

CHEMICAL, NUTRITIONAL AND ANTI-NUTRITIONAL STUDY OF NEW VARIETIES OF OIL SEEDS FROM SUNFLOWER, SAFFLOWER AND GROUNDNUT

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ABSTRACT- Proximate, nutritive and anti-nutritive analyses of some new varieties of oilseeds were determined. Oilseeds studied include Sunflower (*Helianthus annuus* L.) variety LSF-11 & LSF-8, Safflower (*Carthamus tinctorius* L.) variety PBNS-12 & PBNS-40 and Groundnut (*Arachis hypogaea* L.) variety JL-24. The proximate parameter such as moisture, crude fibre, total lipid, crude protein, carbohydrate, ash calcium phosphorus and energy ranged from 3.627-7.393, 0.488-3.411, 25.699-46.224, 15.91-25.20, 21.26-48.93, 2.577-4.866, 0.087-0.150, 0.15-0.41 and 490.651-601.856 g/100g respectively. The predominant fatty acid was found to be Linoleic acid. The protein solubilizations at different pH ranging from 0.5 to 13.5, the maximum seed proteins were extracted at pH 12. The amino acid analysis revealed that the oilseeds were superior with respect to glutamic, arginine, methionine and proline. The anti-nutritional factors like cyanogenic glucoside, tannin, oxalate and hemagglutinin activity contents ranged from 3.458-4.818, 0.412-0.651, 0.079-0.180 and 1:16-1:8 g/100g respectively. Trypsin inhibitor was not found in these varieties. The nutritive values were determined for feed utilization, nitrogen utilization, protein efficiency ratio and feed efficiency ratio ranged between 5.260-6.552g, 0.232-0.296g, 1.368-1.509 and 0.345-0.365 respectively. Results from these studies have revealed that the potential for use of sunflower, safflower and groundnut for enhancement of these nutrients/chemical constituents.

Keyword- Chemical composition, nutritional and anti-nutritional composition, *Helianthus annuus*, *Carthamus tinctorius* and *Arachis hypogaea*.

INTRODUCTION

Oilseeds such as Sunflower, Safflower, Soyabean, Rapeseed and Groundnut are annual plants. They are the largest source of vegetable oils even though most oil-bearing tree fruits provide the highest oil yields like Olive, Coconut and Palm trees [1,2]. Oilseeds are grown in a range of countries. Increases in a small number of crops, including Sunflower, Soyabean and Rapeseed, account for the increase in world production oil. However, according to Food and Agriculture Organization (FAO), more traditional oil crops like groundnut and sesame seeds continue to be important in the food supply and food security of many countries [3].

Sunflower is an important oilseed crop of the world and it ranks third in the production next to Groundnut and Soyabean. The world production of Sunflower seeds increased from 26 to 31 million metric tonnes between 2004 and 2006 [4].

Safflower is a very ancient crop it is a world wide minor crop. According to the FAO data it is grown in large areas in Mexico (85000ha), Ethiopia (72000 ha), USA (54000 ha) and India (35000 ha) [5].

Groundnut is the fifth most important oilseed in the world. It is one of the worlds most popular and universal crops, cultivated in more than 100 countries. During 2003 of 35658.43 thousand tonnes in the world [6].

Oilseeds are used for different purposes: food (raw, roasted or boiled, cooking oil), animal feed (pressings, seeds, green material and straw) and industrial raw material and for medicinal purposes. Oilseeds are a reasonable source of dietary mineral especially, potassium, calcium, phosphorus and magnesium their oil is an excellent source of mono and polyunsaturated fatty acids. They contain about 80% oleic and linoleic acid. They are good sources of oil, crude fibre, protein, carbohydrate and essential amino acid. The presence of anti-nutrients in plant protein sources for livestock feeding is a major constraint that reduces their full utilization. Employing appropriate and effective processing techniques could help to reduce the adverse effects of these anti-nutritive constituents in plant protein sources and thereby improve their nutritive value [7].

The main objective of this research is to investigate the nutritional contents and anti-nutritional factors of Sunflower (*H. annuus* variety LSF-11 & LSF-8), Safflower (*C. tinctorius* variety PBNS-12 & PBNS-40) and Groundnut (*A. hypogaea* variety JL-24). It will also provide knowledge on the nutritional implication of feeding on staples of low nutritive quality, which will help to ensure better health condition of people in developing countries.

MATERIALS AND METHODS

Sample collection:

The seeds under investigation were procured from Oil Seeds Research Station, Latur (Maharashtra, India), Marathwada Agricultural University, Parbhani and Mahatma Phule Krishi Vidyapeeth, Jalgaon (Maharashtra, India). These seeds were authentic, healthy and matured.

Chemical composition:

The sunflower seeds were cleaned and stored properly at room temperature prior to their use in actual experiment.

Moisture, Ash (its analysis) and Calcium contents were determined by the methods as described by Pearson [8]. Crude fibre contents was determined by the method as recommended in the Fertilizer and feeding stuff regulations [9]. Phosphorus was determined according to the procedure of Sumner [10]. Total lipid was determined by the methods of Colowick and Kaplan [11]. Carbohydrate, reducing and non reducing sugar were estimated by the method of Nelson [12]. Crude protein was estimated by "Micro Kjeldahls" method (N X 6.25).

Fatty acid composition:

Powdered samples of experimental seeds were subjected to solvent extraction in Soxhlet apparatus for 20 hrs, using petroleum ether (40-60)°C as solvent. Lipids were then estimated gravimetrically by following the procedure reported by Colowick and Kaplan [13]. Methyl esters of the lipids were prepared by the method of Chowdhary *et al.*, [14]. The Gas Liquid Chromatogram (GLC) analyses were carried out using a CHEMTO gas chromatogram (Model no. 8610 GC) and gas chromatograms were recorded using Flame Ionization Detector (FID) with split ratio 1:50.

Protein solubility:

In the present investigation all the seeds were analyzed for their protein contents and protein solubilization with pH variation in the powdered form, because size of seed powder has been shown to influence the nitrogenous extraction [15, 16]. The seeds were sun dried and powdered to mesh [17].

The effects of pH variation of the solvent on the protein solubilization were studied by varying pH of water, ranging from 0.5 to 13.5, brought by the addition of Hydrochloric acid or sodium hydroxide solution, 1gm of the seed powder was suspended in 20 ml of extractant of desired pH. The contents were shaken in electrical shaker for about 2 hrs at room temperature and centrifuged for 20 minutes at 2000 rpm in a centrifuge. The nitrogen solubilized was determined in supernatant so obtained by "micro Kjeldahls" method [9].

Amino acid profile:

Amino acids were determined by high performance liquid chromatography (HPLC) by the method of Cserhati and Forgacs [18], Kerese [19]. Finely ground samples were

hydrolyzed by adding 4.83g Barium hydroxide and 5ml of boiling water to 500mg of sample. The mixture was evacuated and then heated at 120°C for 8 hrs. After hydrolysis, the pH was adjusted to 3 with HCl, and diluted to 25ml with HPLC grade distilled water. 1ml of sample was vacuum dried using flash evaporator and finally dissolved in citrate buffer (0.1M; pH2.2).

Acid hydrolysis is carried out with 6N HCl at 110°C to 18-22hrs in evacuated and sealed tubes. The hydrolysate was filtered and diluted to 250ml. 1ml of sample was vacuum evaporated at 40°C until dryness. The contents was dissolved in citrate buffer (0.1M; pH2.2). 20µl of this derivatized were injected directly into the HPLC. Detection was accomplished using Shimadzu HPLC detector LC-10A with variable wavelength monitor set at 350-450nm. Resolution of amino acid derivatives was routinely accomplished using a binary gradient system.

The solvent used were: (A) 58.8gm of sodium citrate containing 0.2N sodium (pH 3.2), 210ml 99.5% ethanol and 50ml (60%) Perchloric acid and (B) 58.5gm of sodium citrate containing 0.6N sodium (pH 10), 12.4g Boric acid and 30ml 4N NaOH solution. Solvent was delivered to the column at a flow rate of 4ml/min for 7 to 10 minutes.

Anti-nutritive factors:

Cyanide and Tannin were determined by the method of AOAC [20]. Oxalates were determined by using the method of Talpatra *et al.* [21]. Method of Kakade *et al.*, [22] was used for the determination of Trypsin inhibitor activity. Haemagglutinin activity was determined by the method as given by Liener I.E [23].

Nutritive value:

The experiment was performed on the white male albino rats. Eighteen rats 34 days old were distributed in six groups of three rats, each selected rats were of body weight nearest to the mean of population. They were housed in individual cages. The rats were fed ad-libitum exclusively experimental diets for 10 days [24] including the three days of pre experimental period and water was available ad-libitum.

The experimental diets were isonitrogenous (24.50 g/100g) and isocaloric (3030 kcal/ kg of balanced diet). The balance diet (Table-8) comprised per kg:- 420 g maize yellow, 50 g oil, 430 g groundnut cake, 80 g fish meal (Jawala), 19.6 g mineral mixture and 0.49 vitamin mixture as recommended by Indian Standards Institution (565.4 part I 1970). Casein and seed proteins were added to this basal diet by substitution of the maize yellow to give a total dietary protein contents of 100g/kg. The seed meals used in the study were autoclaved for 30 minutes at 15 lb pressure [25] before being incorporated in the diets to destroy the toxic constituents (Cyanogenetic glycosides, tannin, trypsin inhibitors and haemagglutinins).

The animal testing work was approved by animal ethical committee at Department of Nutrition, College of Veterinary Sciences and Animal Husbandry, Jabalpur.

Analysis

The weight and food intake of the rats were monitored daily. Faeces were collected between days 5 to 10 days on the trial. The fecal matter (excreta) was dried in hot oven at 100°C. Protein efficiency ratio and feed efficiency ratio were calculated by the method given by [26]. Total nitrogen intake and nitrogen voided were estimated by semi-micro Kjeldahl method [9].

Statistical Analysis

Results of *H. annuus* variety LSF-11 and LSF-8 and *C. tinctorius* variety PBNS-12 and PBNS-40 were analyzed for statistical report by using 'student t test'. Descriptive statistics (Mean, standard error mean and standard deviation) were calculated for triplicate determination using the SPSS 10 computer software package and significant differences within treatments were determined using 5% significance level.

RESULT AND DISCUSSION

The result of Proximate Analysis of LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24 varieties of Sunflower, Safflower and Groundnut are shown in Table 1 & 2 shows that the moisture, crude fibre, total lipid, crude protein, total carbohydrate, ash, calcium and phosphorus contents are ranged in 3.627–7.393, 0.488–3.411, 25.699–46.224, 15.91–25.20, 21.26–48.93, 2.577–4.866, 0.087–0.150 and 0.15–0.41 g/100g respectively. Moisture and Phosphorus contents of PBNS-40 was higher than the other variety when compared. However total lipid and crude protein contents was found to be higher in JL-24, which is an indication that it contains more Nitrogenous substances than the other variety and also it is the better source of lipid when compared. The high level of oils in the investigated seeds quality them as good sources of oil for both industrial and culinary applications [27]. There was a significant increase in crude fiber contents in LSF-11 & the total Carbohydrate was found maximum in PBNS-40, where as LSF-8 variety has a higher level of ash and Calcium contents. These results are in good agreement with other varieties of oil seeds [28-33].

The results of gross energy are given in Table - 3 shows that the energy contents in LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24 are 543.055, 512.105, 490.651, 507.701 and 601.856 kcal respectively. These values are in close proximity with other varieties of oil seeds [28-31, 33].

The results regarding Fatty acid profile (Table-4) shows that the total saturated and unsaturated Fatty acid contains in LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24 was found to be 6.08 and 24.78, 4.6 and 23.15, 3.41 and 10.68, 2.91 and 20.62 & 10.44 and 33.51g/100g respectively. These results are in general agreement with other varieties of oil seeds [32, 33].

The protein contents of LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24 were found to be 25.08, 24.81, 15.91, 16.14 and 25.20% respectively. The results of protein solubility are represented graphically and tabular form in (Table-5 & "Fig. (1-5)". The protein solubility of

seed protein was found to be maximum (13.90%) at pH 12, while it was minimum (2.77%) at pH 2 in LSF-11. The protein solubility of seed protein in LSF-8 was found to be higher (12.79%) at pH 12, while it was lower (2.08%) at pH 8. The maximum (9.29%) solubility of seed protein was observed in PBNS-12 at pH 12, while it was found minimum (1.73%) at pH 2.5 and 8. In PBNS-40 the protein solubility of seed protein ranged from 1.90 at pH 5.5 to 9.60 at pH 12. The protein solubility of seed protein in JL-24 was found to be higher (14.60%) at pH 12 and 12.5 while it was lower (2.83%) at pH 2 and 3. These results are in good agreement with other oil seeds [34, 35].

The Amino Acid compositions present in various seed sample are reported in table-6 and their Chromatograms are represented in "Fig. (1-5)". Glutamic Acid (4.899% and 5.083%) is predominant Amino Acid in LSF-11 and LSF-8 respectively. Glutamic Acid is an essential Amino Acid by Reeds [36]. Arginine (1.599%) and Methionine (3.001%) were the predominant Amino Acid in PBNS-12 and PBNS-40 respectively. Arginine is associated with the Cardio Vascular System as a precursor to Nitric Oxide synthesis, which is an important Blood Pressure regulator [37]. The result in this study shows that JL24 contains the highest (6.412%) level of Proline and Aprotic Acid (3.459%), while Serine has not been reported in this variety. It was shown that Ammonia (0.212% and 0.177%), Serine (0.009% and 0.034%) and Methionine (0.243%) are limiting Amino Acid in LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24 respectively. All these values of Amino Acid composition of these seeds were found to be in good agreement with other varieties of oil seeds [38, 39].

Table-7 shows the value of anti-nutritive factors of LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24. The Cyanide contents was found to be maximum (4.818%) in JL-24 while it was minimum (3.458%) in PBNS-12. The Tannin contents was found to be in the range from 0.412% to 0.651% in varieties of LSF-11 & LSF-8, PBNS-12 & PBNS-40 and JL-24. The *A. hypogaea* variety JL-24 contents the highest (0.180%) level of Oxalate while it was lowest (0.079%) in PBNS-12. No Trypsin in Hibiter activity observed in these varieties of oil seed. Haemagglutinin activity was observed in the range from 1:16 to 1:8 in LSF-11 and LSF-8 while it has not been reported in PBNS-12 and PBNS-40. In JL-24 Haemagglutinin activity was found to be 1:8 only on goat blood group. These values were found to be lower than other varieties of oil seeds reported earlier by Gupta [39, 40].

The nutritive values like Feed intake, faeces voided, feed utilization, percentage of feed utilization, nitrogen utilization, nitrogen intake, nitrogen voided, nitrogen utilization and percentage of nitrogen utilization per rat per day are given in Table-9. Gain in body weight, total feed consumed, total protein consumed protein efficiency ratio and feed efficiency ratio per rat for 10 days are given in Table-10. In the collection period of three days the total feed intake, faeces voided, feed utilization, percent of feed utilization, nitrogen intake, nitrogen

voided, nitrogen utilization and percent of nitrogen utilization per rat per day were found to be in ranged between 6.56 to 8.03, 1.20 to 1.48, 5.26 to 6.55, 80.15 to 82.70, 0.25 to 0.32, 0.02 to 0.03, 0.23 to 0.30 and 90.75 to 92.89 percent respectively in the seeds of *H. annuus* variety LSF-11 and LSF-8, *C. tinctorius* variety PBNS-12 and PBNS-40 and *A. hypogaea* variety JL-24.

Crude protein contents and other proximate constituent are not affected by autoclaving and protein digestibility is enhanced by four to forty percent as compared to raw material [41].

The protein efficiency ratio of all the five varieties under study are in general accordance with one another i.e. 1.47 (LSF-11), 1.50 (LSF-8), 1.51 (PBNS-12), 1.50 (PBNS-40) and 1.37 (JL-24) and also with controlled diet 1.36. Also the feed efficiency ratio for *H. annuus* variety LSF-11 and LSF-8, *C. tinctorius* variety PBNS-12 and PBNS-40 and *A. hypogaea* variety JL-24 was found to be 0.36, 0.36, 0.36, 0.37 and 0.35, respectively. The value of feed efficiency ratio for these varieties was found to be in close resemblance with 0.34 of controlled diet, these five varieties under study showed almost same nutritive value in spite of having different chemical composition. It may be due to isonitrogenous inclusion of crude protein of oil seeds [39, 42].

Table 11 shows the statistical report of *H. annuus* variety LSF-11 & LSF-8 and *C. tinctorius* variety PBNS-12 & PBNS-40 indicating non-significant result with respect to all parameters of anti-nutritive factors. Table 12 shows the statistical report of *H. annuus* variety LSF-11 and LSF-8 indicating non-significant result with respect to all parameters, similarly the statistical report of *C. tinctorius* variety PBNS-12 and PBNS-40 indicating non-significant result with respect to all parameters except percent nitrogen utilization and feed efficiency ratio.

CONCLUSION

Significant Genetic variations were observed for the quality attributes studied among the Sunflower, Safflower and Groundnut varieties. This would not only form the basis of selecting seeds with desirable attributes for breeding programmers but also guide Sunflower, Safflower and Groundnut users the right varieties to choose for their products. The data presented in this study suggested that these oil seeds have relatively high levels of unsaturated fatty acid contents as well as amino acid contents. These oil seeds have relatively low levels of some anti-nutritive factors and non-toxic for rats. Their potential for nutritional exploitation is further enhanced by the fact that they would not require prolonged and expensive heat-treatment prior to use. The results of the present nutritional studies with rats suggest that they could be more widely grown and utilized as dietary protein sources and these could be put to far greater use.

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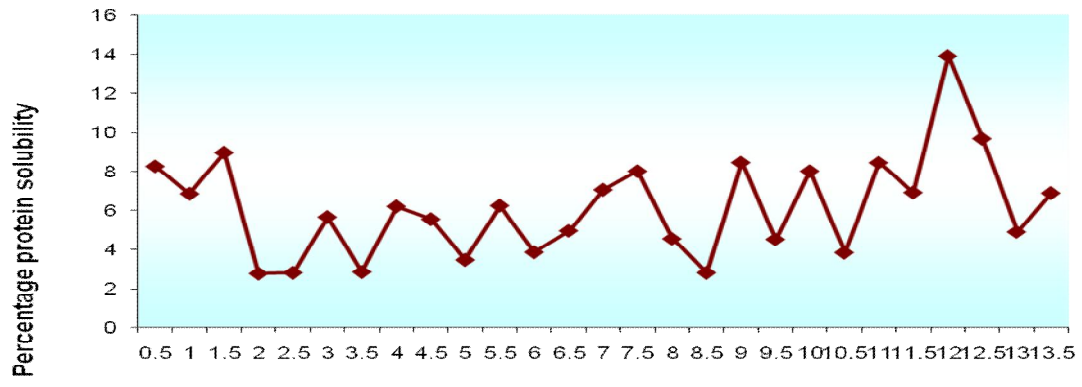


Fig 1: Effect of pH variation Vs. Solubility of seed protein of *Helianthus annuus.L* variety LSF - 11

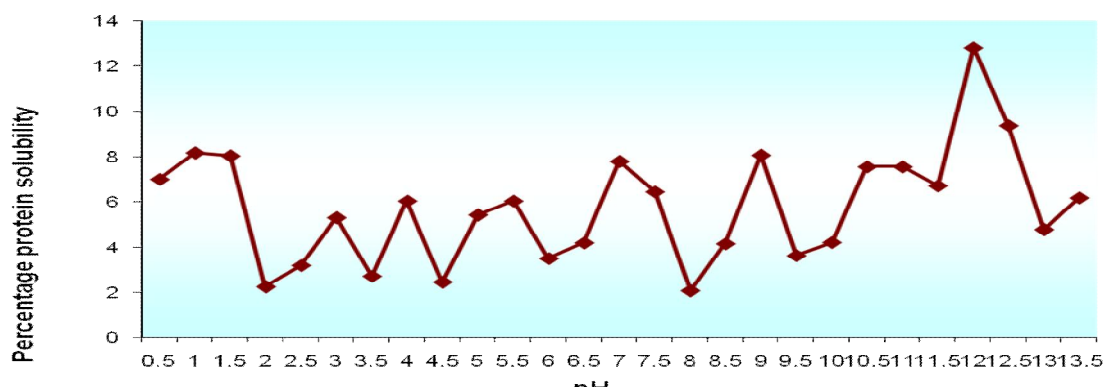


Fig 2: Effect of pH variation Vs. Solubility of seed protein of *Helianthus annuus.L* variety LSF - 8

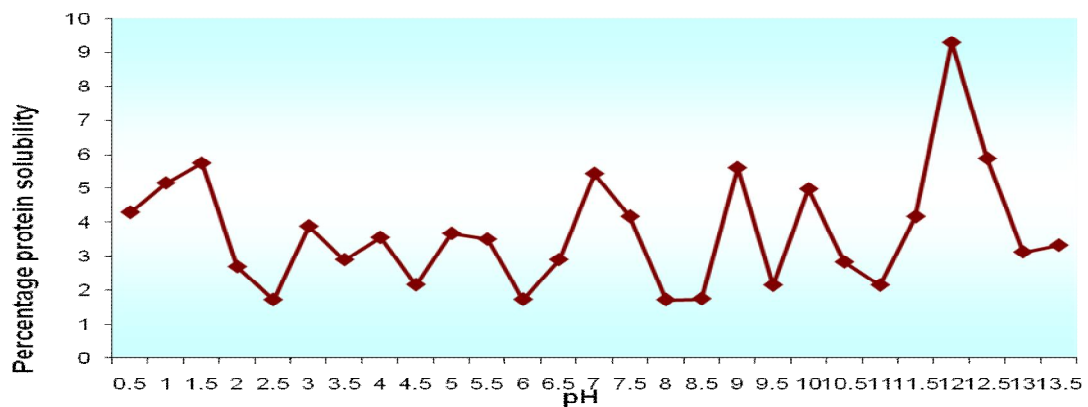


Fig 3: Effect of pH variation Vs. Solubility of seed protein of *Carthamus tinctorius.L* variety PBNS -12

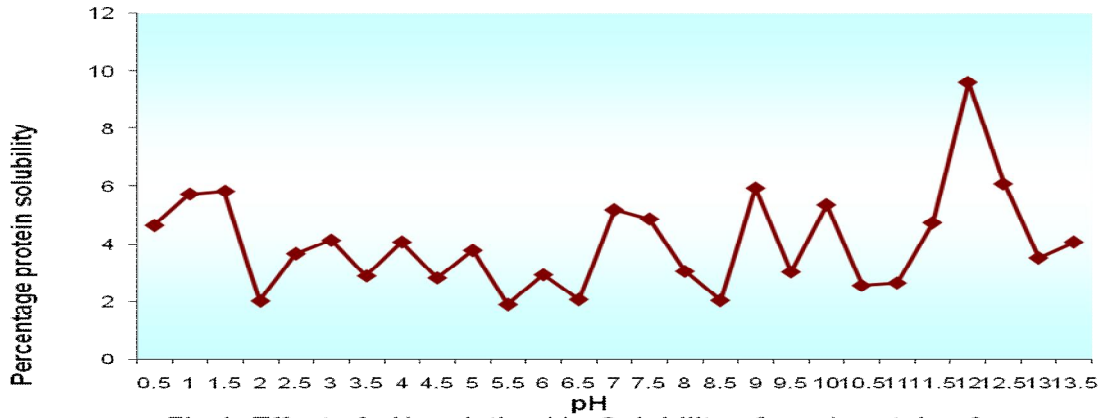


Fig 4: Effect of pH variation Vs. Solubility of seed protein of *Carthamus tinctorius.L PBNS -40*

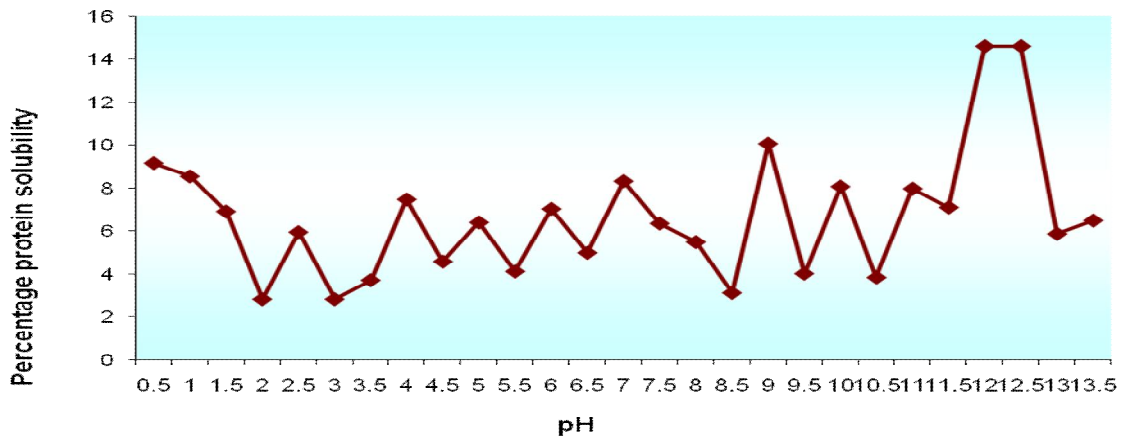


Fig 5: Effect of pH variation Vs. Solubility of seed protein of *Arachis hypogaea. L JL -24*

Fig.1- *Helianthus annuus.L* variety LSF- 11

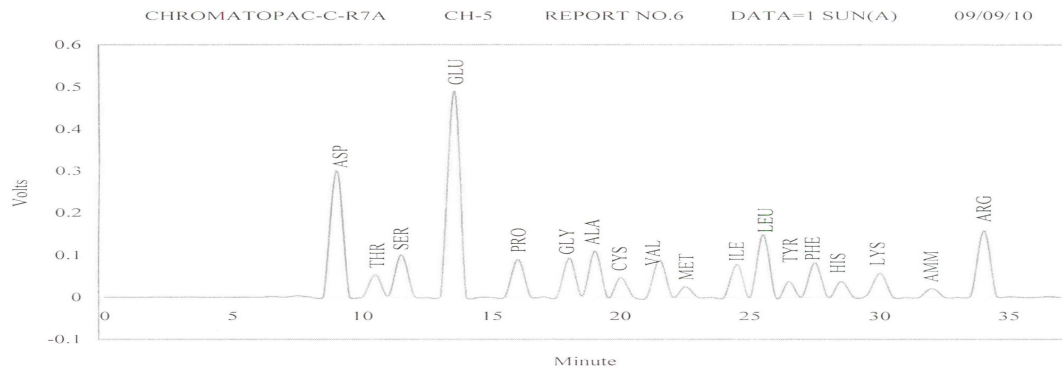


Fig.2- *Helianthus annuus.L* variety LSF- 8

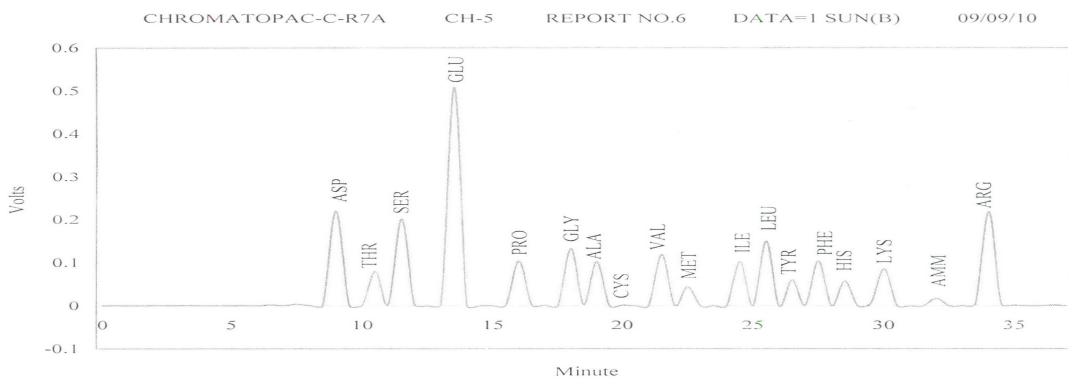


Fig.3- *Carthamus tinctorius.L* variety PBNS- 12

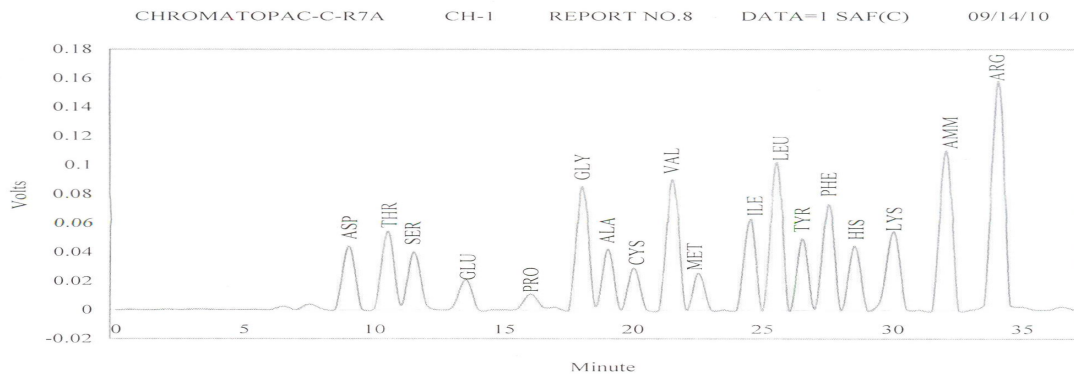


Fig.4- *Carthamus tinctorius.L* variety PBNS- 40

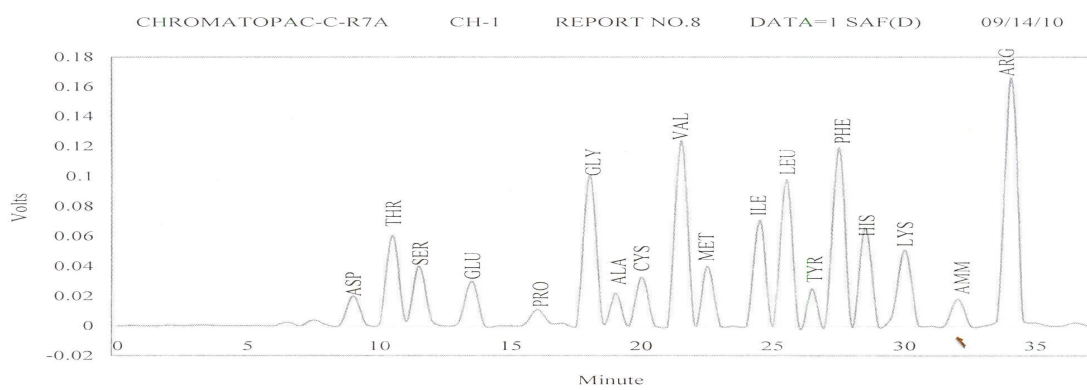


Fig.5- *Arachis hypogaea.L* variety JL-24

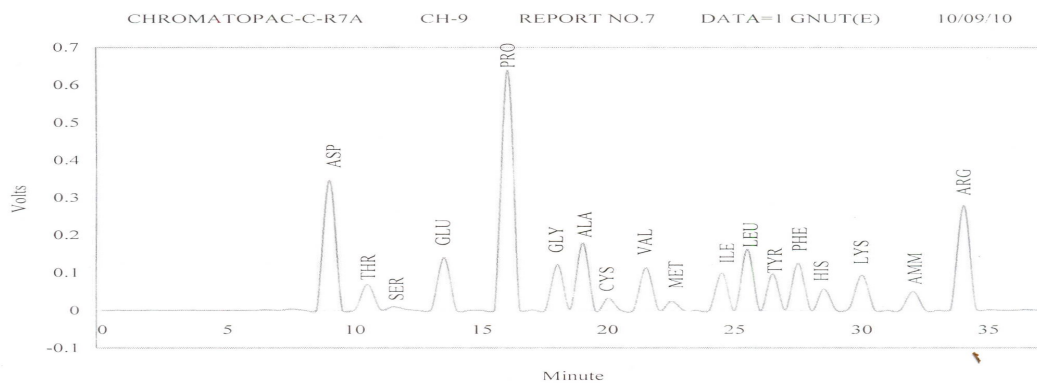


Table 1- Proximate principles of air dried seeds (g / 100 g)

Oil Seeds	Moisture	Crude Fibre	Total Lipid	Crude Protein	Total Carbohydrate	Reducing Sugar	Non-reducing Sugar
Sunflower LSF - 11	4.613	3.411	36.855	25.08	27.76	4.40	23.36
Sunflower LSF - 8	3.627	2.585	30.985	24.81	33.50	5.50	28.00
Safflower PBNS -12	6.326	1.196	25.699	15.91	48.93	7.40	41.53
Safflower PBNS -40	7.393	0.488	28.989	16.14	45.56	6.80	38.76
Groundnut JL - 24	5.529	1.149	46.224	25.20	21.26	2.90	18.36

Each value is an average of three determinations.

Table 2- Minerals and ash contents of air dried seeds (g / 100 g)
Each value is an average of three determinations.

Sr. No	Seeds	Ash	Water Insoluble ash	Water Soluble Ash	Alkalinity of water soluble ash (%meq)	Acid Insoluble Ash	Acid Soluble Ash	Calcium contents	Phosphorus Contents
1	Sunflower LSF - 11	4.823	1.757	3.066	9.676	0.891	3.556	0.107	0.40
2	Sunflower LSF - 8	4.866	1.754	3.112	10.707	0.964	3.326	0.150	0.39
3	Safflower PBNS -12	3.497	1.737	2.054	6.215	0.699	2.478	0.122	0.15
4	Safflower PBNS -40	3.495	1.228	2.401	5.748	0.903	2.844	0.092	0.41
5	Groundnut JL - 24	2.577	0.325	2.252	8.821	0.997	1.638	0.087	0.29

Table 3- Energy of oil seeds in kcal

Samples	Sunflower LSF - 11	Sunflower LSF - 8	Safflower PBNS -12	Safflower PBNS -40	Groundnut JL - 24
Energy In kcal	543.055	512.105	490.651	507.701	601.856

Each value is an average of three determinations.

Table 4- Fatty acid composition of oil seeds (g / 100 g)

FATTY ACIDS	Palmitic	Stearic	Archi-dic	Behenic	Lignoceric	Palm-itoic	Oleic	Linoleic	Linolenic	Ecosenoic	Saturated	Un Saturated.
Carbon Double Bond ratio	16 : 0	18 : 0	20 : 0	22:0	24 : 0	16 : 1	18 : 1	18 : 2	18 : 3	20 : 1	-----	-----
Sunflower LSF - 11	2.44	2.71	0.39	0.41	0.13	----	10.72	13.78	0.24	---	6.08	24.78
Sunflower LSF - 8	2.52	1.39	0.18	0.35	0.16	---	13.52	9.44	0.19	---	4.6	23.15
Safflower PBNS -12	2.02	0.91	0.17	0.10	0.21	---	3.91	6.36	0.23	0.14	3.41	10.68
Safflower PBNS -40	1.73	0.96	0.09	0.08	0.05	---	4.50	15.89	0.20	0.03	2.91	20.62
Groundnut JL - 24	6.20	1.99	0.41	1.82	0.02	---	16.28	16.35	0.88	---	10.44	33.51

All the values are mean of three determinations.

Table 5- Solubility of seed protein of oil seeds at 30°C

Sr. No.	PH Value	Sunflower LSF - 11	Sunflower LSF - 8	Safflower PBNS -12	Safflower PBNS -40	Groundnut JL - 24
1	0.5	8.25	7.00	4.29	4.64	9.16
2	1.0	6.85	8.17	5.16	5.72	8.54
3	1.5	8.97	8.04	5.75	5.82	6.91
4	2.0	2.77	2.25	2.69	2.02	2.83
5	2.5	2.81	3.19	1.73	3.67	5.95
6	3.0	5.67	5.30	3.89	4.13	2.83
7	3.5	2.85	2.71	2.90	2.90	3.71
8	4.0	6.21	6.03	3.56	4.07	7.47
9	4.5	5.56	2.45	2.16	2.83	4.58
10	5.0	3.46	5.42	3.68	3.78	6.40
11	5.5	6.25	6.03	3.51	1.90	4.12
12	6.0	3.85	3.50	1.74	2.94	7.03
13	6.5	4.96	4.20	2.90	2.07	4.99
14	7.0	7.05	7.80	5.44	5.17	8.32
15	7.5	8.00	6.44	4.17	4.86	6.35
16	8.0	4.54	2.08	1.73	3.06	5.49
17	8.5	2.81	4.16	1.76	2.04	3.12
18	9.0	8.45	8.07	5.61	5.93	10.07
19	9.5	4.51	3.63	2.15	3.04	4.02
20	10.0	8.00	4.22	4.98	5.34	8.07
21	10.5	3.83	7.56	2.83	2.56	3.84
22	11.0	8.44	7.56	2.15	2.56	7.97
23	11.5	6.91	6.71	4.17	4.73	7.10
24	12.0	13.90	12.79	9.29	9.60	14.60
25	12.5	9.68	9.36	5.89	6.08	14.60
26	13.0	4.90	4.79	3.13	3.53	5.87
27	13.5	6.88	6.17	3.33	4.07	6.49

Each value is an average of three estimations

Table 6- Amino acid profile of oil seeds

Amino acids (g/100g prot.)	Sunflower LSF - 11	Sunflower LSF - 8	Safflower PBNS -12	Safflower PBNS -40	Groundnut JL - 24
Aspartic acid	3.002	2.201	0.247	0.201	3.459
Threonine	0.539	0.802	0.544	0.061	0.689
Serine	1.012	1.012	0.009	0.034	ND
Glutamic acid	4.899	5.083	0.363	0.021	1.397
Proline	0.898	1.049	0.089	0.010	6.412
Glycine	0.934	1.332	0.857	1.022	1.232
Alanine	1.103	1.028	0.122	0.420	1.792
Cysteine	0.476	0.147	0.287	0.368	0.334
Valine	0.888	1.194	0.911	1.254	1.134
Methionine	0.254	0.443	0.256	3.001	0.243
Isoleucine	0.700	1.030	0.630	0.712	1.001
Leucine	1.490	1.511	1.023	1.002	1.622
Tyrosine	0.379	0.611	0.503	0.224	0.972
Phenylalanine	0.824	1.044	0.734	1.001	1.266
Histidine	0.381	0.3811	0.442	0.667	0.568
Lysine	0.572	0.861	0.662	0.513	0.929
Ammonia	0.212	0.177	0.221	0.189	0.494
Arginine	1.586	2.194	1.599	1.665	2.795
Tryptophan	0.330	0.220	0.277	0.232	0.306

ND: - NOT DETECTED

Table 7- Antinutritive factors in oil seeds

Oil seeds	Cyanide contents mg HCN/100g	Tannin contents g/100g	Oxalate contents g/100g	Trypsin Inhibitor Activity (TIA) Percent inhibition	Haemagglutinin Activity (on Chicken Blood Group)	Haemagglutinin Activity (on Goat Blood Group)	Haemagglutinin Activity (on Human +O Blood Group)
Sunflower LSF - 11	4.175	0.651	0.113	ND	01:16	01:32	01:08
Sunflower LSF - 8	4.026	0.623	0.098	ND	01:08	01:16	01:02
Safflower PBNS -12	3.458	0.511	0.079	ND	ND	ND	ND
Safflower PBNS -40	3.73	0.53	0.085	ND	ND	ND	ND
Groundnut JL - 24	4.818	0.412	0.18	ND	ND	01:08	ND

ND- not detected. & All the values are mean of three determinations.

Table 8- Composition of experimental diet g/kg and protein values percentage

Diet Ingredients	Balance Diet	Sunflower LSF - 11	Sunflower LSF - 8	Safflower PBNS -12	Safflower PBNS -40	Groundnut JL - 24
Maize Yellow	420	380	380	320	320	380
Fat	50	70	70	90	90	70
Groundnut Cake	430	400	400	410	410	400
Oil seeds	-	50	50	80	80	50
Fish Meal (Jawala)	80	80	80	80	80	80
Mineral mixture	19.6	19.6	19.6	19.6	19.6	19.6
Vitamin mixture	0.4	0.4	0.4	0.4	0.4	0.4
Metabolic Energy	3053.06	3029.937	3028.025	3029.492	3030.856	3032.913
Calculated value of protein %	24.891	24.55	24.537	24.426	24.444	24.556
Analysed value of protein %	25.21	24.4	24.12	24.11	24.34	25.25

Table 9- Feed intake, feed utilization, percentage feed utilization, nitrogen intake, nitrogen utilization, percentage nitrogen utilization / rat / day

Diet of selected samples	Feed intake (g)	Faeces voided (g)	Feed utilization (g)	Percent feed utilization	Nitrogen intake (g)	Nitrogen voided (g)	Nitrogen utilization (g)	Percent nitrogen utilization
Balanced Diet	7.872	1.621	6.521	79.41	0.317	0.0337	0.2833	89.37
Sunflower LSF - 11	6.816	1.350	5.466	80.19	0.266	0.0246	0.2414	90.75
Sunflower LSF - 8	6.563	1.303	5.260	80.15	0.253	0.0215	0.2315	91.50
Safflower PBNS -12	7.184	1.243	5.941	82.70	0.277	0.0199	0.2571	92.82
Safflower PBNS -40	6.922	1.200	5.722	82.66	0.270	0.0192	0.2508	92.89
Groundnut JL - 24	8.028	1.476	6.552	81.61	0.324	0.0283	0.2957	91.27

All the values are mean of three determinations.

Table 10- Gain in body weight, total protein consumed, protein efficiency ratio (per) feed efficiency ratio (fer) /rat/10 days

Diet of selected samples	Protein in diet %	Gain in body wt (g)	Total Feed consumed (g)	Total protein consumed(%)	Protein efficiency Ratio (PER)	Feed Efficiency ratio (PER)
Balanced Diet	25.21	26.906	78.724	19.85	(+) 1.355	(+) 0.342
Sunflower LSF-11	24.40	24.488	68.164	16.63	(+) 1.473	(+) 0.360
Sunflower LSF - 8	24.12	23.779	65.629	15.83	(+) 1.502	(+) 0.362
Safflower PBNS -12	24.11	26.128	71.841	17.32	(+) 1.509	(+) 0.364
Safflower PBNS -40	24.34	25.211	69.224	16.85	(+) 1.496	(+) 0.365
Groundnut JL - 24	25.25	27.734	80.281	20.27	(+) 1.368	(+) 0.345

All the values are mean of three determinations.

Table 11- Statistical analysis of new sunflower (LSF11 and LSF-8) and safflower (PBNS-12 and PBNS-40) for their toxic factors

Oil seeds	Cyanide contents mg HCN/100gm	Tannin contents g/100g	Oxalate contents g/100g
Sunflower LSF - 11	4.175	0.651	0.113
Sunflower LSF - 8	4.026	0.623	0.098
Mean	4.101	0.637	0.106
S.D.	0.082	0.016	0.008
S.E.(m)	0.033	0.007	0.003
S.L. at 5%	0.0000	0.0006	0.0000
Safflower PBNS -12	3.458	0.511	0.079
Safflower PBNS -40	3.730	0.530	0.085
Mean	3.594	0.521	0.082
S.D.	0.149	0.011	0.004
S.E.(m)	0.061	0.004	0.002
S.L. at 5%	0.0000	0.0001	0.0009

Table 12- Statistical analysis of new sunflower (LSF11 and LSF-8) and safflower (PBNS-12 and PBNS-40) for their nutritive values

Diet of selected samples	Feed intake (g)	Faeces voided (g)	Feed utilization (g)	Percent feed utilization	Nitrogen intake (g)	Nitrogen voided (g)	Nitrogen utilization (g)	Percent nitrogen utilization	Gain in body wt (g)	Total feed consumed (g)	Total protein consumed (%)	Protein efficiency ratio(PER)	Feed efficiency ratio(PER)
Sunflower LSF - 11	6.816	1.350	5.466	80.19	0.266	0.0246	0.2414	90.75	(+) 24.488	68.164	16.63	(+) 1.473	(+) 0.360
Sunflower LSF - 8	6.563	1.303	5.260	80.15	0.253	0.0215	0.2315	91.50	(+) 23.779	65.629	15.83	(+) 1.502	(+) 0.362
Mean	6.6565	1.3267	5.3634	80.1708	0.2593	0.0230	0.2363	91.1567	(+) 24.1322	66.8953	16.2335	(+) 1.4873	(+) 0.3610
S.E.(m)	0.0513	0.0106	0.0461	0.0098	0.0029	0.0007	0.0022	0.1696	0.1590	0.5675	0.1790	0.0064	0.0006
S.D.	0.126	0.026	0.113	0.024	0.007	0.002	0.005	0.416	0.389	1.390	0.438	0.016	0.002
S.L. at 5%	* 0.1076	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0048
Safflower PBNS -12	7.184	1.243	5.941	82.70	0.277	0.0199	0.2571	92.82	(+) 26.128	71.841	17.32	(+) 1.509	(+) 0.364
Safflower PBNS -40	6.922	1.200	5.722	82.66	0.270	0.0192	0.2508	92.89	(+) 25.211	69.224	16.85	(+) 1.496	(+) 0.365
Mean	7.0526	1.2232	5.8313	82.682	0.2735	0.1947	0.2541	92.8833	(+) 25.6697	70.5322	17.0867	(+) 1.5022	(+) 0.3642
S.E.(m)	0.05871	0.0090	0.0490	0.0087	0.0014	0.0002	0.0013	0.0243	0.2050	0.5852	0.1044	0.0029	0.0003
S.D.	0.144	0.022	0.120	0.021	0.004	0.0004	0.003	0.060	0.502	1.433	0.256	0.007	0.001
S.L. at 5%	0.0000	0.0070	0.0000	0.0020	0.0001	0.0052	0.0002	* 0.1417	0.0000	0.0000	0.0000	0.00001	* 0.1012

S.E. (m) – Standard error mean, S.D. – Standard deviation, S.L at 5% - Significance level at 5%, *Significant