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# Nutrition Evaluation of Oilseed Meals

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## Abstract

The present investigation was carried out to nutritionally evaluate the selected oil seed meals (by-products of oil extraction), including sesame meal, flaxseed meal, and groundnut meal so that it can further be used in value addition in different food products. After the extraction of oil from oilseeds, the residue is obtained. Those residues are known as oilseed meal/oilseed cake which are used as fodder or are discarded as waste. From one ton of oilseed approx. 500 to 650 kilos of the meal is obtained depending on the type of oilseed and as by practice half of the oilseed cake received from the production is being dissipated. Oilseed meals are nutritionally rich and are a major source of protein, fatty acids, polyphenols, and dietary fibre. Composite meal was prepared by mixing sesame, flaxseed & groundnut meal in equal amount for nutritional evaluation. Crude protein, fat, ash, fiber, antioxidant activity, total phenol, phytic acid and protein digestibility of sesame, flaxseed, groundnut and composite meal ranged from 37.16-40.12 per cent, 10.95-32.03 per cent, 3.10-8.72 per cent, 5.66-9.58 per cent, 9.18-11.06 mg TE $100^{-1}$ gm, 583.64-1070.60 mg GAE $100^{-1}$ gm, 276.60-314.00 mg $100^{-1}$ gm, and 75.11-81.09 per cent, respectively. Value added product should be developed from sesame meal, flaxseed meal, and groundnut meal which can be used individually or in combination for enrichment of daily diet at low cost. It can be helpful for improving nutritional status of community and may contribute to eradicate the problem of malnutrition.

**Key words : Oilseed meals, Nutritional, Value Addition, Protein, Malnutrition.**

According to the National Family Health Survey (NFHS) 2019-21, the 5th in the series India has seen no significant improvement in health and nutritional status among the population. The latest data shows, 7.7% of children are severely wasted, 19.3% are wasted and 35.5% are stunted. At the same time, 3.4% children are overweight which was 2.1% in NFHS-4. Anemia among children under-5 has become significantly worse with the current prevalence as 67.1% compared to 58.6% according to NFHS-4. 57% of women of reproductive age are anemic in the country. The country has a dual-burden of over and under nutrition; to combat the present situation present study was planned.

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Oilseeds are seeds mainly grown for the production of oils. The oilseed is an essential part of the agricultural sector in India; it covers approx. 14 per cent of cultivation area next to food grains. India is one of the leading oilseeds producing countries in the world with 19 per cent of the global oilseeds area and accounting for 10 per cent of global output. Major oilseeds present across the country include soya bean, groundnut, castor seed, rapeseed, mustard, sesame, flaxseed, sunflower safflower, nigerseed etc.

After the extraction of oil from oilseeds, the residue is obtained. Those residues are known as oilseed meal/oilseed cake which are used as fodder or are discarded as waste. From one ton of oilseed approx. 500 to 650 kilos of the meal is obtained depending on the type of oilseed and as by practice half of the oilseed cake received

from the production is being dissipated. Oilseed meals are nutritionally rich and are a major source of protein, fatty acids, polyphenols, and dietary fibre. There are several oilseed meals available but for present study sesame seed meal, flaxseed meal, and groundnut seed meal etc has been investigated. All these are nutrient-dense and very economic in nature and can be used for development of human foods that can be directly consumed.

Sesame (*Sesamum indicum*) oil meal is a protein-rich by-product. Expeller sesame meal has a protein content of about 45 per cent and ranging from 32 to 53 per cent whereas solvent extracted sesame meal contains about 48 per cent protein. Expeller sesame meal is rich in fat content, and also in energy. The fat content depends on the process of oil extraction and ranging from 5 to 20 per cent. The fibre content varies from 4-12 per cent and contains two per cent of lignin. Sesame meal from dehulled seeds has a higher nutritional value. Sesame meal has a peculiar amino acid profile being low in lysine and rich in sulfur-containing amino acids. Unsaturated fatty acids (mostly oleic acid C16:0 and linoleic acid C18:1) constitute 80% of the total fatty acids (Heuze *et al*. 2017). Sesame oil meal contains 3.5 per cent of phytic acid (lease 1966).

After the oil extraction flaxseed (*Linum usitatissimum*) meal is obtained which is protein-rich and can be used in different ways for human use. This meal is rich in vitamin B6 and contains fiber up to 2-7 per cent. Vitamin B6 is an essential nutrient which body uses as a coenzyme in enzymatic reactions in the human body (Heuze *et al*. 2017). Flaxseed meal contains total phenolic content ranging from 776 mg $100^{-1}$ gm to 2255 mg $100^{-1}$ gm. It varies according to solvent used for extraction of total phenolic content (Akl *et al*. 2017). Flaxseed meal contains an ample amount of polyunsaturated fatty acid (PUFA), alpha-linolenic acid (omega-3), and conjugated linolenic acid and has so many health benefits; helps to maintain a low level of LDL (Low-density lipoprotein) and have different effects on the body such as antihypertensive, anticancer, antidepression, antiaging, and antiarthritis. As a matter of fact, it helps the body to fight against cardiovascular diseases.

Peanut's also known as groundnut (*Arachis hypogaea*) is a legume crop grown mainly for its edible seeds. It is widely grown in the tropics and subtropics, being important for commercial producers. It is classified as a grain and legume and, due to its high oil content, an oil crop (Dwiwedi *et al*. 2011).World annual production of shelled peanuts was 44 million tonnes in 2016, led by China with 38% of the world's total production. According to PDCAAS (Protein Digestibility Corrected Amino Acid Score); peanut proteins and other legume proteins such as soy proteins are nutritionally equivalent to meat and eggs for human growth and health. The amino acid profiles of the peanut oilseed meals show that this can be a good protein fortificant. Peanut protein promotes optimal immune function, building certain peptide hormones or protein hormones, building enzymes in the body and regulates function of enzymes properly, and reducing hunger to maintain their weight. Various byproducts of peanut processing containing proteins, dietary fibers, and polyphenols can be incorporated into processed foods for functional use (Wu *et al*. 2009). Polyphenols present in peanuts helps to manage the blood pressure and promotes good circulation of blood.

## Materials and Method

**Procurement of raw material :** Peanut meal and sesame meal (mechanical hot pressed) were procured from local market. Flaxseed meal (mechanical cold pressed) was procured from India Mart.

**Nutritional analysis :** The Association of Official Analytical Chemists (AOAC, 2010) methods were used to determine the moisture, carbohydrate, fats, protein, and ash in the finely ground samples. The micro-Kjeldhal apparatus was used to determine the nitrogen concentration of the samples. To get the amount of crude protein from nitrogen, a factor of 5.45 for groundnut meal, 5.30 for sesame and flaxseed meal was applied. The moisture and ash contents of meals were measured using weight difference method, while crude fat was determined using the Socs-Plus apparatus using petroleum ether as the solvent, crude fiber was analyzed as acid and alkali resistant.

*In vitro* protein digestibility (%) was estimated using modified enzymatic method explained by Mertz *et al*. (1983).

Phytic acid content was determined by the method of Davies & Reid (1979).

**Antioxidant profile :** Total phenolic content (TPC) was measured spectrophotometrically using the Folin-Ciocalteu reagent as described by Singleton (1999). Acidified MeOH extract (0.1ml) was added to the reaction mixture, which was then oxidized using 0.5 ml Folin-Ciocalteu reagent (1:10 Folin-Ciocalteu: water) and 0.8 ml 7.5 percent $Na_2CO_3$. Instead of extract, 0.1 ml water was used to prepare the blank. The combination was heated in a water bath at 50°C for 5 minutes and then cooled to room temperature before being measured using a type U-1100 spectrophotometer at 760 nm.

The DPPH radical scavenging activity was measured using methodology given by Brand-Williams *et al*. (1995). Different known sample aliquots were collected using methanol, and the volume was built up to 1 ml. It was then filled with 3 ml of DPPH reagent and properly mixed before being incubated at 370°C for 20 minutes. Absorbance of oxidized solution was read against methanol as a blank at 517 nm.

**Statistical analysis :** The data obtained from nutritional analysis and organoleptic evaluation was statistically analyzed by using mean, standard error and ANOVA (one-way and two-way analysis). Replicates were used for experiments.

## Results

Groundnut meal (GM), sesame meal (SM), flaxseed meal (FM) and composite meal (CM; Peanut meal, sesame meal and flaxseed meal mixed in equal proportions) were analyzed for their nutritional composition. Moisture content of the selected oilseed meals varied from 0.33 per cent to 1.73 per cent. Protein content of sesame, flaxseed, groundnut and composite meal was 37.16 per cent, 36.71 per cent, 40.12 per cent, and 38.06 per cent, respectively. Flaxseed meal contained 32.03 per cent of crude fat, followed by composite meal which contained 19.01 per cent, sesame meal contained 13.54 per cent, and groundnut meal contained 10.95 per cent. The data indicated that ash content was highest in sesame meal i.e. 8.72 per cent followed by groundnut meal with 7.46 per cent, composite meal with 6.64 per cent, and flaxseed meal with 3.10 per cent. Crude fiber content of sesame meal, flaxseed meal, groundnut meal and composite meal was 7.55 per cent, 6.43 per cent, 5.66, and 9.58, respectively (Table 1).

Antioxidant activity was determined as Torolox equivalent antioxidant capacity. The data indicated antioxidant activity of groundnut meal was 11.06mg TE $100^{-1}$ g, followed by sesame meal had 10.77mg TE $100^{-1}$ g, flaxseed meal indicated 10.76mg TE $100^{-1}$ g and composite meal had 9.18mg TE $100^{-1}$ g (Fig. 1).

Total phenol content was determined as Gallic acid equivalent. Total phenol content was 1070.6mg GAE $100^{-1}$ g in flaxseed meal, 711.45mg GAE $100^{-1}$ g in composite meal, 693.44 mg GAE $100^{-1}$ g in groundnut meal and

583.64 mg GAE $100^{-1}$ g in sesame meal (Table 2).

Protein digestibility of sesame, flaxseed, groundnut and composite meal showed significant (P 0.05) difference in its values. In-vitro protein digestibility was observed to be 81.09 per cent, 79.09 per cent, 78.50 per cent, and 75.11 per cent in groundnut meal, flaxseed meal, sesame meal and composite meal, respectively (Table 3).

The amount of phytic acid was significantly (P 0.05) different among sesame, flaxseed, groundnut, and composite meal. Highest amount was 314.00 mg $100^{-1}$ which was found in sesame meal, followed by 304.79 mg $100^{-1}$ g in composite meal, 285.80 mg $100^{-1}$ g in flaxseed meal and 276.60 mg $100^{-1}$ g in groundnut meal (Table 3).

## Discussion

**Peanut meal/groundnut meal :** Present data on nutritional composition of selected oilseed meals indicated that groundnut meal contained 1.73 per cent moisture and 40.12 percent protein (Table 1). Results obtained for protein in present study were similar to values earlier reported by Myint *et al*. (2018), Gupta *et al*. (2011), and Allan *et al*. (2000) .i.e. 41.7 per cent, 42.87 per cent and 41.2 per cent, respectively. Crude protein of meal was quite high might be due to ample amount of protein present in peanut. Crude fat content was 10.95 per cent. Results obtained for crude fat were in accordance with values given earlier by Awoniyi *et al*. (2003), Adewolu *et al*. (2010), Munguti *et al*. (2012) and Heuze *et al*. (2017) who also reported crude fat content as 9.90 percent, 10.56 per cent, 9.40 per cent, and 9.80 per cent, respectively. Crude fat of peanut meal was low as peanut meal was obtained by hot pressed oil extraction method. Crude fiber content (5.66 per cent) found in present meal was almost similar to the values reported in earlier study by Masoero *et al*. (1994), Adewolu *et al*. (2010), and Myint *et al*. (2018) and values were 5.84 per cent, 4.80 per cent and 5.40 per cent, respectively. Ash content obtained in peanut meal (7.46 per cent) in agreement to values similar to values observed in earlier study by Masoero *et al*. (1994), Awoniyi *et al*. (2003), Singh *et al*. (2006), and Singh *et al*. (2010). Antioxidant activity determined as torolox equivalent antioxidant capacity in the form of DPPH radical scavenging activity was 11.06mg TE/100gm. Total phenol content was determined as gallic acid equivalent. High total phenol content (693.44mg GAE $100^{-1}$ gm) observed may be due to presence of proanthocyanidins and free form of p-coumaric acids which are known as polyphenols and have antioxidant properties (Rasmussen *et al*. 2005). In vitro protein digestibility found in groundnut meal (81.09 per cent) was comparable to the values reported earlier as 81.62 per cent by Yang *et al*. (2016). The phytic acid content was 276.60 mg $100^{-1}$ gm.

**Table 1.** Proximate composition of sesame, flaxseed, and groundnut meal (%, on dry matter basis)

| Oilseed meals | Moisture* | Crude protein | Crude fat | Ash Ash | Crude fiber | Carbo-hydrate |
|---|---|---|---|---|---|---|
| Sesame Meal (SM) | 1.60±0.01 | 37.16±0.14 | 13.54±0.15 | 8.72±0.17 | 7.55±0.01 | 31.43±0.42 |
| Flaxseed meal (FM) | 0.33±0.01 | 36.71±0.28 | 32.03±0.26 | 3.10±0.00 | 6.43±0.03 | 21.4±0.09 |
| Groundnut meal (GM) | 1.73±0.11 | 40.12±0.40 | 10.95±0.04 | 7.46±0.07 | 5.66±0.14 | 34.08±0.25 |
| Composite meal (CM) | 1.23±0.07 | 38.06±0.40 | 19.01±0.11 | 6.64±0.08 | 9.58±0.20 | 25.48±0.53 |
| C.D.( P 0.05) | 0.24 | 1.08 | 0.55 | 0.34 | 0.42 | 4.08 |

Values are mean±SE of three independent determinations. * On fresh weight basis; SE=Standard error.

**Sesame meal :** As per data obtained from present study, crude protein content obtained in sesame meal was 37.16 per cent which was similar to the earlier findings of NRC (1984), Isarakul *et al*. (1993), Hossain *et al*. (1997), and Hira *et al*. (2002) which was 35.7 per cent, 35.7 per cent and 36.3 per cent, 38.24 per cent and 35.16 per cent, respectively. Crude protein content observed in sesame meal was similar with protein content of flaxseed meal protein content. Crude fat content (13.54%) was comparable to the 13.11 per cent which was earlier reported by Babiker (2012). Crude fiber content (7.55%) is in agreement with earlier findings of 7.90 per cent, 7.61 per cent, and 7.30 per cent as earlier reported by Brito *et al*. (1982), Hossain *et al*. (1997), and Heuze *et al*. (2017), respectively. Mineral content was high as indicated by high ash content (8.72%). Results of ash was in cordinance with values given earlier by Isarakul *et al*. (1993), Hira *et al*. (2002), Nadeem *et al*. (2005), Heuze *et al*. (2017), and Son *et al*. (2017). Antioxidant activity and total phenol content observed in the present study was found 10.77mg TE $100^{-1}$ gm and 583.64mg GAE $100^{-1}$ gm, respectively. Total phenol content of sesame meal detected higher in comparison to that reported earlier in findings given by Sarkis *et al*. (2015) which might be due to some of the chemical reactions occurring during oil extraction due to which insoluble phenolic compounds convert to soluble forms, and so many new compounds are formed such as sesamol, vanillic acid, 3-hydroxy benzoic acid, filicinic acid, 4-hydroxy benzoic acid, and 3,4-dimethoxy phenol Kang *et al*. (1999). Phytic acid content was 314 mg $100^{-1}$ gm and can be comparable to sesame seed (307.61-324.91) reported earlier by Zebib *et al*. (2015) which indicated phytic acid content of sesame meal might not decrease during oil extraction. In vitro protein digestibility of sesame meal was detected 78.50 per cent in the present study (Table 3).

**Flaxseed meal :** Data obtained from present study indicated that the moisture and crude fat content were 0.33 per cent and 32.03 per cent, respectively. Crude fat was in agreement with the findings reported earlier by Gutierrez *et al*. (2010) and Imran *et al*. (2015), who stated that the fat content of flaxseed meal was ranged from 29.00-32.00 per cent. High fat content observed in flaxseed meal which might be due to reason that because it was obtained by cold press method of oil extraction. Crude protein content was 36.71 per cent which was in agreement with value of crude proteins reported earlier as 37.74 per cent, 37.5 per cent, 36.44 per cent and 38.42 per cent, and 38.40 per cent by Batterhem *et al*. (1991), Bhatty *et al*. (1992), Bell *et al*. (1993) & Bell *et al*. (1993), and Kyntaja *et al*. (2014), repectively. Ash content of present study can be matched with the earlier findings of Heuze *et al*. (2017) .i.e.4.70 per cent. However, Kyntaja *et al*. (2014) reported higher values for ash 5.10

**Table 2.** Total phenol content sesame, flaxseed, and groundnut meal (on dry matter basis)

| **Oilseed meals** | **TPC (mg GAE $100^{-1}$ g)** |
|---|---|
| Sesame Meal (SM) | 583.64±0.34 |
| Flaxseed meal (FM) | 1070.6±0.19 |
| Groundnut meal (GM) | 693.44±0.20 |
| Composite meal (CM) | 711.45±0.33 |
| C.D.( P 0.05) | 0.97 |

Values are mean±SEof three independent determinations.
* SE=Standard error

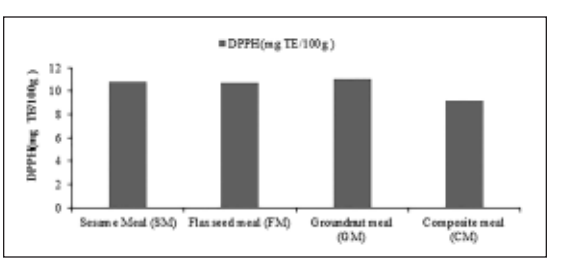


**Fig. 1.** Antioxidant activity of sesame, flaxseed, groundnut, and composite meal.

per cent. Antioxidant activity of flaxseed meal and sesame meal was found similar as per present study i.e. 10.76 per cent and 10.77, respectively. The values for total phenol content in the present study (1070.60mg GAE $100^{-1}$ gm) was found within the range earlier given by (776 mg GAE $100^{-1}$ gm to 2255 mg GAE $100^{-1}$ gm) by Engy *et al*. (2017). Flaxseed meal, total phenol content was detected high which might be due to the presence of secoisolariciresinol diglucoside (SDG). It is also known as lignan and has antioxidant properties for the cure of type-1 and type-2 diabetes. Hyperglycemia in type-2 diabetes can be caused by an increase in the expression of phosphoenolpyruvate carboxykinase (PEPCK), which is a rate-limiting enzyme in the gluconeogenesis. Secoisolariciresinol diglucoside (SDG) suppresses the expression of phosphoenolpyruvate carboxykinase (PEPCK) geneand and this is known as hypoglycemic effect. SDG is effective in preventing and delaying in the development of type-1 and type-2 diabetes because it codes the key enzyme PEPCK, which is responsible for the synthesis of glucose. Once, ingested SDG converts to enterodoil (ED) and entero-lactone (EL); they can inhibit the prostate and endometerium cancer cells Prasad *et al*. (2002). Results of present investigation regarding in-vitro protein digestibility (79.09 per cent) indicated that protein digestibility was good. Phytic acid content was observed 285.80 mg $100^{-1}$ gm in the present study which matched to content (270 mg $100^{-1}$ gm) earlier reported by Bhatty *et al*. (1992).

**Composite meal :** Composite meal was prepared by mixing equal amount of peanut, sesame and flaxseed meal. Present study revealed that moisture, crude protein, crude fat, ash and crude fiber was observed 1.23 per cent, 38.06 per cent, 19.01 per cent, 6.64 per cent, and 9.58 per cent, respectively. Results of present investigation regarding antioxidant activity was found low i.e. 9.18mg TE $100^{-1}$ gm. Total phenol content was observed 711.45mg GAE $100^{-1}$ gm, phytic acid content was observed 304.79 mg $100^{-1}$ gm and protein digestibility was observed 75.11 per cent.

**Comparison of nutrient content of oilseed meals :** Comparison of protein and moisture of all the selected oilseed meals indicated that it was significantly ($P \leq 0.05$) high in groundnut meal. Sesame and flaxseed had almost similar protein. Comparison of fat content of all the oilseed meals indicated that crude fat content of flaxseed meal was significantly high (32.03%) as compared to sesame meal, groundnut meal and composite meal. High fat content in flaxseed meal was due to fact that oil from flaxseed was extracted with cold pressed method in which the oil retention is more in meal. Groundnut meal had lowest fat i.e. 10.95 per cent. Significant ($P \leq 0.05$) difference observed in fat content among all oil seed meals may be due to fat content of oil seed and method of oil extraction used. The comparison of ash content among sesame, flaxseed, groundnut and composite meal revealed that ash content was significantly (P 0.05) high in sesame meal and lowest in flaxseed meal. A variation was observed in crude fiber content among all oil seed meals evaluated. Maximum amount of crude fiber was found in composite meal and lowest found in groundnut meal. Significant ($P \leq 0.05$) differences were

**Table 3.** Phytic acid and protein digestibility of sesame, flaxseed, and groundnut meal (on dry matter basis)

| Oilseed meals | Phytic acid (mg $100^{-1}$ gm) | Protein digestibility (%) |
|---|---|---|
| Sesame meal (SM) | 314.00±0.02 | 78.50±0.04 |
| Flaxseed meal (FM) | 285.80±0.15 | 79.09±0.22 |
| Groundnut meal (GM) | 276.60±0.14 | 81.09±0.08 |
| Composite meal (CM) | 304.79±7.69 | 75.11±0.40 |
| C.D.( P 0.05) | 12.74±0.00 | 0.9±0.00 |

Values are mean±SEof three independent determinations.
* SE=Standard error

observed in crude fiber content among all the oil seed meals. Almost similar antioxidant activity was observed in sesame and flaxseed meal while lowest amount was observed in composite meal. Total phenol content was high in all the seed meals however significant variations was noticed among all oil seed meals being highest in flaxseed meal and lowest in sesame meal. Data in respect to phytic acid content revealed that almost similar values was observed in groundnut and flaxseed meal whereas the significant ($P \leq 0.05$) higher amount was found in sesame meal and lowest amount was found in composite meal. Protein digestibility was significantly ($P \leq 0.05$) low in composite meal. However, sesame, peanut and flaxseed meal had almost similar digestibility.

## Conclusion

The present study was carried out to nutritionally evaluate the by-products of oil extraction. Sesame, flaxseed, groundnut and composite meal (mixture of sesame, flaxseed, and groundnut meal) were nutritionally evaluated. Sesame and groundnut meal other ingredients were procured from local market, Hisar and cold pressed flaxseed meal was procured by India mart. Sesame meal and groundnut meal were cleaned from foreign material, ground and sieved to obtain fine powder for nutritional evaluation.

Results of nutritional evaluation indicated that sesame meal, flaxseed meal, peanut meal and composite meal (SM, GM, and FM were mixed in equal proportions) were rich in crude protein content i.e. 37.16 per cent, 36.71 per cent, 40.12 per cent, and 38.06 per cent, respectively. Sesame meal, flaxseed meal, peanut meal and composite meal moisture content was 1.60 per cent, 0.33 per cent, 1.73 per cent, and 1.23 per cent, respectively. In flaxseed meal, crude fat was higher than sesame meal, peanut meal and composite meal because flaxseed meal was obtained by cold press extraction. Oilseed meals were also find to be rich in minerals as their ash content was found to be high and ranged between 3.10-8.72 per cent. Antioxidant activity was almost similar among sesame meal (10.77 mg TE $100^{-1}$ gm) and flaxseed meal (10.76 mg TE $100^{-1}$ gm) whereas highest was found in groundnut meal (11.06 mg TE $100^{-1}$ gm) and lowest was found in composite meal (9.18 mg TE $100^{-1}$ gm). Total phenol content was highest in flaxseed meal (1070.60 mg GAE $100^{-1}$ gm) followed by composite meal (711.45 mg GAE $100^{-1}$ gm), peanut meal (693.44 mg GAE $100^{-1}$ gm) and lowest amount was found in sesame meal (583.64mg GAE $100^{-1}$ gm). In-vitro protein digestibility ranged between 75.11 to 81.09 per cent. Phytic acid amount was maximum in sesame meal (314 mg $100^{-1}$ gm), followed by composite meal (304.79 mg $100^{-1}$ gm), flaxseed meal (285.80 mg $100^{-1}$ gm) and groundnut meal (276.60 mg $100^{-1}$ gm).

Value added product should be developed from sesame meal, flaxseed meal, and groundnut meal which can be used individually or in combination for enrichment of daily diet at low cost. It can be helpful for improving nutritional status of community and may contribute to eradicate the problem of malnutrition.

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## Conflict of interest

The authors declare that there are no conflicts of interest pertinent to this article.

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