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Studies on physical, chemical and mineral evaluation of oats (*Avena sativa*)

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Abstract

The present investigation was carried out to study the physical, chemical and mineral composition of rolled oats. The analysis of the physical properties of oats showed that the average 1000 Kernel weight was 30.89 gms. Bulk density of oats was found to be 0.419 gm/cm³ whereas true density was 1.19 gm/cm³. Porosity of rolled oats was recorded to be 64.45 per cent, whereas Angle of repose was 46.4° for oats. The results of the chemical analysis showed that the content of moisture in the oats was 4.206%, ash content was about 1.97 per cent, total carbohydrates ranged about 55.75 per cent, the crude protein content was 12.62 per cent, crude fat content was 6.91 per cent and the total fiber content was around 13.65 per cent. The concentration of calcium was recorded to be 60.13mg/100g, oat was observed to have 474.06mg/100g of phosphorus, whereas 115mg/100g of magnesium and 9.23mg/100g of iron was found in oats. The potassium content was observed to be 337mg/100g.

Keywords: Oats, physical properties, proximate composition, minerals

Introduction

Oat remains an important cereal crop in the developing world and the most popularly cultivated species is *Avena sativa* L. And is trivially known as common covered white oat (White 1995) [25].

Oat is predominantly grown in American and European countries, mainly Russia, Canada and United States of America. It is used mostly for animal feeding and to some extent as human food. The use of oat as animal feed has declined steadily owing to emerging use and interest in oats as human health food (Ahmad *et al.*, 2010) [5].

The oats belongs to the family of *Poaceae*. Oats are generally regarded as a minor cereal crop when considered in terms of grain produced annually, or areas sown for production. Traditionally, most of the crop has been used as animal feed (Wani *et al.*, 2014) [24].

Oats have been linked to the health claims attributed to the use of β -glucans 6, 7 and are valuable sources of β -glucans. Oat has recently attracted its research and commercial attention mainly due to its high nutritional value. Oats is a good source of antioxidant vitamin E, phytic acid, phenolic acid and avenantramides. Oat is well accepted in human nutrition and it is an excellent source of different β -glucan, arabinoxylans and cellulose. It contains relatively high levels of protein, lipids (unsaturated fatty acids), vitamins, antioxidants, phenolic compounds and minerals (Wani *et al.*, 2014) [24].

Processing of Oats

Oats are processed in order to produce oat based food products with health-beneficial properties.

- 1. Milling:** Prior to processing of oats into products, the oats are dehulled and groats are subsequently separated and decontaminated. Oat milling is performed to get good quality appearance and taste. The milling operations consist of cleaning, grading, hulling, 'hull, fine and groat separation' and kilning (Zwer 2004) [26].
- 2. Pearling:** Pearling technology, also referred to as debranning and pre-processing, was originally used for polishing of rice and wheat. Application of pearling technology to oat facilitates separation of β -glucan-rich fractions from pericarp, aleurone and sub aleurone layers of oat (Wang *et al.*, 2007) [23].
- 3. Flaking:** Oat groats are mainly flaked. Flaking process involves various unit operations such as cleaning, heat treatment, dehulling, cutting and flaking (or milling). Owing to high amount of lipases, the lipids may be prone to hydrolysis leading to rancidity in the flaked oats. Thus oats for food purpose are heat treated in order to deactivate the enzymes responsible for changes in oat lipids. Steamed oats develop characteristic oat flavour and

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steaming also results in deactivation of enzymes including lipases. In a study, flaking of intact oat groat produced rolled oats of 0.5–0.8 mm thickness. After flaking, the rolled oats were cooled with air to about 45 °C and the product had a moisture content of about 9–11.5% (Deane and Commers 1986)^[7].

- 4. Heat processing:** A typical heat processing operation of oats includes kiln drying and steam stabilization, while superheated steam processing and microwave heating are recent methods used for processing of oats (Prasad Rasane *et al.*, 2013)^[17].

Health benefits of oats

Oats are excellent sources of different dietary fibre components of mixed-linkage (1→3), (1→4)-β-D-glucan arabinoxylans and cellulose (Skendi *et al.*, 2003). The neutral cell wall of polysaccharide β-glucan has outstanding functional and nutritional properties. It achieves high viscosities at relatively low concentrations and is of particular importance in human nutrition (Mallkki *et al.*, 2001).

Oat consumption in human diet has been increased because of health benefits associated with dietary fibres such as β-glucan, functional protein, lipid and starch components and phytochemicals present in the oat grain (Prasad Rasane *et al.*, 2013)^[17].

Oat has a well-balanced nutritional composition. It is a good source of carbohydrates and quality protein with good amino acid balance. Oat contains high percentage of oat lipids especially unsaturated fatty acid, minerals, vitamins and phytochemicals (Head *et al.*, 2010)^[10].

Materials and methods

Rolled oats of the company 'True Elements' was purchased from the market. The proposed research was carried out in Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani.

Measurement of physical properties Thousand grain weight

Thousand grain weight was determined by randomly selecting 100 grains from the overall sample, measuring their weight on a digital electronic balance, and multiplying by 10 to get the mass of 1000 grains. The procedure was done three times.

Bulk density

5 g of sound grains will be weighed on the digital weighing balance and filled into the measuring cylinder earlier filled with reference solution of kerosene or toluene. The increase in the level of liquid will be measured after adding the grains. It is bulk density represented in g/ml (Dutta *et al.*, 1998)^[8].

$$\text{Bulk Density } (\rho_b) = \frac{\text{Weight of grains}}{\text{Volume of grains}}$$

True density

25 g of grains will be filled into the measuring cylinder and volume occupied by them will be measured. It will be then calculated by following formula and represented in g/ml.

$$\text{True Density } (\rho_t) = \frac{\text{Weight of grains}}{\text{Volume occupied}}$$

Angle of repose

The frictional property such as angle of repose (θ) was calculated from the height and diameter of the naturally

formed heap of the food grains on a circular plate as method described by Singh *et al.*, (2013)^[20]

$$\text{Angle of repose } (\theta) = \tan^{-1} \{h/r\}$$

Where, h = Height of heap

r = Radius of base of heap

Porosity (ϵ)

The porosity (ϵ) of the bulk grain was defined as the fractions of the space in the bulk grain that is not occupied by the grain. The porosity, ϵ was calculated using formula

$$\epsilon = \frac{(1 - \rho_b) \times 100}{\rho_t}$$

Where, ρ_b and ρ_t are the bulk and true density, respectively in kg/m^3

Proximate composition of oats

Different chemical properties of samples were analysed i.e. moisture content, ash, fat, protein, total dietary fiber and total carbohydrate. All the determinations were done in triplicate and the results were expressed as the average value.

Moisture content

Moisture content was determined adopting AOAC (2005)^[4] method as following:

$$\% \text{ Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Ash

Drying the sample at 100°C and charred over an electric heater. It was then ash in muffle furnace at 550 °C for 5 hrs as mentioned by AOAC (2005)^[4]. It was calculated using the following formula:

$$\% \text{ Ash content} = \frac{\text{AW}}{\text{IW}} \times 100$$

Where, AW = Weight of Ash and IW = Initial weight of dry matter

Fat

AOAC (2005)^[4] method using Soxhlet apparatus was used to determine crude fat content of the sample. The percent of crude fat was expressed as follows:

$$\% \text{ Crude Fat} = \frac{\text{Weight of dried ether soluble material}}{\text{Weight of sample}} \times 100$$

Protein

Protein content was determined using AOAC (2005)^[4] method. Percentage of nitrogen and protein calculated by the following equation:

$$\% \text{ Nitrogen} = \frac{\text{TS} - \text{TB} \times \text{Normality of acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Where, Ts = Titer volume of the sample (ml), TB = Titer volume of Blank (ml), 0.014 = M eq. wt. of N₂.

$$\% \text{ Protein} = \text{Nitrogen} \times 6.25$$

Total carbohydrate

Total carbohydrate content of the samples was determined as total carbohydrate by difference that is by subtracting the measured protein, fat, ash and moisture from 100 phenol sulphuric acid method as given by AOAC (2005) [4].

Total dietary fiber

Dietary fiber concentration i.e. Total dietary fiber was determined according to (Sungsoo L. *et al.*, 1992) [22].

Mineral composition of oats

Minerals like calcium, magnesium, potassium, zinc, copper, sodium and iron were determined by using titration and spectrophotometric method (Atomic Absorption Spectrophotometer).

Mineral solution preparation

The ash obtained was moistened with glass distilled water (0.5-1 ml) and concentrated HCl was added and evaporated to dryness on a boiling water bath. Again 5 ml concentrated HCl was added and evaporated to dryness as before. Lastly 4 ml of HCl and 5 ml of distilled water were added.

This solution was warmed over a boiling water bath and filtered into the 100 ml volumetric flask using Whatman no.4 filter paper. After cooling the volume was made to 100 ml using distilled water and suitable aliquote was used for the estimation of calcium and iron.

A) Determination of Calcium

Reagents

- 1) Ammonium oxalate
- 2) Conc. ammonia solution (25% v/v)
- 3) Methyl red indicator
- 4) Sulphuric acid (2N)
- 5) N/100 KMNO₄ solution

25 ml mineral solution was diluted to 150 ml with distilled water and neutralized with ammonia solution using methyl red as indicator till pink colour changes to yellow. Further the solution was boiled and 10 ml of 6 per cent ammonium oxalate was added. This mixture was boiled for few minutes and added with conc. glacial acetic acid (99.5 per cent) till the colour was distinctly pink. The mixture was kept aside in warm place (overnight) and when precipitate settled down, the supernatant was tested with a drop of ammonium oxalate to ensure the completion of precipitation. The contents were filtered through Whatman no.4 filter paper and given washings of warm distilled water. The precipitate was transferred to a beaker by making a hole in the centre of filter paper and by giving washings of sulphuric acid (2N, 5ml) twice. Then the solution was heated to 70 °C and titrated against N/100 KMNO₄. Simultaneously a blank was also run. The results were expressed as mg calcium/100g sample (Ranganna, 1986) [19].

$$\text{Formula: } 1\text{ml of } 0.01\text{N KMnO}_4 = 0.2004\text{mg Calcium}$$

B) Determination of iron

Iron content was determined by a-a, dipyrindyl method described in AOAC (2005) [4]. The intensity of the colour developed was read in spectronic 20 at 510 nm. Iron content of the digested sample solution was read from the standard curve of known concentration of iron.

Preparation of standard curve

Pipette 0.0, 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 ml of Fe standard solution into a series of 25 ml volumetric flasks and add to each of them exactly 0.2 ml of conc. HCl. Dilute each of them to exactly 10 ml with water, and then add reagents in the same way as for the sample. Plot the quantity of Fe (in mg) against the absorbance (I.C.M.R, 1990) [11].

Iron content of sample (mg Fe / 100 g sample) =

$$= \frac{\text{Quantity of Fe in aliquot of ash solution (from calibration curve)}}{\text{Aliquot of ash solution taken for determination}} \times \frac{\text{Total volume of ash solution}}{\text{Wt. of the sample taken for ashing}} \times 100$$

C) Determination of magnesium

Magnesium was estimated by colorimetric method given in Ranganna, 1986 [19].

D) Determination of potassium

It was determined by using flame photometric technique as given in Ranganna, 1986 [19].

$$\% \text{ Potassium} = \text{Reading (ppm)} \times \frac{\text{Volume of digest}}{\text{Weight of sample}} \times \frac{100}{1000000}$$

Results and discussion

Physical properties of oats

The analysis of the physical properties of oats showed that the average 1000 Kernel weight was 30.89 gms. Bulk density of oats was found to be 0.419 gm/cm³ whereas true density was 1.19 gm/cm³. Porosity of rolled oats was recorded to be 64.45 per cent, whereas Angle of repose was 46.4° for oats. The values are given in Table 1.

Table 1: Physical properties of oats

Physical Parameters	Observations
1000 Kernel weight (gms)	30.89
Bulk density (gm/cm ³)	0.419
True density (gm/cm ³)	1.19
Porosity (%)	64.45
Angle of repose	46.4°

*Each value represents the average of three determinations

Chemical properties of oats

Data pertaining to various chemical properties like moisture, fat, carbohydrates, protein, ash, and crude fiber were investigated and results obtained are depicted in Table 2.

Table 2: Chemical composition of Oats

Chemical Parameters	Observations
Moisture (%)	4.20
Ash (%)	1.97
Total carbohydrates (%)	55.75
Crude Protein (%)	12.62
Crude Fat (%)	6.91
Total fiber (%)	13.65

*Each value represents the average of three determinations

The grain has been analyzed for the various constituents like moisture, protein, carbohydrates, fat, ash etc. According to Table 2, the results of the analysis showed that the content of moisture in the oats was 4.206%, ash content was about 1.97 per cent, total carbohydrates ranged about 55.75 per cent, the

crude protein content was 12.62 per cent, crude fat content was 6.91 per cent and the total fiber content was around 13.65 per cent.

Mineral composition of oats

The results given with respect to various minerals such as Ca, K, P, Mg and Fe were determined and accordingly results presented in Table 3.

Table 3: Mineral composition of Oats

Minerals	Observations (mg/100g)
Calcium	60.13
Phosphorus	474.06
Magnesium	115
Iron	9.23
Potassium	337

The data regarding calcium, phosphorus, magnesium, iron and potassium content of oats is depicted in Table 3. The concentration of calcium was recorded to be 60.13mg/100g, oat was observed to have 474.06mg/100g of phosphorus, whereas 115mg/100g of magnesium and 9.23mg/100g of iron was found in oats. The potassium content was observed to be 337mg/100g.

Conclusion

Overall it can be concluded that the importance of studying physical properties are considered as the basic data in designing the machinery and equipment used during the harvesting and in the post harvesting operations. Importance of these properties is in determining the size of the machines particularly that of the separation, transfer, and sorting equipment. By evaluating the chemical properties and mineral composition of oats it can be concluded that oats is highly nutritious and healthy grain and can find its use in many food products.

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