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Studies on development of process for preparation of sorghum flakes (Poha)

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Abstract

In present investigation entitled “Studies on Development of process for preparation of Sorghum Flakes (Poha)” sincere efforts were made to exploit the use of sorghum through development of sorghum flakes which could be further used for development of various snacks.

High yielding variety Parbhani Moti which is generally grown in local area was selected for study. Physico-chemical properties of this variety were evaluated. As, Parbhani Moti was found Pearly white and the shape of Parbhani Moti was round and bold hence it was a preferred variety for sorghum flakes preparation as flakes require bold grain.

After studying the physiochemical properties of grains and effect of moisture content of grains on the physical and chemical properties of sorghum flakes it was concluded that from various samples C4 is the most preferred sample, it had 6.03% moisture content, 1.06% fat, 8.52% protein, 80.31% carbohydrate, 2.12% crude fibre and 1.26% ash content. The present investigation can be concluded with note that for preparation of flakes from sorghum grains promising results were obtained when conditioned grains with 35% moisture content were used.

Keywords: Sorghum, Parbhani Moti, sorghum flakes, conditioning

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] popularly called as jowar, is the “king of millets” and is the fifth in importance among the world’s cereals after wheat, rice, maize and barley (Anglani, 1998; Awika and Rooney, 2004) [1, 2, 11, 17, 25].

Sorghum is the primary food crop of rural people of Karnataka and Maharashtra states. It is grown both in rainy and post rainy seasons. In India sorghum millet or jowar is grown in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Gujarat and Tamil Nadu. Jowar is rich in carbohydrate and B-complex vitamins. It is poor in Vitamin A and rich in dietary fibre (Nazni and Pradhepa, 2010) [3]. Indian sorghum grain found to contains 11.9 per cent moisture, 10.4per cent protein, 1.9per cent fat, 1.6 per cent fibre, 72.6 per cent carbohydrates and 1.6 per cent minerals. The major minerals present in the grain are calcium, magnesium, potassium and iron (Shakuntala and Shadaksharaswamy, 2001) [4]. Sorghum with easier-to-digest proteins had been identified and improved protein digestibility was observed. Kaffirins, or prolamins, and glutelins comprise the major protein fractions in sorghum (Weaver *et al.*, 1998 and Duodu *et al.*, 2002) [5, 6].

A number of people have celiac disease (CD) which is defined as an inflammatory response in the small intestinal mucosa exacerbated by prolamins in the cereal grains i.e. wheat (gluten), rye (secalin), and barley (hordein) (Poole *et al.*, 2006) [7]. As a result, there is a great interest in development of gluten free products. Part of this interest gets involved with the replacement of wheat flour with sorghum flour (Goldstein and Underhill, 2001) [8]. Sorghum is often recommended as a safe food for celiac patients, which do not tolerate protein sequences contained in both the gliadins and glutenins of wheat gluten (Kasarda *et al.*, 2001) [9]. Thus, sorghum has the potential to replace wheat flour for those allergic to gluten (Weiser and Koehler, 2008) [10].

Food use of sorghum with the wide variety of products are traditionally consumed in semi-arid tropics. Most of these products are prepared from dehulled whole or cracked grain or ground flour. Dehulling and grinding of sorghum is still done manually in each individual household. Use of refined and semi refined flours with pretreatment like malting, precooking, flaking, and

puffing of sorghum grain or grits has been recommended for improving sorghum products and for diversified food uses (Pushpamma and Sally 1981) ^[11].

Sorghum provides a good basis for gluten-free products and other baked products like cakes and cookies (biscuits) and in snacks and pasta and sorghum is recommended as safe for celiac patients. Therefore, the future promise of sorghum in the developed world is for wheat substitution for people with celiac disease or allergies to gluten (Bogue and Sorenson, 2008) ^[12].

Sorghum grains are consumed in different forms, namely unleavened bread, dumpling (mudde) and boiled rice (annam/bana) like products. Popped sorghum is a very popular, traditional snack food in central India. Popped sorghum had been well utilized during festival times, like Nagarpanchami. The use of malted sorghum flour in supplemented foods for children has been well established (Gopaladas, 1992). Chapati or Roti prepared from a blend of sorghum-green gram are also consumed (Sankarapandian, 2000) ^[13].

Materials and Method

Materials

The present study was designed to standardize the procedure for preparation of sorghum flakes. The investigation was conducted in Department of Food Trade and Business Management, of College of Food Technology, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani.

Sorghum grains

Sorghum (*Sorghum bicolor* L.) variety viz. Parbhani Moti was procured from Sorghum Research Station, VNMKV, Parbhani. The grains were carefully cleaned. The samples were packed in high density polyethylene and stored at room temperature until use. Three replicates of each sample were used for analysis.

Packaging materials

High Density Sealable Polyethylene bags for containment and safe storage of products, was procured from local market of Parbhani.

Equipments

Sorghum Flaking (Poha mill) Machine, different analytical equipment were made available from Pilot plant, laboratories of College of Food Technology, VNMKV, Parbhani.

Chemicals

Analytical grade chemicals required for analysis were made available from different Departments and Niche Area Lab, of College of Food Technology, VNMKV, Parbhani.

Method

Product development

Standardization of flaking method

A series of experiments were conducted using sorghum grain to optimize the process conditions for the preparation of flakes.

Cleaning of grain

Sorghum grains were sorted manually to remove broken kernels and foreign material and cleaned.

Soaking of grains

Sorghum grains were soaked in water to obtained moisture content from 20% to 40%. Moisture content of grains was

determined at different soaking periods and optimum time was selected.

Conditioning

Conditioning was done for about 1-2 hours to equilibrate the moisture content throughout the grain. Conditioned grains with different moisture content i.e. 20, 25, 30, 35 and 40% were used to standardize the flaking method.

Roasting

Conditioned grain were then roasted in hot sand of temperature about 230-240 °C for just enough time (5-6 minutes) that initiates the popping of grains which indicated that grains were ready for flaking.

Flaking

The roasted sorghum grains were passed through heavy duty flaking rolls rotating at a speed of 70-80 rpm to process them into flakes.

Process for sorghum flaking is summarized as follows:

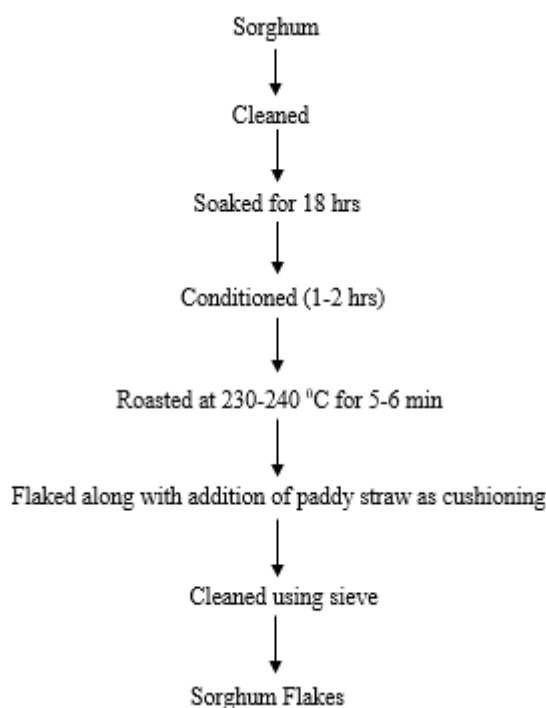


Fig 1: Process flow sheet for preparation of sorghum flakes

Physical properties of sorghum grain

Thousand kernel weight and volume

One thousand kernels were counted and weighed by a digital weighing balance in three replication and mean value was recorded.

Thousand kernel volume

Volume was calculated by measuring cylinder and the amount of kerosene displayed by 1000 kernels (Dutta *et al.*, 1988) ^[14].

Bulk density

25 g of sound grains were 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 was measured after adding the grains. It is bulk density represented in g/L (Dutta *et al.*, 1988) ^[14].

$$\text{Bulk Density } (\rho') = \frac{\text{Weight of grains}}{\text{Volume displayed}}$$

Porosity

Porosity is the per cent of the volume of inter grain space to the total volume of grain space. It is represented as per cent porosity (Thompson and Isaac, 1967) ^[15].

$$\% \text{ Porosity} = \frac{\text{Volume of inter grain space}}{\text{Total volume of grain space}}$$

Water absorption capacity of grains

A 10 g (+/- 0.01 g) sample of grains were soaked in distilled water for 4 hrs at room temperature. Grains were surface dried after removal from the beaker and weighed (Hsu *et al.*, 1983). Water absorption capacity is defined as the increase in weight due to absorption of water.

Angle of repose

It is the steepest angle between the base and slope of cone formed on a free vertical fall of grain mass to a horizontal plane when material is free falling or sliding. It was determined by making a circular pile of the grains freely falling. The height of the pile was taken (h) and its radius (r) is also taken. Angle of repose was then calculated by following formula. Angle of repose was determined using a method described by Mohsenin (1986) ^[16].

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

Flaking percent

It is measured by taking the mean of grain subjected to flaking against the actual flakes prepared (Dutta *et al.* 1988) ^[14].

$$\text{Flaking \%} = (\text{Actual flakes prepared} / \text{No. of grains used for flaking}) \times 100$$

Volume of 100 flakes

It is the amount of volume occupies by 100 flakes in 1 L measuring cylinder (Bello *et al.*, 1992) ^[17].

Proximate analysis

Proximate analysis was carried out for sorghum grain and flaked sorghum product by following methods. Proximate composition *viz.*, moisture, crude protein, ash, fat and crude fibre contents were determined according to standard procedure of AOAC (1990) ^[18, 19], AACC (1995).

Moisture

The moisture content of grains and flakes was determined by oven drying at 105°C for 3 hours until the moisture content comes to constant point (AOAC Method 44-19, 1990) ^[18, 19].

$$\text{Moisture (\%)} = \{(W1 - W2) / W1\} \times 100$$

W1 = Weight of sample before drying

W2 = Weight of sample after drying

Ash content

5 grams of each of the samples was weighed into a small dry crucible of known weight. The material in the crucible was charred on a low furnace. The charred material was ashed in a muffle furnace at 550 °C for 6 hours. The ashed material was removed from the furnace and cooled. It was kept in a desiccator and weighed (AOAC, 1990) ^[18, 19].

$$\text{Ash (\%)} = (\text{Weight of ash} / \text{Weight of sample}) \times 100$$

Protein

The protein content of ground flour and flakes was determined with the help of method given by AOAC (Microkjeldahl method). 200 mg sample was digested in 30 ml volumetric flask with 5ml concentrated H₂SO₄, 1g catalyst mixture and 5ml H₂O₂ for 45 mins. Till a clear liquid was obtained. Digest was added to 25ml volumetric flask and making up volume by adding distilled water. 10ml boric acid along with 5 drops of indicator mixture was taken in 125 ml conical flask and placed under the condenser whose tip extends below the surface of the solution. 5 ml of the digest was placed into a micro-kjeldahl distillation apparatus and 5ml concentrated NaOH was added to make the solution strongly alkaline. Above 45 ml of the distillate was collected. Titration was done with Std. H₂SO₄ till the colour of distillate changed from green to violet (AOAC, 1995) ^[18, 19].

Fat

Fat determination of grains and flakes was carried out according to the AOAC (1990, 920.85) ^[18, 19] standards. 2 g of sample were weighed in a Soxhlet extraction thimble. Predried boiling flask was weighed. Anhydrous ether was added to boiling flask. Boiling flask, condenser, soxhlet apparatus etc. was assembled and extraction was performed in the soxhlet extractor at the rate of 5 to 6 drops per second 4 hours by heating the solvent. Boiling flask with extracted fat was dried in hot air oven at 100 °C for 30 min and cooled in desiccator and the weighed.

$$\text{Fat (\%)} = (\text{Weight of fat} / \text{Weight of sample}) \times 100$$

Total carbohydrates

It was estimated by the phenol-sulphuric acid method of Wankhede and Tharanathan, (1979) ^[20]. The sample was weighed (0.5 g) accurately in test tube and kept in ice water bath for few minute followed by the addition of cold H₂SO₄ (72 per cent) with gentle stirring. The viscous paste was diluted with distilled water to obtain final concentration 2 N with respect to acid. It was then refluxed at 98 °C for 3-4 hours to achieve complete hydrolysis. The sugar content was estimated by Phenol-H₂SO₄ method; using glucose as standard. The orange yellow color was read at 480 nm on spectrophotometer. From the calibrated curve the concentration of sugar in hydrolyzate was calculated and per cent total sugar in the sample was quantified. (Wankhede and Tharanathan, 1979) ^[20].

Estimation of crude fibers

About 2 to 5 g of moisture and fat-free samples were weighed into 500 ml beaker and 200 ml boiling 0.255 N (1.25 w/v) H₂SO₄ was added. The mixture was boiled for 30 min keeping the volume constant by addition of water at frequent intervals. At the end of this period, the mixture was filtered through a muslin cloth and the residue washed with hot water till free from acid. The material was then transferred to the same beaker and 200ml of boiling 0.313 N (1.25 per cent) NaOH solution added. After boiling for 30 min the mixture was filtered through muslin cloth. The residue was washed with hot water till free from alkali followed by with some alcohol and ether. It was then transferred to crucible, dried over night at 80 – 100 °C and weighed. The crucible was heated in a muffle furnace at 550 – 650 °C for 2-3 hr, cooled and weighed again. The difference in the weights represented the weight of the crude fiber Ranganna (1985) ^[21].

Result and Discussion

Physical properties of sorghum grain

The understanding of physical quality attributes is critical in designing end product and its use, different individual grains have different physical characteristics that may dictate end product quality and application. Physical properties of kernel such as size, shape and weight plays important role in the

efficiency of milling in terms of flour yield, colour, chemical composition and acceptability (Liman *et al.*, 2012) [22]. Physical characteristics of the selected sorghum genotypes viz., 1000-kernel weight, volume, true density, bulk density and angle of repose were studied. The results pertaining to physical properties of sorghum are presented in Table 1.

Table 1: Physical properties of sorghum (*Sorghum bicolor*) grain

Sr. No.	Physical properties	Sorghum (<i>Sorghum bicolor</i>) (Parbhani Moti)
1	Thousand kernel weight (g)	31.25
2	Thousand kernel volume (ml)	29
3	True Density(g/ml)	1.21
4	Bulk Density (g/ml)	0.76
5	Angle of Repose (Degrees)	32° 42'

* Each value is a mean of three determinations

Data tabulated in the Table-1 revealed that the 1000 kernel weight and 1000 kernel volume of the Sorghum grain (Parbhani Moti) were 31.25 g and 29 ml respectively. The true density of grain was 1.21 g/ml, bulk density was found to be 0.76 g/ml and the angle of repose of was 32° 42'.

Proximate composition of sorghum grains

Proximate composition generally represents the nutritional quality of product. It is necessary to observe the proximate composition of grain so as to judge the nutritional quality of final product (Hammond, 1996) [23]. The data pertaining to proximate composition of sorghum grain (Parbhani Moti) is depicted in Table 2.

Table 2: Proximate chemical composition of sorghum (*Sorghum bicolor*) grain

Chemical composition sorghum grain		
Sr. No.	Components	Sorghum (<i>Sorghum bicolor</i>) (Parbhani Moti)
1	Moisture (%)	6.23
2	Crude Protein (%)	8.51
3	Fat (%)	1.60
4	Total Carbohydrates (%)	80.14
5	Crude Fiber (%)	2.12
6	Ash (%)	1.26

* Each value is a mean of three determinations

It is evident from Table 2 that the moisture content of sorghum (var. Parbhani Moti) grain was 6.23%. The crude protein content in the grain was found to be 8.51%, whereas the fat content in the grain was 1.60%. The total carbohydrates in the grain was 80.14%, carbohydrate content is inversely related to protein content, this is due to starch which is denser than protein and under growing conditions more starch is deposited in kernels than protein thereby increasing kernel density but decreasing protein content (Hoseney *et al.*, 1994) [24]. Crude fiber content of the sorghum

was 2.12% and the ash content was 1.26%.

Standardization of flaking process for sorghum

Flaking of grains generally involves soaking, conditioning, flaking and drying. The purpose of soaking is increase the moisture content of grains which prevents the bursting the grains at high pressure, while the conditioning process is applied to distribute the moisture content of grain till equilibrium is attained. Further, the process of flaking involves application of high pressure to change structure. Further the drying process reduces the moisture content to desired level so as to prevent sticking of flakes, increase the breaking strength and storage life. In present investigation, the efforts were made to initially optimize the moisture content of grains before flaking and to find out the optimum moisture content of flakes. In this context different trials were taken with varying concentration of moisture in soaked and conditioned grains.

In order to optimize the moisture content of grains for flaking, different unorganized trials were taken for flaking of grain from the moisture content 20% to 40%. As an outcome of random trials it is learnt that when moisture content of grains is less than 10%, it is resulting into excessive breakage of grains during flaking. While if the moisture content of conditioned grains is more than 50% then the sorghum grains are becoming excessively sticky and yield of product was drastically reduced. Hence, on the basis of initial trials it was decided to carry out further experimentation with different levels of moisture content (viz. 20% (C1), 25% (C2), 30% (C3), 35% (C4) and 40% (C5)) of conditioned grains.

Effect of moisture content of conditioned grains on physical properties of flakes

Physical properties of flakes made with different initial moisture content were measured and results are presented in Table 3.

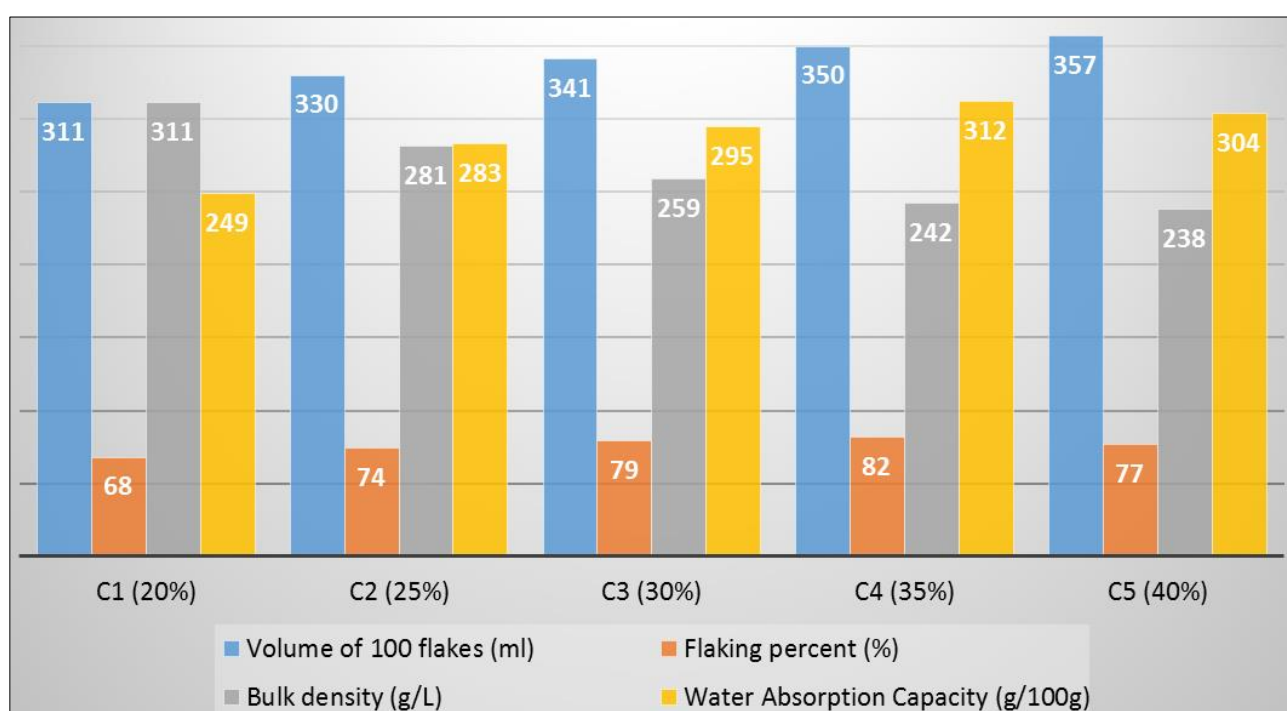
Table 3: Effect of moisture content of conditioned grains on physical quality of sorghum flakes

Sr. No.	Grains with different initial M.C. before flaking (%)	Volume of 100 flakes (ml)	Flaking percent (%)	Bulk density (g/L)	Water absorption capacity (g/100g)
1	C1 (20%)	311	68	311	249
2	C2 (25%)	330	74	281	283
3	C3 (30%)	341	79	259	295
4	C4 (35%)	350	82	242	312
5	C5 (40%)	357	77	238	304

* Each value is a mean of three determinations

Data presented in Table 3 revealed that there was significant variation in the physical parameters of flakes when conditioned grains with moisture content ranging from 20 to 40% were used for preparation of flakes. It is evident that with increase in moisture content of grains increases, volume of 100 flakes goes on increasing. Significant variation observed in volume of flakes from 20-40% moisture content of grain, further increase in moisture did not showed significant variation. Highest flaking percent (82 per cent)

was recorded at a moisture content of 35% in sample C4 and its 100 flake volume was 350 ml. C1, C2 and C3 had a very low flaking percentage of 68%, 74% and 79% their 100 flakes volume was 311 ml, 330 ml and 341 ml. As grain moisture increased from 20 to 35%, the flake volume and percent flaking increased. The increased levels of moisture (thereby gelatinization) resulted in more starch pasting, which led to stronger flakes (less breakage), (Anderson, 1993) ^[25].

**Fig 2:** Effect of moisture content of conditioned grains on physical quality of sorghum flakes

The highest 100 flakes volume was observed in C5 with 357 ml 100 flakes volume however the flaking percentage for C4 was low (77%) Flaking percent found to decrease above 35% moisture content of grains. This is due to fact that, at excessive moisture levels, too much gelatinization occurs and the processing efficiency is lost because the starch becomes tacky. At longer soaking time grains are too wet, matted the rolls during processing, and could increase power consumption (Mc Donough *et al.*, 1998) ^[25].

From Table 3 and Fig 1 it is clear that water absorption capacity of flakes has a direct relation with the moisture content of grain up to a certain limit after which it starts to decline. In this study also the water absorption capacity of flakes increase when the moisture content of grains was increased from 20% to 35% but after 35% it starts to decline as it was seen in for the sample C1, C2, C3 and C4 which showed increase in their water absorption capacity until the moisture content of grains was 35% but after that in sample C5 which was prepared from grains having 40% moisture content showed decline in water absorption capacity. Bulk

density had an inverse relation with the moisture. As the moisture increase from 20% to 40%, bulk density also declined from 311 to 238 g/L. This is due to gelatinization of starch which in excess results in affecting the textural characteristics of the product. Highest water absorption capacity was found in C4 (312 g/100g) and the lowest (249 g/100g) one was recorded for C1. Earlier study revealed that water absorption capacity had significant negative relationship with bulk density of grain (Gikuru and Mark, 2006).

Effect of moisture content of conditioned grains on chemical composition of flakes

Flaking is the process which involved exposure of grains at high temperature for short time to retain more nutrients. Flaking process is expected to retain more nutrients and digestibility compared to any other process. Hence, chemical composition of flakes is determined and results are summarized in Table 4.

Table 4: Effect of moisture content of conditioned grains on chemical composition of sorghum flakes

Sr. No.	Flake samples	Moisture (%)	Protein (%)	Fat (%)	Crude fibre	Carbohydrate (%)	Ash
1	C1	5.23	8.60	1.62	2.14	80.99	1.27
2	C2	5.55	8.57	1.61	2.13	80.72	1.27
3	C3	5.87	8.54	1.61	2.13	80.44	1.26
4	C4	6.03	8.52	1.60	2.12	80.31	1.26
5	C5	6.13	8.51	1.60	2.12	80.22	1.26
SE+		0.017	0.048	0.032	0.020	0.016	0.022
CD at 5%		0.053	0.146	0.096	0.061	0.050	0.067

* Each value is a mean of three determinations

Table-4 revealed that the moisture content of grain prior to flaking do not have any significant impact on the chemical composition of sorghum flakes. The chemical composition of flakes obtained from grains with different moisture content was almost similar to each other except variance was observed in moisture content. Sample C5 had highest moisture content of 6.13% whereas C1 had lowest of 5.23%. This was because of the initial moisture content of conditioned grains, as C1 had lowest moisture content prior to flaking hence it showed lowest after flaking, similarly C5 had highest moisture prior to flaking hence it showed highest (Vannalli, 2008) ^[26].

Highest protein content was recorded in C1 (8.60%) and C5 (8.51) had the lowest. Highest fat content was found in C1 (1.62%) whereas C4 and C5 had the lowest fat content i.e. 1.60%. C1 also had more percentage of carbohydrates (80.99%) whereas C5 (80.22%) had the lowest carbohydrate. C4 and C5 had lowest crude fibre and ash content (2.12% and 1.26% resp.) whereas C1 had highest crude fibre and ash content i.e. 2.14% and 1.27% respectively.

Conclusion

Effect of moisture content of grains on physical properties of sorghum flakes was studied. 100 flakes volume and moisture content of conditioned grains showed a positive relation, it increased from 311 to 357 ml. Flaking percentage increased from 68% to 82% along with the increase in moisture content up to 35% but after 35% a decline in flaking percentage was noted. Water absorption capacity also showed a similar trend as it continuously increased from 249 to 312 g/100g along with moisture which increased from 20% to 35% from sample C1 to C4 but after exceeding 35% moisture content it showed a significant decline as water absorption capacity of C5 was noted to be 304 g/100g which was less than that of C4. Bulk density had an inverse relation with the moisture. As the moisture increase from 20% to 40%, bulk density also declined from 311 to 238 g/L.

Chemical properties of most of the sample remained same but on the basis of physical properties and above findings it was conclude that the sample C4 having 35% of moisture during conditioning and having 6.03% moisture content, 8.52% protein, 1.06 fat, 80.31% carbohydrate, 2.12% crude fiber and 1.26% ash results in better physical, chemical and textural quality characteristics of sorghum flakes.

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