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Chemical and bio-chemical studies of new varieties of safflower (*Carthamus tinctorius* L.) PBNS-12 and PBNS-40 seeds

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Abstract. Seeds of new safflower (*Carthamus tinctorius* L.) variety (PBNS-12 and PBNS-40) were analyzed for contents of moisture, crude fiber, lipids, proteins, carbohydrates, minerals, energy, toxic compounds (such as cyanogenic glucoside, tannins and oxalates) and nutritive value. In addition, detailed studies were conducted on the fatty acid composition, protein solubility, and amino acid profile. The results of chemical composition showed that moisture percentage ranged between 6.326 – 7.396 %, crude fibre 0.488 – 1.196 %, total lipid 25.699 – 28.989 %, crude protein 15.91 – 16.14 %, total carbohydrate 45.56 – 48.93 %, ash 3.495 – 3.497, calcium 0.092 – 0.122 %, phosphorus 0.15 – 0.41 %, and energy 490.651 – 507.701 Kcal/100g. Lipid analyses revealed that PBNS-40 variety has higher levels of unsaturated fatty acids (20.62 %) and PBNS-12 variety has higher levels of saturated fatty acids (3.41 %). Amino acid analyses revealed that PBNS-12 and PBNS-40 have higher level of arginine 1.599 % and 1.665 % respectively. The maximum seed proteins of PBNS-12 and PBNS-40 were extracted at pH 12 (9.29 and 9.6 respectively). The toxic factors showed that cyanogenic glucoside, tannins and oxalate content are ranged between 3.458 – 3.730 HCN/100g, 0.511 – 0.530 %, 0.079 – 0.085 % respectively. Haemagglutinin activity and trypsin inhibition was not found in these varieties. The nutritive values were determined for feed utilization average ranged between 5.722 – 5.941%, nitrogen utilization 0.2508 – 0.2571%, protein efficiency ratio (PER) 1.496 – 1.509% and feed efficiency ratio (FER) 0.364 – 0.365% respectively. Based on the data related to nutritive and toxic composition of seeds it appears that both hybrids can be good source of nutrient and energy needs for animal nutrition with little dangers for toxicity.
Key words: PBNS-12 and PBNS-40, chemical composition, nutritive value, protein solubility and antinutritive factors.

Introduction. India is the largest producer of safflower in the world (350,000 ha), followed by Mexico (85000 ha), Ethiopia (72000 ha) and U.S (54000 ha). Safflower (*Carthamus tinctorius* L.) has become an oil crop used both for food and industrial purposes in many other countries (Zehra Ekin 2005). In India, it is grown in winter season in the Deccan rabbi zone and accounts for about 8 percent of the value of total agriculture produce (Ravi et al 2008). Until this century, after cheaper aniline dyes became available, safflower was mainly grown as for north and south Germany and Alsace in France for dye (Dajue & Mundel 1996).

The proximate composition of safflower seed shows that the seed contain 20 – 40% oil, 10 – 20% protein and 35 – 45% hull fraction (Rahamatalla et al 2001). The seeds of safflower are rich in oil (20 – 40%) with higher levels of unsaturated fatty acid (Nagaraj et al 2001; Atasie et al 2009) and protein (15 – 20%) and therefore are of great nutritive value for human and animal consumption. Safflower seed is mainly grown as edible oil for cooking, during extraction of oil its protein solubility is affected by many factors such as pH, temperature, meal solvent ratio etc (Baudet & Mossess 1971). Toxic factors are found at some level in almost all foods for a variety of reasons. However, their levels are reduced in modern crops, probably as an outcome of the process of domestication (Sarkiyayi & Agar 2010).

Safflower is also used for health care for middle and old aged people (Hanania et al 2004; Zhang et al 1997). They are good sources of essential amino acid and fats. The industrial application of them depends on the knowledge of nutritional importance and functional properties.

Our breeding station has produced two new hybrids and this study was conducted to investigate chemical composition, nutritive value, and possible toxicity, of the new cultivars, which represent natural resources with potential economic for use in human and animal nutrition.

Material and Method

Sample collection: New indigenous hybrid seeds of *C. tinctorius* variety PBNS–12 and PBNS–40 have procured from all India Co-ordinate Research Project on Safflower Department of Agricultural Botany, Marathwada Agricultural University, Parbhani (Maharashtra).

Chemical composition: The oil seeds were cleaned and stored properly at room temperature prior to their use in actual experiment.

Moisture, ash (its analysis) and calcium content were determined by the methods as described by Pearson (1962). Crude fibre content was determined by the method as recommended in the Fertilizer and Feeding stuff regulations (Pearson 1973). Phosphorus was determined according to the procedure of Sumner (1944). Total lipid was determined by the methods of Colowick & Kaplan (1957). Carbohydrate, reducing and non reducing sugar were estimated by the method of Nelson (1944). Crude protein was estimated by "Micro Kjeldahl'' method (Pearson 1973) (N X 6.25).

Fatty acid composition: Powdered seeds were subjected to lipid extraction in Soxhlet extractor for 20 hrs, using petroleum ether (40-60)^{0}C as solvent by the methods as described by Colowick & Kaplan (1957). Methyl esters of the lipids were prepared by the method of Chowdhary (1984). The GLC analyses were carried out using a CHEMITO gas chromatogram (Model no. 8610 GC) and gas chromatogram was recorded using Flame Ionization Detector with split ratio 1:50. A BP-70 capillary column with moderate polar, with oven temperature programme- Initial temperature 100^{0}C, hold time of 2 minutes; Final temperature 230^{0}C, hold time 20 minutes and Injection temperature 275^{0}C, Detector temperature 300^{0}C. The gas flow rates used were 10^{0}C/minute carrier gas (Nitrogen). 0.4µL test solutions were injected directly into GC column.

Protein solubility: In the present investigation all the seeds were analyzed for their protein content and protein solubilization with pH variation in the powdered form, because size of seed powder has been shown to influence the nitrogenous extraction (Dijang 1952, 1953). The seeds were sun dried and powdered to mesh (Deshmukh & Sohonie 1965).

The effect of pH variation of the extractant 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, 1g of the seed powder was suspended in 20 mL of extractant of desired pH . The content were shaken in electrical shaker for about 2 hours 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 Kjeldahl" method (Pearson 1973).

Amino acid profile: Amino acids were determined by high performance liquid chromatography (HPLC) by the method of Cserhati & Forgacs (1999), Kerese (1984). 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^{o}C for 8 hours. 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^{o}C to 18-22 hrs in evacuated and sealed tubes. The hydrolysate was filtered and diluted to 250mL. 1mL of sample was vacuum evaporated at 40^{0}C until dryness. The content 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) 58.5g 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 content of the seeds were determined by the method of AOAC (1970). Oxalates were determined by using the method of Talpatra et al (1948). The method of Kakade (1969) was used for the determination of Trypsin inhibitor activity. Haemagglutanin activity was determined by the method as given by Linear (1955).

Nutritive value: The experimental diets were isonitrogenious (24.50 percent) and isocaloric (3030 Kcal/Kg). The balance diet comprised (per Kg) of: 420g maize yellow, 50g oil, 430g groundnut cake, 80g fish meal (Jawala), 19.6g mineral mixture and 0.49 vitamin mixture as recommended by I.S.I.(565.4 part I 1970). Casein and seed proteins were added to balance diet by substitution of the maize yellow to give a total dietary protein content of 100g/Kg. The seed meals used in the study were autoclaved for 30 minutes at 15 1b pressure (Kaduskar & Netke 1978) before being incorporated in the diets to destroy the toxic constituents (Cyanogenitic glycosides, tannin and trypsin inhibitors). Crude protein content and other proximate constituent are not affected by autoclaving (Gupta et al 1988) and protein digestibility is enhanced by four to forty percent as compared to raw material (Sangle et al 1993).

The experiment was performed on the white male albino rats. Eighteen rats of aged 34 days old were distributed to six groups each having three rats. Rats selected were of body weight nearest to the mean of population. They were housed in individual cages. The rats were feed ad libitum exclusively experimental diets were fed for ten days (Bressiani et al 1977) including three days of pre experimental period and water was available ad libitum. The weight and food intake of the rats were monitored daily. Faeces were collected between days 5 and days 10 of the trial. The faecal (excreta) were dried in hot oven at 100^{o}C. Protein efficiency ratio and feed efficiency ratio were calculated by the method given by Osborne et al (1919). Total nitrogen was estimated by “Semi-Micro Kjeldahl” method as usual (Pearson 1973).

Results and Discussion. The mean values of the proximate constituents and energy of *C. tinctorius* variety PBNS-12 as well as PBNS-40 are shown in (Tables 1-3).

Moisture content ranged from 6.326 percent in *C. tinctorius* PBNS–12 to 7.393 percent in PBNS–40 was found to be in close resemblance to each other and also with other varieties of *C. tinctorius* (Gupta & Shrivastava 2004; Nagraj 1995; Salunkhe et al 1992; Thakur et al 2005). The total lipid, crude fibre, crude protein and total carbohydrate of the PBNS-12 and PBNS-40 averaged 25.699, 1.196, 15.91, 48.93 and 28.989, 0.488, 16.14, 45.56 g/100g respectively. The PBNS-12 had a higher level of crude fibre and total carbohydrate, while the total lipid and crude protein was found to be higher in PNBS-40. However, these value lies in close accordance with other oil seeds (Cancalon 1971; Kumar et al 1992). The major portions of carbohydrate of these seeds under study were present in non reducing form. The seeds of *C. tinctorius* variety PBNS–12 and PBNS–40 have ash content 3.497 percent and 3.495 percent respectively, which are in close proximity with each and also with other variety of *C. tinctorius* (Nollet 1996). The variety PBNS-12 has higher calcium content (0.122 percent) than other variety of PBNS-40 (0.092 percent). However, these are in general agreement with other oil seeds (Thakur et al 2005; Kumar et al 1992). Phosphorus content of *C. tinctorius* variety PBNS -12 (0.15 percent) is lower than PBNS - 40 (0.41 percent). The gross energy ranged from 490.651 Kcal in PBNS-12 to 507.701 Kcal in PBNS-40. However, these values are in general agreement with other oil seeds (Gupta & Shrivastava 2004; Nollet 1996). An observation from the analytical results in this study with regard to the proximate constituents and energy value is relatively high nutrient density especially the crude protein and energy in PBNS-40.

Table 1

Proximate principles of air dried seeds of *C. tinctorius* variety PBNS-12 and PBNS-40 (g/100g)

Sr.No	*Seeds*	*Moisture*	*Crude Fiber*	*Total Lipid*	*Crude Protein*	*Total Carbohydrate*	*Reducing Sugar*	*Non-reducing Sugar*
1	PBNS –12	6.326	1.196	25.699	15.91	48.93	7.40	41.53
2	PBNS -40	7.393	0.488	28.989	16.14	45.56	6.80	38.76

*Each value is an average of three determinations.

Table 2

Minerals and ash content of air dried seeds of *C. tinctorius* variety PBNS-12 and PBNS-40 (g/100g)

Sr.No.	*Seeds*	*Ash*	*Water Insoluble Ash*	*Water Soluble Ash*	*Alkalinity of Water Soluble Ash (% meq)*	*Acid Insoluble Ash*	*Acid Soluble Ash*	*Calcium Content*	*Phosphorus Content*
1	PBNS –12	3.497	1.737	2.054	6.215	0.699	2.478	0.122	0.15
2	PBNS -40	3.495	1.228	2.401	5.748	0.903	2.844	0.092	0.41

*Each value is an average of three determinations.

Table 3

Energy of *C. tinctorius* variety PBNS-12 and PBNS-40 seeds in kcal

Energy	*PBNS - 12*	*PBNS – 40*
In kcal	490. 651	507 .701

*Each value is an average of three determinations.

The fatty acids present in various seed samples along with there weight, percentage are reported in Table 4. A perusal of the tabulated fatty acid profile show that the saturated (viz. Palmitic acid) content of the two *C. tinctorius* variety lies in the sequence PBNS-12 (2.02 percent) > PBNS-40 (1.73 percent). However, in both the varieties of the total unsaturated fatty acid content predominant. *C. tinctorius* variety PBNS–12 and PBNS-40 shows lower content of Ecosenoic acid (0.14 percent and 0.03 percent respectively), also shows lower content of Oleic acid (3.91 percent and 4.50 percent) and higher content Linoleic acid (15.89 percent) in PBNS-40 than PBNS-12 (6.36 percent). Linoleic acid is lowest (6.36 percent) in the variety PBNS-12. These results are in good agreement with other varieties of oil seeds (Nagaraj et al 2001; Atasie et al 2009).

The Protein content of *C. tinctorius* variety PBNS–12 and PBNS-40, was found to be 15.91%, 16.14% respectively. The results of protein solubility are represented graphically and tabular form (In Figs 1-2 and in Table 5 respectively). The solubility of seed protein was found to be maximum i.e. 9.29% at 12.0 pH in *C. tinctorius* variety PBNS–12, 9.60% at 12.0 pH in *C. tinctorius* variety PBNS-40. The solubility of seed protein was found to be minimum i.e.1.73 % at 2.5 and 8.0 pH in *C. tinctorius* variety PBNS–12, 1.90% at 5.5 pH in *C. tinctorius* variety PBNS-40. These results are in good agreement with other oil seeds (Lah & Cheryan 1980; Singhai Benu & Shrivastava 2004; Wilson et al 1965; Stevenson & Miller 1959).

Table 4

Fatty acid composition of *C. tinctorius* PBNS-12 and PBNS-40 seeds (g/100g)

FATTY ACIDS	*Palmitic*	*Stearic*	*Archidic*	*Behe-nic*	*Ligno-ceric*	*Palmi-toleic*	*Oleic*	*Linoleic*	*Linole-nic*	*Ecose-noic*	*Satu-rated*	*Unsa-turated*
Carbon Double Bond ratio	16 : 0	18 : 0	20 : 0	22 : 0	24 : 0	16 : 1	18 : 1	18 : 2	18 : 3	20 : 1	-----	------
PBNS-12	2.02	0.91	0.17	0.10	0.21	- - -	3.91	6.36	0.23	0.14	3.41	10.68
PBNS-40	1.73	0.96	0.09	0.08	0.05	- - -	4.50	15.89	0.20	0.03	2.91	20.62

*Each value is an average of three determinations.

Table 5

Solubility of seed protein of *C. tinctorius* variety PBNS-12 and PBNS-40

pH	*PBNS-12*	*PBNS-40*
0.5	4.29	4.64
1	5.16	5.72
1.5	5.75	5.82
2	2.69	2.02
2.5	1.73	3.67
3	3.89	4.13
3.5	2.9	2.9
4	3.56	4.07
4.5	2.16	2.83
5	3.68	3.78
5.5	3.51	1.9
6	1.74	2.94
6.5	2.9	2.07
7	5.44	5.17
7.5	4.17	4.86
8	1.73	3.06
8.5	1.76	2.04
9	5.61	5.93
9.5	2.15	3.04
10	4.98	5.34
10.5	2.83	2.56
11	2.15	2.65
11.5	4.17	4.73
12	9.29	9.6
12.5	5.89	6.08
13	3.13	3.53
13.5	3.33	4.07

*Each value is an average of three determinations.

Quantitative and qualitative estimation of amino acid composition in the seed proteins of *C. tinctorius* variety PBNS-12 and PBNS-40 and the results of the amino acid are given in (Table 6 and chromatograms are represented in Figure 3 and 4). *C. tinctorius* variety PBNS-12 and PBNS-40 were found to content highest amount of arginine (1.599 g/100g) and methionine (3.001 g/100g) respectively. However Serine (0.009 and 0.040 g/100g respectively) is the most limiting amino acid. And other amino acids are lying in between them in decreasing order. Arginine is a factor for maintaining the nitrogen balance in muscles; and can enhance the lean tissue to fat tissue body fat ration; a great factor for weight management (Amino acid 2005). Essential amino acids in oil seeds contribute to

good health and well being. Deficiency of lycine leads to physical and mental handicap (Papes et al 2001). The antioxidant activity of these amino acids suggests a disease preventive role as exemplifies by arginine which is beneficial for preventation of cardiovascular disease (Balsubramanian et al 1980). However all these values of amino acid composition of these seed proteins under study were found to be in good agreement with their other varieties and other oil seeds reported earlier (Gupta & Shrivastava 2006; Singh et al 2003; Evans & Bandemer 1967).

Table 6

Amino acid profile of *C. tinctorius* variety PBNS-12 and PBNS-40

Amino acids (g/100g protein)	*PBNS-12*	*PBNS-40*
Aspartic acid	0.247	0.201
Threonine	0.544	0.061
Serine	0.009	0.040
Glutamic acid	0.363	0.021
Proline	0.089	0.010
Glycine	0.857	1.022
Alanine	0.122	0.420
Cysteine	0.287	0.368
Valine	0.911	1.254
Methionine	0.256	3.001
Isoleucine	0.630	0.712
Leucine	1.023	1.002
Tyrosine	0.503	0.224
Phenylanine	0.734	1.001
Histidine	0.442	0.667
Lysine	0.662	0.513
Ammonia	0.221	0.189
Arginine	1.599	1.665
Tryptophan	0.277	0.232

*Each value is an average of three determinations.

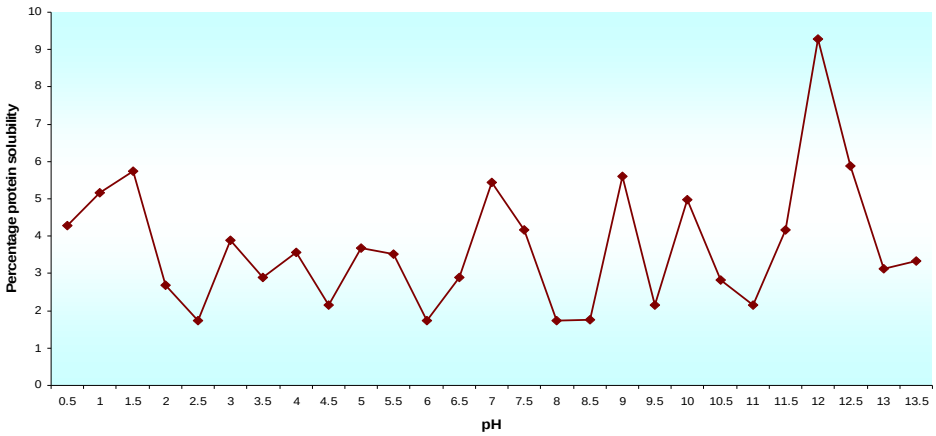

Fig. 1. Effect of pH variation vs solubility of seed protein of *C. tinctorius* PBNS-12.

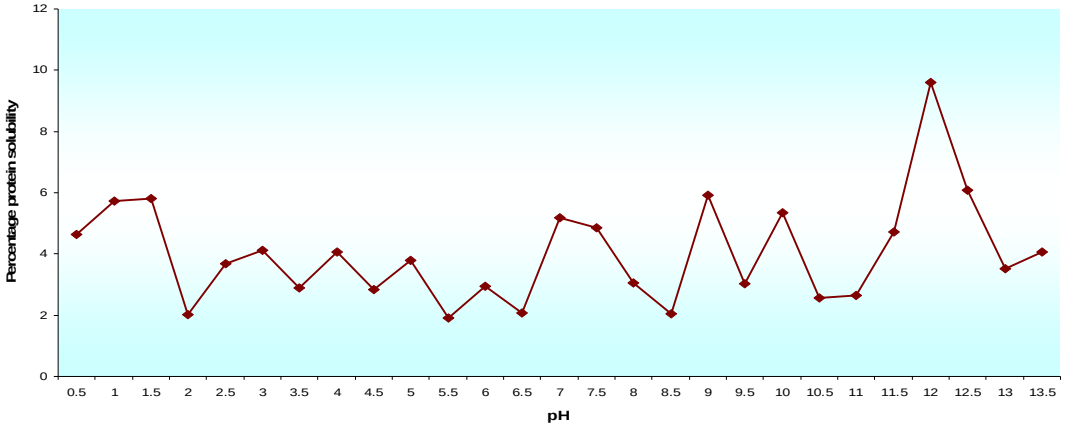

Fig. 2. Effect of pH variation vs solubility of seed protein of *C. tinctorius* PBNS-40.

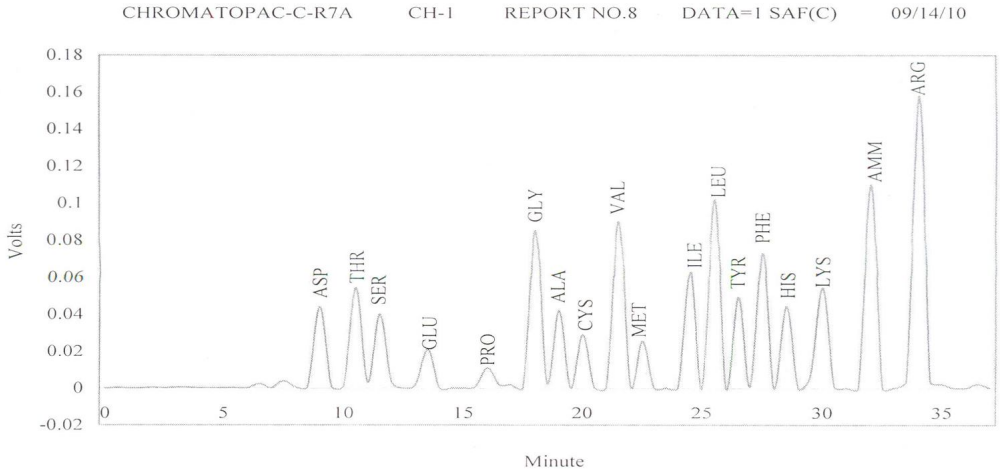

Fig. 3. Amino acid composition of *C. tinctorius* PBNS-12.

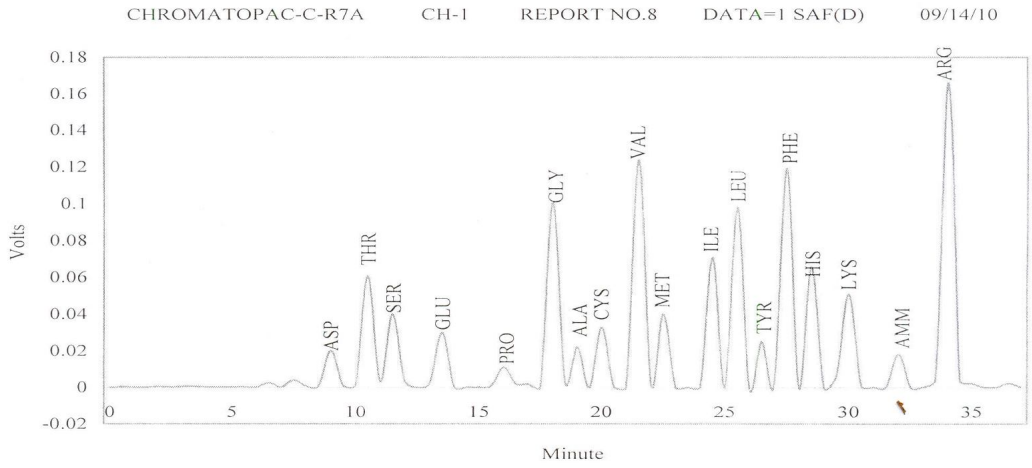

Fig. 4. Amino acid composition of *C. tinctorius* PBNS-40.

Table 7 shows the value of cyanide content, tannin content, oxalate content, trypsin inhibitor activity and haemagglutanin activity of *C. tinctorius* variety PBNS-12 and PBNS-40 seeds. Cyanide content varied from 3.458 mg/100g in PBNS-12 to 3.730 mg/100g in PBNS-40; oxalate content varied from 0.079 g/100g in PBNS-12 to 0.085 g/100g in PBNS-40; tannin content varied from 0.511 g/100g in PBNS-12 to 0.530 g/100g in PBNS-40 while no inhibition of trypsin and haemagglutinating activity was observed in PBNS-12 and PBNS-40. These values were in closely resembles to each other and was found to be

in close proximity with other oil seeds (Dominguez et al 1993; Montgomery 1969; Chubb 1982).

Table 7

Anti-nutritive factors in new varieties of *C. tinctorius* PBNS-12 and PBNS-40 seeds

Oil seeds	*Cyanide content mg HCN/100g*	*Tannin content g/100g*	*Oxalate content g/100g*	*Trypsin Inhibitor Activity (TIA) Percent inhibition*	*Haemagglu-tinin activity (on chicken blood group)*	*Haemagglu-tinin Activity (on goat blood group)*	*Haemagglutinin Activity (on human +O blood group)*
PBNS-12	3.458	0.511	0.079	ND	ND	ND	ND
PBNS-40	3.730	0.530	0.085	ND	ND	ND	ND

ND - not detected; * - Each value is an average of three determinations.

Table 8

Composition of experimental diet g/kg and protein values in percentage

Diet Ingredients	*Balanced Diet*	*PBNS- 12*	*PBNS- 40*
Maize yellow	420	320	320
Fat	50	90	90
Groundnut cake	430	410	410
Oil seeds	-	80	80
Fish meal (Jawala)	80	80	80
Mineral mixture	19.6	19.6	19.6
Vitamin mixture	0.4	0.4	0.4
Metabolic energy	3053.06	3029.492	3030.856
Calculated value of protein %	24.891	24.426	24.444
Analyzed value of protein %	25.21	24.11	24.34

In the present experiment the balance diets are given in Table 8 and feed intake denotes the food consumed in last three days. Feed intake, Faeces voided, Feed utilization, Percentage of feed utilization, Nitrogen utilization, Nitrogen intake, Nitrogen voided, Nitrogen utilization, 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 ten days are given in Table 10. The feed utilization for *C. tinctorius* variety PBNS-12 and PBNS-40 was found to be 5.941g, 5.722g respectively, where as nitrogen utilization for these varieties was found to be 0.2571g, 0.2508g respectively. The value for feed utilization and nitrogen utilization of these varieties were found to be in close resemblance with the values of feed utilization (6.521g) and nitrogen utilization (0.2833g) of controlled diet and also with other oil seeds (Gupta & Shrivastava 2003; Gopalan et al 1980; Shrivastava et al 1991). The protein efficiency ratio of all the two varieties under study is in general accordance with one another ie. + 1.509 (*C. tinctorius* variety PBNS-12), + 1.496 (*C. tinctorius* variety PBNS-40) and also with controlled diet (+ 1.355). These two varieties under study showed almost same nutritive value in spite of having different chemical composition. It may be due to isonitrogeneous inclusion of crude protein of oil seeds (Shrivastava et al 1991).

Statistical analysis: Results of chemical composition, fatty acid composition, protein solubility, anti-nutritive factors, amino acid profile and nutritive value of *C. tinctorius* variety PBNS-12 and PBNS-40 were submitted to statistical significance 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 are determined using 5% significance level. The results of statistical analysis are given in Tables 11-12.

Table 9

Feed intake, Feed utilization, Percent feed utilization, Nitrogen intake, Nitrogen utilization, percent 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
PBNS –12	7.184	1.243	5.941	82.70	0.277	0.0199	0.2571	92.82
PBNS -40	6.922	1.200	5.722	82.66	0.270	0.0192	0.2508	92.89

*Each value is an average of three determinations.

Table 10

Gain in body weight, Total protein consumed, Protein efficiency ratio (PER) and Feed efficiency ratio (FER)/Rat/10 Days

Diet of selected samples	*Protein in diet %*	*Gain in body weight (g)*	*Total feed consumed (g)*	*Total protein consumed (%)*	*Protien efficiency ratio (PER)*	*Feed efficiency ratio (PER)*
Balanced diet	25.21	26.906	78.724	19.85	(+) 1.355	(+) 0.342
PBNS-12	24.11	26.128	71.841	17.32	(+) 1.509	(+) 0.364
PBNS-40	24.34	25.211	69.224	16.85	(+) 1.496	(+) 0.365

*Each value is an average of three determinations.

Table 11

Statistical analysis of *C. tinctorius* varieties for anti-nutritive factors

Oil seeds	*Cyanide content mg HCN/100g*	*Tannin content g/100g*	*Oxalate content g/100g*
PBNS-12	3.458	0.511	0.079
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 *C. tinctorius* varieties for nutritive value

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 weight (g)*	*Total feed Consumed (g)*	*Total protein Consumed (%)*	*Protein Efficiency ratio (PER)*	*Feed Efficiency Ratio (PER)*
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
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)	0.0587	0.0090	0.049	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%	0.000	0.0070	0.000	0.002	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 sevel at 5%
* - Indicate significant

Conclusion. The *C. tinctorius* variety PBNS-12 and PBNS-40 are the potential sources of oil as well as a good source of protein supplement in livestock and human food particularly. The data presented in this study suggested that these oil seeds have relatively high levels of unsaturated fatty acid content as well as amino acid content. The data presented in this study suggested that these oil seeds have relatively low levels of some anti-nutritive factors. Also these oil seeds were found to be essentially non-toxic for rats. 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. Their potential for nutritional exploitation is further enhanced by the fact that they would not require prolonged and expensive heat-treatment prior to use.

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