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Physico-chemical characteristics and cooking quality of *Kodra* (*Eleusine coracana* L.) millet of Himachal Pradesh

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The present study was carried out in the department of Food Science, Nutrition and Technology, CSK Himachal Pradesh Agricultural University, Palampur with the objective to explore the physico-chemical characteristics and cooking quality of *Kodra* (*Eleusine coracana* L.). The samples of *Kodra* grains used in the present investigation were procured from local farmers of district Sirmaur of Himachal Pradesh. *Kodra* grains were assessed for nutritional composition and cooking quality. Results of the study showed that *Kodra* grains were found to contain valuable nutrients. The physical characteristics revealed the mean length and width of *Kodra* grain as 1.43 and 1.40 mm, respectively. The average moisture content of *Kodra* was recorded as 8.52 per cent. Expressed on dry matter basis the value for average ash content was 3.48 per cent and fat content was 3.53 per cent. *Kodra* was high in protein and also rich in mineral content.

Key Words : Kodra (*Eleusine coracana* L.), Physical characteristics, Cooking quality, Proximate composition

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INTRODUCTION

Kodra (*Eleusine coracana* L.) also known as ragi or *mandal* is consumed without dehulling. Interesting crop characteristics of *Kodra* is the ability to withstand cultivation at altitudes over 2000 m above sea level, its favorable micronutrient contents (high iron and calcium content), its high drought tolerance, and the long storage time of the grains. *Kodra* contains less fat and more calcium then other millets. It is richer in essential amino acids than wheat. Its protein quality (EAAI) is higher than other millets, maize, wheat, ray, barley and oat. *Kodra* is considered as a helpful famine crop for the reason that it is stored for lean years (Kalinova and Moudry, 2006 and FAO, 2012). Depending upon the species and agro-climatic conditions, the proximate composition varies. The fibre content of millet is higher than major cereals like wheat and rice. It is gluten-free and therefore can be an excellent option for those who are suffering from gluten allergy and bowel disease.

Kodra plant is utilized as a folk medicine for the treatment of liver disease, measles, pleurisy, pneumonia and small pox. Traditionally in hill areas of Himachal

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Pradesh, it is recommended for pregnant and nursing mothers, children and elderly. This is largely consumed as traditional preparations by applying different processing techniques. Sprouted grains of *Kodra* are recommended for infants and elderly people. The commercial importance and market value of these crops are now less known to the general public, although they are quite important from the point of sustainable agriculture and food security (FAO, 1995 and 2017). Unlike other major cereals, millets have not been exploited to their full potential. Processing the not-so-popular millets into nutritious ready-to-eat food products would increase their consumption by improving their market value.

Farmers in Himachal Pradesh now cultivate *Kodra* only for their own consumption or as fodder to the animals and only for preserving the tradition crops. It is grown only in the interior and remote areas of Himachal Pradesh. *Kodra* is losing its importance/popularity in the local food culture although it is rich in nutrient. Its consumption at rural level is also decreasing. Keeping in view the importance of this millet the study was undertaken with the objectives to evaluate physico-chemical characteristics and cooking quality of *Kodra*.

METHODOLOGY

Kodra (*Eleusine coracana* L.) grains were collected from the region of Sirmaur, Himachal Pradesh, India which were cleaned manually for removing adhering dirt, dust and foreign particles.

To study the physical characteristics and cooking quality the grains were kept in as airtight food grade polyethylene terephthalate container at low temperature (4– 7^{0}C) until further examination. To study the functional properties and proximate composition the samples were ground to a fine powder with the help of mixer grinder and stored in airtight food grade polyethylene terephthalate containers at 4– 7^{0}C until further analysis.

Physical characteristics:

The colour determinations were carried out by using a reflectance colorimeter KONICA MINOLTA, Chroma-Meter CR-400. The shape of the millet grains were observed from their physical appearance through visual perception. For weight determination thousand *Kodra* grains in triplicate were selected randomly and weighed in an electrical weighing balance. The size of 10 grains in triplicate was measured in terms of length (L), width (W) and thickness (T) with the help of Vernier Caliper. The bulk density was measured according to the method given by Narain *et al.* (1978). The true density was measured by toluene displacement method, in which 1000 grains in triplicate were weighed and put in graduated cylinder containing a known amount of toluene and rise in toluene level was noted. The ratio of the weight of grains to the volume displaced toluene gave the true density. Porosity was analyzed by using the relationship of bulk density and true density.

$$\textbf{Porosity} = \frac{\textbf{True density} - \textbf{Bulk density}}{\textbf{True density}} \textbf{ x 100}$$

Dimensional properties:

Geometric mean diameter and Arithmetic mean diameter was calculated based on the measured dimensions *i.e.* length (L), width (W) and thickness (T) of *Kodra* samples (Ramashia *et al.,* 2018). Dispersibility, sphericity, aspect ratio, surface area and sample volume of *Kodra* grains were calculated as per the method used by Ramashia *et al.* (2018).

Cooking quality:

For estimating optimum Cooking time distilled water was brought to boil in 500 ml spout less beakers fitted with bulb condenser to prevent loss of water during cooking. 20 g of seeds of millet was added to them. Boiling was continued, and samples (4–5 seeds) were withdrawn using a spatula at 5 min intervals upto 30 min and thereafter after every 2 min and tested for softness by pressing between finger and thumb. The time from addition of seeds till achievement of the desirable softness was recorded as the cooking time. The cumulative length and width of 10 seeds were measured after cooking for minimum cooking time. Cooked length–breadth ratio of the 10 cooked seeds was determined by dividing the cumulative length to the cumulative breadth of cooked seeds. Water uptake ratio was determined according to the method of Hamid *et al.* (2016). Gruel solid loss, hydration capacity and hydration index of seeds was determined by the method of Wani *et al.* (2017).

Chemical composition:

Proximate constituent's *viz*., Moisture, ash, crude fat and crude fibre contents in the samples were determined by standard methods of AOAC (2010). Nitrogen was analyzed by Micro-kjeldhal (AOAC, 2010) and was multiplied by factor 5.83 for converting it into crude protein. Energy in the samples was determined by chromic oxide method of O'Shea and Maguire (1962). Amino Acids were determined by the method of Dadwal *et al.* (2018).

Determination of minerals:

One gram finely ground sample was taken in 150 ml conical flask. To this 25 ml of di-acid mixture (HNO_3: $HClO_4$ in 5:1 v/v) was added and kept overnight. Digestion was done next day by heating samples till clear white precipitates settle down at the bottom. The crystals were dissolved by diluting in double distilled water. The contents were filtered through Whatman filter paper No. 42. The filtrate was made to 100 ml with double distilled water and used for determination of zinc and iron by using atomic absorption spectrophotometer, Model 3100, Perkin Elmer. Calcium was determined with the help of flame photometer, Mediflame, 127. Phosphorus was estimated by the method of Chen *et al.* (1956).

Statistical analyses:

The experiments were carried out in triplicate and the data so obtained were subjected to analysis of variance (ANOVA) using statistical package OPSTAT (Sheoran *et al.,* 1998). The obtained data were interpreted at 5 per cent level of significance ($P \leq 0.05$).

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physical characteristics of *Kodra* (*Eleusine coracana*):

Kodra grains were dark brown in colour (Plate 1) with spherical shape. Colour values of *Kodra* grains are given in Table 1 and the values were expressed as Chromatic components, L*, a* and b*. L* values correspond to lightness/darkness and extends from 0 (black) to 100 (white) with higher values corresponds to more lightness. a* and b* values corresponds to sample's color dimensions, with a* values describing sample's red (+a) to greenness (-a), while b* values describe the sample's yellow (+b) to blueness (-b). Larger a* values indicate more redness and larger the b* values indicate more yellowness. *Kodra* showed low L value (63.26 ± 0.51) which indicates its darker colour. One thousand *Kodra* grains were weighed and the results revealed that the weight of *Kodra* grains was 2.45± 0.06 g, similar studies have been conducted by Shobana and Malleshi (2007). Bulk density, true density and porosity of *Kodra* are shown in Table 1. As is clear from the data, the bulk density and true density of *Kodra* was observed as 0.62± 0.01 g/ml and 1.37 ± 0.10 g/ml, respectively. Some researchers have reported comparatively higher bulk density and true density of *Kodra i.e.* 0.70 ± 0.01 g/ml and 1515.6 – 1613.4 kg/m^3, respectively (Nazni and Shobana, 2016 and Ramashia *et al.*, 2018). The difference in reported and observed values might be attributed to the difference in variety and growing conditions. Porosity is defined as the volume fraction of the air or the void fraction in the sample and it depends upon the shape dimension and roughness of the grain surface. Porosity of *Kodra* grains was found to be 57.35 ± 3.10 per cent.

Table 1 : Physical properties of *Kodra* (*Eleusine coracana* L.)

Parameters			
Shape		Spherical	
Colour		Dark brown	
L* - 63.26 ± 0.51	a* - 1.93 ± 0.09	b* - 11.22 ± 0.19	
Weight (g per 1000 grains)		2.45 ± 0.06	
Bulk density (g/ml)	0.62 ± 0.01	Geometric mean diameter (mm)	1.38 ± 0.04
True density (g/ml)	1.37 ± 0.10	Arithmetic mean diameter (mm)	1.39 ± 0.04
Porosity (%)	57.35 ± 3.10	Sphericity (%)	96.97 ± 3.88
Length (mm)	1.43 ± 0.90	Aspect ratio (%)	98.16 ± 7.70
Width (mm)	1.40 ± 0.05	Surface area (%)	5.86 ± 0.35
Thickness (mm)	1.33 ± 0.42	Sample volume (mm^3)	1.33 ± 0.12
Length – width ratio	1.02 ± 0.07	Dispersibility (%)	86.33 ± 5.57

Dimensional properties of *Kodra* (*Eleusine coracana*):

Dimensional properties of *Kodra* are presented in Table 1. As clear from the data that the average length, width, thickness and length-width ratio of *Kodra* was 1.43 ± 0.90 mm, 1.4 ± 0.05 mm,1.33 ± 0.42 mm and 1.02± 0.07, respectively. Geometric mean Diameter (mm) and Arithmetic mean diameter (mm) of *Kodra* were found to be 1.38 ± 0.04 and 1.39 ± 0.04, respectively. The determination of dispensability of *Kodra* was observed as 86.33 ± 5.57 per cent. However, sample volume and surface area of *Kodra* was observed as 1.33 ± 0.12 and 5.86 ± 0.35 per cent, respectively. Aspect ratio and sphericity were found to be 98.16 ± 7.70 and 96.97 ± 3.88 per cent, respectively. The results of present investigation are in accordance with Ramashia *et al.* (2018) who reported the average length, width, thickness, sample volume, surface area and sphericity of finger millet cultivars were as 1.41 – 1.67 mm, 1.28 – 1.47 mm, 1.22 – 1.35 mm, 0.83 – 1.07 mm^3, 5.73 – 6.97 mm^2, and 73.75 to 92.43 per cent, respectively.

Cooking quality of *Kodra* (*Eleusine coracana* L.):

Data with respect to optimum cooking time (OCT) and gruel solid loss of *Kodra* is given in Table 2. As clear from the data, the millet cooked to soft edible texture in 30 min as indicated by maximum spreadability of grains when pressed between two glass slides and gruel solid loss after cooking was 1.03 ± 0.06 per cent. Dharamraj *et al.* (2012) reported the less cooking time (min) and higher solid loss of finger millet *i.e.* 6.0 ± 1.0 and 3.7 ± 0.07, respectively. The more time taken by *Kodra* to cook might be due to the difference in hardness of seed. Data in Table 2 shows the water uptake ratio and cooked length-width ratio of *Kodra* were 2.31 ± 0.01 and 1.15 ± 0.02, respectively. Water uptake ratio is the ratio of cooked grain to its original weight. The water uptake by a grain is largely influenced by the surface area as well as its protein and carbohydrate content. The increase in the length – width ratio after cooking might be due to the absorption of water, because during cooking, the grains swell and absorb water. The Hydration capacity and hydration index of *Kodra* seed was found to be 1.30 g/ 1000 seed and 31.40 ± 1.43 per cent, respectively. Hydration capacity and hydration index of *Kodra* seed have been reported as 2.39± 0.01 and 99.7±0.51, respectively by Nazni and Bhuvaneswari (2015). Hydration capacity determines the extent to which seeds absorb water on soaking and it depends upon chemical composition of seed coat and cotyledons. The difference in the reported and observed values could be attributed to the difference in the chemical composition of the seed coat and cotyledons (Wani *et al.,* 2017).

Table 2 : Cooking quality of *Kodra* (*Eleusine coracana* L.)

Parameters	Mean ± SD
Cooking time (min)	30.00 ± 0.00
Gruel solid loss (%)	1.03 ± 0.06
Cooked length–width ratio	1.15 ± 0.02
Water uptake ratio	2.31 ± 0.01
Hydration capacity (g/1000 Seed)	1.30 ± 0.00
Hydration index (%)	31.40 ± 1.43

Proximate composition:

Proximate composition is an important parameter for getting the information about the nutritional and biochemical quality of food. Major components of food item like moisture, crude fat, crude fibre, crude protein and ash content are included in the proximate composition. Data in Table 3 reveals the moisture content of *Kodra*. The moisture and ash content of *Kodra* was found to be 9.55 ± 0.41 and 2.77 ± 0.05 per cent, respectively. Gull *et al.* (2015) investigated the chemical composition of finger millet flour and reported the moisture content as 12.06 ± 0.4 per cent and ash content as 2.20 ± 0.12 per cent. The difference in moisture content might have been due to the varietal differences and agro-climatic conditions under which the *Kodra* was grown. The fat content in *Kodra* was 1.39 ± 0.23 per cent. The present results are in agreement with Mathanghi and Sudha (2012) who reported 1 – 2 per cent fat content in finger millet (*Eleusine coracana* L.).

As evident from data, *Kodra* contained 9.08 ± 0.24 per cent crude protein and 4.67 ± 0.19 per cent crude fibre content. Thippeswamy *et al.* (2016) reported the protein and fibre content of finger millet flour as 6.12 ± 0.15 and 11.95 ± 0.99 g/100g, respectively. In the present study the higher crude protein content and variation in fibre content might have been due to cultivar variation, agroclimatic conditions under which the *Kodra* was grown and the processing of seeds. In the present study dehulled *Kodra* seeds were analyzed. As is clear from the data that total carbohydrate content of *Kodra* was 72.52 ± 0.25 per cent. Dharmaraj *et al.* (2012) reported

Table 3 : Proximate composition of *Kodra* (*Eleusine coracana* L.)

Parameters	Mean ± SD
Moisture (%)	8.52 ± 0.04
Ash (%)	3.48 ± 0.07
Crude fat (%)	3.53 ± 0.12
Crude protein (%)	12.76 ± 0.47
Crude fibre (%)	5.44± 0.34
Total carbohydrate (%)	66.26 ± 0.17
Energy (Kcal/100g)	281.33 ± 4.65

the carbohydrates (%) of decorticated finger millet as 72.97 ± 0.1 per cent. The present results were found in agreement with the results of Dharmaraj *et al.* (2012).

Amino acids composition and Mineral content:

As is clear from the Fig. 1 *Kodra* contained only four essential amino acids in the detectable limit *i.e.* threonine (27.89µg/mg), lysine (3.71 µg/mg), leucine (12.69 µg/mg) and Norvaline (13.14 µg/mg). It also contained semi essential and non essential amino acids *i.e.* serine (5.27µg/mg), arginine (27.23µg/mg), glutamine (20.34µg/mg), proline (14.17µg/mg) and tyrosine (12.07µg/mg). Almost similar results heve been reported by Katake *et al.* (2016) who reported the lysine content in finger millet genotypes to be in the range of 2.21-4.39 mg per 16 g N.

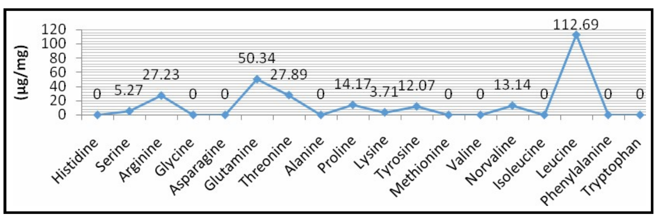

Fig. 1 : Amino acids composition of *Kodra* (*Eleusine coracana* L.)

Mineral composition of *Kodra* is given in Fig. 2. As is clear from the data that calcium, iron, zinc and phosphorus, phytate phosphorus and non- phytate phosphorus content in *Kodra* were estimated as 294.78 ± 2.77, 2.43 ± 0.05, 1.96 ± 0.11, 217.54 ± 2.64, 25.26 ± 0.14 and 192.26 ± 0.31 mg/100g, respectively. Desai *et al.* (2010) reported higher values of calcium, iron and phosphorus content of finger millet *i.e.* 359.4, 13.7 and 284.3 mg/100g, respectively. The difference in the reported values may attribute to the difference in growing conditions and in varieties.

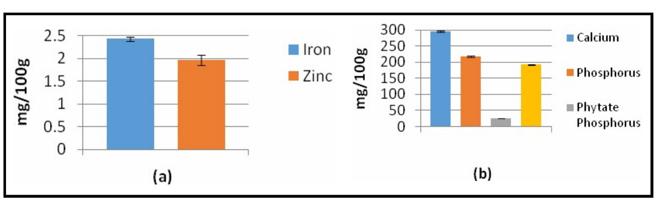

Fig. 2 : Iron and zinc content (a) calcium, phosphorus, phytate phosphorus and non – phytate phosphorus content (b) in *Kodra* (*Eleusine coracana* L.). The values are mean ± SD (n = 3)

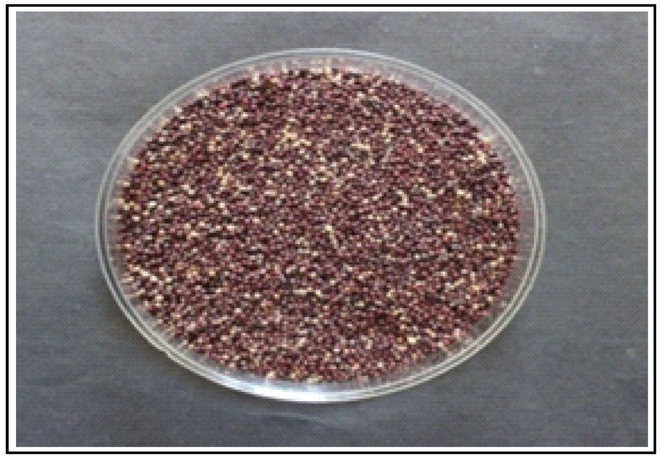

Plate 1 : Physical appearance of *Kodra* (*Eleusine coracana* L.)

Conclusion:

From the present study it can be concluded that *Kodra* grain is a rich source of proteins, minerals thus, can serve an important role in the diet due to their various health improving benefits. *Kodra* grains showed good cooking quality. Therefore, processed *Kodra* could be utilized for developing high quality value added products. Now-a-days millets are considered as forgotten foods. *Kodra* is one of such millets. Development of value added products from the *Kodra* can enhance its post-harvest utilization at household level as well as commercial products. This may be helpful in encouraging their production, which will generate more income to the growers.

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