ASSET Series B (2008) 7 (1): 54-62

ASSET
An
International
Journal

# PROTEIN FRACTIONS OF LEGUMES AND CEREALS CONSUMED IN NIGERIA

**T. F. AKINHANMI , L.A AROGUNDADE*, M. O. TIAMIYU, E. OLORUNTOBA AND B.J. OSINAME**

Department of Chemistry, University of Agriculture, UNAAB
Post Office, Box 28, Alabata, Abeokuta, Nigeria
*Corresponding author; Phone number : +2348035080660
E- mail address : aroglaw@yahoo.com

## ABSTRACT

Protein fractions of the various legumes and cereals consumed in Nigeria were determined. The albumin, globulin, prolamin, acid and alkali-glutelin in them were in the range 0.2- 31.2 g/100g respectively. The oil seeds had higher ($p<0.05$) globulin, acid and alkali soluble glutelin than other food species but the pulses were richer ($p<0.05$) in albumin. Total extractable protein (TEP) in cereals, pulses and oil seeds were in the range of 8.3 -58.4 g/100g.

**Keywords:** Protein fractions, Pulses, Oil-seeds, Cereals

## INTRODUCTION

Plant Protein plays significant role in the world protein demand. It provides nearly *65%* of the world human protein requirements with 10 - 15 % from cereals and 45 - 50% from legumes (Mahe *et al.*, 1994). Exploiting the potentials of home grown-legume and cereals, particularly the under-utilized ones as supplements in human and livestock feed demands that their protein be characterized. One of the resourceful means for characterizing vegetable protein in the grain seeds involves fractionation vis-à-vis solubility potentials (i.e., albumin, globulin, prolamin, and glutelin) (Rakosk, 1989; Hamada, l997). Fractionation helps in understanding the molecular basis of solubility. The proportion of protein fraction gives an insight into the plausible uses of such vegetable protein (Jideani *et al.*, 1994; Hamada, 1997). Several studies have concentrated on the fractionation of oriental food grains ( Schofield and Booth, 1983; Kasarda *et al.*, 1976; Sethi and Kulkarni,1993; Dorward and Pusztai, 1986; Singh *et al.*, 1988; Thank and Shibasakki,1976;Singh and Jambunathan, 1982) . However, there are limited reports on protein fractions of tropical grain seeds (Schofield and Booth, 1983; Sethi and Kulkarni, 1993; Jideani *et al.*, 1994; Guo and Yao, 2006). This study reports the protein fractions of some cereals and leguminous grains grown in Nigeria.

## MATERIALS AND METHODS

Legumes *(eight)* and cereals *(six)* were obtained from Ibadan and Abeokuta, Nigeria and extraneous materials were removed and ground in its dried state with kitchen grinder. The flour was defatted with successive extraction with *n*-hexane in ratio 1:2 (*solid : solvent ratio*) at room temperature. The hexane was decanted and the flour air dried. The dried flour was ground to pass through 4.25µm sieve and then stored in air tight container for use as defatted flour samples (Arogundade *et al.*, 2004; Seena and Sridhar, 2005). The fractionation of protein in the hexane- defatted samples was carried out as described by Chen and Butshue (1970) with modification. A 200mg of each food sample was sequentially extracted in a centrifuge tube at room temperature for an hour in each case with $2cm^3$ of distilled water, sodium chloride (0.5M), aqueous ethanol (70%), acetic acid (0.1M) and sodium hydroxide (0.1M) to obtain albumin, globulin, prolamin, acid soluble glutelin and alkaline-soluble glutelin, respectively. At the end of each extraction, the slurry was centrifuged (3500rpm, 45min) and the soluble protein in the supernatant was determined by the Biuret method (Ibanoglu and Ercelebi, 2007).

***Statistical analyses***

Each analysis was replicated while the mean and standard error (SE) were reported. Analysis of variance (ANOVA) was performed using Duncan's Multiple Range Test (SAS, 1999).

## RESULTS AND DISCUSSION

The various protein fractions of legumes and cereals are shown in Tables 1- 3. The albumin content of oil seeds ranged from 5.1 - 8.4 while those of pulses 6.5 - 18.l and cereals ranged from 0.4— 6.6 g/100g. Lima bean had higher albumin while polished rice was least. Pulses were higher in albumin compared to oil seeds and cereals (Fig.1a). Globulin fraction in oil seeds, pulses and cereals ranged from 9.4 -16.6 g/100g, 3.6 -10.8 g/100g and 1.1 -5.0 g /100g, respectively. Benniseed had higher globulin compared to others. Lima bean showed lower globulin compared to other pulses. Oil seeds are richer in globulin than pulses and cereals (Fig.1b). Prolamin ranged from l.6-3.9 g/100g; 0.3-2.3 g/100g and 1.5-11.8 g/100g in oil seeds, pulses and cereals, respectively. Brown Sorghum was high in prolamin (11.8 ± 0.9g/100g) compared to other staple foods. Prolamin contents recorded for sorghum and wheat were 11.8 and 6.1 g/100g, respectively, against a range of 0.3 to 3.9g/100g for the other foods. Although, Figure 1c showed that cereals were richer in prolamin, only sorgum and wheat were actually having outstanding in prolamin content while the remaining cereals were in the same range with what was obtainable in the other foods. Acid - glutelin content of oil seeds, pulses and cereals were in the range of 2.8- 11.5 g/100g, 0.2- 1.4 g/100g and 0.6 - 1.9g/100g, respectively. The two groundnut cultivars showed higher acid soluble glutelin. Oil seeds contain more acid soluble glutelin than pulses and cereals (Fig.1d). Alkaline soluble glutelin in pulses, cereals and oil seeds ranged from 4.3 -12.0g/100g, 3.0 - 13.3g/100g and 22.3 - 31.2 g/100g respectively. This protein fraction represents the protein pool in oil seeds and cereals considered. Oil seeds were higher in alkaline-glutelin compared to cereals and pulses (Fig.le). The protein fraction in the oilseeds is in the order; alka-

ISSN 1595—9694 © UNAAB 2003

line-glutelin > globulin ≈ albumin > acid – glutelin > prolamin. In the pulses albumin ≈ globulin > alkaline-glutelin > prolamin > acid-glutelin.

**Table Ia : Protein fractions in oil seeds[SA]**

| Common name | Scientific name | Local Yoruba name | Code | Albumin | Globulin | Prolamin | Acid-Glutelin | Alkali-Glutelin |
|---|---|---|---|---|---|---|---|---|
| Elongated melon | *Citrullus utilissm L.* | Egusi itoo | OS-11 | $6.2^{k} \pm 0.2$ | $14.0^{g} \pm 0.2$ | $1.8^{o} \pm 0.2$ | $4.3^{m} \pm 0.3$ | $30.6^{a} \pm 0.1$ |
| Rounded melon | *Citrullus lunatus L.* | Egusi baara | OS-12 | $8.4^{d} \pm 0.4$ | $10.0^{i} \pm 0.0$ | $3.9^{m} \pm 0.3$ | $4.0^{m} \pm 0.0$ | $27.5^{b} \pm 0.2$ |
| Beniseed | *Sesamum inducum* | Iyanmati | OS-21 | $5.8^{kl} \pm 0.0$ | $16.6^{f} \pm 0.2$ | $2.3^{n} \pm 0.0$ | $2.8^{n} \pm 0.3$ | $22.3^{d} \pm 0.2$ |
| Red Groundnut (spiked white) | *Arachis hypogaea L.* | Epa | OS-31 | $6.5^{k} \pm 0.1$ | $11.3^{h} \pm 0.6$ | $1.6^{o} \pm 0.0$ | $11.5^{h} \pm 0.0$ | $27.5^{b} \pm 0.1$ |
| Red groundnut | *Arachis hypogaea L* | Epa | OS-32 | $5.1^{l} \pm 0.0$ | $9.4^{i} \pm 0.3$ | $2.3^{no} \pm 0.3$ | $10.0^{i} \pm 0.7$ | $31.2^{a} \pm 0.4$ |

[SA]Means followed by different letters in either rows or columns are significantly (*$P < 0.05$*) different from one another

**Table Ib : Protein fractions in pulses[SA]**

| Common name | Scientific name | Local Yoruba name | Code | Albumin | Globulin | Prolamin | Acid-Glutelin | Alkali-Glutelin |
|---|---|---|---|---|---|---|---|---|
| Cowpea | *Vigna unguilata.* | Ewa oloo | PS-11 | $10.2^{de} \pm 0.2$ | $10.1^{de} \pm 0.1$ | $2.3^{k} \pm 0.1$ | $0.5^{no} \pm 0.0$ | $6.4^{h} \pm 0.1$ |
| Cowpea | *Vigna unguilata.* | Ewa drumu | PS-12 | $13.5^{b} \pm 0.6$ | $10.8^{c} \pm 0.2$ | $0.6^{no} \pm 0.0$ | $0.4^{o} \pm 0.0$ | $4.3^{i} \pm 0.2$ |
| Cowpea | *Vigna unguilata.* | Ewa oloyin | PS-13 | $8.8^{f} \pm 0.1$ | $8.7^{f} \pm 0.0$ | $1.9^{kl} \pm 0.1$ | $1.4^{lm} \pm 0.0$ | $7.6^{g} \pm 0.2$ |
| Cowpea | *Vigna unguilata.* | Ewa sokoto | PS-14 | $10.1^{e} \pm 0.2$ | $7.3^{g} \pm 0.1$ | $1.1^{mn} \pm 0.1$ | $1.0^{mno} \pm 0.0$ | $6.4^{h} \pm 0.0$ |
| Lima bean | *Phaseolus lunatus L.* | Pakala | PS-21 | $18.1^{a} \pm 0.1$ | $3.6^{j} \pm 0.1$ | – | $0.7^{no} \pm 0.1$ | $12.0^{c} \pm 0.3$ |
| Pigeon pea | *Cajanus cajan Druce* | Otili | PS-31 | $6.5^{h} \pm 0.5$ | $10.8^{cd} \pm 0.8$ | $0.3^{op} \pm 0.0$ | $0.2^{p} \pm 0.1$ | $8.3^{fg} \pm 0.2$ |

[SA]Means followed by different letters in either rows or columns are significantly (*$P < 0.05$*) different from one another

**Table Ic : Protein fractions in cereals[SA]**

| Common name | Scientific name | Local Yoruba name | Code | Albumin | Globulin | Prolamin | Acid-Glutelin | Alkali-Glutelin |
|---|---|---|---|---|---|---|---|---|
| White maize | *Zea mays L.* | Agbado funfun | CS-11 | $2.7^{hi} \pm 0.0$ | $4.8^{fg} \pm 0.3$ | $1.6^{kl} \pm 0.1$ | $1.9^{k} \pm 0.1$ | $5.3^{f} \pm 0.1$ |
| Yellow maize | *Zea mays L.* | Agbado pupa | CS-12 | $4.2^{g} \pm 0.1$ | $2.5^{hij} \pm 0.1$ | $2.0^{jk} \pm 0.0$ | $0.6^{no} \pm 0.0$ | $4.9^{f} \pm 0.1$ |
| White guinea corn | *Sorghum bicolor Pers* | Oka-baba funfun | CS-21 | $3.1^{h} \pm 0.0$ | $1.9^{k} \pm 0.2$ | $2.7^{hi} \pm 0.1$ | $0.9^{mno} \pm 0.0$ | $6.8^{d} \pm 0.3$ |
| Brown guinea corn | *Sorghum bicolor Pers* | Oka-baba pupa | CS-22 | $6.6^{de} \pm 0.0$ | $1.1^{lmn} \pm 0.1$ | $11.8^{b} \pm 0.9$ | $1.2^{lm} \pm 0.1$ | $13.3^{a} \pm 0.1$ |
| Rice | *Oryza sativa L.* | Iresi | CS-31 | $0.4^{o} \pm 0.1$ | $2.6^{hi} \pm 0.1$ | $1.5^{kl} \pm 0.2$ | $0.8^{mno} \pm 0.2$ | $3.0^{h} \pm 0.5$ |
| Wheat | *Triticum aesti-vum* | Wiiti | CS-41 | $2.3^{ij} \pm 0.1$ | $5.0^{f} \pm 0.2$ | $6.1^{e} \pm 0.1$ | $1.2^{lm} \pm 0.1$ | $10.9^{c} \pm 0.1$ |

[SA]Means followed by different letters in either rows or columns are significantly ($P < 0.05$) different from one another

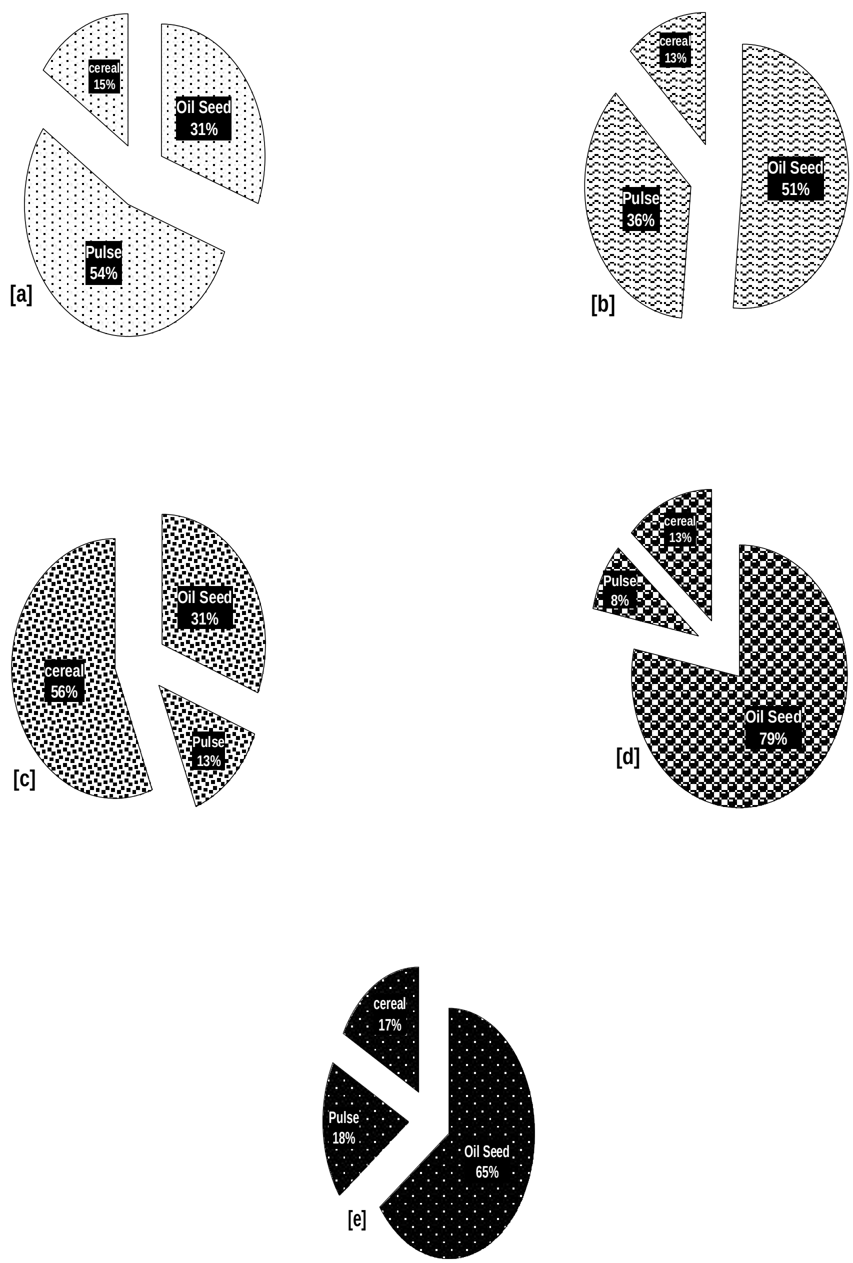


**Figure 1: Relative distribution of [a] Albumin [b] Globulin [c] Prolamin [d] Acid-soluble Glutelin and [e] alkaline-soluble glutelin in pulses, oil seeds and cereals.**

These results are in agreement with those reported by other workers in which the major protein fractions of pulses were albumin and globulin (Derbyshire *et al.*, 1976; Singh *et al.*, 1988; Singh and Jambunathan, 1982). Protein distribution in cereals did not follow any regular pattern, but alkaline-glutelin was higher in cereals compare to other fractions. Different plant materials have different proportions of the various fractions. Significant differences ($p<0.05$) in protein fractions were also observed among cultivars in agreement with other workers (Hamada, 1997; Sogi *et al.*, 2002).

Extractable protein (EP) in the various defatted foods samples are shown in Figs. 2 - 4. Oil seeds contained higher extractable protein in the range of 49.8% - 58.4% while pulses and cereals were 17.8 % - 34.4 % and 14.2 — 34%, respectively.

Though reasonable amount of protein was extracted from the samples, the alkaline-soluble glutelin may not make meaningful contribution to food system when used as supplement, because high concentration alkali treatment may cause some chemical changes which reduces nutritional value and aid formation of toxic compounds such as lysinoalanine (De Groot and Slumps, 1969) which was responsible for kidney damage in rats (Woodward and Short, 1973) . High alkali concentration can also cause racemization of some amino acid (Hamada, 1997). Thus proteins extractable with water, salt, alcohol and acetic acid are regarded as *"effective total soluble protein"* (ETSP) while those that could not be extracted under these mild conditions is called *"residue protein* "(RP) according to Hamada (1997).

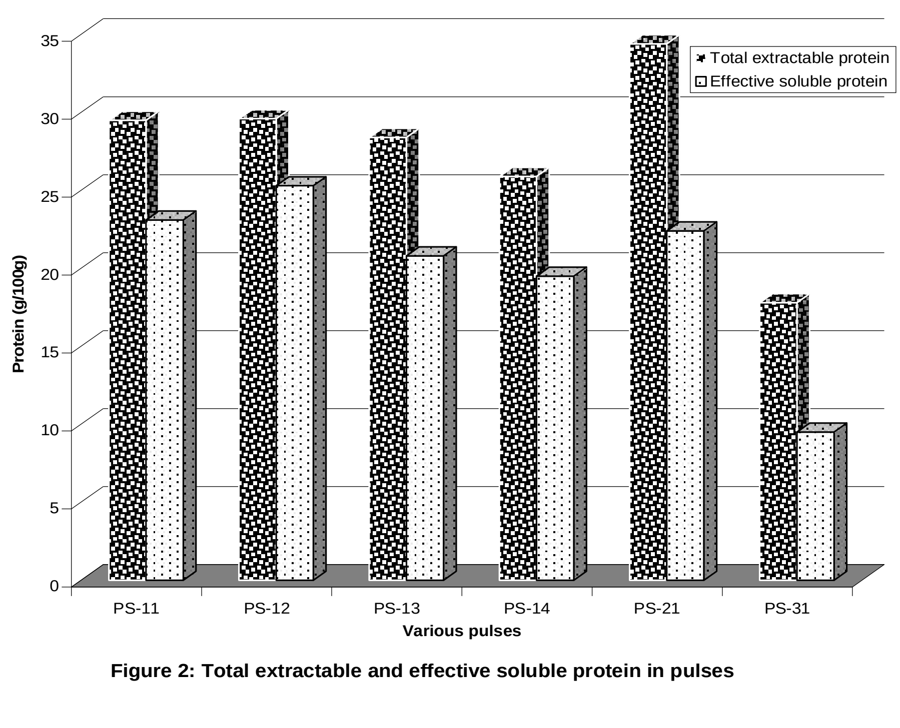


**Figure 2: Total extractable and effective soluble protein in pulses**

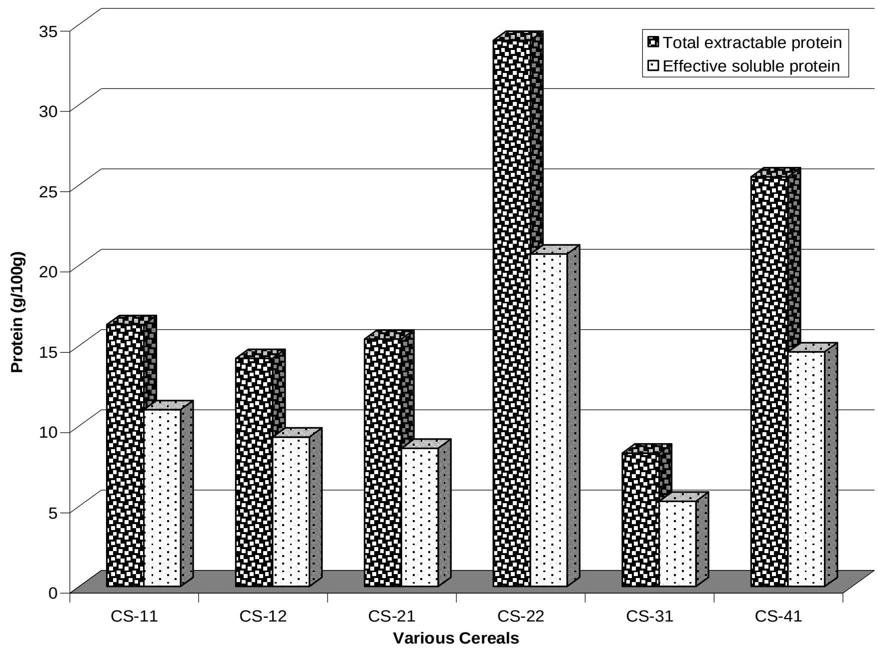


**Figure 3: Total extractable and effective soluble protein in cereals**

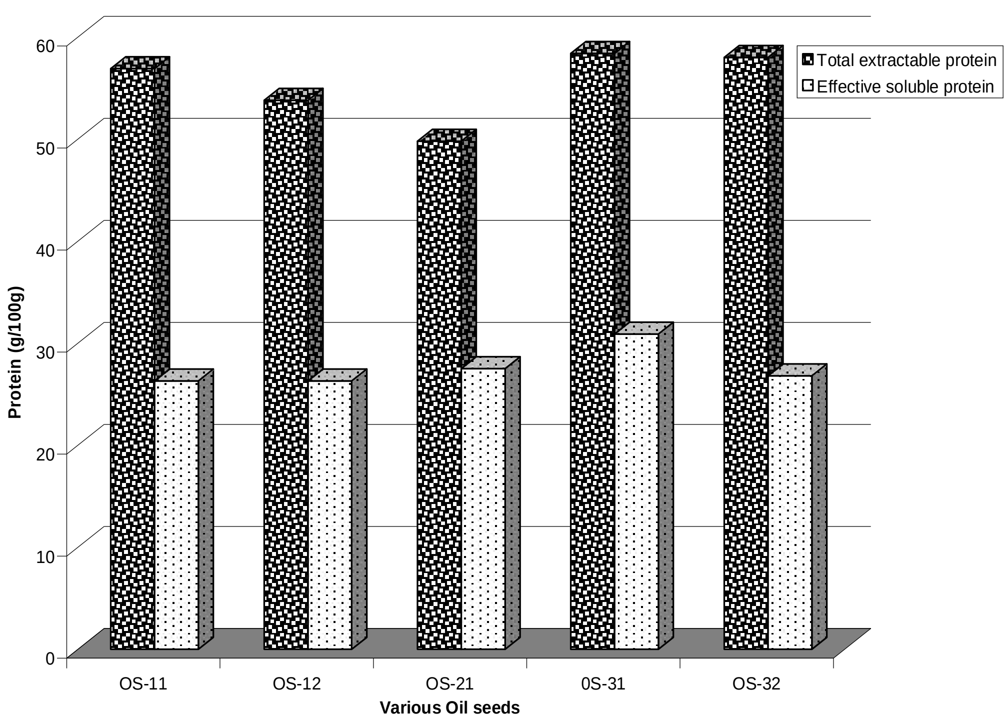


**Figure 4:Total extractable and effective soluble protein in oil seeds**

The ETSP in pulses and cereals ranged from 53.4 - 85.5% and 55.8 - 67.5% of the total extractable protein - TEP (Figs.2 and 3) while that of oil seeds ranged from 46.2 - 2 55.2% of the TEP (Fig 4). RP in the oil seeds is half the EP. This is an indication that defatted oil seeds have high fraction containing high molecular weight polypeptides that were aggregated or cross-linked by disulphide bridges. A method for solubilizing oil seed protein involving the use of food grade dissociating and disulphide breaking agent to overcome aggregation and disulphide cross linking of the protein may be needed. The use of lower alkaline concentration or solvent at pH 9 with concurrent addition of food grade disulphide breaking agent such as sodium sulfite and surfactants (e.g. sodium stearoyl lactylate, glyceryl -1-monostearate) can make more protein available from these oil seeds (Circle *et al.,* 1964) .

## CONCLUSION

Protein fractions vary with grain types and cultivars, but oil seeds are richer in globulin, acid- soluble glutelin and alkaline soluble-glutelin than pulses and cereals. Albumin and prolamin are better obtained from pulses and cereals respectively. Proteins in most cereals and pulses can be solubilized by solvents such as water, salt, alcohol and weak acids. Oil seeds may require the use of food grade dissociating and disulfide breaking agent to make protein available.

## REFERENCES

**Arogundade, L. A., Akinfenwa, M. O., Salawu, A. A.** 2004. Effect of NaCI and its patial or complete replacement with KC1 on some functional properties of defatted *Colocynthis citrullus* L. seed flour. *Food Chemistry,* 84, 187-193.

**Chen, C.H., Bushuk, W.** 1970. Nature of proteins in triticale and its parental species I. Solubility characteristics and amino acid composition of endosperm protein. *Canadian Journal of Plant Science , 50,* 9-14

**Circle, S.J., Meyer, E. W., Whittaey, R. W**. 1964. Rheology of soy protein dispersions. Effect of heat and other factors on gelation. *Cereal Chemistry,* 41: 157-172.

**Be Groot, A.P., Slumps, P.** 1969. Effect of severe alkaline treatment of protein on amino acid composition and nutritive value. *Journal of Nutrition,* 98: 45-48.

**Derbyshire, E**., **Wright, D**.**J., Boulter, B**. 1976. Isolation of legume- like protein from *Phaseolus aureus and Phaseolus vulgaris.Phytochemistry,* 15: 411- 414

**Dorwad**, **P.M., Pusztai, A.** 1986. Nutritional evaluation of soya beans *Glycine max.*
Nitrogen balance and fractionation studies. *Journal of Science of Food and Agriculture,*37:1001-1010.

**Guo, X., Yao, H.** 2006. Fractionation and characteristics of tartary buckwheat flour proteins. *Food Chemistry,* 98; 90 - 94.

**Hamada, J.S.** 1997. Characterization of protein fractions of rice bran to device effective method of protein solubilization. *Cereal Chemistry.* 74:662-668.

**Ibanoglu, E., Ercelebi, E. A.** 2007. Thermal denaturation and functional properties of egg protein in the presence of hydrocolloid gums. *Food Chemistry*, 101, 626 - 633.

**Jideani, I. A.,Owusu, R.K., Muller,** H .G. 1994. Protein of *acha.(Digitaria exilis Stapj):* Solubility fractionation, gel filtration and electrophresis of protein fractions. *Food Chemistry,* 51: 51-59.

**Kasarda, D. D., Bernardin, J.E., Nimmo, C.C.** 1976. Wheat proteins . *Adv. Cereals Sci., Technol.,* 1:158-236.

**Mahe S., Gaussers, N., Tome, D.** 1994. Legume proteins for human requirements. *Grain Legumes (AEP) 7. P 15-17*

**Rakosky, J.**1989. Protein additives in food service preparation. Van Nostrand Reinhold, New York, USA. SAS 1999.*Statistical Analysis System,* Gary, NC, USA

**Schofield, J.D., Booth, M.R.**1983. Wheat proteins and their technological significance. In *Developments in Food Protein* 2ed. **B.J.F.** Hudson. Applied Science Publishers, London and New York, pp 1- 65.

**Seena, S., Sridhar, K. R.** 2005. Physicochemical, functional and cooking properties of under explored legumes, *Canavalia* of the southwest coast of India. *Food Research International,* 38, 803 -814.

**Sethi, P., Kulkarni, P.** 1993. Fractionation of *Leucaena* seed - kernel proteins based on their solubility characteristics. *Food Chemistry* 48: 173-177.

**Singh, U., Jambunathan, R.** 1982. Distribution of seed protein fractions and amino acids in different anatomical parts of chickpea and pigeon pea. Plant. Plant foods Human Nutr.3 1, 347. In *Postharvest Biotechnology of Food Legumes* eds. D.K. Salunkhe, S.S. Kadan and J. K.Chavan.CRC Press, Inc., Boca Raton, FL, pp.41

**Singb, D.K., Rao, A.S., Singh, R., Jambunathan, R.** 1988. Amino acid composition of storage proteins of a promising chickpea *(Cicer arietinum L)* cultivar. *Journal of the Science of Food and Agriculture* , 43:373-379.

**Sogi, D.S., Arora, M.S., Garg S.K., Bawa, A. S**. 2002. Fractionation and electrophoresis of tomato waste seed proteins. *Food Chemistry, 76:* 449 *-454.*

**Thank, V.H., Shibasaki, K.** 1976. Major proteins of soybean seeds. A straight forward fractionation and their characterization. *Journal of the Agricultural and Food Chemistry*,24:1117-1121.

**Woodard, J.C., Short, D.D.** 1973. Toxicity of alkali treated soy protein in rats. *Journal of Nutrition* , 103: 569-574.