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EFFECT OF PROCESSING CONDITIONS ON THE NUTRITIVE VALUE OF SUNFLOWER MEAL

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The effect of processing conditions on the proximate composition of sunflower seed cake and meal was investigated. Maximum amount of oil was extracted when the seeds were crushed in a screw press (screw to cone distance 3 mm). The sunflower meal obtained after pre-pressing (screw to cone distance 12 mm) showed higher nutritional value (net protein utilization, true digestibility, protein efficiency ratio, biological value) because of lesser damage to the protein.

Key words: Screw pressing, Pre-pressing, Sunflower meal, Nutritive value.

Introduction

Industrial processing of oil seeds for maximum oil extraction using expellers causes changes in the natural properties of oilseed meals [1-2]. The pressed cake of sunflower *(Helianthus annus* L.) seed remaining after oil extraction contains 35-50% protein with an amino acid profile comparable to other oilseed meals [3]. Many researchers have reported that the quality of protein in sunflower meal is adversely affected at high and prolonged processing temperature due to the destruction of heat labile amino acids or partial conversion of proteins into a less insoluble form [1, 2, 4-6].

The objective of the present investigation was to determine the effect of processing conditions on the nutritive value of sunflower meal.

Materials and Methods

Sunflower seed (*Helianthus annus* L.) used in the research was obtained from the Ghee Corporation of Pakistan Ltd., Lahore. The clean seed was dehulled in a locally made dehuller and separator.

Processing

(a) Sunflower cake. PCSIR-IDRC model oil expeller was used for the extraction of oil. Sunflower seed cake was prepared as follows:

Screw pressing. Sunflower kernels (50 kg) were crushed by the shearing action of screw press. The distance between the screw and cone was adjusted to 3 mm. The samples were pressed twice to get maximum extraction of oil.

Pre-pressing. Sunflower kernels (50 kg) were pre-pressed twice by increasing the distance between screw and cone to 6, 9 and 12 mm.

The temperature in the chamber of oil expeller was measured by a thermometer placed in a narrow metalic tube like chamber which is in contact with the inner portion of screw press where residual sunflower cake moves during oil extraction. The temperature in the press system is developed to required level by feeding a few trial batches of sunflower seed. Variation in temperature during screw pressing and pre-pressing is shown in Table 2.

Direct solvent extraction. 10 kg of finely ground sunflower kernels were refluxed in a Soxhlet extractor for 20 hr. with *n*-hexane to reduce the oil content to the minimum. The defatted meal was dried at 60 ± 2° and ground to 60 mesh size.

(b) Sunflower meal. The sunflower cake obtained after screw pressing or pre-pressing was refluxed in a solvent extractor as above to reduce the oil content to a minimum of 2 %. The defatted cake was dried at 60 ± 2° and ground to a 60 mesh size. The extracted screw pressed and pre-pressed meals and direct solvent extracted meal were used to formulate diets for the biological evaluation.

Biological Evaluation

Preparation of diets. The biological evaluation of screw pressed, pre-pressed and solvent extracted sunflower meal (SFM) was carried out by conducting feeding trials for 10 days on 21 days old albino rats (Sprague Dawley strain) weighing 30-32 g each. The basal diet contained 72.5% corn starch, 10% glucose, 10% corn oil, 1% vitamins, 4% minerals, 2.5% cellulose [7]. Experimental diets were prepared by replacing corn starch in basal diet by 20, 20, 21, 21, 20 and 11.2 g of screw pressed SFM, (diet 1), pre-pressed SFM obtained after keeping the distance between screw and cone at 6 mm (diet 2), 9 mm (diet 3), 12 mm SFM, (diet 4), solvent extracted SFM (diet 5) and casein (BDH Ltd.) supplemented diet (diet 6) respectively. All diets were isonitrogenous i.e. they contained 10% crude protein.

Experimental animals. The albino rats were fed on a stock diet fed for a period of one week, and then randomly divided into seven groups of four rats each. The experimental

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diets were randomly alloted to each group. Each group was weighed and introduced into the metabolic cages which were kept in the experimental room at temp. 27.0 ± 1°. The experiments were conducted in triplicate. All groups were fed *ad libitum* in special aluminium cups for a period of 10 days. During the experimental period, food consumed by rats, weight gain of rats, food refusals and faeces were collected to determine the nutritive value of the diets.

(a) Net protein utilization (NPU). NPU of the experimental diets was determined according to procedure of Miller and Bender [8].

(b) True digestibility (TD). TD was calculated from the following formula:

$$\% \text{ TD} = \frac{\text{I} - (\text{F}-\text{F}_k)}{\text{I}} \times 100$$

where I=Dietary nitrogen intake of test group, F=Faecal nitrogen of test group, F_k = Faecal nitrogen of protein free group.

(c) Protein efficiency ratio (PER). PER of diets was determined from weight gain and protein intake ratio [9] i.e. PER – gain in weight/protein intake.

(d) Biological value (BV). BV was calculated by applying the following formula:

$$\% \text{ BV} = \frac{\text{NPU}}{\text{TD}} \times 100$$

Analytical method. The moisture, ash, crude fibre, crude protein, fat contents of sunflower meal were estimated according to AOAC Method [10], phytic acid was determined by the procedure of Wheeler and Ferrel [11]. The data obtained for various observations were subjected to analysis of variance and Duncan's multiple range test [12].

Results and Discussion

The proximate composition of sunflower seed and seed fractions i.e. kernels and hulls are shown in Table 1. Dehulling of seeds increased the protein (22.8-28.0%), fat (36.3-46.9 %), and phytic acid (2.2 - 2.5%) contents whereas ash (6.5 - 3.5 %) and crude fibre (14.7 - 5.8%) contents were decreased. Dehulling of sunflower seed showed highly significant difference (P≤ 0.01) in protein, fat, ash, crude fibre contents of seed and seed fractions. The difference in phytic acid contents of sunflower seed and hulls is highly significant but it showed non-significant difference in between seed and kernels. The effect of processing conditions i.e. screw pressing or pre-pressing, on the amount of oil extracted from sunflower kernels and composition of its cakes is shown in Table 2. The different composition of the cakes were due to the different amounts of oil and moisture remaining after processing. The protein, oil, ash, crude fibre and phytic acid contents of sunflower meal (SFM) used in the experimental diets are shown in Table 3. Higher amount of crude fibre in sunflower meal showed the incomplete removal of hull fraction of seed during processing. Non-significant change in the composition of SFM obtained after screw pressing or pre-pressing followed by solvent extraction indicated maximum removal of oil from the cake.

The averge gain per group of albino rats fed experimental diets 1 through 6 for 10 days varied from 46.4 - 84.7 g, (Table 4), a maximum gain from the casein supplemented diet, followed by SFM diet 5 (83.5 g). The minimum weight gain

TABLE 1. PROXIMATE COMPOSITION OF SUNFLOWER SEED KERNELS AND HULL[1].

Constituents analysed(%)	Sunflower seeds[2]	Sunflower kernels[2]	Sunflower hulls[2]	Significant difference
Moisture	6.1	5.0	8.2	H.S.
Protein	22.8	28.0	16.9	H.S.
Fat	36.3	46.9	8.2	H.S.
Ash	5.5	3.5	6.8	H.S.
Crude fibre	14.7	5.8	35.7	H.S.
Phytic acid	2.2	2.5	1.0	H.S.
Nitrogen free extract	20.7	15.6	32.4	H.S.

(1) Dry matter basis; (2) All values in the table represent average of triplicate readings; H.S. = Highly significant (P≤ 0.01).

TABLE 2. EFFECT OF PROCESSING ON THE PROXIMATE COMPOSITION OF SUNFLOWER CAKE.

Processing conditions[1]					Oil				
Distance between screw and cone	Temperature (°C)	Process	Moisture	Protein	Extracted[2]	Residual[3]	Ash	Crude fibre	Phytic acid
3.0	84	Screw pressing	9.0	48.2	89.5	6.6	6.2	10.1	4.2
6.0	79	Pre-pressing	11.1	47.7	85.4	8.8	6.0	9.9	4.1
9.0	75	Pre-pressing	11.2	45.0	78.8	15.5	5.7	9.4	4.0
12.0	67	Pre-pressing	10.7	44.3	76.7	16.1	6.5	9.2	3.9
Significant difference			S	S	H.S.	H.S.	N.S.	N.S.	N.S.

(1) Two extractions.; (2) On oil basis.; (3) On cake basis.; N.S.= Non-significant.; S= Significant (P ≤ 0.05).; H.S. Highly significant (P≤ 0.01)

(46.4 g) for albino rats fed diet 1 indicated that screw pressing (3 mm) at 84° adversely affected the quality of meal. The increase in screw to cone distance from 6–12 mm and decreased temperature (79-67°) showed a corresponding increase in weight gain from 60.9–78.5 g. This clearly indicated that SFM obtained after pre-pressing (12 mm) at lower temperature (67°) caused less damage to the proteins. The observations are consistent with the findings of Sosulski and Fleming [13], Dimitrova [6] and Shah *et al.* [2] who observed that the quality of protein in oilseed meals was adversely affected because the seeds were extracted at higher temperature.

The average NPU of the diets 1 through 6, ranged from 48.5 - 73.2 % maximum being observed in the standard diet 6 containing casein and the minimum in diet 1 (Table 4); incorporated with screw pressed (3 mm) SFM. Among the experimental diets, the highest NPU was observed in the solvent extracted SFM incorporated diet 5 (56.3 %) which was significantly lower ($P \leq 0.01$) than the standard casein diet 6 but was non-significant from diet 4 containing SFM extracted after pre-pressing (12 mm). The NPU values of screw pressed SFM indicated that maximum damage occurs to proteins after screw pressing at 3 mm and 84°, and minimum to the meal obtained after pre-pressing at 12 mm and 67°. Similar observations were made by Keith [14] and Dimitrova [6] who showed a decrease in NPU and feed efficiency of SFM obtained after processing at 100-130°.

Total digestibility was highest for standard casein diet 6 (89.5%) followed by diet 5 (79.9%) and diet 4 (77.3%) which contained SFM extracted with solvent and pre-pressed at 12 mm respectively (Table 4). The diets 1 through 3 incorporated with SFM extracted under comparatively high temperature and pressure showed TD (69.9–76.1%) because of partial protein denaturation and hence lesser absorption in the digestive system. The results indicated that TD of pre-pressed meal (12 mm) was almost at par with solvent extracted SFM.

The average PER values of diets 1 through 6 were 1.4, 1.6, 1.7, 1.9, 2.0, 2.4 respectively (Table 4). The increase in screw to cone distance i.e. from 3 mm to 12 showed a corresponding increase in PER from 1.4 - 1.9 PER of diet 5 (2.0) containing solvent extracted SFM is significantly lower ($P \leq 0.01$.) than that of standard casein diet 6 (2.4) because of better amino acid profile of the latter [13] but showed non-significant difference with pre-pressed SFM at 12 mm (1.9), and a significant difference with the screw pressed SFM (3 mm). The data on PER value of diet containing screw pressed SFM (3 mm) indicated (Table 4) that some heat sensitive material in the meal was destroyed or inactivated by pressing or heating at 84° (Table 2). Destruction or inactivation of this component adversely affected nutritive value of meal by decreasing its PER from 2.0–1.4. The results are in agreement with the observations of Rosenberg [9] and Sosulski and Fleming [13] and Sastry and Subramanian [15] who reported that processing at higher temperature adversely affect the protein quality of oilseed meals.

The average BV of diets 1 through 6 varied from 68.9 - 81.8% (Table 4) maximum being in standard casein diet 6. The diet 5 containing SFM (12 mm) showed improvement in BV (70.5%) but was not as significant as NPU and PER values for the same diet. The results indicated that BV of diet 2 was worst affected and might be due to the formation of polyphenol protein complexes rendering some of the essential amino acids inaccessible to the digestive process of monogastric animals.

TABLE 3. EFFECT OF PROCESSING ON THE PROXIMATE COMPOSITION OF SUNFLOWER MEAL[1].

Processing conditions	Moisture	Protein	Oil	Ash %	Crude fibre	Phytic acid	N.F.E.[3]
Solvent extraction	7.8	51.4	1.8	6.2	10.9	4.3	29.6
Screw press (3 mm)[2]	5.5	51.7	2.1	6.6	10.7	4.5	28.9
Pre-pressing (6 mm)[2]	6.4	50.5	2.0	6.6	11.0	4.5	29.9
Pre-pressing (9 mm)[2]	6.6	50.1	2.0	6.5	10.8	4.4	30.6
Pre-pressing (12 mm)[2]	6.7	51.3	1.9	6.6	11.1	4.5	29.8
Significant difference	S	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

(1). On dry matter basis.; (2). Followed by solvent extraction.; (3). NFE, Nitrogen free extract = 100 - (Protein + Oil + Ash + Crude fibre).; N.S. = Non-significant.; S= Significant ($P \leq 0.05$).

TABLE 4. NUTRITIVE VALUE OF DIETS CONTAINING CASEIN AND SUNFLOWER MEAL.

Protein source	Weight gain[1] (g)	Protein intake[1] (g)	NPU[1] (%)	TD[1] (%)	BV[1] (%)	PER[1]
SFM, 3mm (diet 1)	46.4	32.1	48.5	69.9	69.4	1.4
SFM, 6 mm (diet 2)	60.9	37.4	51.2	74.3	68.9	1.6
SFM, 9 mm (diet 3)	69.3	39.6	52.8	76.1	69.4	1.7
SFM, 12mm (diet 4)	78.5	41.8	54.5	77.3	70.5	1.9
SFM, solvent extracted (diet 5)	83.5	41.7	56.3	79.9	70.5	2.0
Casein(diet 6)	84.7	35.3	73.2	89.5	81.8	2.4
Significant difference	H.S	H.S.	H.S.	H.S.	H.S.	S

1. Per group of 4 rats after 10 days, average of three replicates.; S=Significant ($P \leq 0.05$).; H.S. = Highly significant ($P \leq 0.01$).

In the light of present investigations it is concluded that the sunflower seeds should be pre-pressed twice for oil extraction by maintaining 12 mm distance between the screw and cone of PCSIR-IDRC expeller followed by solvent extraction. Biological evaluation indicated that pre-pressed sunflower meal could be used as substitute of costly vegetable and animal protein for poultry rations thereby lowering the cost as feed and having economic impact on the poultry production industry.

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