II. REVIEW OF LITERATURE

Protein being the costly component of the fish feed, a number of experiments have already been carried out using algae, leaves, grasses, tubers, industrial by-products, slaughter house residues, animal wastes, seed kernels and other plant products. After carefully going through the extensive literature available on the use of alternate proteins incorporating the above mentioned substances, a limited number of investigations which are closely associated with the objectives of the present investigation are cited under the Review of literature.

Shiau et al., (1987) conducted a two-month feeding trial for tilapia with diets containing 24 percent and 32 percent protein levels. In both, 30 percent of the fishmeal protein was replaced by soybean meal (SBM) with and without methionine supplementation. For SBM without supplementation (32 percent protein level) growth and feed conversion were significantly reduced but not so for the 24 percent protein level. With supplementation, the differences between the test and the control groups were not significant for either protein level. The cause for reduced growth may be the presence of trypsin inhibitors and less than optimal aminoacid balance in SBM protein.
Murai et al. (1986) replaced 75 percent fishmeal with methanol-treated or untreated soyflour supplemented with essential aminoacids to the levels in fishmeal-cum-torula yeast control diet and got a 350 percent weight gain in 4 weeks for carp fingerling. The weight gain was only 90 percent in the control group.

For tilapia fry, Desilva and Gunasekera (1989) prepared isocalorific diets of 20, 25 and 30 percent protein with 0, 13, 25, 37 and 50 percent substitution of *Phaselous aureus* as protein source in the fish feed. At all three dietary protein levels best growth and conversion ratio were observed at 25 percent of *P. aureus* substitution.

*Leucaena leucocephala* leaf meal was added to the 20 percent protein diet at 0, 20, 40 and 80 percent level for Nile tilapia. With the increase of leaf meal the mean weight gain of the females decreased with loss of weight at 80 percent level (Santiago et al., 1988). In the males, the 80 percent gave a low weight gain and in fry, production was highest only at 20 percent level. On the basis of both fry production and growth, leucaena leaf meal should not exceed 40 percent of the diet of Nile tilapia brood stock.

Dabrowski et al. (1989) observed a decrease in the...
pancreatic chymotrypsin activity of rainbow trout with increase of soybean meal. Asgah and Bedawi (1988) fed carp on feed containing cidir fruit as a replacement for the bran-barley mixture and reported a reduction in weight gain at 75 percent replacement.

Jack bean, *Canavalia ensiformis* was evaluated (Palacios et al., 1988) as a partial substitute for fishmeal in the diets of tilapia. With increase in jack bean meal supplementation the mortality also increased. However, in the seeds which were subjected to de-toxifying processes (soaking) the toxin was eliminated and increase in weight gain and protein efficiency ratio PER were observed.

*Cirrhtnus mrigala* fingerlings were fed with feed containing seed kernels of *Glirtcldta macu.lata, Albizzia lebbeck* and *Enterolobium saman* in place of groundnut oil cake by Raj and Kutty (1984). The fish fed on seed kernels showed higher nitrogen assimilation than the control group but the metabolism was very high.

Capper et al. (1982) replaced 20 percent of soybean meal with unroasted and roasted mustard oil cake in the feed for carp. Unroasted diet resulted in the depression of weight gain and feed conversion ratio while roasted cake did perform well. Wee and Wang (1987) observed significant growth response in tilapia
when the feed was supplemented with soaked leucaena leaf meal.

Higuera et al. (1988) evaluated the efficiency of lupin seed meal as crude meal and as preheated meal as an alternative protein source in the feed for rainbow trout at 10, 20, 30 and 40 percent protein level with aminoacid supplementation. The performance showed that crude lupin meal can be incorporated only up to 30 percent and the heat-treated form at no level at all.

Olvera et al. (1988) fed tilapia with autoclaved and aqueously treated seed of Sesbania grandiflora and found that the survival, growth and food utilization were adversely affected with the increase in the incorporation of the seed.

Raj (1989) incorporated clitoria leaf powder to the tune of 10, 20, 30 and 40 percent in a 35 percent protein feed for common carp and observed a conversion ratio of 2.9, 4, 2.4 and 2.4 respectively.

Leucaena leucocephala seed kernel at a level of 10, 20, and 30 percent was incorporated in 35 percent protein feed of Sarotherodon mossambica by Daniel and Sahayaraj (1990). The rate of production (dry weight) was observed to be 2.8, 2.5 and 1.8 mg/g/day.

Chakrabarty et al. (1973) fed catla, rohu, mrigal
and common carp on 6 diets namely zooplankton, silkworm pupae, soybean, prawn waste, mustard oil cake and rice bran and groundnut oil cake and wheat bran. Soybean gave the best results in catla and silkworm pupae and groundnut oil cake and wheat bran gave high growth to rohu and mrigal.

Local feeds like leftover rice, barley, wheat, fish offals and blood meal were mixed by Asgah and Bedawi (1984) to get three feeds containing 53, 43 and 33 percent protein and on feeding common carp with them, they obtained highest biological value in 43 percent protein feed, with increased protein (73.5 percent) and aminoacid contents of the flesh.

Low-cost ingredients like soybean meal, copra cake, maize, rice bran, napier and carpet grass meals were tested for their digestibility by grass, carp (Law, 1986). The experiment shows that copra cake and rice bran were poorly digested whereas maize, soybean meal, napier and carpet grass meal had better digestion coefficients.

• Hauser (1975) fed juvenile Tilapia zillii, on trout pellets (40 percent protein) catfish pellets (32 percent) rabbit pellets (16 percent) and iceberg lettuce (0.9 percent) and observed an intestinal fat deposition of 21.4, 53.8, 8.0 and 0 percent respectively.
Evaluation of different grains as basic ingredient in the 25 percent protein feed for carp and tilapia (Viola and Arieli., 1983) indicated that an average daily gain of 2.55 g and 2.53 g respectively, for tilapia and for carp, the values were 4.5 g and 4.6 g respectively.

Wilson and Poe (1985) fed Ictalurus punctatus with diets having 25 and 35 percent of protein prepared out of soybean meal as a protein source (in raw and heat-processed form) and the result showed that the growth and protein efficiency ratio decreased for the raw and inadequately heated soybean meal whereas eliminating the trypsin inhibitor activity (upto 83 percent) through adequate heating improved the performance.

Jayaram and Shetty (1980A) studied the effect of three pelleted feeds with the incorporation of groundnut oil cake, silkworm pupae and fishmeal as sources of protein on rohu, catla and common carp. Silkworm pupae and fishmeal diets had the conversion ratios of 2.5 and 2.6 for common carp and 3 and 3.8 for catla.

Davies and Wareham (1988) evaluated the efficiency of an industrial single cell protein called Eurolysine fodder protein (EFP) as an alternate for fishmeal at 5, 10, 15 and 20 percent level. No significant difference was observed between the mean
final weights of the fish fed on the control diet and of those fed on 5 and 10 percent of EFP. However, the fish fed 15 and 20 percent EFP showed much reduced growth response when compared to the control group.

The effect of partially replacing protein by carbohydrates in eel diets was studied by Degani and Viola (1987). The growth of eels fed 40 percent protein and 38 percent wheat meal was greater than that of the eels fed 50 percent protein and 20 percent wheat meal or 30 percent protein and 56 percent wheat meal. The protein efficiency ratio was lower in eels fed with a low percentage of protein (30 percent) than in eels fed with a high percentage of protein (40 or 50 percent). Degani et al. (1989) observed better food conversion in high protein diets (30 - 40 percent) than in low protein diets (25 - 30 percent) for *Clarias gariepinus*.

The digestibility of the proteins of broad bean (*Vicia faba*) and soybean (*Glycine max*) was analysed by Grabner and Hofer (1985) under invitro conditions simulating the alimentary tracts of rainbow trout and carp. The protein digestibility of broad bean was lower than that of soybean and the difference was more pronounced for carp than trout.

On feeding *Anabas testudineus*, with 3 experimental diets Patra and Ray (1988) have observed
the RNA, DNA and protein content in the flesh to be highest for those fed with the mixture of groundnut oil cake, rice bran and goat blood followed by those fed with mustard oil cake, rice bran and fishmeal.

Though it is possible to incorporate the legume seed kernels, oilcakes, seed meals and other seed products as reviewed above, the presence of antinutritional and toxic substances like phytates, oxalates, tannins, polyphenols, trypsin inhibitors, protease inhibitors and off-taste and off-flavour substances in these poses a problem in their usage. However, as mentioned in the introduction, studies have been carried out by a number of scientists on the possibility of eliminating or reducing the undesirable substances in order to make the legumes more safe and improved for consumption. Some of the techniques which are generally followed are decortication, roasting, boiling, autoclaving, leaching, soaking, germination, fermentation, acid treatment and alkali treatment and these are reviewed hereunder.

Seed treatment

Decortication or dehulling

Gad et al. (1982A) observed the presence of phytic acid in legumes like faba beans, lentils, lupin seed and fenugreek. Subjecting the different seeds to
processes like cooking of decorticated lentil seeds and
decortication followed by steeping of lupin seeds has
resulted in the reduction of phytic acid. In faba beans
and lupin seeds (Gad et al., 1982B) reduction of
oxalates was observed on steeping and decortication.

In amaranth seeds Lorenz and Wright (1984) have
studied the reduction of tannin by decortication.
However, decortication did not reduce the phytate
content, for the phytates occur not only on the hull but
throughout the kernel. Okolie and Ugochukwu (1989)
observed the presence of hydrocyanic acid in the intact
seeds, in the testa and in the cotyledons of Phaseolus
aureus, Vigna unguiculata, Cajanus cajan and
Canavalia gladiatus to a level of 381-1093, 285-1223
and 208-953 mg/kg respectively. In some cases,
hydrocyanic acid content in the testa was 3-5 times
higher than in the cotyledons. Soaking in water for 24
h led to appreciable loss in hydrocyanic acid while
boiling for 3 h caused drastic reduction (49-95
percent). Soaking the seeds in water and subsequent
removal of testa prior to boiling decreased hydrocyanic
acid in bean meals.

Pawar and Parlikar (1990) observed a reduction of
polyphenols (66.9 - 71.3 percent), ash, crude fibre
and phytates (60.0 - 74.2 percent) by dehulling of pearl
millet. Significant increase in the recovery of soluble proteins from 61.1 to 78.6 percent and invitro protein digestibility from 66.3 to 82.8 percent was also observed on dehulling and soaking of the grains.

In *Viciajaba*, Youssef et al (1987) have observed an increase in Cu, Zn and K and a decrease in Fe, Mn, P, Ca, Mg and Na on dehulling, whereas, soaking for 12 h followed by dehulling resulted in a higher level of Fe, Cu, Zn, Ca and Na and quite a lower level of K.

Roasting

Katq et al. (1981) observed that roasting soybeans at 200°C for 10, 20 and 30 min resulted in increase in the volatile substances and in a change in the flavour from beany or objectionable to desirable by sensory evaluation. Barroga et al. (1985) observed a 17 percent reduction of polyphenols in mung bean on roasting for 10 min.

Trugo and Macrae (1984) have noted the degradation of seven chlorogenic acids during roasting in arabica and robusta coffee. The losses were about 60 percent during mild roasting and 100 percent after severe roasting, a percentage increase of 5.99 in fat, 1.32 in protein, 17 in calories and 4.96 in carbohydrates and a percentage decrease of 2.88 of ash,
6.02 of oxalates, 15.38 of phytic acid, 51.3 of tannin and 34.6 of hydrogenic acid were observed for maize by Ayatse et al. (1983).

Fruits of the plant *Parkia filicoideae*, (Leguminosae) give seeds with 36 percent protein. 120°C is observed to be the most suitable roasting temperature for obtaining beans of highest quality (Ibiyemi et al., 1989).

Lysine is the limiting aminoacid in sunflower protein and Miller and Pretorius (1985) have observed a decrease in the available lysine form 3.4 to 0.9 percent while heating the sunflower meal.

Srivastav et al. (1990) have observed an increase in the protein digestibility of bengal gram, maize and soybean after roasting, indicating the possible destruction of protease inhibitors and opening of the protein structure.

Soaking/Steeping/Leaching and Thermal treatment

Ketiku et al. (1978) noted a significant reduction of hydrocyanic acid in cassava after soaking in static water and Rauchberger et al. (1979) observed a decrease in glucosinolates in rape seed meal on pretreatment of the seeds for 30 min by steaming at
100C and leaching the meal at p  4-8.

Grant et al. (1982) observed the efficiency of heat treatment (above 75C) after soaking in eliminating lectins in *Phaseolus vulgaris*. Al-Bakir et al. (1982) brought about complete inactivation of trypsin inhibitor activity in *Vicia faba, Lens esculenta, Cicer arietinum, Vigna sinensis* and *Phaseolus aureus* by heating the soaked seeds.

In lupin seed, Rahma and Rao (1984) noted a reduction in trypsin inhibitor activity, amylase inhibitor activity hemagglutinin activity and caseinolytic activity on soaking the boiled seeds (20 min). Jood et al. (1988) have suggested a 24 h soaking of the legumes for reduction of flatus producing substances like raffinose, stachyose and verbascose. Polyphenols are concentrated in the seed coat of mung bean and Barroga et al. (1985) observed a reduction of 24-50 percent of polyphenols by soaking and 73 percent by boiling.

Durigan et al. (1987) have reported that the lectins and digestive enzyme inhibitors in drybean cultivars are completely inactivated by soaking the seeds in water and then autoclaving the same for 10 min at 121C. In the bitter yams, Webster et al. (1987) have observed the elimination of bitter substances
(alkaloids, polyphenols and sapogenins) through baking followed by leaching of the same in running water overnight. Steeping, followed by boiling brings about reduction of considerable amounts of phytic acid from peas (82 percent) and lentils (76 percent) and improvement in the net protein utilization, true protein digestibility and biological value of legume seeds (Manan et al., 1987).

A reduction of antinutritional factors was observed by Ayyagari et al. (1989) on soaking and heat-processing of *Lathyrus sativus*, soybean, groundnut, chick pea, pigeon pea and some other legumes and grains.

**Cooking (Autoclaving/boiling)**

Khan et al. (1979) observed 10-20 min cooking at 121°C to be adequate to eliminate antinutritional factors present in chick peas, mash beans, mung beans and cow peas and to improve their protein utilization as compared to raw beans. Goulet et al. (1985) observed autoclaving to increase the apparent digestibility coefficient of zein and rapeseed and the net protein ratio of rape seed due to the protein structure modification partly by deamidation.

Nnanna and Phillips (1987) observed significant
improvement in the invitro protein digestibility of cowpeas by cooking but not by germination or by decortification.

Granum (1979) reported a reduction in the amylase inhibitor activity in wheat flour and rye flour by boiling. Semino and Cerletti (1987) have reported the degradation of trypsin inhibitors by thermal treatment of lupin seed for 30 min at 100°C. Tan et al. (1984) have reported that autoclaving of winged bean at 120°C (1.05 kg/cm²) destroys more than 90 percent of the chymotrypsin inhibitor substances.

Henderson et al. (1986) have found that heat treatment reduce the antinutritional factors like trypsin inhibitors, lectin, phytic acids and oligosaccharides to negligible levels in cucurbita seed meals.

In Phaseolus vulgaris, Fernandez et al. (1982) observed a reduction of tannins or polyphenols on subjecting the bean to heat treatment indicating the heat-labile nature of the toxin. Antunes and Sgarbieri (1980) eliminated toxicity from P. vulgaris by heating the soaked beans for 25 min at 97°C but maximum protein efficiency ratio was attained after 10 min. However, autoclaving (121°C for 15 min) decreased the availability of lysine. Hemagglutinins (lectins) present
in *P. vulgaris* were removed by Bender (1983) by subjecting the seeds to high temperature (boiling at 100°C) treatment for 10 min since low temperature treatment (80°C heating) resulted in increase of lectins (Bender and Reaidi., 1982) indicating the danger of consuming poorly cooked leguminous seeds. The same was observed by Boufassa et al. (198§). Durigan et al. (1987) also noted the presence of heat-resistant growth-inhibiting substances in the whole bean of *Phaseolus vulgaris*.

Gad et al., (1982B) eliminated 22.4 - 31.9 percent of oxalates present in fenugreek seeds by boiling and Jood et al. (1988) observed autoclaving and cooking of chick pea and blackgram to decrease the starch content and to increase the level of total soluble sugars, of reducing sugars and of starch digestibility. Protein digestibility of chick pea and black gram was also improved by autoclaving (Jood et al., 1989).

Continuous reduction of phytic acid with an increase in temperature in fababeans was observed by Henderson and Ankrah (1985) and they also observed that, at high temperatures, the phytic acid gets leached out into the medium. Egbe and Akinyele (1990) also observed such a reduction in the antinutritional factors like phyto hemagglutinins, hydrocyanic acid,
polyphenols and tannins and the same to be present in the cooking water to a considerable amount indicating the necessity to change the cooking water.

Rao and Belavady (1978) observed an increase in the flatulent oligosaccharides like verbascose, stachyose, raffinose and sucrose contents on cooking (15 rnin/15 lb) in *Cajanus cajan, Cicer arletlnum, Phaseolus aureus* and in jojoba meal, which has simmondsin and three other related cyanomethylenecyclohexyl glycosides. Moist as well as dry heat treatment even at very high temeprature, even for long hours, did not detoxify the meal (Verbiscar et ah, 1980).

In amaranth grain, Garcia et al. (1987) have reported that cooking of the material gives higher food intake, weight gain and protein efficiency ratio than non-heat treated samples, which indicates the removal of unknown thermolabile factors in the process. Ravindran and Ravindran (1988) have observed 3.1 g/kg of phytic acid, 2170 TIU of trypsin inhibitor activity (TIA), 7.6 g/kg of tannins and 58 mg/kg of hydrocyanic acid in *Mucuna utilis*. They have also observed a complete destruction of TIA by cooking and 80.3 percent invtro digestibility when compared to a 71.5 percent for the raw beans.
Saini (1989) has studied the thermal stability of trypsin and chymotrypsin inhibitor activities in soybean, mung bean, rye and triticale. The result shows that these protease inhibitors are resistant to dry heat (at 105°C for 15 min) but autoclaving (5 min at 121°C) virtually destroys all the inhibitors.

In winged bean (Tan et al., 1983) hemagglutinating activity is stable in dry heat (100°C for 2 h) but could be destroyed completely in autoclaving (120°C, 1.05 kg/cm for 5 min).

Rahman (1983) subjected two varieties of chick peas to cooking (for 1 h, 2 h) and to autoclaving for 1 h at 121°C and observed a decrease in lysine, histidine, arginine, tryptophan, protein solubility and vitamin content with increased cooking time and has therefore recommended autoclaving at 121°C for not more than 1 h to minimise losses in vitamins and amino acids. Rajyalakshmi and Geervani (1990) have observed loss of thiamine (75 - 100 percent) and niacin (24-75 percent) by boiling of cereals and millets. They also have observed a decrease of 9-24 percent of invitro protein digestibility for millets and an increase of 15-32 percent for legumes.
Germination

Rao and Belavady (1978) observed a decrease in the oligosaccharides like verbascose, stachyose, raffinose and sucrose which produce flatus in pulses like *Cajanus cajan, Cicer arietinum, Phaseolus aureus* and *Phaseolus mungo* by germination for 24, 48 and 72 hours.

Legumes contain phytic acid which interferes with the utilization of mineral elements and Gad et al. (1982A) have observed a reduction of the same in fenugreek seed by steeping and germination. Gad et al. (1982B) have also observed a reduction in oxalate content in dry faba beans, lentils, peas, chick peas and lupin seeds by sprouting.

Cyanogenic glucosides, which on hydrolysis yield hydrocyanic acid which depresses growth by interference with the absorption of certain essential amino acids, were reduced (76.1 percent) by germination of limabean varieties for six days by Toloughobo et al.; 1984).

Henderson and Ankrah (1985) studied the effect and found that soaking and germination helped in the elimination of phytates by releasing inorganic phosphate due to the action of endogenous phytase.
Field bean seeds showed an activation of proteolytic and amylolytic enzymes, increase in the contents of ascorbic acid and nitrogenous substances and reduction in phytate phosphorus and proteolytic enzymes by germination (Bednarski et al., 1985).

Jood et al. (1985) subjected legumes like bengal gram, red gram and broad bean to germination for the elimination of flatus producing oligosaccharides and the result showed a complete disappearance of the substances on germination beyond 48 hours and they have recommended 24 h germination as a reasonable good treatment for the reduction of the substances and to increase the digestibility. The process also helps to increase ascorbic acid, niacin and available iron contents.

El-Mahdy and El-Sebaiy (1982 A), while, studying the effect of 96 h germination on the nitrogenous constituents, protein fractions, in vitro digestibility and antinutritional factors of fenugreek seeds *Trigonella foenum Graecum L.*, have found an increase in total nitrogen, free aminoacid nitrogen (298 percent), total non-protein nitrogen (204 percent), albuminoid nitrogen, amido nitrogen, ammonia nitrogen and crude protein, but decrease in protein nitrogen; 66 percent increase in trypsin
inhibitor activity, a slight increase in pancreatic digestibility, 33.7 percent decrease in digestibility by pepsin followed by pancreatin and a small decrease in peptic digestibility.

In triticale, the first man-made cereal, a cross between wheat and rye, Wu (1982) has reported an increase of lysine from 3.5 to 5.9 g/16 g of nitrogen on 1-8 days of germination. Lysine increase indicated the improvement in the nutritive value of the seed.

Fenugreek seeds, *Trigonella foenum-Graecum*, on germination in the dark for 96 h, have shown a decrease of total lipid extracts. Total saturated fatty acids, free fatty acids, total chlorophyll and carotenoid pigments have increased, whereas the total unsaturated fatty acids, triglycerides, phospholipids and unsaponifiable matter have decreased (El-Sebaiy and El-Mahdy., 1983).

In cowpeas, *Vigna unguiculata*, Nnanna and Phillips (1987) found no change in the aminoacid profile. Invitro protein digestibility also was not improved by germination but was improved by cooking. However, the contents of niacin, thiamin and riboflavin increased on germination.

By germinating the soybean seeds for six days,
Mostafa et al. (1987) have observed a reduction in the trypsin inhibitor activity by 32 percent in addition to the decrease in oil content, acid value, iodine value, total unsaturated fatty acids, total ash and reducing sugars. However solubility of protein was high, protein digestibility by pepsin improved, total saturated fatty acids, non-protein nitrogen, aminoacid components, and the functional properties of soybean flour increased.

For Chick pea and black gram Jood et al. (1988) observed a decrease in the starch content and an increase in the level of total soluble sugars, reducing sugars, non-reducing sugars and starch digestibility. An increase in the protein digestibility also was observed for these two legumes on germination by Jood et al. (1989).

Fermentation

The seeds of African locust bean plant (Parkia Jilicoidea) are usually boiled and fermented and then pounded to get a traditional food called 'daddawa'. The aim of fermentation is to enhance flavour and the keeping quality. Eka (1980) has said that fermentation should be encouraged for it increases the aminoacid contents, Vitamin Bi and B2, and decreases the aritinutritional and toxic substances like oxalic acid,
phytic acid and hydrogenic acid. Other changes brought about by fermentation are increase in crude protein, fat content and ash (K, Na, Zn, Mg, Ca, Cu, Fe and P) and decrease in total carbohydrates, crude fibre and vitamin C. Rajyalakshmi and Geervani (1990) observed an increase in thiamine and niacin in millets and cereals on fermentation.

Aliya and Geervani (1981) while assessing the protein quality and vitamin B content of commonly used fermented products of legumes and millets found that, upon fermentation, there is decrease in the crude protein content. The decrease was 6.7 percent in bengal gram dhokla, 8.0 percent in green gram dhokla, 4.0 percent in bajra ambali, 5.6 percent in ragi ambali, whereas no change was seen in jowar ambali. They also observed an increase in temperature of batters, thiamin and riboflavin contents and decrease in pH. Slight increase (not significant) in the protein efficiency ratio, true digestibility and biological value were also observed in the fermented food. Fermentation after cooking is recommended by them.

On natural and pure culture fermentation of pearl millet flour for 72h, Khetarpaul and Chauhan (1989), observed a decrease in pH and increase in titrable acidity. No change was observed in protein content and
ash content. Fat content increased in natural fermentation and decreased in pure culture fermentation. Thiamine content increased at 20°C and at 25°C and decreased at 30°C.

Chemical treatment

The objectionable odour of the fermented soft pulp of cassave (*Manihot esculenta* crantz) due to the presence of butanoic acid along with acetic acid and propanoic acid was treated with alkali (NaHCO₃) or H₂O₂ (3M H₂O₂) by Onochuku (1985) to remove the odour successfully.

Padmaja (1989) has suggested the spraying of the leaves of cassava with NaOH or NH₃ to reduce the toxins like cyanogenic glucosides and condensed tannins. Ross and Bhatnagar (1989) subjected the soybean protein for catalytic subunit > of cAMP (adenosine cyclic 3'5' monophosphate dependent protein kinase) isolated from bovine cardiac muscle at mildly acidic p and found it improving the functional properties of soybean protein for use in the food system.

Improvement in the emulsification of poppy seed meal by the incorporation of NaCl upto 0.1M was reported by Srinivas and Rao (1986).

Han (1988) has removed 87 percent of phytic acid
from soybean meal by washing with 1 N hydrochloric acid. Also, 50 percent of cottonseed phytate was hydrolysed by the endogenous phytase upon incubation for 16 h at 60 C. Han and Wilfred (1988) have reported that the water insoluble phytates from soybean and cottonseed meals can be hydrolysed with Aspergillus \textit{Itcuum} which has phytase (enzyme).

Guar seed meal which has toxic substances like polyphenols, lignins, trypsin inhibitors, saponins and foul-smelling substances like organic acids, aldehydes and cyanogens was detoxified by Misra et al. (1984) by treatment with ethariol- Hcl (100: 1 v/v) solvent. The biological value of the meal was improved after treatment. Taha et al. (1987) have extracted sesame seed with 0.04 M NaOH which resulted in 91.7 percent of meal nitrogen. They also have removed 50 percent of phytates at 5.4 pH.

Guar (\textit{Cyamopsls tetragonoloba}) has saponins, polyphenols and unpleasant flavour components. Its nutritional quality was improved by extracting the meal with 1 N hydrochloric acid (Tasneem and Subramanian., 1986).

Rauchberger et al. (1979) found the pretreating of rapeseed meal for 30 min by steaming at 100 C before leaching at pH 4.8 to be the effective method for the
elimination of glucosinolates which have growth-inhibiting compounds and goitrogenic substances.

Spies et al. (1962) have successfully destroyed allergens present in castor bean by heating the same with calcium hydroxide at a pH of 5.9 to 8.7.