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Nutritional quality analysis of sunflower seed cake (SSC)

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Abstract

Sunflower is a huge yearly forb from the genus *Helianthus* that is grown as a crop for its edible fruit and oil. The flowers at the centre of the head of the plant are known as 'Disk flowers' which further facilitate to mature into the fruit of the plant called as 'Sunflower seeds'. The sunflower seeds are excellent source of dietary fibre, amino acids, vitamin E, vitamin B (vitamin B1 or thiamine, vitamin B5 or pantothenic acid and folate), and minerals (phosphorus, calcium, potassium, magnesium, zinc, iron, manganese, selenium and copper) and are also rich in cholesterol-lowering phytosterols. The residual part or by product left after the extraction of oil from the seeds, is known as Seedcake (SC). Over the years the sunflower seed cake (SSC) has been used as animal feed, organic fertilizer and soil compost. Considering the nutritional potential of sunflower seedcake, as it still remains with multifarious nutrients, this underutilized SSC can be a valuable source of remedies of various nutritional deficiencies or other health problems. In regard to this influential aspect the aim of this investigation was to evaluate the nutritional quality of SSC. The nutritional composition was estimated by standard procedures. The chemical analysis of the sunflower seed cake was resulted as moisture (9.23g), crude protein (37.10g), crude fat (0.69g), ash (7.49g), crude fibre (21.50g), carbohydrate (23.97g) and energy (250.56kcal), iron (6.44mg), calcium (650mg), phosphorus (711.33mg) and phytic acid (700mg) per 100g on dry weight basis. Hence, it can concluded from the above mentioned results that SSC was nutritionally rich as a source of protein, fibre, carbohydrate and energy that can be beneficial for various therapeutic purposes.

Keywords: *Helianthus annuus*, sunflower seed cake, SSC, nutrients, nutritional analysis, standard procedures, therapeutic benefits

Introduction

Our nature has provided us a vast variety of food and one of the major sources for food availability are the plants, including their stems, leaves, flowers, roots, fruits, seeds and vegetables. In human nutrition, plant based foods are very essential as they promote good health and our mother nature also provide us impeccable crate of such vegetation which make our body to bloom, gleam and repair thoroughly. Among all the vegetation, seeds are one of the beneficial supplies for our body and health as these are loaded with numerous nutrients and beneficial oils. The residual part or by product left after the extraction of oil from the seeds, is known as Seedcake (SC). The various oil seed cakes like soya bean seed cakes, rapeseed cake, sunflower seed cake and cotton seed cake are rich in proteins, antioxidants, fibres, vitamins and minerals.

Amid above mentioned seed cakes, one popular seedcake is the Sunflower seedcake (SSC). Over the years this seed cake have been used as animal feed, organic fertilizer and soil compost but from past years, considering the nutritional potential of sunflower seedcake as it still remains with multifarious nutrients, various researches are being conducted for its human consumption. In the circumstances of hunger, nutritional crisis and deprivation of food sources, if the appropriate and innovative use of this underutilized seed cake, in developing the food products would be done, then due the nutritional quality and health benefits of SSC, an encouraging solution can be achieved. This underutilized SSC can be a valuable source of remedies of various nutritional deficiencies or other health problems. Therefore advance process and complete development of SSC is of great importance. As comparing to proteins of SSC, peptides exhibit better characteristics because they have specific biological properties such as anti-oxidation, anti- hypertension, antitumor, anti-hyper lipidemia and anti-bacterium and that's why SSC can be broadly used in health promoting and functional foods.

Helianthus annuus, often known as Sunflower, is a huge yearly forb from the genus *Helianthus* that is grown as a crop for its edible fruit and oil. It is also used for food for

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wild birds or feed for livestock. The sunflower plant was firstly domesticated in America. The wild variety of *Helianthus annuus* is annual and has many flower heads whereas the domestic variety generally has a single large flower head at top with an unbranched stem. And because of the flower head's shape, the name is derived as Sunflower as it resembles to sun. The height of the plant is approximately of 3 meters (9.8 ft.) with an erect rough hairy stem. On a record the tallest sunflower was recorded with a height of 9.17 meters (30.1 ft.) (Schiffer, 2014 and Guinness World Record, 2014) [33]. The leaves of sunflower are expanded, coarsely toothed, rigid and usually disjunctive. The outer flowers known as 'Ray flowers' generally harmonize to petals and the flowers at the centre of the head are known as 'Disk flowers' that further mature into the fruit of the plant called as 'Sunflower seeds' (Golob *et al.* 2002) [11].

In the world of oil production, sunflower is the fourth most crops after palm, soya bean and rapeseed oil, with a production of 15.8 million tonnes in 2014 (FAO, 2018) [8]. While the global production of sunflower seed oil in 2019 and 2020 was amounted to 21.2 million metric tonnes (Shahbandeh, 2020) [36]. The production of sunflower seeds in India was 216,000 metric tonnes by the end of Fiscal Year 2019.

There is a vast range of sunflower meal products available in market from low quality straw like meals to high quality flours. Sunflower seed cake or meal can be produced from complete or decorticated seeds and can be mechanically or solvent extracted. The quality of the meal can varies according to the characteristics of the particular plant like as composition of seeds, ration of hulls/kernel, dehulling potential, growth and storage conditions and also the technique of processing as dehulling, mechanical or solvent extraction (Golob *et al.* 2002; NRC, 1973) [11, 26]. Depending on the degree of dehulling and extraction process, the colour variation from grey to black can be seen in the sunflower seedcake as meals with less hulls are lighter.

In decreasing order of abundance, the main amino acids which were found in the sunflower cake are leucine, valine, tyrosine, isoleucine, arginine, threonine, lysine, phenylalanine, methionine and cysteine, histidine and tryptophan. On an average, the Sunflower Seed Meal (SFM) contain, moisture 9.0 percent, dry matter 1.0 percent, crude protein 34.1 percent, crude fibre 12.3 percent, ash 6.6 percent, calcium 0.3 percent and phosphorus 1.3 percent. The edible proteins of this seed cake are good for human consumption (Bamgboye and Adejumo, 2007) [3]. As a functional component in food formulation, the plant proteins are an alternative to animal protein, which are also inexpensive and sustainable. In the aspects of broad availability, the Sunflower seeds are easier to procure especially for the areas where other seeds like soy, cotton seed, rapeseed etc. are rarely produced or not produced as mentioned above in the production data. Various research activities conducted in current years have also mentioned clearly about the potential of sunflower proteins as great value added element for human nutrition.

The sunflower seeds also contain dietary fibres, amino acids, vitamin E, vitamin B (vitamin B1 or thiamine, vitamin B5 or pantothenic acid and folate), and minerals (phosphorus, calcium, potassium, magnesium, zinc, iron, manganese, selenium and copper). These are also rich in cholesterol-lowering phytosterols. There are various options of healthy snacks in which the sunflower seeds are the most common as these can be used as a part of meal and for garnishing. These

are the most common ingredients in many recipes (Science Daily, 2005) [34]. Sunflower meal also contains some beneficial elements like calcium, phosphorus and B vitamins (Grompone, 2005) [13].

There are many uses of oil, extracted from sunflower; for cooking (vegetable oil), for manufacturing of margarine etc. After the extraction of oil, the sunflower seed cake's composition chiefly depends upon the method of extraction and the variety of seeds. In sunflower seed cake the main components are Protein and Crude Fiber. Due to abundance of many amino acids, high bioavailability, sunflower seed cake (SSC) protein is an important source of plant protein (Malik *et al.* 2016) [22]. The sunflower seeds are also beneficial in various therapeutic conditions like lowering the blood sugar, cholesterol and blood pressure levels as they have vitamin E, magnesium, linoleic fatty acids and various plant compounds. Even so, utilization of sunflower seed cake is confined as it is generally used as animal feed or due to lack of attention paid to it so now it has become essential to reach to the new approaches for better applications of sunflower seed cake in foods. Therefore, the aim of this study was to analyse the nutritional composition of sunflower seed cake (SSC) so that much awareness can be spread and further food applications can be developed to utilize this underutilized by-product.

Global scenario of sunflower production

According to the Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India (2003) [7] the total produce of sunflower in Karnataka was accounted for 45.05 percent, Andhra Pradesh for 30.77 percent and Maharashtra for 16.48 percent covering an area of 53.99 percent, 25.77 percent and 17.18 percent respectively throughout the year 2002-2003 in the country.

Food and Agricultural Policy Research Institute (FAPRI) reveals that a dynamic growth of 2.3% per annum is expected in the production and consumption of the world oil cake over the forecast period 2006-15. According to the data given by Food and Agricultural Organisation (FAO), the worldwide annual production (2006-2007) of sunflower oil cake was 29.7 megatons (Sivaramakrishnan *et al.* 2009) [38].

A report by Oil World (2011) [27] stated that the sunflower meal that is a by-product of sunflower seeds after oil extraction is the 4th most important oil meal after soybean meal, rapeseed meal and cotton seed meal. The sunflower meal is available worldwide and the global production was estimated to 21.8.5 million tonnes. Ukraine and Russia are the main producers with an output of 6.3 and 5.1 million tonnes respectively. With an output of 4.8 million tonnes, the European Union (EU-27) is the 3rd producer of sunflower meal (Index Mundi, 2019) [16].

In pursuance of Krishisewa (2013) [19] the major sunflower producing states of India are Andhra Pradesh, Maharashtra, Bihar, Orissa and Tamil Nadu followed by Karnataka with an output of 3.04 lakh tonnes within the area of 7.94 lakh hectares. Gulbarga district of Karnataka is the top most zones for the produce of sunflower for 31,298 tonnes that is 12.45 percent of India's sunflower production. The other top 4 districts are Raichur, Bijapur, Bellary and Bagalkot that accounts for 54.55 percent of it. The India's overall produce of sunflower was estimated to be 251,299 tonnes in 2010 (World Atlas Data, 2010) [48].

In India the sunflower meal is imported from Ukraine and Tanzania at Chennai, Vishakhapatnam and Andhra Pradesh for approximately 1513.077 tonnes, 20599.98 tonnes and

7023.778 tonnes respectively (Seair, 2016) [35].

Among the three most cultivated oil crops, the sunflower (*Helianthus annuus* L.) is grown worldwide. The sunflower meal or cake (by product of the oil extraction process) constitutes up to 36% of the mass of the processed seeds (Yegorov *et al.* 2019) [49].

Nutritional characteristics of sunflower seeds

Miller *et al.* (1986) [23] observed the phosphorus content in sunflower seeds which is mostly occur in the form of Phytic acid that is 1.6 percent in sunflower seeds, 4.3 percent in seed cake and 3.1 percent in protein concentrate.

Blended with wheat or other flours, sunflower seed cake can be used for human consumption. Instead of its dark color, concentrates of sunflower protein (71%) have great digestibility. The sunflower seed cake remained after the oil extraction process, have high values of crude protein 15-45 percent, and ether extract up to 3.5-48 percent (San and Villamide, 2000) [32].

The total phenolic content of sunflower seeds range between 10-42g/kg which shows that sunflower seeds are rich in phenolic components (Leonardis *et al.* 2003) [20]. The sunflower seed cake after the oil extraction had almost similar phenolic antioxidants as present in seeds. But it may differ on the basis of content of hulls in seed cake and the variety of seeds as per region (Weisz *et al.* 2009) [47]. In these phenolic compounds, Chlorogenic and Caffeic acids compose 70 percent of total phenolic components in sunflower flour (Sabir *et al.* 1974) [30].

The nutritional values of whole sunflower cake according to the study "Proximate composition and protein quality evaluation of recipes containing sunflower cake" done by Srilatha and Krishnankumari (2003) [39] were, moisture 5.80 percent, protein 23.60 percent, crude fat 11.01 percent, crude fibre 30.18 percent, ash 5.66 percent and carbohydrate 23.75 percent.

Isik and Izli (2007) [17] stated that the compounds of sunflower based protein fractions cooperate positively as the lipids present in sunflower seeds increase functionally as well. Hence the use of these obtained fractions from sunflower press cake for the food application is hopeful.

On the basis of the type of extraction process, the residues which are obtained in the process of oil extraction are valuable and nutritious by-product as these contain high proteins which range from 40% to 50% of the degreased core of the seeds (Gonzalez *et al.* 2007) [12].

About 64gm of dry roasted sunflower seeds contain 17mg of vitamin E, niacin 4.5gm, pantothenic acid 4.5gm, folic acid 151mcg and pyridoxine 0.5 mg. The mineral content in 128gm of sunflower seed is as iron 4.9 mg, calcium 89.6 mg, magnesium 165mg, phosphorus 1487 mg, potassium 1088mg, zinc 6.8 mg, copper 2.3 mg, manganese 2.7mg, sodium 3.8 mg and selenium 102 mcg.

Gandhi *et al.* (2008) [10] developed method for producing sunflower seed cake with low poly phenols and phytates. The developed seed cake had 58 percent proteins, 0.2 percent phytates and 0.3 percent poly phenols. This sunflower meal is safe for human consumption and for value addition of protein isolation because it does not discolor the proteins.

In various studies, it has been shown that sunflower seed cake has high level of antioxidants that can be further beneficial for technological utilization. Many polyphenols in sunflower such as caffeic, chlorogenic and ferulic acids have shown a high anti-oxidative capacity in several studies. So, the by-

products if sunflower are crucial sources of natural antioxidants and phenolic components (Weisz *et al.* 2009) [47]. A study 'Phenolic and antioxidant potential of Sunflower meal' conducted by Wanjari and Waghmare (2015) [45, 46] also explained that sunflower seed cake is an excellent source of natural antioxidants. The phenolic compounds donate hydrogen atom to lipid radical which are produced during lipid oxidation and that's why it could be added to foods to hinder the production of bad flavors and noxious components which are formed during lipid oxidation. Therefore, the sunflower seed cake is an interesting human food as this has potential of high phenolic antioxidants.

According to a study done by Bhise *et al.* (2015) [4] the defatted sunflower seed cake has a great capability to work as an efficient source of edible protein as it was observed that the functional properties of sunflower seed cake are excellent. It has high fat and water absorbing capacity, foaming capacity and bulk density.

According to Malik *et al.* (2016) [22] the protein in sunflower seed cake (SSC) is very crucial source of plant protein as it has plentiful amino acids, excellent bioavailability with the absence of anti-nutritional properties.

The content of protein in the sunflower by-product is high i.e. 40 to 50%. Essential amino acids (lysine, methionine, cysteine and tryptophan), minerals and B group vitamins are present in the sunflower cake (Yegorov *et al.* 2019) [49].

Therapeutic properties of sunflower seeds

In sunflower flour, the 70 percent of phenolic compounds are Chlorogenic and Caffeic acids (Sabir *et al.* 1974) [30]. These polyphenols have various health boosting factors in which most are connected to the treatment of metabolic diseases, along with several actions like anti-oxidant, anti-inflammatory, antilipidemic, anti-diabetic and antihypertensive. The chlorogenic acids has revealed antimicrobial action counter to ample of organisms such as bacteria, yeasts, molds, viruses and amoebas. Therefore these antimicrobial characteristics can be beneficial for food industry in the search of new and natural components in preserving food products. Along with this, chlorogenic acid also has an antioxidant activity counter to lipids, against the degeneration of bioactive compounds exhibit in food products it has protective properties and also has prebiotic activity. Over all, this revealed that coalition of such properties makes the chlorogenic acid as a splendid component for incorporating it in functional foods and dietary supplements (Galvez *et al.* 2017) [9].

Sukharevich *et al.* (1977) [40] in their research interchange the soybean seed cake and corn-steep liquor with 3-4 percent of SSC that resulted into 30-65 percent increment in the levels of mycoheptin in fermentation broth. The levels of amphotericin also increased 27 percent by the replacement if soybean seed cake and corn-steep liquor with 3 percent of SSC. Thus SSC is a complete value substitute for soybean and corn-steep fermentation culture. Hence, this study shows that SSC can be a potential source for antifungals and antibiotics.

Velioglu *et al.* (1998) [43] found that sunflower seeds contain antioxidant value of 0.153, antioxidant activity of 72.9, oxidation rate ratio 0.271 and coefficient of antioxidant activity as 279.7.

The sunflower seeds contain substantial amount of magnesium that is considered very crucial for maintaining the nerve and muscle tone in body. Magnesium is also predicted to be useful in bronchial asthma, muscle cramps, hypertension

and migraine. Sunflower seeds are also loaded with selenium that is anti-oxidative in nature and found to reduce the danger of prostate cancer (Vogt *et al.* 2003) [44].

It was found by Phillips *et al.* (2005) [28] that sunflower seeds have a high content of Phytosterols i.e. 270-289mg/100gm. These phytosterols are capable of lowering the levels of cholesterol, reduces the risk of colon cancer and helping in boosting the immunity.

Sunflower seeds have anti-inflammatory activity of tocopherols that could prove to have a promising role in chronic inflammatory circumstances such as bronchial asthma, osteoarthritis and rheumatoid arthritis (Singh *et al.* 2005) [37].

According to Awad *et al.* (2007) [2] the sunflower seeds also have abundance of phytosterols that may act as a precautionary factor for breast cancer. They observed that beta-sitosterol, usually generous form of phytosterols, prevent the development of various particular types of tumour cells *in vitro* and also reduced the size and area of tumour progression *in vivo*. The outcome revealed that exposure to beta-sitosterol boosts the adornment in the transformed cell membrane and consequently prevents the growth of tumour cells. So, these observations sustain the assumption that beta-sitosterol is a promoting agent for apoptosis and incorporating more phytosterols in diet can be a defensive factor for breast cancer. One of the studies also reported that the risk allied with postmenopausal breast cancer also decreased by the consumption of sunflower seeds contrast to no consumption (Zaineddin *et al.* 2012) [50].

Gandhi *et al.* (2008) [10] has developed some simple methods for reduction of the polyphenols and phytates from sunflower cake and for evaluating its nutritional profile. In the results, it was shown that the maximum reduction of poly phenols was obtained with aqueous acetone followed by 0.5M HCl treatments. The optimized treatment of sunflower meal was analysed to know the proximate composition of phytates and poly phenols. It was revealed in the results that the sunflower meal has 58 percent (crude protein) and percent (crude fat). The amount of residual poly phenols and phytates were 0.3 percent and 0.2 percent respectively. For making defatted or degreased sunflower meal with low profile of phytates and poly phenols, this process was developed.

A study 'Hypoglycaemic Properties of Aqueous Extracts of *Anacardium occidentale*, *Moringa oleifera*, *Vernonia amygdalina* and *Helianthus annuus*: A comparative study on some biochemical parameters in Diabetic rats' done by Luka *et al.* (2013) [21] stated that the anti-diabetic benefits of sunflower seed extract were found beneficial when induced in normal, glucose loaded hyperglycemic and streptozotocin (STZ) type 2 diabetic rats. The extra dose of 250 and 500 mg/kg also decreased the plasma glucose levels up to 17.78 percent and 24.83 percent respectively in normal rats and 22.03 percent and 27.31 percent respectively in diabetic rats. It was also found that sunflower seeds lowered the plasma glucose level in rats. The induced diabetic rats were found to have improved body weight, liver glycogen content, glycosylated haemoglobin, plasma malondialdehyde, glutathione level and serum insulin level when compared to normal rats.

Methodology

Nutritional analysis of SSC

Proximate composition

Determination of a group of closely associated compounds is

known as its proximate composition. It consists of estimating amount of moisture, protein, fat, ash, fibre, carbohydrate and energy. The proximate composition was estimated by standard procedures.

- (a) **Moisture:** Moisture is a key component of food. It is determined to analyse the chemical composition of food material on moisture free basis as well as to assess the shelf life of the products. The method given by NIN (2003) [25] is used for determining the moisture.

Method: In a dried and weighed petri dish, ten gram sample was weighed. At regular intervals the weight of the sample along with the petri dish was noted unless a constant weight was observed. The percentage of moisture was calculated using following formula:

$$\text{Moisture (g/100g)} = \frac{\text{Initial weight(g)} - \text{Final weight(g)}}{\text{Weight of the sample (g)}} \times 100$$

- (b) **Crude protein:** Estimation of protein content was determined by the nitrogen present in the sample by using the Micro Kjeldahl Method (NIN 2003) [25]. After estimating amount of nitrogen it is multiplied with 6.25 (general factor).

Method: With 0.5g of digestion mixture (98 parts K₂SO₄ + 2 parts CUSO₄) and 2ml concentrated H₂SO₄, 100mg of moisture free sample in triplicate was digested on digestion rack until it became clear. A blank reagent test tube was run simultaneously. Then further it was diluted by adding 10ml of NaOH (40%) to make it alkaline. The ammonia steam released during distillation was accumulated in a conical flask having 2 drops of indicator and 25ml of 4 percent boric acid. The total matter was titrated with 0.1N HCl in a conical flask unless end point of pink colour is obtained. The amount of HCl utilized was noted for titration value and further calculated by the formula mentioned below:

$$\text{Total Nitrogen (g) \%} = \frac{14.01 \times 0.1 \times (\text{titer value} - \text{blank value})}{\text{Weight of the sample (mg)}} \times 100$$

$$\text{Protein \%} = \text{Total Nitrogen \%} \times 6.25 \text{ (general factor)}$$

- (c) **Crude Fat:** The amount of fat was estimated in the form of crude ether extract through improved Soxhlet method by using the SOCS PLUS fat Extraction unit (NIN 2003) [25].

Method: 5gm of moisture free sample was taken in a thimble. The thimble with its holder was placed a flat bottom flask whose empty weight was noted already. Then 80ml of petroleum ether was filled in the flask and further it was loaded in the apparatus. The temperature was set to 100°C and the procedure was left to run for 60 minutes. After this increase the temperature to 200°C that was just double to the initial boiling temperature. For collecting the fat remained in the sample, the sample was rinsed three to four times. The flasks were removed from the apparatus and placed in the oven. When the flasks get cooled the thimble was removed and the weight of flasks with the remaining fat was noted down and future the fat was calculated by using the formula mentioned below:

$$\text{Fat (g/100g)} = \frac{\text{Weight of flask with extracted fat(g)} - \text{Weight of empty flask(g)}}{\text{Weight of sample (mg)}} \times 100$$

(d) **Ash:** The inorganic residue left after burning of any organic matter is known as the ash content of any food material. Determination of total ash by done method given by NIN (2003) [25].

Method: 5gm of moisture free sample was weighed in a previously heated, cooled and weighed crucible. Sample was then completely charred on the hot plate, followed by heating in a muffle furnace at 600°C for 3-5 hours. The crucible was then cooled in a desiccator and weighed. The process was repeated till constant weight is obtained and the ash obtained was almost white or greyish in colour. Ash content of samples was calculated using the following formula:

$$\text{Ash} \left(\frac{\text{g}}{100\text{g}} \right) = \frac{\text{Weight of ash (g)}}{\text{Weight of sample taken (g)}} \times 100$$

(e) **Crude fibre:** The fibre content was determined by the method of acid alkali digestion. Fibre is an insoluble matter of food that is indigestible by the diastatic and proteolytic enzymes and can't be utilized other than microbial fermentation. Fibre is generally composed of lignin, cellulose and hemicellulose (NIN, 2003) [25].

Method: For estimating the crude fibre content, 5gm of fat and moisture free sample was taken in a beaker and 200ml of H₂SO₄ (1.25%) was added into the beaker. Further distilled water was added at frequent intervals to keep the volume constant. Boiled for 30 minutes and then filtered through whatman paper 54. The residue was washed with hot water unless it became free from acid. The residue was then transferred to the beaker again, added with 200ml of NaOH (1.25%) and boiled again for 30 minutes by keeping the volume constant with distilled water. The residue was again filtered with whatman paper 54, washed with hot water and then with alcohol and ether also. Then the residue was transferred in the crucible and weighed along with residue (W₁). The crucible was then placed in the oven for drying the residue at 130°C for 2-3 hours. When got cooled, the crucible was weighed (W₂). After that the crucible was heated in the muffle furnace at 600°C for 2-3 hours and after getting cooled down it was weighed again (W₃). Crude fibre was calculated by the formula mentioned below:

$$\text{Crude fibre\%} = \frac{(W_2 - W_1) - (W_3 - W_1)}{\text{Weight of sample}} \times 100$$

Where, W₁ = Weight of empty crucible

W₂ = Weight of crucible with dry residue

W₃ = Weight of crucible with heated residue

(f) **Carbohydrate:** The carbohydrate was calculated by subtracting the sum of moisture, crude protein, crude fibre, ash and fat from 100 (NIN, 2003) [25]. The formula mentioned below was used for determining carbohydrate:

$$\text{Carbohydrate (g/100g)} = 100 - (\text{moisture} + \text{crude fibre} + \text{ash} + \text{crude protein} + \text{fat})$$

(g) **Energy:** The energy value of the samples was estimated by using physiological fuel values of protein, fat and

carbohydrate i.e. 4, 9, 4 kcal per gram respectively (NIN, 2003) [25]. The calculation was done as mentioned in the formula below:

$$\text{Energy (kcal/100g)} = (\% \text{ protein} \times 4) + (\% \text{ carbohydrates} \times 4) + (\% \text{ fat} \times 9)$$

Mineral estimation

Preparation of mineral solutions

The mineral solutions of the chosen samples were prepared via method of wet ashing compiled by Jain and Mogra (2006) [18]. A mixture of acids was added with the plant material that digested it and made a clear white precipitate. Further it was then dissolved in water for making up to definite volume. For the estimation of the selected minerals, an aliquot from this was used.

Wet ashing

One gram moisture free sample was taken in a digestion tube and 5ml concentrated HNO₃ was mixed into it and was left overnight. Further it was heated slowly for 30 minutes and cooled. Then 5ml perchloric acid was added and heated over digestion rack until the particles got completely digested and a clear solution was obtained. After digestion, using double distilled water the volume of digested matter was made up to 100ml.

a) **Iron:** The iron content of the sunflower seed cake was estimated by using Atomic Absorption Spectrophotometer Bishnoi and Brar, (1988) [5].

Method: The diluted sample was drawn up in the atomizer burner assembly through a capillary and by the means of a stream of compressed air; it converted into a fine spray. After condensation of large droplets, it was mixed with acetylene and burnt in a long flame from the hallow cathode lamp. A monochromatic wave entered, that had been set at a wavelength of the element to be determined and fell on the photo multiplier tube (photo cell). The light radiation converted into electrical energy by that tube, which was then measured by galvanometer.

$$\text{Fe (ppm)} = \frac{\text{ppm Fe (from calibration curve)} \times \text{Vol.}}{\text{Weight of dry plant (g)}}$$

Where, Vol. = Total volume of the plant digest (ml)

Convert the ppm into mg/g dividing by 0.001.

b) **Calcium:** The calcium content was determined by the titrimetric method given by Cheng and Bray (1951) [6]. Ethylene diamine tetra acetic acid (EDTA) solution (0.01N) was prepared and standardized against standard calcium chloride (0.01N) solution.

Method: 5ml of digested sample was taken in triplicates in conical flasks. Then 1ml of 4N NaOH and 50mg ammonium purpurate indicator were added to the mineral solution. The titration of the sample with 0.01N EDTA solution was done. At the end point the colour change from orange red to lavender purple indicated the readings. Calcium content was calculated by the formula mentioned below:

$$\text{Ca (mg/100g)} = \frac{V_{\text{EDTA}} \times N_{\text{EDTA}} \times 20 \times 100}{\text{Weight of Sample (g)}}$$

Where, V = Volume of EDTA

N = Normality of EDTA

c) Phosphorus: In acidic medium, the orthophosphorus of the ash solutions reacts with ammonium molybdate and forms phosphor-molybdic acid solution. This compound was reduced by amino-naphthol sulphonic acid reagent that gives intense blue colour and measured by the colorimeter.

Method: The phosphorus content was estimated by pipetting out 0.4, 0.8, 1.2, 1.6 and 2ml of working solution in volumetric flask of 25ml and 0.5ml of mineral solution was taken in another volumetric flask. Later, 1ml of perchloric acid (70%), 1ml of ammonium molybdate and 0.5ml of amino naphthol sulphonic acid reagents was added in each volumetric flask and for blank flask 1ml of distilled water was used. All the flasks were shaken well and left for 10minutes and made volume up to 25ml. The intensity of colour was read at 720nm. A standard curve was prepared and concentration of the test samples was estimated (Jain and Mogra, 2006) [18].

$$\text{Phosphorus (mg/100gm)} = \frac{a \times V1 \times 100}{1000 \times V2 \times W}$$

Where, a = Concentration of phosphorus in sample aliquot obtained from graph (mg/ml)

V1 = Total volume of a mineral solution made

V2 = Volume of mineral solution used for analysis

W = Weight of sample taken (g).

Anti-nutrient profile: Due to presence of anti-nutritional factors the nutrient quality and digestibility of plant nutrients is affected. Therefore, presence of these anti nutritional factors was analysed in the sunflower seed cake.

a) Phytic acid: Phytate is a hexa phosphate of inositol that is widely present in the plant seeds. Phytic acid is the main storage form of phosphorus, consisting 1 to 5 percent in weight in legumes, cereals, nuts shells and oilseeds. The estimation of phytic acid content was done by following the method compile by Jain and Mogra (2006) [18].

Method: 10g of finely ground sample was taken in a conical flask, added with 50ml with hydrochloric acid and shaken in a shaker for 3hours and filtered. The filtrate was reduced to 25ml over a water bath. After that the filtrate is neutralized by adding the sodium hydroxide as required. 10ml of ferric chloride (0.01%) solution was added later on and it was heated over the water bath for 15 minutes. When cooled to the room temperature, a pre-weighed filter paper was folded like a funnel and placed on a glass funnel over the conical flask from which the filtrate was filtered. Then it was washed with ethanol and ether. The filter paper was then dried in the oven and weighed. To calculate the amount of phytic acid the formula is mentioned below:

$$\text{Phylin phosphorus (mg/100g)} = \frac{\text{Weight of dried precipitate}}{\text{Weight of dried precipitate}} \times 100$$

Statistical analysis of data

The data was statistically analysed as per the objectives of the study. The data was analysed using the Microsoft Excel programme of Windows 2010.

▪ The nutrient composition of the sunflower seed cake was expressed as mean \pm S.D.

- Mean (\bar{X}) : $\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$
Where X = Observation
n = Number of Observation
i = 1, 2, 3 n
- Standard deviation (SD):

$$\text{SD } (\sigma) = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$$

Where X = Observation

\bar{X} = Mean of observation

Results and Discussion

Nutritional analysis of SSC

The nutritional analysis is the process that determines the information about the nutritional content of food by laboratory evaluation and standard methods. Hence, for the results the data was analysed statistically under following heads:

Proximate composition

The data in table 4.1 states the proximate composition in the form of mean values and standard deviation. The content of moisture was found to be 9.23 percent. The crude protein was analysed for 37.10 percent. The amount of crude fat, ash and crude fibre valued for 0.69, 7.49 and 21.50 percent respectively. The remaining amount for carbohydrate energy was calculated as 23.97 percent and 250.56 kcal per 100g respectively.

Rodriguez *et al.* (1998) found the chemical composition of full fat hulled sunflower seeds as moisture 3.32g, protein 21.23g, fat 45.71g, ash 2.6g, fibre 13.4g and carbohydrate 13.74g per 100g.

Srilatha and Krishnankumari (2003) [39] in their research showed that the whole sunflower seed cake contained 5.80 percent moisture, 23.60 percent protein, 11.01 percent fat, 30.18 percent fibre, 5.66 per ash and 23.75 percent of carbohydrate.

The study conducted by Anjum *et al.* (2012) [1] concluded that the dry roasted sunflower seeds have 18.75g of protein, 10.93g of fibre and 578.12 kcal of energy per 100g.

The findings of Srivastava and Verma (2014) stated that the proximate composition of 100g sunflower seed flour was valued for 3.1g moisture, 19.69g of protein, 4.48g ash, 53g of fat, 18.72g of carbohydrate and 630.64 kcal of energy.

According to the study done by Heuze *et al.* (2019) [15] the nutritional content of sunflower seed cake was found to be protein 37.7 percent, fibre 22.8 percent, ash 7.7 percent, fat 0.48 percent, and carbohydrate 31.32 percent. The energy was 280.4 kcal per 100g.

Table 1: Proximate composition of sunflower seed cake (Mean ± S.D.)

Nutrient	Sunflower seed cake (100g)
Moisture	9.23 ± 0.20
Crude Protein	37.10 ± 0.52
Fat	0.69 ± 0.31
Ash	7.49 ± 0.45
Crude fibre	21.50 ± 0.43
Carbohydrate	23.97 ± 0.92
Energy (kcal)	250.56 ± 1.95

The above mentioned values are (Mean ± S.D.) of three observations.

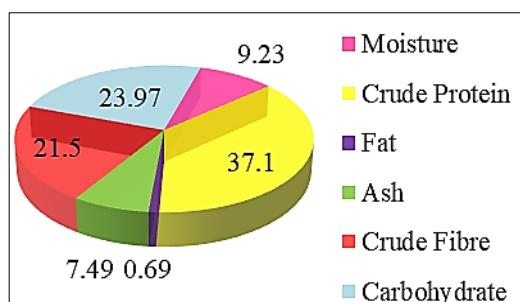


Fig 1: Proximate composition of sunflower seed cake (g/100g)

Mineral estimation

The table 4.2 concludes the data on mineral content of sunflower seed cake. The analysed results describe that the iron content was 6.44 (mg/100g), calcium was 650 (mg/100g) and the phosphorus content was 711.33(mg/100g).

According to Ratcliff (1977) the mineral profile of sunflower seed cake for calcium, phosphorus and iron was estimated to be 480mg, 840mg and 10mg per 100g respectively.

As per USDA (2008) the sunflower seeds contained 78mg/100g calcium, 5.25mg/100g iron and 660mg/100g of phosphorus content

The study done by Srivastava and Verma (2014) stated that the 100g of sunflower seed flour had 277mg calcium, 667.66mg phosphorus and 4.9mg of iron content.

Heuze *et al.* (2019) [15] in their study emphasised that the seed cake of sunflower comprised of 440mg/100g calcium, 1160mg/100g phosphorus and 2.53mg/100 iron content.

Table 2: Mineral profile of sunflower seed cake (Mean ± S.D.)

Minerals	Sunflower seed cake (mg/100g)
Iron	6.44 ± 2.30
Calcium	650 ± 382.23
Phosphorus	711.33 ± 439.75

The above mentioned values are (Mean ± S.D.) of three observations.

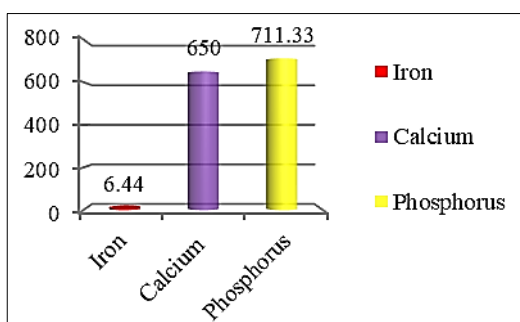


Fig 2: Mineral profile of sunflower seed cake (mg/100g)

Anti-nutrient profile

The anti-nutrients are those compounds that hinder the function of absorption of various essential nutrients.

Phytic acid

The phytic acid is generally present in the seeds, legumes and grains that is present in depository form of phosphorus. In present study, the phytic acid content of sunflower seed cake was found to be 700mg/100g.

In the research conducted by Eklund (1975) the total Phytate phosphorus of protein concentrate of sunflower seed was found to be 52 percent and in the lipid protein concentrate of sunflower seed the phytic acid was found to be 880mg/100g.

As per the investigation conducted by Miller *et al.* (2003) the pressed cake of sunflower had 4300 mg/100g of phytic acid.

Gandhi *et al.* (2008) [10] developed a process to reduce the phytates of protein isolate of sunflower seed cake and found that the phytic acid of sunflower seed cake after processing was 200mg/100g.

Summary and Conclusion

Our nature has provided us a vast variety of food and one of the major sources for food availability are the plants, including their stems, leaves, flowers, roots, fruits, seeds and vegetables. In human nutrition, plant based foods are very essential as they promote good health and our mother nature also provide us impeccable crate of such vegetation which make our body to bloom, gleam and repair thoroughly. Among all the vegetation, seeds are one of the beneficial supplies for our body and health as these are loaded with numerous nutrients and beneficial oils. The residual part or by product left after the extraction of oil from the seeds, is known as Seedcake (SC). The various oil seed cakes like soya bean seed cakes, rapeseed cake, sunflower seed cake and cotton seed cake are rich in proteins, antioxidants, fibres, vitamins and minerals. Amid above mentioned seed cakes, one popular seedcake is the Sunflower seedcake (SSC). Over the years this seed cake have been used as animal feed, organic fertilizer and soil compost but from past years, considering the nutritional potential of sunflower seedcake as it still remains with multifarious nutrients, various researches are being conducted for its human consumption.

Therefore, the present study “Nutritional Quality of Sunflower Seed Cake (SSC)” was conducted to evaluate nutritional quality of sunflower seed cake (SSC).

The SSC was found to have 9.23 percent moisture, 37.10 percent crude protein, 0.69 percent crude fat, 7.49 percent ash, 21.50 percent crude fibre, 23.97 percent carbohydrate and 250.56 kcal energy per 100g. In continuation the mineral content was analysed as iron 6.44 (mg/100g), calcium 650 (mg/100g) and phosphorus was 711.33(mg/100g). The phytic acid is generally present in the seeds, legumes and grains that is present in depository form of phosphorus. In present study, the phytic acid content of sunflower seed cake was found to

be 700mg/100g.

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