*J. Plant Biochemistry & Biotechnology* Vol. 14, 77-79, January 2005

## Short Communication

# Chickpea Seed Proteins as Affected by Mineral Supply Levels

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**Accumulation of different protein fractions in chickpea seed harvested from plants grown under four concentration levels (0, 25, 50 and 100 mM) of sulphur, nitrogen, potassium and phosphorus has been studied. Whereas globulins showed an increase with the increasing concentration of all the four minerals, albumins increased under sulphur, nitrogen and potassium, and glutelins increased under potassium and phosphorus. An increase in nitrogen regime led to increased contribution of tryptophan in the seed protein due to albumins and globulins and methionine contribution due to albumins, globulins and glutelins. Under higher supplies of sulphur, relative contribution of tryptophan due to albumins and methionine contribution due to albumins and globulins had increased.**

***Key words***: albumins, globulins, glutelins, prolamins, *Cicer arietinum.*

Legumes represent a good and easily affordable source of proteins in human diet. Alongwith cereals, they feed almost seventy per cent of the world population. Though a rich source of proteins, they are low in sulphur-containing amino acids and tryptophan. Of the four protein fractions, globulins represent the largest proportion and prolamins are the lowest in leguminous seeds. The globulins further consist of two subfractions, i.e. 11 S (legumin-like) and 7S (vicilin-like) (1). The 11 S fraction as compared to 7S fraction is richer in sulphur-containing amino acids and the efforts are thus directed towards screening for lines with increased proportion of seed protein fractions containing higher amount of desired amino acids and nutritionally superior polypeptides. The process of synthesis and accumulation of storage proteins in the seed is regulated by a number of genetic and environmental factors (2). A number of studies on mineral supply levels showed that in garden pea the proportion of legumin increased under conditions of potassium and phosphorus deficiency and the amount of vicilin increased and that of legumin and albumin showed a decrease in the sulphur-deficient environment (3). In soybean, sulphur deficiency resulted in 40% decrease in glycinin with contrasting increase of β-conglycinin (4). The present paper deals with the changing levels of four seed protein fractions in chickpea grown under different concentration regimes of four minerals.

Plants of chickpea line '537' were grown in bags filled with thoroughly washed sand. Nutrient solutions of different concentrations were prepared using formulations of Machlis and Torrey (5); watering was done as per requirement. Before the appearance of flowers, concentration of nutrient solution was changed to give four different concentration levels, i.e. 0, 25, 50 and 100 mM of each of the four minerals (sulphur, nitrogen, potassium and phosphorus) separately. Half mature (20 DAF) and mature seeds from these plants were harvested, their testa removed, cotyledons dried under vacuum and stored in deep freeze. Separation of four protein factions was carried out using methods of Croy *et al* (6) with slight modifications as given by Chandna and Matta (7). Protein concentration of four fractions was determined following the method of Lowry *et al* (8) and amino acids like tryptophan, methionine and cysteine were estimated using colorimetric methods (9-11).

The status of four protein fractions in the half mature and mature seeds harvested from plants grown under different supply levels of sulphur, nitrogen, potassium and phosphorus is shown in Fig.1. Whereas, with increased supplies of sulphur, nitrogen and potassium the amount of albumins increased in half mature seeds (from 26.8 to 30.2, 26.0 to 29.0 and 20.5 to 24.0 mg $g^{-1}$ seed meal, respectively), it was found to decrease (23.5 to 20.5 mg $g^{-1}$ seed meal) under phosphorus supply. Globulins exhibited a decrease under increasing supply levels of sulphur (112.4 to 103.5 mg $g^{-1}$ seed meal), nitrogen (112.0 to 102.5 mg $g^{-1}$ seed meal) and phosphorus (108.0 to 101.5 mg $g^{-1}$ seed meal) but registered an increase (101.5 to 107.8 mg $g^{-1}$ seed meal) with increasing concentration levels of potassium. On the other hand, in case of glutelins an

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increase from 21.0 to 23.2 mg $g^{-1}$ seed meal was observed under increasing supply of phosphorus (Fig.1). However, prolamins showed an increase under increasing levels of potassium and phosphorus supply.

In mature seeds, the amount of albumins followed a decrease from 28.2 to 24.1 mg $g^{-1}$ seed meal under increasing concentration levels of phosphorus. However, the amount of globulins registered an increase under all the four minerals i.e. from 128.0 to 135.0 mg $g^{-1}$ seed meal under nitrogen supply, 131.0 to 139.0 mg $g^{-1}$ seed meal under sulphur supply, 127.0 to 135.2 mg $g^{-1}$ seed meal under potassium supply and 123.5 to 130.2 mg $g^{-1}$ seed meal under phosphorus supply (Fig.1). The amount of glutelins increased under changing levels of potassium (28.8 to 31.5 mg $g^{-1}$ seed meal) and phosphorus (27.5 to 30.2 mg $g^{-1}$ seed meal) and that of prolamins increased from 5.5 to 6.9 mg $g^{-1}$ seed meal as the supply levels of phosphorus increased from 0.0 mM to 100 mM.

The effect of increasing concentration levels of four minerals on the relative contribution of amino acids like tryptophan, methionine and cysteine can be seen in Table 1. As is vivid from this table and Fig.1, increasing levels of nitrogen supply led to an increase in the amount of albumins, globulins and in the relative contribution of tryptophan due to these fractions. An increase in methionine contribution in case of albumins, globulins and glutelins and that of cysteine in case of glutelins and prolamins could also be noticed under higher regimes of nitrogen. With increased sulphur levels, an increase was observed in the amount of albumin and globulin fractions and in the relative contribution of tryptophan due to albumins, relative contribution of methionine due to albumins and globulins and relative

**Table 1.** Effect of mineral supply on relative contribution of tryptophan, methionine and cysteine due to seed protein fractions (albumins (A), globulins (B), glutelins (C), prolamins (D) in chikpea line ‘537’

| Mineral conc. (mM) | Tryptophan contribution (%) | | | | Methionine contribution (%) | | | | Cysteine contribution (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D |
| Suphur | | | | | | | | | | | | |
| 0 | 21.9 | 50.7 | 17.3 | 10.1 | 23.1 | 45.8 | 21.9 | 9.2 | 26.1 | 47.8 | 16.9 | 9.0 |
| 25 | 23.4 | 49.8 | 16.8 | 10.0 | 23.9 | 47.4 | 20.6 | 8.1 | 24.1 | 50.3 | 17.8 | 7.8 |
| 50 | 26.1 | 49.2 | 15.6 | 9.1 | 25.0 | 48.8 | 18.7 | 7.5 | 23.2 | 51.4 | 18.7 | 6.7 |
| 100 | 28.5 | 48.8 | 14.2 | 8.5 | 25.5 | 50.9 | 17.3 | 6.3 | 20.8 | 53.9 | 19.8 | 5.5 |
| Nitrogen | | | | | | | | | | | | |
| 0 | 23.8 | 45.8 | 18.3 | 12.1 | 20.6 | 51.5 | 18.3 | 9.6 | 25.9 | 48.6 | 15.3 | 10.2 |
| 25 | 24.3 | 48.5 | 16.4 | 10.8 | 21.2 | 50.8 | 18.6 | 9.4 | 22.7 | 48.0 | 18.5 | 10.8 |
| 50 | 25.1 | 51.3 | 14.9 | 8.7 | 21.7 | 52.3 | 18.8 | 7.2 | 22.2 | 45.8 | 20.4 | 11.6 |
| 100 | 26.7 | 52.7 | 14.1 | 6.5 | 22.1 | 53.1 | 19.1 | 5.7 | 19.5 | 44.7 | 23.2 | 12.6 |
| Potassium | | | | | | | | | | | | |
| 0 | 16.3 | 59.4 | 13.4 | 10.9 | 22.1 | 39.8 | 28.5 | 9.6 | 18.7 | 45.8 | 24.5 | 11.0 |
| 25 | 18.7 | 57.7 | 14.1 | 9.5 | 23.5 | 42.4 | 24.3 | 9.8 | 21.8 | 46.5 | 22.7 | 9.0 |
| 50 | 21.2 | 55.6 | 14.9 | 8.3 | 23.8 | 43.7 | 22.3 | 10.2 | 22.0 | 47.9 | 21.9 | 8.0 |
| 100 | 23.1 | 54.5 | 16.1 | 6.3 | 24.9 | 45.1 | 19.1 | 10.9 | 23.6 | 50.5 | 19.1 | 6.8 |
| Phosphorus | | | | | | | | | | | | |
| 0 | 18.9 | 53.6 | 17.9 | 9.6 | 21.8 | 49.7 | 18.8 | 9.7 | 19.3 | 53.6 | 16.5 | 10.6 |
| 25 | 17.8 | 54.9 | 16.5 | 10.8 | 20.6 | 48.9 | 21.2 | 9.3 | 20.8 | 51.2 | 17.7 | 10.3 |
| 50 | 16.9 | 55.5 | 15.6 | 12.0 | 20.5 | 47.5 | 24.7 | 8.0 | 22.4 | 49.3 | 18.8 | 9.5 |
| 100 | 15.3 | 57.6 | 14.4 | 12.5 | 19.3 | 46.7 | 21.5 | 7.5 | 23.5 | 46.2 | 21.4 | 8.9 |

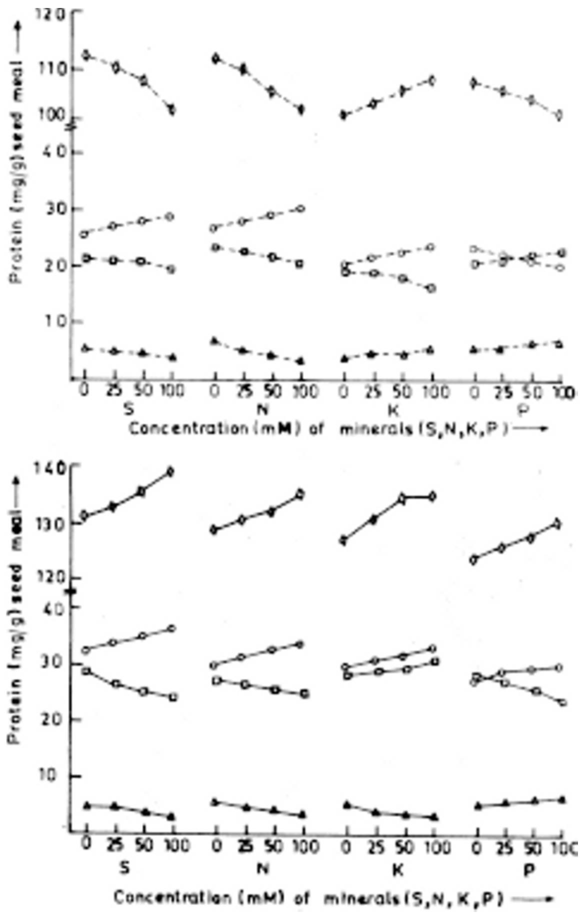


**Fig. 1.** Effect of different supply levels of sulphur (S), nitrogen (N), potassium (K) and phosphorus (P) on protein fractions of half mature (----) and mature (——) seeds of chikpea line '537'; o=albumins, ◊ = globulins, □ = glutelins, Δ = prolamins.

contribution of cysteine due to globulins and glutelins. Similarly, with increased supply level of potassium, three fractions viz. albumins, globulins and glutelins registered an increase. Under enhanced supplies of phosphorus, the proportion and accumulation of globulins, glutelins and prolamins went up and an increase in relative contribution of tryptophan due to globulins and prolamins, methionine due to glutelins and cysteine contribution due to albumins and glutelins was also observed.

Synthesis and accumulation of seed protein fractions is a function of the interplay of a number of genetic and environmental factors during seed development. Besides screening for lines with nutritionally superior polypeptides and characterization of protein fractions with higher content of sulphur-containing amino acids, studies on regulation of storage protein synthesis during seed development promise altered proportion of seed protein fractions tilted towards better and balanced amino acid pool. Changes in environmental factors are known to work through controls at post-transcriptional level as has been shown by Beach *et al* (12) in case of legumin synthesis under conditions of sulphur availability. With respect to the four chickpea protein fractions, globulins in the present study were found to register an increase with increase in supply levels of all the four minerals. Thus, globulin being the major fraction in the seed, any further increase in its proportion and contribution of limiting amino acids due to this fraction are likely to be achieved through the use of higher concentration levels of these four minerals.

## Acknowledgements

Financial support from the Department of Atomic Energy, Trombay and a Research Fellowship to RS by the University Grant Commission, New Delhi are thankfully acknowledged.

Received 9 June, 2004; revised 31 December, 2004.

## References

1 **Derbyshire E, Wright DJ & Boulter D,** *Photochemistry,* **15** ( 1976)3.

2 **Chandna M & Matta NK,** *Physiol Mol Biol* **5** (1999) 139.

3 **Randall RJ, Thomposn JA & Schroeder HE,** *Aust J Plant Physiol,* **6** (1979) 11.

4 **Gayler KR & Sykes GE,** *Plant Physiol,* **67** (1985) 958.

5 **Machlis L & Torrey JG,** In *Plants in action - A laboratory manual of plant physiology* (1956) p 41.

6 **Croy RRD, Hogue MS, Gatehouse JA & Boulter D,** *Biochem J,* **218** (1984) 795.

7 **Chandna M & Matta NK,** *Phytochemistry,* **29** (1990) 3395.

8 **Lowry OH, Rosebrough NJ, Farr AL & Randall RJ,** *J Biol Chem,* **193** (1951) 265.

9 **Spies JR & Chambers DC,** *Anal Chem,* **21** (1949) 1249.

10 **MacCarthy TE & Sullivan MX,** *J Biol Chem,* **141** (1941) 871.

11 **Goa J,** *Acta Chemica Scandinavica,* **15** (1961) 853.

12 **Beach LR, Spencer D, Randall PJ & Higgins TJ,** *Nucl Acids Res,* **13** (1985) 999.