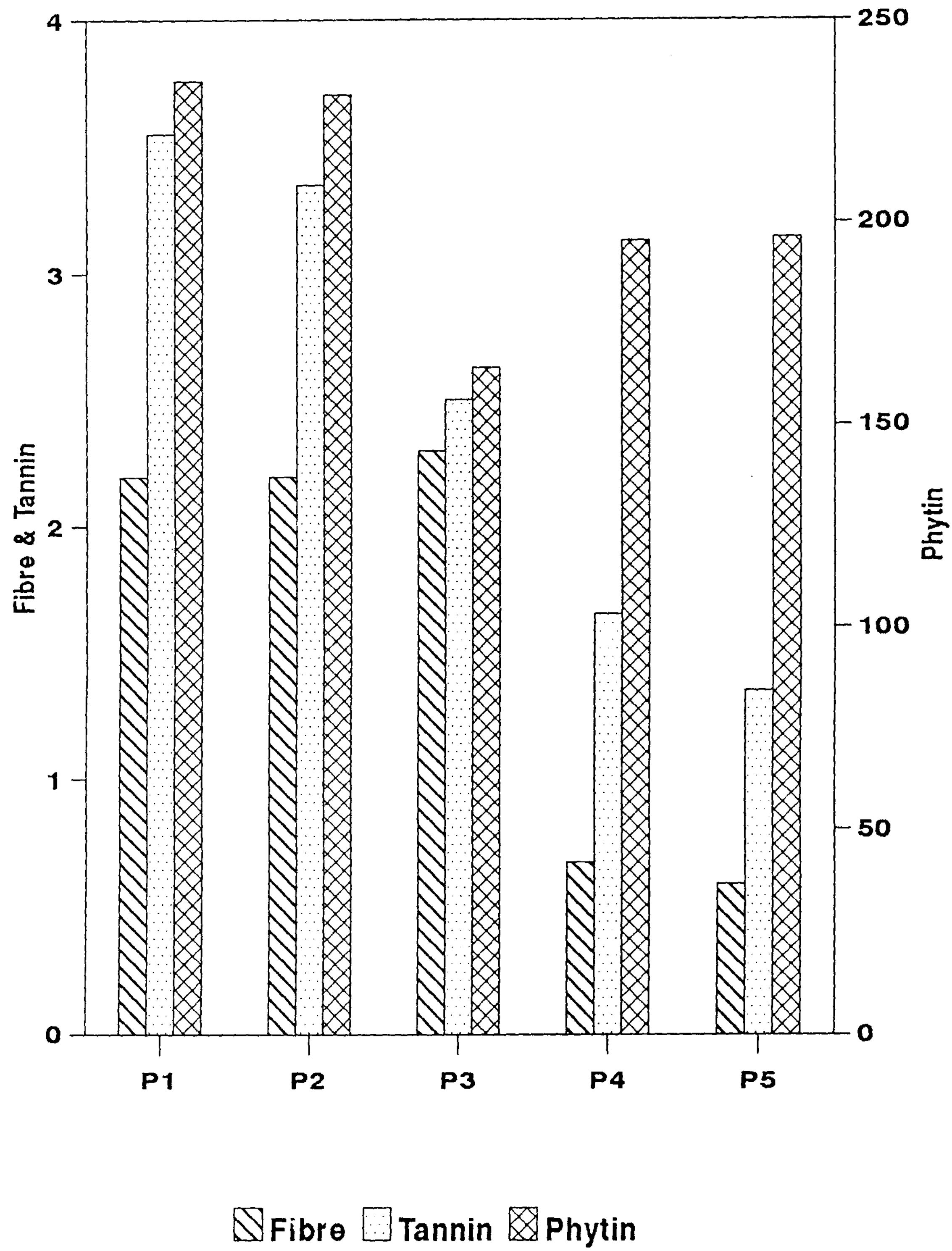


Fig. 5. Effect of processing on antinutritional factors of blackgram

Table 16 Effect of processing on antinutritional factors in fresh greengram

Processing techniques	Fibre (%)	Phytic acid mg/100	Tannin mg/100g
P1	1.98 ± 0.18 (9.00)	19.50 ± 5.70 (2.90)	2.50 ± 0.09 (3.60)
P2	1.78 ± 0.09 (5.00)	189.50 ± 1.20 (4.30)	2.30 ± 0.12 (5.20)
P3	1.86 ± 0.85 (4.50)	160.00 ± 9.10 (5.60)	1.95 ± 0.06 (3.07)
P4	0.51 ± 0.04 (7.80)	175.35 ± 3.40 (1.90)	1.15 ± 0.08 (6.09)
P5	0.48 ± 0.03 (6.25)	180.30 ± 4.80 (2.60)	1.05 ± 0.09 (8.50)
CD	0.49	17.87	0.79

Fibre	P1	P3	P2	P4	P5
Phytin	P1	P2	P5	P4	P3
Tannin	P1	P2	P3	P4	P5

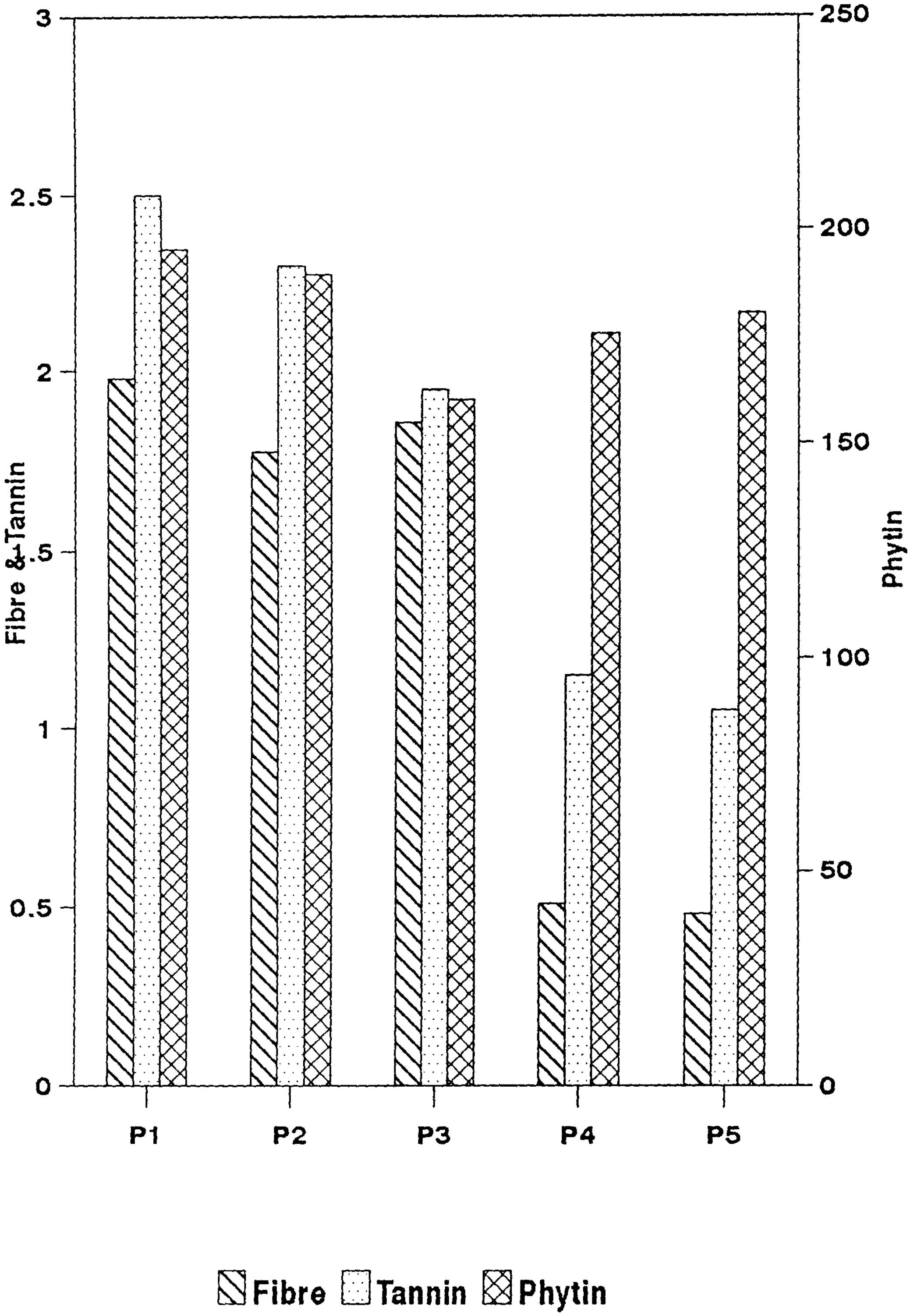


Fig. 6. Effect of processing on antinutritional factors of greengram

Among processed blackgram samples significant variation in phytic acid loss was noted between P_2 and other processed samples (P_3, P_4 and P_5). Germination and dehusking were found to reduce the phytic acid. Similarly a comparison of P_3 with P_4 and P_5 depicted significant varation in phytic acid. Significant loss in phytic acid was observed between P_4 and P_5.

In greengram, variation in phytic acid loss was significant between P2 and P_3, but with P_4 and P_5, the loss was not significant. As in the case of blackgram, no significant variation was noted between P_4 and P_5. Variation in phytic acid loss between P_3 and P_4 was not significant, however significant variation between P_3 and P_5 was observed.

Comparison of tannin content between fresh blackgram and other processed blackgram samples depicted significant variation except in P_2. While in greengram significant variation in tannin loss was observed only with P_4 and P_5.

Among processed samples comparison of dried (P_2) with other processed samples P_3, P_4 and P_5 depicted significant variation in tannin loss in blackgram. While in greengram significant variation in tannin loss was noted in P_4 and P_5.

Comparison of germinated samples (P_3) with P_4 and P_5 depicted significant variation in tannin loss in blackgram and greengram. However no significant variation in tannin loss was observed between P_4 and P_5 in both greengram and blackgram.

All the processing techniques resulted in reduction of antinutritional factors in both pulses except fibre, which slightly increased after germination in blackgram (Fig. 5 and 6).

Significant loss of phytic acid and tannin was observed due to germination in both pulses. Subhalakshmi et al. (1976) and Rao and Deosthale (1982) have also reported that by germinating for 24 - 25 hours, 22 - 25% of tannin was lossed from greengram.

Maximum reduction of fibre and tannin was observed for split and dehusked sample. While maximum elimination of phytic acid was observed in germinated sample. Sathe and Salunkhe (1984) reported that among the processing methods germination appeared to be quite effective in decreasing phytic acid concentration.

No significant variation in dried and fresh samples was observed for fibre, phytic acid and tannin in blackgram and greengram.

4.5.2 **Effect of cooking treatments on antinutritional factors in fresh samples** (Tables 17 and 18)

All the cooking treatments significantly reduced the fibre content of fresh blackgram and greengram significantly.

In blackgram among cooked samples no significant variation in fibre was observed between boiled and steamed samples either soaked or unsoaked. Similar observation was also made in greengram.

In blackgram and greengram comparison of P_1C_5 (sample cooked under pressure) with boiled and steamed showed no significant variation.

Among cooked samples significant loss of fibre was observed in P_1C_6 (roasted) sample, on comparison with all other sample except P_1C_7 (fried) in blackgram. In greengram no such significant loss was observed. Comparison of P_1C_7 and P_1C_8 with samples cooked in water media revealed significant variation in fibre loss in P_1C_7 with P_1C_4. While in greengram no such observations was made.

Comparison of phytic acid in fresh blackgram and greengram with cooked samples revealed significant loss of phytic acid in cooked sample.

Among cooked samples significant loss of phytic acid was observed in soaked samples on comparison with unsoaked boiled

Table 17 Effect of cooking treatments on the antinutritional factors in fresh blackgram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P1	2.20 ± 0.10 (4.5)	234 ± 15.40 (6.5)	3.55 ± 0.45 (1.2)
P1C1	1.90 ± 0.10 (5.20)	170 ± 13.20 (7.70)	1.50 ± 0.15 (10.00)
P1C2	1.80 ± 0.09 (5.00)	111 ± 1.50 (1.30)	0.90 ± 0.08 (8.80)
P1C3	1.80 ± 0.06 (4.40)	162 ± 3.80 (2.30)	1.35 ± 0.15 (11.10)
P1C4	1.90 ± 0.07 (3.60)	100 ± 3.90 (3.90)	0.89 ± 0.08 (8.90)
P1C5	1.80 ± 0.05 (2.70)	112 ± 5.60 (5.00)	0.92 ± 0.06 (6.50)
P1C6	1.60 ± 0.05 (3.10)	162 ± 9.60 (5.90)	1.24 ± 0.12 (9.60)
P1C7	1.70 ± 0.05 (2.90)	171 ± 10.10 (5.90)	1.32 ± 0.12 (9.00)
P1C8	1.80 ± 0.03 (1.60)	183 ± 11.10 (6.00)	1.12 ± 0.03 (2.60)
CD	0.15	53.61	0.336

Fibre	P1	P1C1	P1C4	P1C2	P1C3	P1C5	P1C8	P1C7	P1C6
Phytin	P1	P1C8	P1C7	P1C1	P1C6	P1C3	P1C5	P1C2	P1C4
Tannin	P1	P1C1	P1C3	P1C1	P1C6	P1C8	P1C5	P1C2	P1C4

Table 18 Effect of cooking treatments on the antinutritional factors of fresh greengram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P1	1.96 ± 0.18 (9.00)	195 ± 5.70 (2.90)	2.50 ± 0.09 (3.60)
P1C1	1.72 ± 0.09 (5.20)	121 ± 7.30 (6.00)	0.98 ± 0.01 (1.00)
P1C2	1.70 ± 0.12 (7.00)	83 ± 3.80 (4.60)	0.52 ± 0.03 (5.70)
P1C3	1.72 ± 0.13 (7.50)	119 ± 4.30 (3.60)	0.96 ± 0.05 (5.20)
P1C4	1.71 ± 0.08 (8.20)	98 ± 5.10 (5.20)	0.43 ± 0.04 (9.30)
P1C5	1.71 ± 0.14 (8.20)	112 ±10.20 (9.10)	0.58 ± 0.06 (10.30)
P1C6	1.60 ± 0.13 (8.10)	83 ± 9.10 (10.90)	6.09 ± 0.09 (13.00)
P1C7	1.70 ± 0.09 (5.30)	82 ± 2.50 (3.00)	0.78 ± 0.03 (3.80)
P1C8	1.71 ± 0.78 (12.20)	78 ± 3.60 (4.60)	0.92 ± 0.02 (2.10)
CD	0.15	53.61	0.336

Fibre	P1	P1C1	P1C3	P1C8	P1C2	P1C7	P1C4	P1C5	P1C6
Phytin	P1	P1C1	P1C3	P1C5	P1C4	P1C2	P1C6	P1C7	P1C8
Tannin	P1	P1C1	P1C3	P1C1	P1C1	P1C6	P1C5	P1C2	P1C4

or steamed samples on blackgram while in greengram no such significant loss was observed in soaked samples.

Comparison of P_1C_5 with boiled (P_1C_1, P_1C_2) and steamed (P_1C_3, P_1C4) samples revealed significant loss of phytic acid in P_1C_5 with P_1C_1 and P_1C_3. While in greengram no such observation was made.

Among P_1C_6 (roasted), P_1C_7 (fried) and P_1C_8 (micro oven cooked) samples in blackgram and greengram significant variation in phytic acid was observed. Comparison of these samples with samples cooked in water media revealed significant retention with soaked (P_1C_2 and P_1C_4) samples and pressure cooked samples in blackgram, while in greengram no such observations were made.

Tannin content of cooked samples were reduced significantly in fresh blackgram and greengram. Among boiled and steamed samples, significant loss of tannin was observed in soaked samples (P_1C_2 and P_1C_4) when compared with unsoaked sample (P_1C_1 and P_1C_3), in both pulses.

Significant loss of tannin was observed in P_1C_5 (samples cooked under pressure) when compared with unsoaked samples (P_1C_1 and P_1C_3) while no significant variation was observed with soaked samples (P_1C_2 and P_2C_4) in blackgram and greengram.

Among P_1C_6 (roasted) P_1C_7 (fried) and P_1C_8 (micro oven cooked sample) significant variation in tannin loss was observed in both the pulses. Comparison of these samples with samples cooked in water media revealed, significant variation in tannin loss with soaked sample in greengram. Significant variation in blackgram was noted between P_1C_6 with P_1C_2 and P_1C_8 with P_1C_1.

4.5.3 Effect of cooking treatments on antinutritional factors in dried pulses (Tables 19 and 20)

Cooking treatments as a whole is found to reduce the fibre content in blackgram and greengram.

A comparison of fibre content among dried sample and cooked samples in blackgram depicted significant variation in fibre content. While in greengram significant variation in fibre content was not observed with P_2C_1, P_2C_3, P_2C_6 and P_2C_7.

Statistical treatment of the data revealed that between boiled and steamed samples no significant loss in fibre was observed either in soaked sample or unsoaked ones. Similar observation was made in greengram also. In pressure cooked samples of greengram and blackgram, slight reduction in fibre content was noted. In blackgram, P_2C_5 (pressure cooked sample showed significant variation with boiled and steamed samples. (P_2C_1, P_2C_2, P_2C_3 and P_2C_4). While in greengram, significant variation was noted only with P_2C_1 and P_2C_3.

Table 19 Effect of cooking treatments on the antinutritional factors of dried blackgram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P2	2.10 ± 0.01 (4.20)	231.50 ± 10.30 (13.30)	3.35 ± 0.25 (9.50)
P2C1	1.85 ± 0.09 (4.80)	166.65 ± 1.90 (11.40)	64.5 ± 0.13 (8.90)
P2C2	1.70 ± 0.07 (4.10)	81.05 ± 6.30 (7.20)	0.80 ± 0.01 (110.50)
P2C3	1.88 ± 0.03 (1.50)	170.30 ± 2.10 (1.70)	1.24 ± 0.03 (2.40)
P2C4	1.70 ± 0.04 (2.30)	80.90 ± 6.20 (7.60)	0.81 ± 0.11 (13.50)
P2C5	1.50 ± 0.01 (1.66)	140.50 ± 3.80 (2.70)	0.88 ± 0.10 (11.30)
P2C6	1.90 ± 0.13 (1.50)	110.13 ± 9.60 (8.70)	1.50 ± 1.12 (8.00)
P2C7	1.90 ± 0.03 (1.59)	132.50 ± 4.80 (3.60)	1.47 ± 0.13 (8.80)
P2C8	1.80 ± 0.03 (1.60)	142.40 ± 4.20 (2.95)	0.96 ± 7.11 (11.40)
CD	0.15	3.61	1.336

	1	2	3	4	5	6	7	8	9
Fibre	P2	P2C6	P2C4	P2C3	P2C1	P2C8	P2C2	P2C4	P2C5
Phytin	24	P2C3	P2C1	P2C8	P2C5	P2C7	P2C6	P2C2	P2C4
Tannin	P2	P2C6	P2C7	P2C1	P2C3	P2C8	P2C5	P2C4	P326

Table 20 Effect of cooking treatment on the antinutritional factors of dried greengram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P2	1.70 ± 0.01 (5.80)	189.50 ± 8.20 (6.00)	2.30 ± 0.12 (9.10)
P2C1	1.62 ± 0.09 (5.50)	94.50 ± 4.80 (5.00)	0.97 ± 0.08 (8.20)
P2C2	1.50 ± 0.08 (5.20)	44.30 ± 3.90 (8.80)	0.56 ± 0.04 (10.70)
P2C3	1.63 ± 0.12 (7.30)	93.20 ± 4.10 (4.20)	0.88 ± 0.03 (3.40)
P2C4	1.52 ± 0.08 (5.20)	43.50 ± 3.40 (7.80)	0.45 ± 0.01 (2.20)
P2C5	1.04 ± 0.08 (5.70)	57.50 ± 3.10 (5.30)	53.50 ± 0.05 (0.09)
P2C6	1.60 ± 0.09 (14.40)	45.40 ± 2.50 (5.50)	0.93 ± 0.05 (0.05)
P2C7	1.60 ± 0.08 (5.00)	56.40 ± 3.50 (6.20)	0.89 ± 0.07 (7.80)
CD	0.15	53.61	0.33

	1	2	3	4	5	6	7	8	9
Fibre	P2	P2C3	P2C1	P2C6	P2C7	P2C4	P2C2	P2C1	P2C5
Phytin	P2	P2C1	P2C3	P2C5	P2C7	P2C8	P2C6	P2C2	P2C4
Tannin	P2	P2C1	P2C6	P2C1	P2C3	P2C8	P2C2	P2C5	P2C4

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Among P_2C_6 (roasted), P_2C_7 (fried), P_2C_8 (micro oven cooked) blackgram and greengram samples, no significant variation in loss of fibre content was observed. When these samples were compared with samples cooked in water media, significant variation was observed with P_2C_5 (pressure cooked sample) in blackgram and greengram, except between P_2C_5 and P_2C_8 where there was no significant variation in fibre loss in greengram.

P_2C_6 (roasted) and P_2C_7 (fried) samples in blackgram showed significant variation in fibre with soaked samples, while in greengram no significant variation in fibre loss was observed with soaked and unsoaked samples.

Comparison of P_2C_8 with P_2C_1, P_2C_2, P_2C_3 and P_2C_4 did not show significant loss of fibre both in greengram and blackgram.

Comparison of phytic acid content in dried blackgram and greengram with other cooked samples depicted significant variation in phytic acid. Among cooked samples maximum loss of phytic acid was observed in soaked and cooked samples of the two pulses. Among cooked samples in blackgram, significant loss of phytic acid was observed in soaked samples when compared with unsoaked samples both in boiled and steamed samples. While in greengram no such significant loss of phytic acid was observed. In both pulses no significant variation in phytic acid was observed between boiled and steamed samples. Comparison of P_2C_5 (pressure cooked sample) with P_2C_1 (boiled) and P_2C_3 (steamed) samples revealed no significant variation in phytic acid in blackgram, while with soaked samples P_2C_2 and P_2C_4 significant variation was noted. In greengram no significant variation in phytic acid was noted with P_2C_1, P_2C_2, P_2C_3 or P_2C_4.

Among P_2C_6, P_2C_7 and P_2C_8 no significant variation in phytic acid loss was observed both in greengram and blackgram.

In greengram, though there is greater reduction of phytic acid in soaked sample , significant variation was not found when P_2C_6, P_2C_7 and P_2C_8 were compared with samples cooked in water media.

In black gram comparison of P_2C_6 (roasted) with samples cooked in water media, significant variation in phytic acid loss was observed with P_2C_1 and P_2C_3. Comparison of P_2C_7 and P_2C_8 with sample cooked in water media depicted no significant variation in phytic acid except P_2C_8 with soaked samples viz. P_2C_2 and P_2C_4 which showed significant loss of phytic acid.

All the cooking treatments were found to reduce the tannin content of dried pulses both in greengram and blackgram. In both the pulses significant variation in tannin loss was depicted among cooked samples when compared with the dried sample.

Among cooked samples,no significant variation was noted between boiled and steamed samples (P_2C_1 and P_2C_3) either soaked or unsoaked in both blackgram and greengram. While significant variation in tannin was noted between soaked (P_2C_2 and P_2C_4) and unsoaked samples (P_2C_1 and P_2C_3) either boied or steamed.

When P_2C_5 was compared with P_2C_1, P_2C_2, P_2C_3 and P_2C_4 significant variation in tannin was noted only with unsoaked samples (P_2C_1 and P_2C_3) in tannin retention.

Among P_2C_6, P_2C_7 and P_2C_8, no significant variation was noted between P_2C_6 and P_2C_7 in both the pulses while in blackgram significant variation in P_2C_8 (micro oven cooked) was observed when compared with P_2C_6 and P_2C_8 while in greengram no such variation in tannin retention was observed.

Significant retention of tannin was observed in P_2C_6 and P_2C_7 when compared with soaked samples P_2C_2 and P_2C_7. In both blackgram and greengram, no such variation was observed with P_2C_1 and P_2C_3.

P_2C_8 when compared with samples cooked in water media showed significant loss of tannin with unsoaked samples (P_2C_1 and P_2C_2) in blackgram while in greengram no significant loss in tannin was observed with all the samples cooked in water media.

Cooking treatments as a whole reduced the fibre, phytic acid and tannin content of all dried samples of blackgram and greengram significantly. Rao and Deosthale (1983) had reported that all the cooking treatments resulted in a significant loss of phytic acid and tannin.

In blackgram and greengram maximum loss of fibre, phytic acid and tannin was observed in soaked sample. Soaking and cooking removed about 65-75 per cent of phytic acid and 75-80 per cent of tannin in both pulses. Khan et al., (1988) reported soaking bengalgram in water for 4 hours resulted in reduction of phytic acid (12.5 per cent) and boiling the presoaked grams increased the loss of phytic acid to 25 per cent. Sangle et al., (1993) reported 13-30 per cent loss of tannin by different soaking treatments in soybean samples.

Samples cooked under pressure was observed to have significantly low levels for fibre and phytic acid in both the pulses. Drastic reduction in pressure cooking might be due to destruction of phenols at high temperature and some leaching of the components in cooking water. Belavady and Banerjee (1953) reported that reduction in phytic acid P on pressure cooking might be due to increase in phytic acid activity.

No significant variation in fibre, phytic acid and tannin content was observed between P_2C_6 (roasting), P_2C_7 (frying) and P_2C_8 (cooking in micro oven) in both the pulses except in P_2C_8 in blackgram which showed significant tannin loss.

4.5.4 **Effect of cooking treatments on antinutritional factors in germinated pulses** (Tables 21 and 22)

Cooking treatments as a whole is observed to reduce the fibre content of germinated pulses. Statistical treatment of the data revealed significant loss of fibre in all the cooked samples both in blackgram and greengram.

Among cooked samples no significant variation in fibre retention was observed between boiled and steamed samples (P_3C_1 and P_3C_3). Similar observations were also made between soaked and unsoaked samples (P_3C_1 and P_3C2) either boiled or steamed in both the pulses.

Comparison of P_3C_5 (pressure cooked) samples with P_3C_1, P_3C_2, P_3C_3 and P_3C_4) depicted no significant variation in fibre loss in greengram and blackgram.

Among P_3C_6, P_3C_7 and P_3C_8 significant retention of fibre was observed between P_3C_6 and P_3C_7 in greengram and blackgram. Comparison of P_3C_6 and P_3C_7 with samples cooked in water media depicted no such significant variation in fibre retention in both the pulses.

Comparison of P_3C_8 with all the samples cooked in water media depicted significant variation in blackgram and greengram except with P_3C_5 (pressure cooked sample).

Table 21 Effect of cooking treatments on antinutritional factors of germinated blackgram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P3	2.30 ± 0.20 (8.60)	164.20 ± 4.40 (2.67)	2.50 ± 0.11 (4.40)
P3C1	1.70 ± 0.10 (5.88)	53.50 ± 4.10 (7.66)	0.88 ± 0.09 (10.22)
P3C2	1.65 ± 0.09 (5.45)	44.30 ± 3.10 (6.99)	0.70 ± 0.08 (10.70)
P3C3	1.76 ± 0.08 (4.54)	50.20 ± 2.80 (5.57)	0.95 ± 0.61 (1.05)
P3C4	1.65 ± 0.06 (3.63)	39.50 ± 4.30 (10.88)	0.71 ± 0.08 (11.26)
P3C5	1.71 ± 0.08 (4.67)	61.00 ± 2.80 (4.59)	76.00 ± 0.04 (5.26)
P3C6	1.65 ± 0.10 (6.06)	39.6 ± 2.70 (6.81)	0.70 ± 0.06 (8.57)
P3C7	1.76 ± 0.08 (4.54)	64.7 ± 2.3 (3.55)	0.77 ± 0.08 (10.38)
P3C8	1.85 ± 0.12 (6.48)	65.4 ± 1.5 (2.29)	0.73 ± 0.08 (10.95)
CD	0.15	53.61	0.336

	1	2	3	4	5	6	7	8	9
Fibre	P3	P3C8	P3C3	P3C7	P3C5	P3C1	P3C2	P3C4	P3C6
Phytin	P3	P3C8	P3C7	P3C5	P3C1	P3C3	P3C2	P3C6	P3C4
Tannin	P3	P3C3	P3C1	P3C7	P3C5	P3C8	P3C4	P3C2	P3C6

Table 22 Effect of cooking treatments on the antinutritional factors of germinated greengram

Cooking treatments	Fibre (%)	Phytic acid mg/100	Tannin ug/g
P3	1.80 ± 0.09 (5.00)	160.00 ± 9.10 (5.68)	1.95 ± 0.16 (3.07)
P3C1	1.40 ± 0.08 (5.71)	34.45 ± 3.50 (10.15)	0.77 ± 0.01 (1.29)
P3C2	1.43 ± 0.03 (2.39)	33.45 ± 2.50 (7.47)	0.41 ± 0.03 (19.51)
P3C3	1.50 ± 0.01 (0.66)	36.00 ± 2.10 (5.83)	0.84 ± 0.08 (9.52)
P3C4	1.43 ± 0.03 (2.09)	30.95 ± 1.60 (5.16)	0.54 ± 0.06 (11.11)
P3C5	1.40 ± 0.03 (0.66)	40.50 ± 3.80 (2.70)	0.88 ± 0.10 (11.30)
P3C6	1.90 ± 0.13 (1.50)	34.00 ± 9.60 (8.70)	1.50 ± 1.12 (8.00)
P3C7	1.90 ± 0.03 (1.59)	34.30 ± 4.80 (3.60)	1.47 ± 0.13 (8.80)
P3C8	1.80 ± 0.03 (1.60)	41.50 ± 4.20 (2.95)	0.96 ± 7.11 (11.40)
CD	0.15	3.61	1.336

	1	2	3	4	5	6	7	8	9
Fibre	P3	P3C6	P3C4	P3C3	P3C1	P3C8	P3C2	P3C4	P3C5
Phytin	P3	P3C3	P3C1	P3C8	P3C5	P3C7	P3C6	P3C2	P3C4
Tannin	P3	P3C6	P3C7	P3C1	P3C3	P3C8	P3C5	P3C4	P3C6

Phytic acid content of all the germinated sample was reduced by cooking treatments in blackgram and greengram. Significant variation in phytic acid retention was observed in germinated sample on comparison with cooked samples.

In germinated blackgram and greengram no significant loss in phytic acid was observed on soaking. Similarly no significant variation in phytic acid retention was observed by boiling, steaming and pressure cooking.

Among P_3C_6, P_3C_7 and P_3C_8 no significant variation in phytic acid was observed in blackgram and greengram. On comparison between samples cooked in water media and other cooked samples no significant variation was observed in both the pulses.

Tannin concentration of all the germinated pulse sample was also observed to be reduced on cooking. Among cooked samples maximum loss of tannin was observed for soaked samples and roasted samples in both the pulses.

Comparison of tannin content among germinated pulses with other pulses depicted significant variation.

Among cooked samples in blackgram and greengram no significant variation in tannin content was observed between boiled and steamed samples, soaked and unsoaked sample ie., between P_3C_1 and P_3C_3, P_3C_1 and P_3C_2. Comparison of boiled and steamed samples (P_3C_1, P_3C_2, P_3C_3 and P_3C_4) with P_3C_5 depicted no significant variation in blackgram and greengram.

Among P_3C_6, P_3C_7 and P_3C_8 no significant variation in tannin loss was observed. Comparison of P_3C_6, P_3C_7 and P_3C_8 with samples cooked in water media, revealed no significant retention of tannin in both the pulses except in between P_3C6 with P_3C_1 and P_3C_3.

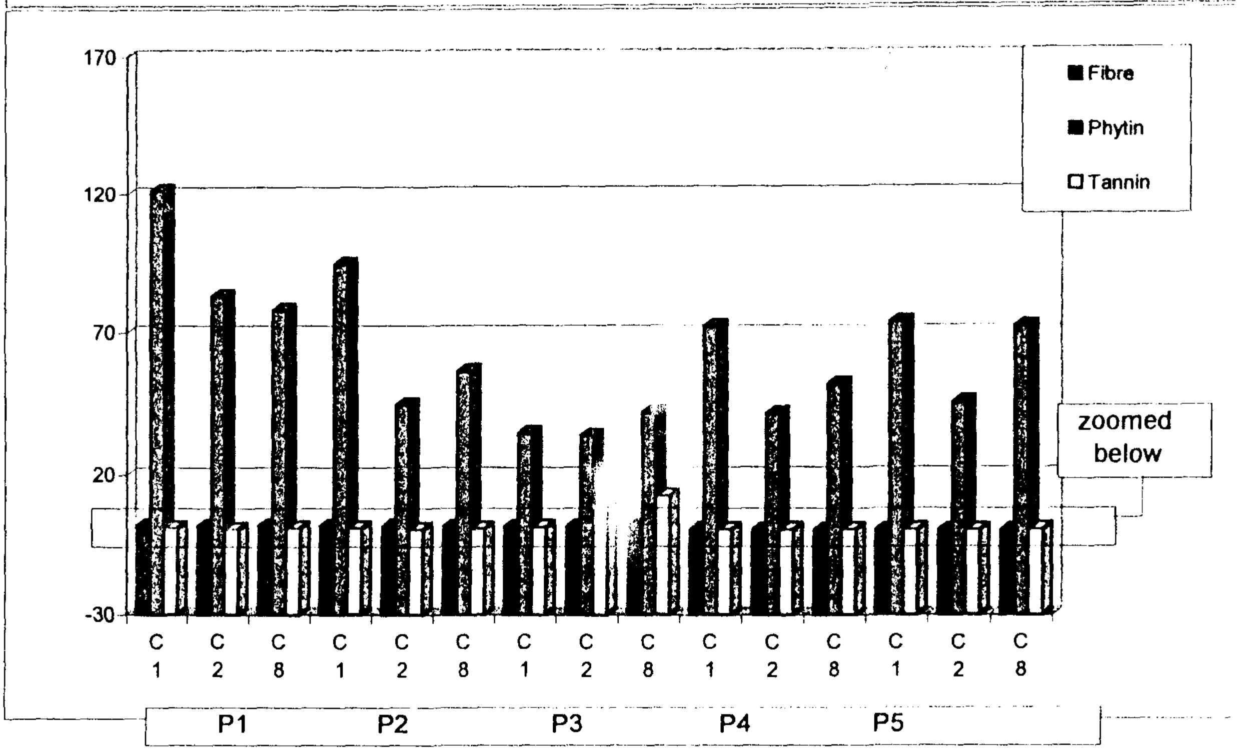
All the cooking treatments significantly reduced the fibre, phytic acid and tannin contents of germinated blackgram and greengram. Bishnoi et al. (1994) reported that all the cooking treatments reduced the phytic acid and tannin levels of pulses. Belavady and Banerjee (1953) Rao and Deosthale (1983) also reported significant losses of phytic acid and phenolic compounds by germination, soaking and cooking.

Soaking and cooking resulted in maximum loss of phytic acid and tannin, while minimum loss for these constituents were observed in micro oven cooked sample (Fig. 7 and 8). Roasting was also effective in reducing the phytic acid considerably to a very low level. Olghobo and Fetuga (1984) reported that germination and soaking were most effective in decreasing phytate contents.

No significant variation in phytic acid loss was observed for different cooking treatments applied on blackgram

Fig -- 8

EFFECT OF SELECTED COOKING TREATMENTS ON ANTINUTRITIONAL FACTORS OF FRESH & PROCESSED GREENGRAM



Y - SCALE (0 TO 2.5) ZOOMED PICTURE

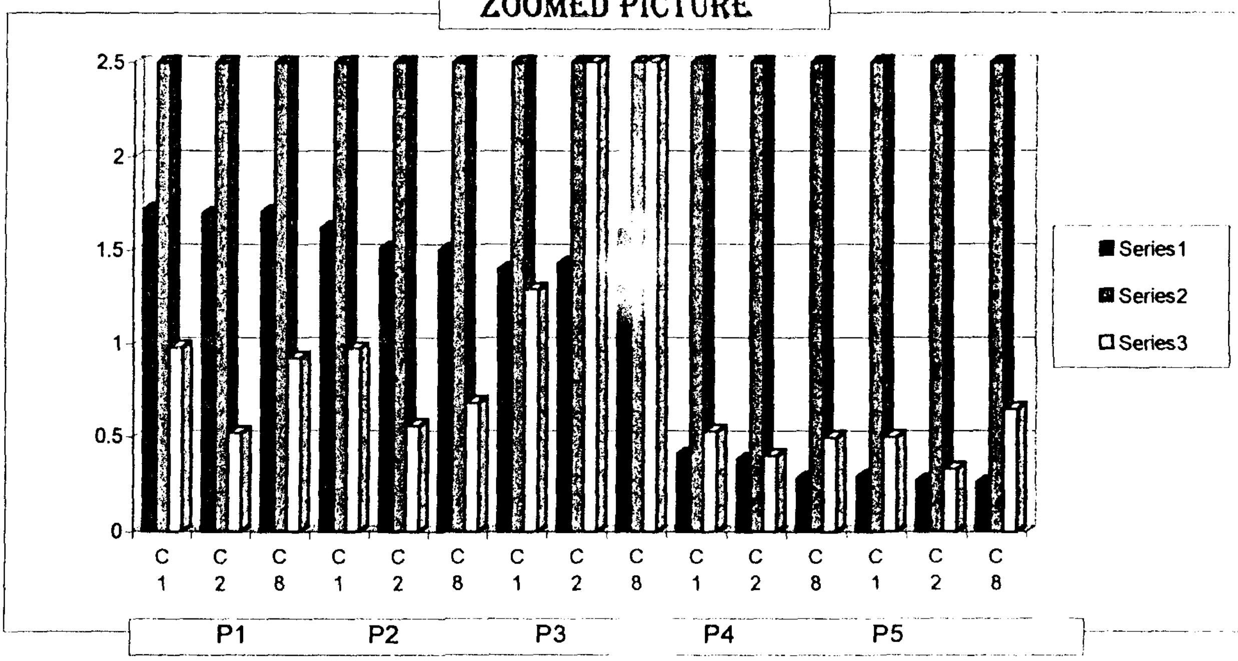
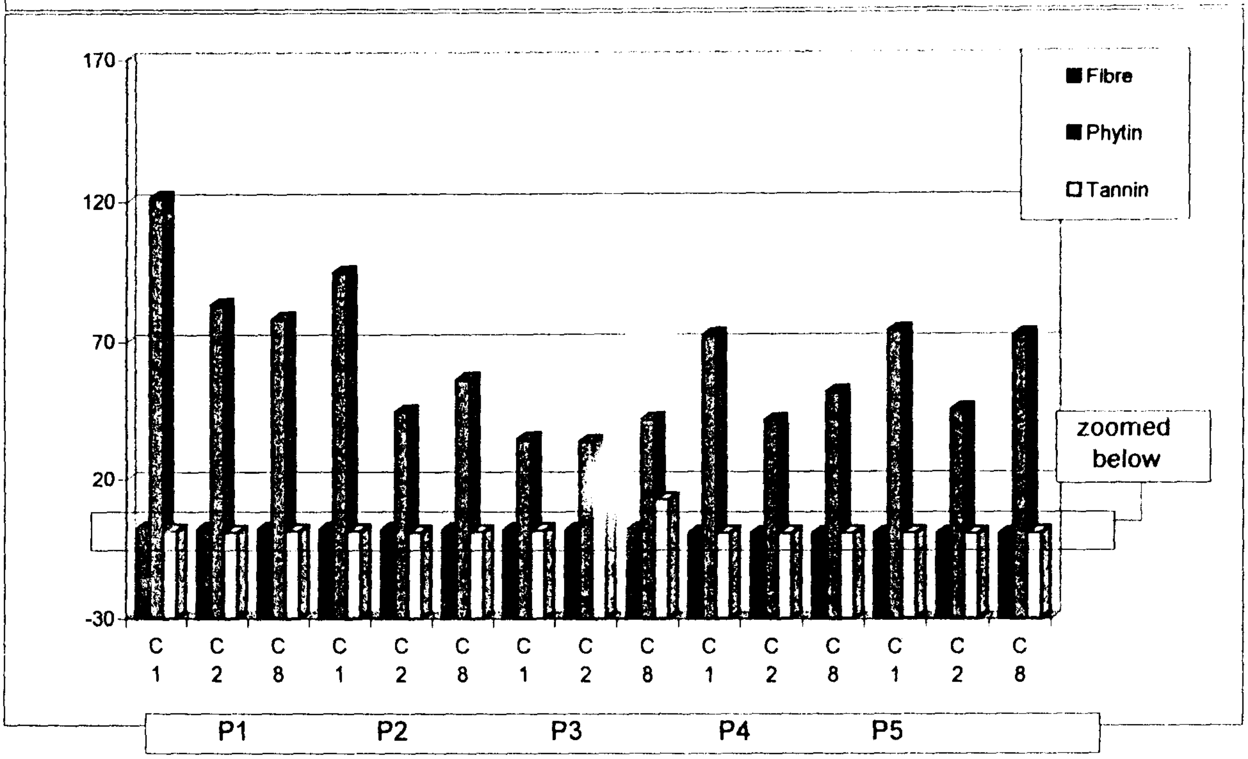
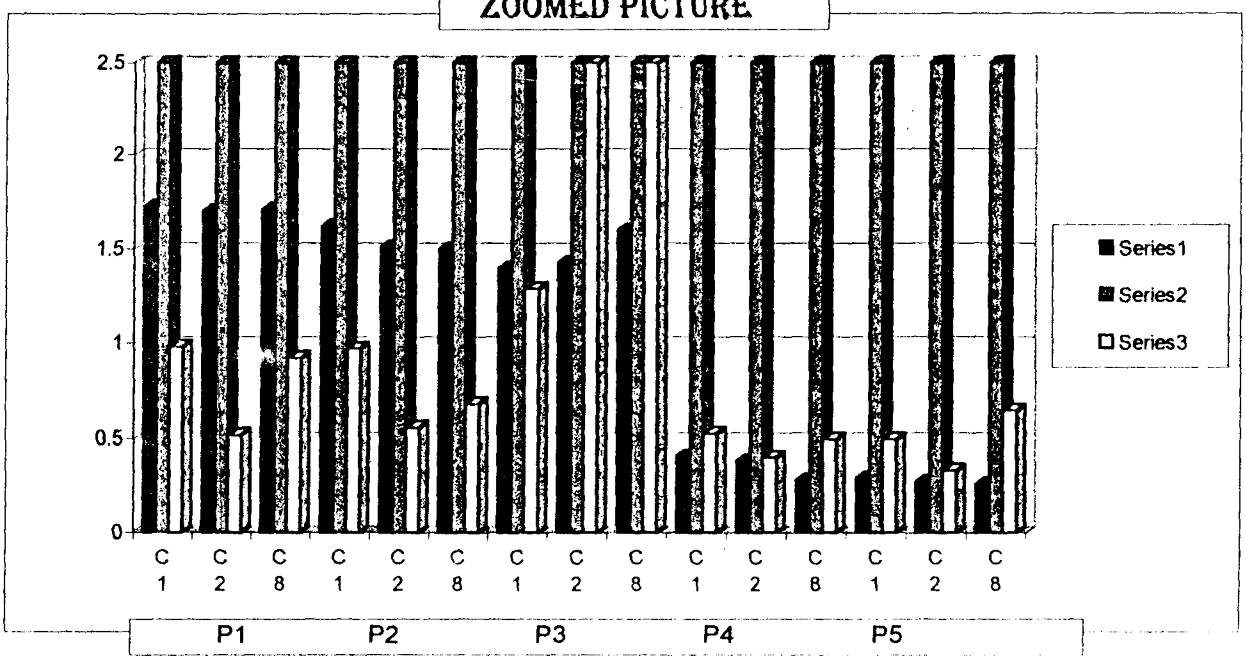


Fig -- 8

EFFECT OF SELECTED COOKING TREATMENTS ON ANTINUTRITIONAL FACTORS OF FRESH & PROCESSED GREENGRAM



Y - SCALE (0 TO 2.5)
ZOOMED PICTURE



and greengram. 60-75 per cent of phytic acid was removed by different cooking treatments in germinated pulses, 57 to 79 per cent of tannins were removed by different cooking treatments in greengram and blackgram. Attia et al., (1994) reported that significant losses of antinutritional factors occurred upon cooking the pulses by various methods and 58.7 - 62.2 percentage of phytic acid and 53.6 - 59.9 percentage of tannin were removed as a result of cooking.

4.5.5. **Effect of cooking treatments on antinutritional factors in loosened pulses** (Tables 23 and 24)

Comparison of fibre content in loosened blackgram and cooked blackgram samples depicted significant variation in fibre except in P_4C_1. While in greengram significant variation was noted except in P_4C_1, P_4C_2 and P_4C_3.

Among cooked samples no significant variation was noted between boiled samples (P_4C_1, P_4C_2) and steamed samples (P_4C_3, P_4C_4). Similarly variation in fibre content between soaked and unsoaked samples was not significant. Similar observation was also made in greengram for boiled and steamed samples.

Comparison of P_4C_5 (pressure cooked) with boiled and steamed samples, depicted significant variation with P_4C_1 in both the pulses. Among P_4C_6, P_4C_7 and P_4C_8 no statistically significant variation was observed in fibre retention.

Table 23 Effect of cooking treatment on the antinutritional factors of loosened blackgram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P4	1.67 ± 0.00 (0.00)	195.40 ± 5.30 (2.70)	1.65 ± 0.09 (0.60)
P4C1	0.48 ± 0.01 (2.08)	81.05 ± 1.80 (2.20)	0.50 ± 0.03 (6.00)
P4C2	0.40 ± 0.02 (5.00)	47.00 ± 2.60 (5.50)	0.35 ± 0.02 (5.70)
P4C3	0.39 ± 0.01 (2.56)	81.02 ± 2.90 (3.52)	0.47 ± 0.08 (17.02)
P4C4	0.30 ± 0.09 (3.00)	59.93 ± 4.50 (7.50)	0.38 ± 0.07 (18.40)
P4C5	0.30 ± 0.03 (1.00)	75.90 ± 5.0 (6.58)	0.34 ± 0.07 (20.50)
P4C6	0.29 ± 0.05 (2.70)	59.93 ± 3.9 (6.50)	0.34 ± 0.01 (2.90)
P4C7	0.25 ± 0.06 (2.40)	66.20 ± 2.1 (3.17)	0.37 ± 0.07 (18.90)
P4C8	0.38 ± 0.04 (4.38)	63.00 ± 4.8 (7.60)	0.39 ± 0.07 (17.90)
CD	0.15	53.61	1.33

	1	2	3	4	5	6	7	8	9
Fibre	P4	P4C1	P4C2	P4C3	P4C8	P4C4	P1C5	P4C6	P4C7
Phytin	P4	P4C1	P4C3	P4C5	P4C1	P4C8	P4C4	P4C6	P4C2
Tannin	P4	P4C1	P4C3	P4C8	P4C4	P4C7	P4C2	P4C5	P4C6

Table 24 Effect of cooking treatments on the antinutritional factors of loosened greengram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P4	0.51 ± 0.04 (7.84)	175.35 ± 3.40 (1.93)	61.50 ± 0.08 (6.95)
P4C1	0.41 ± 0.01 (2.43)	72.00 ± 9.00 (12.50)	0.53 ± 0.01 (18.86)
P4C2	0.38 ± 0.03 (7.89)	41.15 ± 2.30 (5.58)	0.40 ± 0.08 (20.00)
P4C3	0.39 ± 0.04 (10.25)	67.00 ± 0.32 (4.77)	0.50 ± 0.06 (12.00)
P4C4	0.26 ± 0.08 (30.76)	48.80 ± 2.10 (4.30)	0.32 ± 0.04 (12.50)
P4C5	0.26 ± 0.03 (11.53)	56.75 ± 2.50 (4.40)	0.53 ± 0.05 (9.43)
P4C6	0.26 ± 0.04 (15.38)	41.25 ± 2.40 (5.81)	0.40 ± 0.04 (10.0)
P4C7	0.26 ± 0.03 (12.5)	48.80 ± 2.10 (4.30)	0.45 ± 0.06 (13.33)
P4C8	0.28 ± 0.02 (7.14)	51.50 ± 2.10 (4.07)	0.50 ± 0.04 (8.0)
CD	0.13	53.61	0.33

	1	2	3	4	5	6	7	8	9
Fibre	P4	P4C1	P4C3	P4C2	P4C8	P4C4	P4C5	P3C6	P4C7
Phytin	P4	P4C1	P4C3	P4C5	P4C8	P4C4	P4C7	P4C6	P4C2
Tannin	P4	P4C1	P4C5	P4C3	P4C8	P4C7	P4C2	P4C6	P4C4

Significant variation was also noted between P_4C_7 with P_4C_2 and P_4C_3 in greengram while in the case of blackgram significant variation was noted between P_4C_7 and P_4C_2.

Comparison of P_4C_8 with other samples depicted no significant retention of fibre in blackgram and greengram.

Phytic acid content of all the loosened pulse samples was found to be significantly reduced by all the cooking treatments in blackgram and greengram.

Among samples cooked in water media, no significant variation was noted between boiled, steamed or pressure cooked samples in greengram and blackgram. Though the maximum loss of phytic acid was observed in soaked pulse samples, significant variation between cooking treatments were not observed.

Among samples cooked by means of oil (P_4C_7), roasted (P_4C_6) and micro oven cooked (P_4C_8) no significant variation was observed both in blackgram and greengram.

Comparison of P_4C_6, P_4C_7 and P_4C_8 with samples cooked in water media (P_4C_1, P_4C_2, P_4C_3, P_4C_4 and P_4C_5) also depiçted no significant variation in blackgram and greengram.

Tannin concentration of all loosened pulse samples was reduced by cooking treatments.

Among cooked samples no significant variation in tannin retention was observed among boiled and steamed samples and also between soaked and unsoaked samples of blackgram and greengram.

Comparison of P_4C_5 with boiled and steamed samples also depicted no significant variation in both the pulses.

Among P_4C6, P_4C_7 and P_4C_8 also no significant variation in tannin was observed in both the pulses.

Comparison of P_4C_6, P_4C_7 and P_4C_8 pulse samples with samples cooked in water media depicted no significant variation in tannin in both the pulses.

All the cooking treatments resulted in significant loss of fibre, phytic acid and tannin. Reddy et al., (1985) reported significant losses of antinutritional factors due to dehulling and cooking.

Maximum loss of phytic acid and tannin were observed in soaked and cooked samples and roasted samples in greengram and blackgram. Igbedioh et al., (1994) reported that dehulling and boiling resulted in great loss of phytic acid and removed about 53 per cent in pigeon pea. Deshpande and Cheriyan (1984) reported significant loss of tannin occurred upon soaking.

In both the pulses maximum loss of fibre was observed for P_4C_4, P_4C_5, P_4C_6 and P_4C_7 samples. Igbedoih et al., (1994) reported effect of different treatments like soaking, soaking and dehulling and boiling, roasting and autoclaving on crude fibre of pulses.

No significant variation in phytic acid and tannin content was observed among samples cooked by different methods in blackgram and greengram, while all the cooking treatments resulted in drastic reduction of antinutritional factors viz. fibre, phytic acid and tannin. Rao and Deosthale (1983), Salunkhe (1982) and Padma and Sumathi (1994) also reported significant reduction of antinutritional factors by various cooking treatments.

4.5.6 Effect of cooking treatments on antinutritional factors of splitted and dehusked pulses (Tables 25 and 26)

Comparison of fibre content in dehusked pulses with other cooked samples in blackgram and greengram depicted significant variations.

Among cooked samples in blackgram and greengram, no significant variation in fibre retention was observed between P_5C_1 and P_5C_2, P_5C_3 and P_5C_4. Between P_5C_1 and P_5C_3, and P_5C_2 and P_5C_4 also, similar observations were made.

Comparison of P_5C_5 (pressure cooked) sample with other cooked samples also depicted no significant variation in blackgram and greengram.

Table 25 Effect of cooking treatments on the antinutritional factors of split and dehusked blackgram

Cooking treatments	Fibre (%)	Phytic acid mg/100g	Tannin mg/100g
P5	0.59 ± 0.08 (13.50)	196.20 ± 3.90 (1.90)	1.35 ± 0.05 (3.70)
P5C1	0.36 ± 0.03 (8.30)	83.02 ± 6.70 (8.00)	0.75 ± 0.03 (4.00)
P5C2	0.31 ± 0.03 (9.60)	39.85 ± 1.60 (4.00)	0.50 ± 0.02 (4.00)
5C3	0.36 ± 0.02 (5.50)	89.43 ± 2.10 (2.30)	0.66 ± 0.01 (1.50)
P5C4	0.36 ± 0.05 (13.80)	32.50 ± 0.6 (1.80)	0.37 ± 0.00 (0.00)
P5C5	0.30 ± 0.06 (5.00)	71.80 ± 1.20 (1.60)	0.35 ± 0.01 (2.80)
P5C6	0.30 ± 0.07 (4.50)	51.75 ± 2.10 (4.00)	0.45 ± 0.02 (4.40)
P5C7	0.30 ± 0.06 (5.00)	61.00 ± 0.50 (0.80)	0.49 ± 0.04 (8.10)
P5C8	0.33 ± 0.06 (18.1)	67.00 ± 1.80 (2.60)	0.58 ± 0.05 (8.60)
CD	0.15	53.61	0.33

	1	2	3	4	5	6	7	8	9
Fibre	P5	P5C1	P5C3	P5C4	P5C8	P5C2	P5C5	P5C6	P5C7
Phytin	P5	P5C3	P5C1	P5C5	P5C8	P5C7	P5C6	P5C2	P5C4
Tannin	P5	P5C1	P5C3	P5C8	P5C2	P5C7	P5C6	P5C4	P5C5

Table 26 Effect of cooking treatments on the antinutritonal factors of split and dehusked greengram

Cooking treatments	Fibre (%)	Phytic acid mg/100	Tannin mg/100g
P5	0.48 ± 0.03 (6.25)	180.30 ± 4.80 (2.60)	1.05 ± 0.10 (8.50)
P5C1	0.29 ± 0.02 (6.80)	73.60 ± 2.10 (2.80)	0.50 ± 0.10 (2.00)
P5C2	0.27 ± 0.01 (3.70)	45.10 ± 2.80 (6.20)	0.33 ± 0.00 (0.00)
P5C3	0.29 ± 0.01 (3.40)	68.80 ± 2.00 (2.90)	0.52 ± 0.01 (1.90)
P5C4	0.24 ± 0.01 (4.10)	46.15 ± 1.50 (3.20)	0.40 ± 0.02 (5.00)
P5C5	0.24 ± 0.01 (4.10)	72.00 ± 2.00 (2.70)	0.45 ± 0.02 (4.40)
P5C6	0.26 ± 0.03 (11.50)	70.50 ± 3.50 (4.90)	0.60 ± 0.01 (1.60)
P5C7	0.24 ± 0.94 (16.60)	71.10 ± 4.20 (5.90)	0.62 ± 0.05 (8.00)
P5C8	0.26 ± 0.03 (11.5)	72.00 ± 2.90 (4.00)	0.65 ± 0.05 (7.60)
CD	0.15	53.61	0.33

	1	2	3	4	5	6	7	8	9
Fibre	P5	P5C1	P5C3	P5C2	P5C6	P5C8	P5C4	P5C5	P5C7
Phytin	P5	P5C1	P5C5	P5C8	P5C7	P5C6	P5C3	P5C4	P5C2
Tannin	P5	P5C8	P5C7	P5C6	P5C3	P5C1	P5C5	P5C4	P5C2

Among samples cooked in other media ie. P_5C_4, P_5C_7 and P_5C_8 statistically significant variation was not observed in both blackgram and greengram.

Comparison of the samples like P_5C_6, P_5C_7 and P_5C_8 with samples cooked in water media, revealed no significant variation in blackgram and greengram.

Phytic acid concentration of all split and dehusked samples of blackgram and greengram were reduced by all cooking treatments in blackgram and greengram.

Among samples cooked in water media, no significant variation between boiled and steamed samples were observed in blackgram and greengram, either soaked or unsoaked. Similar observation was also made between boiled and steamed samples.

Among samples of P_5C_6, P_5C_7 and P_5C_8 no significant variation was observed in phytic acid retention in blackgram and greengram.

Comparison of P_5C_4, P_5C_7 and P_5C_8 with samples cooked in water media depicted no significant variation in both pulses.

Tannin concentration of split and dehusked pulses samples were reduced by cooking treatments in greengram and blackgram.

Among boiled samples in blackgram and greengram no significant variation was observed between soaked (P_5C_2) and unsoaked (P_5C_1) samples. Similar observation were also made in the case of greengram. Between boiled (P_5C_1) and steamed (P_5C_3) samples variation in tannin loss was not significant in both the pulses.

Comparison of P_5C_5 with boiled and steamed samples in both pulses was not significant, except between P_5C_5 and P_5C_1 which was significant in blackgram.

Among roasted (P_5C_6), fried (P_5C_7) and micro oven cooked (P_5C_8) samples no significant retention of tannin was observed in both pulses. Comparison of these samples with samples cooked in water media also depicted no significant variation.

All the cooking treatments resulted in significant loss of antinutritional factors in split and dehusked samples. Bishnoi et al., (1994), Khan et al., (1988) and Igbedoih et al., (1994) reported significant loss of crude fibre, phytic acid and tannin during cooking.

In greengram and blackgram no significant variation in fibre loss was observed among cooking treatments. Gooneratne et al., (1994) reported processing and cooking resulted in significant degradation of fibre.

Maximum loss of phytic acid was observed in soaked samples in greengram and blackgram. Khan et al., (1988) reported soaking bengal gram resulted in significant loss of phytic acid. No significant variation in phytic acid was observed among cooking treatments in both the pulses.

In greengram maximum loss of tannin was observed in cooked samples followed by sample cooked under pressure, while in blackgram maximum loss of tannin was observed for sample cooked under pressure followed by soaked samples. Rao and Deosthale (1983) reported that the drastic reduction in pressure cooking might be due to destruction of phenols at high temperature and some leaching of the components in cooking water.

4.6 Association between minerals and anti nutritional factors

The two grams, viz., blackgram and greengram samples collected as such; dried and cooked, germinated and cooked, loosened and cooked, split dehusked and their cooked samples were all analysed for various minerals and antinutritional factors such as fibre,. phytic acid and tannin as already discussed.

Correlations were worked out between important minerals viz., P, Ca and Fe and the three antinutritional factors.

Both blackgram and greengram (processed and uncooked) showed significant correlation between P and tannin (0.972^{*}, 0.951^{*}), Ca and tannin. In greengram, however, a significant correlation was observed between P and Fibre (0.873^{*}) and between Fe and Tannin (0.896^{*}) also.

In the samples of blackgram and greengram, significant association was observed between Fe and tannin (0.749^{*}, 0.842^{**}).

A significant correlation between Fe and phytic acid (0.814^{*}), Ca and phytic acid (0.781^{*}) could also be observed in blackgram and greengram respectively.

After germinating the blackgram and greengram, when these constituents were analysed a significant correlation was observed between Fe and fibre (0.932^{*}) in the case of blackgram and P and fibre (0.820^{*}) in the case of greengram. In loosened greengram when cooked, a significant correlation was observed betwen P and Fibre (0.856^{**}). Split and dehusked blackgram after cooking showed a highly significant correlation between Ca and fibre (-0.921^{**}).

Tannin and phytic acid are the two constituents in pulses which are lost during different processing. Hence no significant correlation of these constituents with minerals in the processed pulses were not generally attained. While in unprocessed pulses when raw and cooked samples were compared significant correlation was observed.

Eventhough pulses are moderate sources of minerals, processing and cooking were found to reduce the mineral contents. Antinutritional factors which immobilise minerals were also found to be reduced drastically by these treatments. Among the different treatments germination was found to conserve the minerals better than other processing technique. Germination was also effective in reducing the phytin and tannin contents significantly. Among different cooking methods applied, cooking in water media was found to be better in retaining minerals and in removing antinutritional constituents.

Summary

SUMMARY

The study entitled "Effect of processing on mineral status of selected pulses" is an assessment of the influence of different processing techniques on the mineral status of blackgram (Co_4) and greengram (Pusa 90-11) and the role of antinutritional factors present in these pulses on the immobilisation of minerals. The effect of processing and cooking treatments on antinutritional factors was also studied.

The processing techniques, included drying (P_2), germination (P_3), pre treatment for loosening (P_4) and splitting and dehusking (P_5). The processed pulses were then subjected to various cooking treatments such as boiling (C_1), Soaking and boiling (C_2), steaming (C_3), soaking and steaming (C_4), cooking under pressure (C_5), roasting (C_6), frying (C_7) and micro oven cooking (C_8).

Processing techniques as a whole reduced the mineral levels of fresh pulses. Among different processing techniques applied on blackgram and greengram, minimum mineral loss was observed for drying, followed by germination, loosening outer husk and splitting and dehusking. Drying resulted in significant loss of Ca and Mg. Germination resulted in significant loss of

Ca, Fe, Zn and Cu. However, retention of Ca, Mg and Zn were significant in germinated samples when compared with loosened pulse samples. In blackgram and greengram significant variation between P_4 and P_5 was observed for Ca, Mg and Cu loss.

All the cooking treatments reduced the mineral contents of the dried pulse samples. Samples cooked in water media retained minerals more than other samples, especially in samples boiled and cooked under pressure. Soaking and boiling, significantly retained phosphorus in both the pulses while boiling, cooking under pressure and roasting retained calcium better than other cooking methods. Retention of iron was more, in unsoaked and boiled samples among dried pulses. Maximum loss of Mn, Zn and Cu in greenram was observed in samples cooked in micro over and maximum retention of these minerals was found in samples cooked under pressure. No significant retention of Mn was observed for different cooking treatments. Retention of Cu was better in samples cooked in water media, in both the pulses.

Cooking treatments as a whole reduced the mineral concentrations of germinated blackgram and greengram, except Mg which was higher in samples cooked under pressure in blackgram and boiled samples in greengram. Among cooking methods, boiling resulted in minimum loss of minerals except Mg, for which the minimum loss was observed for steamed samples in both the pulses.

Soaking greengram and blackgram for three hours in water and cooking helped significantly to retain P when compared to other cooking methods, while soaking and steaming reduced Ca and Fe significantly in both the pulses. Similarly in greengram, soaked samples either boiled or steamed and fried samples showed maximum loss of minerals such as Ca, Fe, Mg, Zn and Cu. While in blackgram maximum loss of P, Mg, Mn, Zn and Cu were observed in micro oven cooked samples. Cooking in water media retained maximum amount of Mg, Mn, Zn and Cu in both the pulses. Significant variation in P, Ca and Zn content was observed between roasted and fried samples in blackgram, while no such variation was observed in greengram.

All the cooking treatments reduced the mineral contents of loosened blackgram and greengram. Soaked blackgram samples retained P and Mg significantly better when compared to unsoaked samples. In both the pulses, no significant variation among samples, cooked in water media, was observed for Fe and Mn. Among cooked blackgram samples, no significant variation in Fe, Mg, Mn and Cu was observed among roasted, fried and samples cooked in micro oven, while in greengram such observations were not made for these minerals.Zn. Boiled had maximum loss of P, Ca, Mn, Zn and Cu while Fe, Zn and Cu were lost significantly in boiled blackgram.

All the cooking treatments reduced the mineral contents except Mg and Cu in splitted and dehusked blackgram and greengram. In blackgram, maximum loss of Ca, Fe and Mg was observed in steamed samples, while in greengram maximum loss of Ca was observed in steamed samples and Fe and Mg in samples cooked under pressure. However among boiled and steamed samples, no significant variation in Fe, Mn and Mg was observed in the two pulses. Maximum loss of P in both the pulses was observed in fried samples. While no significant variation in P, Ca, Fe, Mg, Mn and Cu retention was observed between fried and micro oven cooked sample.

Processing as a whole resulted in reduction of fibre, phytin and tannin levels of fresh pulses. However in germinated blackgram samples, fibre was found to be slightly increased. Loss of fibre, phytin and tannin observed in dried samples, (P_2) was not significant. The two processing techniques viz. removal of outer husk and splitting resuted in loss of fibre and tannin, while germination, loosening and splitting and dehusking resulted in significant loss of phytin. Germination also reduced tannin level considerably in both the pulses.

All the cooking treatments reduced these constituents in dried samples significantly. Among these treatments, soaking and cooking was most effective in reducing phytin (65 to 75 percent) and tannin (75 to 80 per cent). In pressure cooking also, significant loss in fibre and phytin in both the pulses, was observed.

Cooking of germinated blackgram and greengram, by various methods resulted in significant loss of fibre, phytin and tannin. Soaking and cooking of germinated pulses was most effective in reducing the phytin and tannin levels. Roasting also effectively reduced the phytic acid. 60-75 per cent of phytin and 57 to 79 per cent of tannin were removed in germinated pulses after cooking.

Among various cooking treatments applied soaking and cooking and roasting resulted in maximum loss of phytin and tannin in loosened blackgram and greengram. All the cooking treatments resulted in significant loss of phytin fibre and tannin, however no sginficant variation was observed among various cooking treatments for phytin and tannin.

Significant association between loss of minerals and antinutritional constituents were also observed. Significant correlation between minerals viz, P, Ca and Fe and antinutritional factors viz. phytic acid, tannin and fibre were observed more in unprocessed and cooked samples than in processed and cooked pulses. A positive correlation was observed between minerals and antinutritional constituents in both pulses except between calcium and fibre in split and dehusked blackgram when cooked.

Cooking of splitted and dehusked samples by various methods drastically reduced the levels of fibre, phytin and tannin. Soaking and cooking effectively decreased the levels of phytin on both pulses. Maximum loss of tannin was observed for soaked and cooked samples and for samples cooked under pressure. No variation in fibre loss was observed among cooking treatments except in splitted and dehusked samples.

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* Original not seen

Appendix

APPENDIX - I

Effect of processing on mineral profile and
antinutritional factors of pulses
Abstract of ANOVA

df - 4

	Minerals	Processing
Mean sum of square	P	1053.53**
	Ca	1383.66**
	Fe	0.20**
	Mg	3000.00**
	Mn	128.41**
	Zn	132.23**
	Cu	0.01**
	Fibre	0.09**
	Phytic acid	5007.41**
	Tannin	6815.72**

** Denotes 1 per cent level of significance of the corresponding 'F' value

APPENDIX - II

Effect of cooking treatments on mineral profile
and antinutritional factors of pulses
Abstract of ANOVA

		df - 32
	Minerals	Processing
	P	1832.06**
	Ca	252.48**
	Fe	0.07**
Mean sum of square	Mg	1653.42**
	Mn	0.01
	Zn	124.00**
	Cu	0.00**
	Fibre	0.02**
	Phytic acid	1239.59**
	Tannin	571.98**

** Denotes 1 per cent level of significance of the corresponding 'F' value

Abstract

EFFECT OF PROCESSING ON THE MINERAL STATUS OF SELECTED PULSES

by

Seji Kochappan.N

ABSTRACT OF THE THESIS

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ABSTRACT

The present study entitled "Effect of processing on mineral status of selected pulses" was an assessment of the effect of various processing techniques viz., drying, germination, pretreatment for loosening and splitting and dehusking, on mineral status as well as on the antinutritional factors present in the pulses. Role of antinutritional factors or the immobilisation of minerals in the pulses were also ascertained. The pulses selected for this study were blackgram (CO_4) and greengram (Pusa 91-92).

The processed pulses were subjected to various cooking treatments such as boiling, soaking and boiling, steaming, soaking and steaming, cooking under pressure, roasting, frying and micro oven cooking.

Processing techniques as a whole reduced the mineral contents of fresh pulses. Among different processing techniques applied on blackgram and greengram, minimum mineral loss was observed in dried samples, followed by germinated samples, pulses in which outer husk were loosened and pulses which were split and dehusked. Drying resulted in a significant loss of Ca and Mg while germination resulted in the loss of Ca, Fe, Zn and Cu. Significant retention of Ca, Mg and Zn were observed in

germinated samples compared to husk loosened pulse samples. Significant variations in P, Ca, Fe and Mg were observed between husk loosened and split/dehusked samples.

All the cooking treatments reduced the mineral contents of processed pulse samples. Dried samples cooked in water media retained minerals more than other samples. Maximum loss of Mn, Zn and Cu in dried greengram was observed in the samples cooked in micro oven and maximum retention of these minerals in samples, when cooked under pressure. Roasting retained Ca better than other cooking methods.

In the germinated samples also, boiling was found to retain more minerals. Soaking and cooking retained phosphorus better when compared to other cooking methods in both the pulses, while cooking in micro oven resulted in maximum loss of minerals. Cooking in watermedia ensured maximum retention of Mg, Mn, Zn and Cu in both the pulses.

In split and dehusked blackgram and greengram, steaming resulted in maximum loss of Ca, Fe and Mg in blackgram. While in greengram, this treatment resulted in maximum loss of Ca.

Processing as a whole reduced the fibre, phytin and tannin levels of fresh pulses. Among processing techniques applied husk loosening and splitting and dehusking were most effective in reducing the fibre and tannin contents while germination reduced phytin.

All the cooking treatments applied on processed pulses significantly reduced the fibre, phytin and tannin levels. Among cooking treatments applied soaking and cooking was most effective in reducing the phytin and tannin levels of all the processed samples. Pressure cooking and roasting reduce were also observed to the phytin and tannin levels considerably.

There was association between loss of minerals and antinutritional constitutents in processed and cooked pulses. Correlation between the important minerals P, Ca and Fe and phytin, tannin and fibre was found to be significant in various processed and cooked samples of both pulses. A position correlation was observed between minerals and antinutritional constituents, phytin, tannin and fibre in both the pulses except between Ca and fibre in split and dehusked blackgram when cooked.

Among the different processing techniques administered germination was found to be ideal for improving minerals, while among cooking treatments applied boiling, steaming and pressure cooking had depicted similar trends. Since pulses are moderate sources of mineral and since mineral deficiency are common antinutritional problem prevalent in our state, information on ideal cooking method of pulses need to be in the community.