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Quality evaluation of moringa (*Moringa oleifera*) seed and defatted cake

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Abstract
The moringa seeds are gaining interest due to its medicinal and nutrient-rich profile. The objective of this study was to explore the quality evaluation of moringa seed and its defatted cake. The proximate analysis was carried out using the methods suggested by the various authors. The moringa has been found to have a protein content of 32.66%, carbohydrates of 14.43%, fat content of 36.12%, fiber content of 68.5% and ash content of 4.79%. The defatted moringa seed cake, a by-product of extracting oil from moringa seeds, exhibits a compelling nutritional profile. The seed cake obtained after the extraction of oil from the moringa seeds was also analyzed for the for its nutritional compassion. The defatted moringa seed cake had found to have moisture content of 4.99%, protein content of 51.28%, carbohydrate of 25.70%, fat content of 0.45%, fiber content of 10.56% and ash content of 6.50%. The defatted seed cake found to have the highest content of protein due to the large amount of oil has been removed from the seed; therefore, it can be further utilized to fortify other edible food items.

Keywords: Moringa seed, defatted cake, oil cake, oil residue, quality analysis

1. Introduction

Moringa oleifera, a deciduous tropical plant belonging to the *Moringaceae* family, is commonly found and cultivated throughout the tropical reasons of the world. This plant displays an annual leaf-shedding pattern in response to seasonal changes and possesses a lightweight wooden compared to other tree varieties. The cultivation of the moringa tree is widespread throughout tropical and subtropical regions, encompassing thirteen distinct species worldwide. Its natural habitat primarily lies in South Asia, where it thrives along the Himalayan foothills and covers the lower areas of Himalayan. Additionally, the moringa tree has a wide distribution range, stretching from northeastern Pakistan to northwestern India. Some research has demonstrated the various nutritional and medicinal properties in almost every part of the moringa tree, including its leaves, fruits, barks, gums, and roots. Among these components, the leaves particularly stand out as a valuable source of essential nutrients and medicinal attributes. Hence, they are widely recognized and acclaimed by researchers for their extensive nutritional and mineral content (Paliwal *et al*., 2011) [8].

The moringa seed are produced worldwide for commercial as well as for domestic purpose which includes India, Ethiopia, Kenya, Tanzania, and the Philippines, among others. India with the maximum production stand as foremost global producer, yields an impressive 2.2 million tonnes of pods yearly, cultivating them across a vast area of 43,600 hectares which is equivalent to 51 tonnes per hector of pods. In India, it is worth noting that Andhra Pradesh leads in both area and production, encompassing 15,665 hectares, followed by Tamil Nadu (13,042 hectares) and Karnataka (10,280 hectares). In the remaining states, moringa occupies a collective area of 4,613 hectares (APEDA, 2018).

The moringa trees are seasonal in terms of fruit-bearing and tree comes to flowering within 5-6 months of sowing and comes to harvest in 7-8 months. The pods attain edible maturity 65 days after flowering. The peak harvest may be reach during the month of March–August if the sowing of moringa seed performed in the month of June-September. Usually, the length of moringa pods are ranged 25-75 cm long with 4-10 cm circumferential length. The weight of matured moringa pods are ranged as 70-180 g and largely depends on stage of maturity and variety of tree. According to a survey, the genetically improved PKM-1 variety have the ability to develop fruits after four months of transplanting and can yield an impressive 50-55 tons of pods per hectare, which is equivalent to 220 pods per tree per year. In general, the fresh and matured moringa pods are consumed during various traditional food preparation over the year as per availability. In general, it has been seen that the moringa pods harvested at proper maturity stage are used for different purposes. The optimum maturity stage of moringa pods could be reached at 7-8 month after date of sowing. The harvesting of moringa pods at earlier stage or under mature pods significantly reduces the yield. In contrast to this beyond the maturity stage the moringa pods dry and seed entraps into hard cell seed coat. Usually, the early and over matured moringa pods are not preferred during various food preparation. The over matured and hard moringa seed contains oil in significant range depends on the variety and region.

The moringa fruit grows in the form of elongated pods and bears a similar resemblance to large capsules. The size of the fruit may vary between 18 and 50 cm in length and diameter may vary from 1 to 3 cm. Morphologically, the surface of the moringa pods exhibits the development of numerous separate 5-10 ribs. As the fruits reach maturity, they undergo a transformation from green to a pale brown color, with the solidification of both the flesh (known as pulp) and the seeds. Within a fully matured moringa fruit, multiple seeds are formed, typically taking on a globular or slightly triangular shape. The matured moringa seed possesses three wings that are papery in nature and bears a dark brown or blackish colour. The fresh and matured moringa pods may be prepared and consumed similarly to green beans as a nutritious diet. Its seeds can be used as a natural coagulant in water treatment (Okuda and Ali, 2018).

The chemical analysis of the moringa seed and defatted cake is important because it provides essential information about the composition and properties of materials, which is vital in various industries for quality control, product development, regulatory compliance, and environmental management. It helps stakeholders make informed decisions and ensures that products and processes are safe, efficient, and meet quality standards.

In the present experiment, exploration of quality its significance has been carried out. our objective is to clarify the makeup of the sample under scrutiny and provide the obtained data which can be valuable and can be used in a wide range of applications, including food production, environmental management, product development and safety assurance.

2. Material and Methods

Fig 1: Whole moringa seeds

Fig 2: Moringa seed kernels

Dry and matured moringa seeds of PKM-1 variety were procured from the local market of Raipur (C.G). The mature moringa seeds were cleaned to remove foreign materials such as stones, leaves, broken seeds, etc. The defatted moringa seed cake is a byproduct obtained after extracting oil from moringa seeds was also analyzed and compared with the moringa seeds. The chemical analysis of defatted moringa seed cake typically involves determining its composition in terms of various nutrients by proximate and antioxidant analysis

Fig 3: Moringa seed defatted cake

2.1 Quality analysis of moringa seed and defatted cake

The quality inspection is an essential process employed in diverse domains such as food science, agriculture, environmental science, and industrial processes. It consists of determining the essential chemical elements of a substance, typically based on its weight in a dry state. The primary elements examined in proximate analysis are the following: fixed carbon, volatile matter, moisture content, ash content, and frequently, crude fiber in food analysis. Chemical analysis of the samples was carried out using the standard Methods of Analysis of the Association of Official Analytical Chemists and Argungu *et al.*, 2022 [5]. The parameters analyzed and the methods used are as below;

2.1.1 Determination of moisture content

The empty petri dish (W_1) was weighed and 5 g of the sample was taken and weighed again (W_2). The sample was dried in an oven drier, at 105 °C for 24h. After that the sample with petri dish was allowed to cool in a desiccator. The dried sample with petri dish (W_3) was weighed again. (Argungu *et al.*, 2022) [5]. The moisture was then calculated using the following formula as shown in Equation 1;

$$\text{Moisture content}(\%) = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad \text{Eq. (1)}$$

2.1.2 Determination of ash content

An empty crucible was weighed (W_1) and 5 g of sample was added to the crucible and weighed again (W_2). The sample was placed in a muffle furnace at 500 °C – 600 °C for 3h and allowed to cool in a desiccator. The weight of the crucible and dry sample (W_3) was then taken again (Argungu *et al.*, 2022) [5]. The ash content was calculated using the equation 2.

$$\text{Ash content}(\%) = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad \text{Eq. (2)}$$

2.1.3 Determination of fat content

The fat content of the sample was determined by the solvent extraction technique using a soxhlet apparatus. 20 g of pulverized sample were placed in the thimble of the soxhlet extractor. Extraction was carried out for 6 hour or till the deposition of colorless solvent in the extraction chamber. At the end, vacuum rotary evaporator was used to recover the solvent from the oil-solvent mixture followed by oven drying (60 ℃, 1 h) for residual solvent removal. The fat content of moringa seed and defatted cake was calculated according to following equation.

$$\text{Fat content }(\%) = \frac{W_1 - W_2}{W_2} \times 100 \qquad \text{Eq. (3)}$$

Where,
W1 = Weight before extraction
W2 = Weight after extraction

2.1.4 Determination of crude fiber content

Crude fiber is loss on ignition of dried residue remaining after digestion of sample with 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH solutions under specific conditions. Method is applicable to materials from which the fat can be and is extracted to obtain a workable residue, including grains, meals, flours, feeds, fibrous materials, and pet foods.

The crude fiber content was determined by using the FibroTRON apparatus. The equation 4 has been used to calculate the fiber content of the sample,

$$\text{Fibre content}(\%) = \frac{W_2 - W_1}{\text{Weight of Sample}} \times 100 \qquad \text{Eq. (4)}$$

Where,
W_1= weight of sample after drying
W_2 = Weight of sample after ashing

2.1.5 Determination of crude protein content

The estimation of crude protein involves the estimation of total nitrogen usually by the Kjeldahl procedure. The percentage of crude protein was obtained by multiplying the nitrogen content with a factor of 6.25 (Argungu *et al*, 2022) [5].

$$\text{Kjeldahl Nitrogen }(\%) = \frac{(V_s - V_b) \times N \times 14.01}{W \times 10} \qquad \text{Eq. (5)}$$

$$\text{Crude Protein }(\%) = \text{Kjeldahl Nitrogen }(\%) \times 6.25 \quad \text{Eq. (6)}$$

Where,
VS = volume (mL) of standardized acid used to titrate a test;
Vb = volume (mL) of standardized acid used to titrate reagent blank;
N = Normality of standard HCl;
14.01 = atomic weight of N;
W = weight (g) of test portion;
10 = factor to convert mg/g to percent; and
F = factor to convert N to protein. i.e. 6.25

2.1.6 Determination of total carbohydrate content

Carbohydrates are the important components of storage and structural materials in the plants. They exist as free sugars and polysaccharides. The determination of the carbohydrate content involved subtracting the combined quantities of moisture, crude fiber, protein, oil, and ash from a total of one hundred.

$$\text{Total carbohydrates }(\%) = [100 - (\text{moisture content} + \text{oil content} + \text{ash content} + \text{protein content} + \text{fiber content})] \text{ Eq. 7}$$

3. Result and Discussion

3.1 Chemical Properties of Moringa Seed

The moringa seed are known for its various medicinal and nutritional uses. The proximate composition of seeds plays an important role for deciding and evaluating nutritional and functional qualities of end products. Moringa seeds are used in various applications. The proximate composition of moringa seed kernels is presented in Table 1.

3.1.1 Determination of moisture content

The moisture content of moringa seed kernels were found to be 5.19% (wb). The values of moisture content of moringa seed were observed to be close to the values reported by Abiodun *et al.* (2012) [1] as 4.70%. Moreover, the moisture content of the seeds may vary according to the temperature, humidity and storage conditions.

3.1.2 Determination of ash content

Ash is one of the components in the proximate analysis of biological materials, consisting mainly of salty, inorganic constituents like calcium, phosphorus, iron and zinc etc. In the current study, the ash content of moringa seed kernels was determined to be 4.79%. Previous research by Anwar *et al.* (2005) [3] found the ash content in moringa seed to range from 5.90% to 7.00%. Similarly, Adegbe *et al.* (2016) [2] reported the ash content in moringa seed as 5.00%.

3.1.3 Determination of fat content

The fat content of moringa seed oil was determined using the soxhlet apparatus. The maximum fat content of moringa seed was found to be 36.12% using the hexane as the solvent. The obtained fat content values are consistent with those reported in previous studies (Rahman *et al.*, 2009) [9] obtain an oil yield of 37.50% using hexane solvent. The small variation that was noticed could be due to variations in sample origin or differences in environmental conditions.

3.1.4 Determination of fiber content

The crude fiber content describes the plant cell wall components (including cellulose, hemicellulose, lignin), which are usually not or barely digestible, and thus the portion of the feed that is not energetically usable by the animals. The crude fibre content found in moringa seed kernel was recorded as 6.85% (Table 1). Anwar *et al.* (2005) [3] have previously reported that the crude fiber content in moringa seed ranges from 6.52 to 7.50%.

3.1.5 Determination of protein content
Protein is a crucial nutrient that plays a vital role in repairing and building body tissues, making it an essential component of a healthy diet. The present investigation revealed that moringa seed kernels has protein content of 32.66% (Table 1). Similarly, Barakat and Ghazal (2016) [6] reported a protein content of 35.54% in moringa seed. Also, Adegbe *et al*. (2016) [2] reported a protein content of 39.57% in moringa seed flour.

3.1.6 Determination of total carbohydrate content
The analysis of the nutritional content of moringa seeds revealed a significant amount of total carbohydrates. The total carbohydrates in the moringa seed kernel was found to be 14.43%. This indicates that moringa seeds could be a good source of energy due to their carbohydrate content. Barakat *et al*. (2016) [6] reported that the raw moringa seed contained 20% carbohydrate. The variation observed may be due to the growth conditions of the moringa tree and plant variety. However, the results are not significantly different from previous studies.

Table 1: Proximate composition of moringa seed kernels

S.N.	Parameters	Value
1	Moisture content (%)	5.19
2	Ash content (%)	4.79
3	Fat content (%)	36.12
4	Protein content (%)	32.66
5	Fiber content (%)	6.85
6	Total carbohydrates (%)	14.43

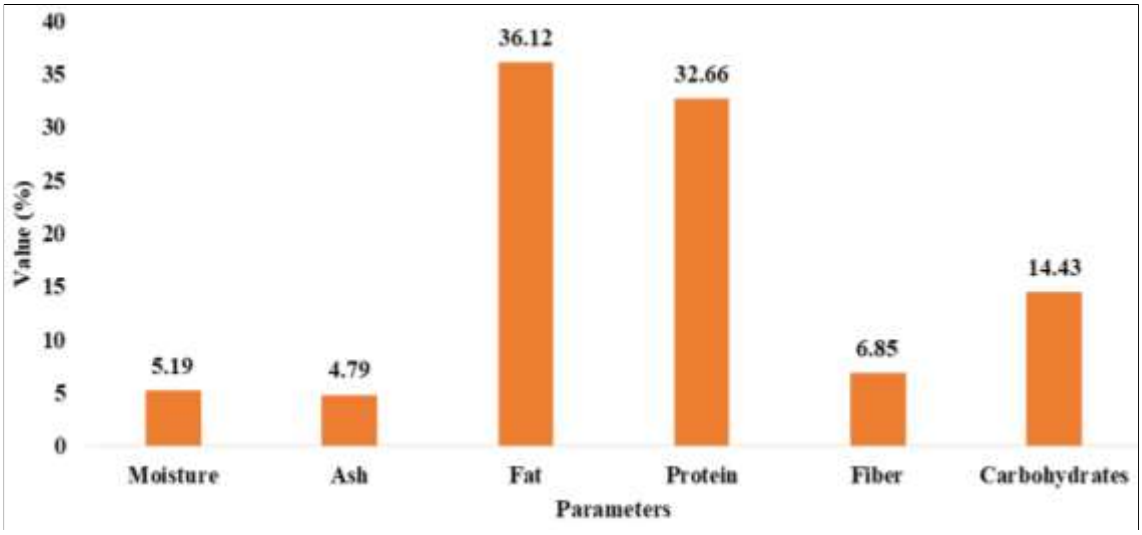

Fig 4: Proximate composition of moringa seed kernel

3.2 Chemical Properties of Defatted Moringa Seed Cake
3.2.1 Determination of moisture content
The moisture content of moringa seed cake that has been defatted has been found to be at 4.99% as shown in Table 2. The moisture content of the defatted moringa cake can be differ from the study to study and greatly depends on the oil extraction techniques used for defatting the cake. Similarly, in a study conducted by Abiodun *et al.* (2012) [1], found that defatted moringa seed flour contained 5.03% moisture content.

3.2.2 Determination of ash content
The ash content of defatted cake was found as 6.50% (Table 2). Ash contained of defatted cake obtained by Abiodun *et al.* (2012) [1] was 10%. The defatted cake has slightly higher ash content this may be possible due to the concentration of the minerals and inorganic material in the defatted cake after the removal of oil.

3.2.3 Determination of fat content
The defatted moringa seed flour contained negligible amount of fat content, which is about 0.45%. The fat content in the defatted cake mainly depends on the efficiency of the oil extraction technique used for defatting the moringa seed kernels. This shows that the fat content in the defatted cake may vary from study to study. Abiodun *et al.* (2012) [1] reported that the defatted cake contains a higher fat content of about 3.06%, which is higher than the mentioned study.

3.2.4 Determination of fiber content
As per the findings, the defatted moringa seed flour exhibited a crude fibre content of 10.56%. The results of the analysis are similar to the study of other researchers. The results shoes that the crude fiber content in the defatted cake slightly increased by some percentage. According to Abiodun *et al.* (2012) [1], the crude fibre content in defatted moringa seed cake flour was 12.96%.

3.2.5 Determination of protein content
Protein content in defatted moringa seed flour was found to be 51.28% (Table 2). Abiodun *et al*. (2012) [1] determined the highest protein content in defatted moringa seed flour as 50.80%. After the extraction of oil from the moringa seed kernels, the concentration of protein in the defatted cake increases drastically. This might be due to the reduction in oil content. Argungu *et al.* (2022) [4] also reported that the defatted moringa seed cake had 53.23% protein.

3.2.6 Determination of total carbohydrate content
The findings of our study indicate that the defatted moringa seed flour possesses a carbohydrate content of 25.70% (Table 2). The total carbohydrates in the defatted cake has

drastically increased carbohydrates by the 10.27%. This indicate that the moringa seed defatted cake had additional carbohydrates in the same quantity of the sample. Similarly, Govardhan *et al.* (2002) [11] founded that the defatted moringa seed cake had the 30.42% of total carbohydrates.

Table 2: Proximate composition of defatted moringa seed cake

S. N.	Parameters	Values
1	Moisture content (%)	4.99
2	Ash content (%)	6.50
3	Fat content (%)	0.45
4	Protein content (%)	51.28
5	Fiber content (%)	10.56
6	Total carbohydrates (%)	25.70

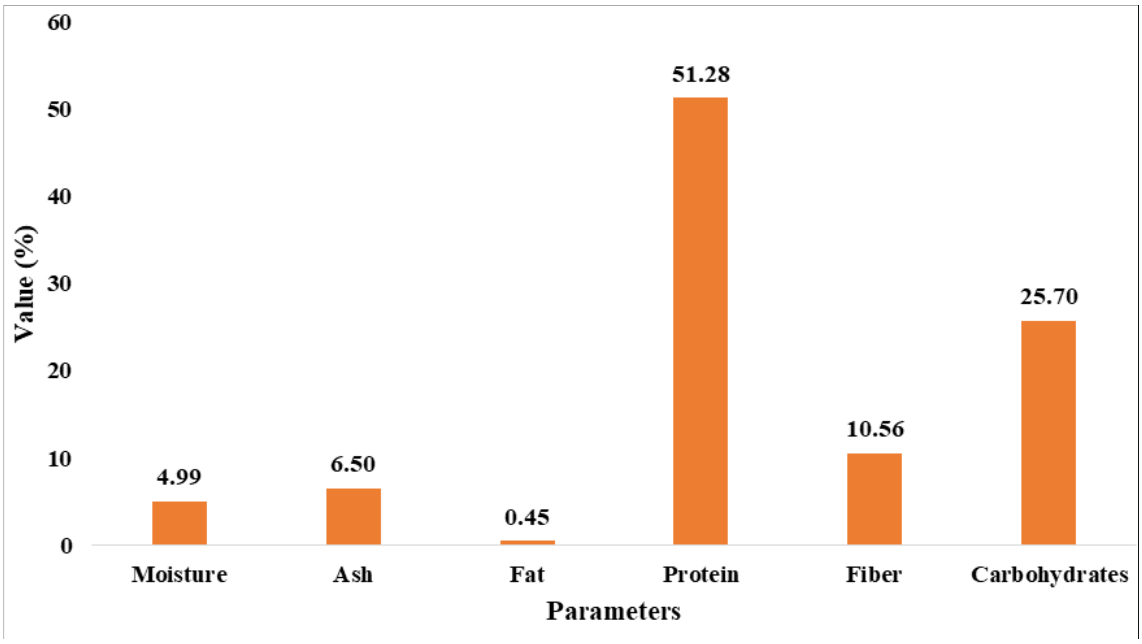

Fig 5: Proximate composition of defatted moringa seed cake

4. Conclusion

The removal of the majority of fats, the cake becomes a concentrated source of plant-based nutrients. There is an increase in the nutritional composition of defatted cake in terms of ash, fiber, protein and carbohydrate due to reduction of the fat from moringa seeds. The protein content of defatted cake increases as much double as the seed constituent. These results underscore the versatility and nutritional value of moringa seeds and their byproducts, offering a potential avenue for food and feed applications. Further exploration of these findings could lead to valuable applications in the food and agriculture industries.

Moringa seeds and their extracted cake exhibit high amount of protein, showing a valuable source of protein as vital macronutrient. The presence of a substantial amount of fat of 36.12% in the seed kernel suggests that it may hold immense potential for utilization in the extraction of oil. The increased protein content of the defatted moringa seed may emerge as the natural plant-based protein source as a highly promising constituent in the formulation of both food and feed. These findings convey the valuable insights into the respective applications of moringa seeds and its by-products across a large no of industries.

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