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Physical Properties of Sorghum Millet, Pearl Millet and Whole Wheat Grains in a Diabetic Diet

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Abstract

The rapid changes in diet and lifestyle of people in developing countries has lead to incidence of chronic diseases such as cardio vascular complications, hypertension, obesity and among them diabetes mellitus is a serious problem. The main aim of the study is Physical Properties of Sorghum Millet, Pearl Millet and Whole Wheat Grains In A Diabetic Diet**.** The data obtained on proximate composition, dietary fibre and change in moisture per cent during storage were calculated as mean value of three replicates ± their standard deviation. Diet is known to play a pivotal role in Diabetes Mellitus specifically in Non- Insulin Dependent Diabetes.

Keywords: Physical, Moisture, Storage, Diabetes, Insulin

1. INTRODUCTION

The rapid changes in diet and lifestyle of people in developing countries has lead to incidence of chronic diseases such as cardio vascular complications, hypertension, obesity and among them diabetes mellitus is a serious problem. Everything are collectively referred to as Syndrome-X-or-Metabolic-Syndrome. Shocking statistics on diabetes revealed that twenty per cent of the world's diabetics are Indians. Thirty per cent of diabetics in urban India are below the age of forty and that by 2025, WHO has estimated that India would have the highest number of diabetics followed by China and can be called as "diabetic capital" of the world. Globally there are about 177.7-million-diabetics-**(WHO,2003).**

The term diabetes mellitus was derived from the Greek words meaning passing through and sweet as honey (diabetes= flow through meh = honey). It is a chronic metabolic disorder with a strong hereditary basis, associated with high blood glucose. Basically it is caused by the deficient secretion of insulin by pancreatic cells. The two main types of diabetes classified by WHO are Insulin Dependent Diabetes or Type 1 and Non-Insulin Dependent Diabetes or Type 2. About ninety per cent of diabetics belong to Type -2 **(Reddy, 1999).**

Conventional treatment of diabetes mellitus is through insulin and oral glycemic drugs. However, this treatment may lead to micro- vascular and neurological complications. Insulin has also been reported to increase cholesterol synthesis and secretion of very low density lipoprotein which is not desirable for human health **(Subbulakshmi and Naik, 2003).**

2. LITERATURE REVIEW

***Manay and Sadaksharaswamy 1966*: defined that the name 'millet is applied to myriad small seeded grasses which have their origin in Asia or Africa. Millets are important crops for dry land farmers. They are highly nutritious and climate compliant crops. However due to drudgery in preparation, their consumption is decreased over the years in India. In order to revive the demand of millets in India, there is a need to bring all the stakeholders in production to consumption system value chain on a common platform and link poor dry land farmers with market and the consumers at large**.** Apart from maize and sorghum, the major millet crops of India are pearl millet (*Pennisetum glaucum L.*) called bajra and finger millet (*Eleusine coracana*) known as ragi. These millets, along with maize and sorghum are considered as 'coarse grains' and constitute the food of the economically weaker sections of the population in India.

***Kim J.C. et al 1968*:** Furthermore, millets serve as conventional staple bread of the arid regions across the world. In India, millets are grown on about seventeen million hectares with annual production of eighteen million tonnes and comprise ten percent to the country's cereal grain basket. They are commonly known as nutri-cereals which are nutrient dense in terms of protein, essential fatty acids, dietary fibre, B - group vitamins, minerals such as calcium, iron, zinc, potassium and magnesium. They help in rendering health benefits like reduction in blood glucose level (diabetes), blood pressure regulation and provision of shield against thyroid, cardiovascular and celiac diseases. However, increased consumption of millets as food has significantly declined over the past three decades.

Wall and Blessin (1970): It has become imperative to reorient the efforts on to regenerate millet demand through value-addition of processed foods through diversification of processing technologies, nutritional evaluation and creation of awareness backed by backward integration. In the concerned context it is important to explore ways for creating awareness on nutritional merits of millets.

Freeman and Watson (1971): The importance of nutrition as a foundation for healthy food development is underestimated. Now-a-days people are very conscious about their healthy living practices to overcome metabolic disorders and life style diseases**.**

Jellum and Powell (1971): Millets offer nutritional security and there is a need for promoting millets as they are highly nutritious. These have been important food staples inhuman history, particularly in Asia and Africa.

***Bhatia et al 1972*:** Sorghum and other millets consumption as direct food has significantly declined over the past three decades. The decline in demand has led to the decline in millets production considerably in India. Production of sorghum in India has come down from 7 million tonnes during 2010-11 to 4.2 million tonnes during 2015-16; bajra production was reduced from 10.4 million tonnes to 8.1 million tonnes, production of ragi reduced to 2.2 million tonnes to 1.8 million tonnes and small millets production came down to 0.39 million tonnes from 0.44 million tonnes during the same period.

3. METHODOLOGY

3.1 Procurement of Samples

For the present investigation, local cultivars of sorghum, pearl millet and whole wheat grains were procured from farmers of village. The other ingredients were procured from local market. All the reagents used in the present investigation were of analytical grade.

3.2 Evaluation of physical properties of Sorghum, Pearl millet and Whole wheat grains

The physical properties of grains impact the cooking and sensory quality of the products formulated from the aforesaid millets used in the present study. The physical quality characteristics viz. thousand kernel weight, thousand kernel volume, per cent flour recovery, per cent milling loss, bulk density, hydration capacity and pericarp color were studied for sorghum, pearl millet and whole wheat. The estimations were done in triplicates.

3.3 Statistical Analysis of Data

The data obtained on proximate composition, dietary fibre and change in moisture per cent during storage were calculated as mean value of three replicates ± their standard deviation. Significant difference between sensory quality characteristics of products was calculated using ANOVA (One way classification). Significant differences between freshand stored biscuits and difference between composite flour blend biscuits was calculated using ANOVA (Two way classification).

4. RESULTS

In the present study sorghum (***Sorghum bicolour***), pearl millet (***Pennisetum glaucum***), and whole wheat (***Triticum aestivum***) were selected for the preparation of three composite flour blends i.e. CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (PSW). The food products namely composite flour blend based biscuits and chapattis were formulated. These grains were evaluated for physical characteristics, composite flour blends for functional properties whereas the products were evaluated for nutritional quality, sensory quality and storage stability. The suitability of the formulated food products in diabetic diet was judged through GTT curve and glycemic index of products. The results of the present study have been presented under following headings:

4.1 Evaluation of physical properties of sorghum millet, pearl millet and whole wheat grains

Physical properties of grains are indicative parameter of grain quality and yield. Besides these, they are also an important parameter to be used in designing of processing technology such as equipments used for cleaning, milling and storage of grains. Results on physical characteristics such as thousand kernel weight, thousand kernel volume, bulk density, hydration capacity, pericarp colour and per cent flour recovery of sorghum, pearlmillet and whole wheat have been presented in the following subheads:

4.1.1 Thousand Kernel Weight

The weight of the kernel shows the quality of the grains and yield. The thousand kernel weight of sorghum millet and pearl millet and whole wheat grains were found to be 29.2 g,10.3g and 31.30 g respectively (Table 4.1). **Deivasigamani and Swaminathan (2018)** reported the sorghum millet grains' thousand kernel weight of 31.09 ± 0. 49g.However **Vengaiah *et al.* (2015)** reported the thousand kernel weight of wheat to be 30g.

Badau *et al.* (2007) reported the thousand kernel weight of pearl millet grain in a wide spectrum of 8.1-12.1g.

4.1.2 Thousand Kernel Volume

The thousand kernel volume of sorghum millet, pearl millet and whole wheat grains was found to be 27,6.9 and 38.40 ml. **Badau *et al.* (2005)** reported 5.8 -10.0 ml of thousand kernel volume of pearl millet grains whereas **Thilagavathi *et al.* (2015)** reported thousand kernel volume of pearl millet as 6.46 ± 0.06. **Bavdhankar (2015)** reported thousand kernel volume of sorghum millet to be 30ml. **Vengaiah *et al.* (2015)** reported the thousand kernel volume of wheat to be 40.45.

4.1.3 Hydration capacity

The hydration capacity of sorghum millet and pearl millet and whole wheat were found to be 5.05g, 1.25g and 8.01g. **Sibian *et al.* (2017)** reported hydration capacity of pearl millet seeds ranging from 0.00234 to 0.003g in distilled water and different concentration solutes. Moreover (**Bavdhankar (2015) certain** studies have reported the hydration capacity of pearl millet to be 1.60 g and of sorghum millet to be 5.00g respectively.

4.1.4 Bulk Density

Bulk density is the ratio of the mass to a given volume of a grain sample including the interstitial voids between the particles and commonly affected by particle size of the grain and excessive moisture content**.** The bulk density of sorghum millet and pearl milletgrains was found to be 0.85 g/cc and 1.10 g/cc. **Bavdhankar (2015)** reported the bulk density of sorghum millet as 1.20 and of pearl millet as 1.30. **Vengaiah *et al.* (2015)** reported 0.65 g/cc.

4.1.5 Pericarp colour

Colour is an important intrinsic factor for grading, trade, and processing of grain. The pericarp colour of the sorghum millet in Munsell soil colour chart was found to be mustard yellow, while the pearl millet was found to be grey and wheat to be white. **ICAR-AICRP (2017)** reported a similar colour of pearl millet to be grey and **Dykes and Rooney (2006)** reported colour of sorghum millet pericarp to be yellow.

Table 4.1 Physical characteristics of sorghum millet and pearl millet and whole wheat grai

S.No.	Physical properties	Sorghum millet	Pearl Millet	Whole wheat grains
1.	Thousandj kernel weight(g)	29.2 ± 0.03	10.3± 0.02	31.30±0.03
2.	Thousand kernel volume(ml)	27±0.28	6.9±0.04	38.40±0.02
3.	Bulk density (g/cc)	0.85± 0.007	1.10±0.2	0.76±0.01
4.	Hydration capacity(g)	5.05±0.45	1.25±0.03	8.01±0.02
5.	Pericarp colour	Mustard yellow	Grey	White

4.1.6 & 4.1.7 Per cent flour recovery and Percent Milling losses

The grinding loss for sorghum millet, pearl millet flour and whole wheat flour were 3.72,5.57 and 4.82 per cent respectively. Sieving losses were 27.71, 28.09 and 28.74 per cent, respectively for sorghum millet, pearl millet and whole wheat flour. The total percentage of flour recovery for sorghum millet flour and pearl millet flour was found to be 68.58, 67.34 and 67.46 per cent respectively (Table 4.2).

Table 4.2 Per cent flour recovery of sorghum millet and pearl millet andwhole wheat grains

Grains	Grinding losses (%)	Sieving losses (%)	Flour recovery (%)
Sorghum millet	3.72± 0.06	27.71 ±0.08	68.58± 0.02
Pearl millet	5.57 ±0.06	28.09± 0.04	67.34± 0.09
Whole wheat grain	4.82±0.04	28.74±0.04	67.46±0.01

*All results are mean ± standard deviation for three replicates

4.2 Functional properties of sorghum, pearl millet and whole wheat CompositeFlour Blends

4.2.1 Water Absorption

Water absorption is the amount of water taken up by the flour to achieve the desired consistency or optimal result. Water absorption gives an indication of the amount of water available for gelatinization. The ability of flour to absorb water depends on availability of hydrophilic groups which bind water molecules **(Kulkarni *et al.,* 2002).** The highest value of water absorption was reported in CFB3 (PSW) as presented in Table 4.3.

4.2.2 Fat absorption

The oil or fat capacity of flour is important aspect as it improves the mouth feel of the product and retains the flavor **(Abulude *et al.,* 2005).** The oil absorption capacity of food protein depends upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrphobicity. The oil absorption capacity also makes the flour suitable in facilitating flavor and mouth feel when used in food preparation. The ability of these flours to bind with oil makes it useful in food systems where optimum oil absorption is desired. **(Chandra and Samsher, 2013).** The value of fat absorption is highest in CFB1 (WSP).

4.2.3 Sedimentation value

The sedimentation value is the simple and rapid way to estimate the strength of the flour. The volume of the sediment depends largely on the quantity of gluten in the wheat and the extent to which the gluten is swollen (gluten quality). The test, therefore is a combined measure of the quantity and quality of gluten **(Zeleny *et al.*, 1960).** The value of sedimentation value was maximum for CFB3 (PSW) i.e.12.41 and lowest for CFB2(SWP)i.e. 11.11.

4.2.4 Emulsion activity and Emulsion stability

Emulsion activity is a major determinant of dough strength. A protein – protein interaction due to hydrophobic interaction on the surface of the protein would form a strong oil-water interface and would result in a stable emulsion **(Mao and Hua,2012).** The highest emulsion activity was for CFB3(PSW) of 21.75 whereas it was minimum for CFB2(SWP) of 20.50.

The emulsion stability was lowest for CFB1 (WSP) was 22.43 and highest for CFB2 (SWP) of 23.69. Water absorption capacity contribute to dough formation and stability, while fat absorption and emulsion capacities are pivotal factors in baking that contribute to texture **(Olapade and Oluwole, 2013).**

4.2.5 Particle size distribution

Particle size distribution (PSI) determines the structure of grains. The more intact structure of a cereal grain resulted into slow digestion of the starch molecules. Larger food particles have a lower surface – to- volume ratio and this may reduce the excess of enzymes to the interior of the particle. Packaging design and material required for packaging is also influenced by PSI**.** The particle size distribution for composite flour blends from 16 mesh size to 100 mesh size are presented in Table 4.4.

Table 4.3: Functional properties of Composite Flour Blends

Functional properties	CFB 1 (WSP)	CFB 2 (SWP)	CFB 3 (PSW)
Water absorption (ml/100g)	139.63±0.01	139.76±0.26	137.45±0.43
Fat absorption(ml/100g)	132.23±0.04	132.67±0.11	131.42±0.61
Sedimentation value(ml)	12.40±0.01	11.11±0.21	12.41±0.02
Emulsion activity(%)	21.47±0.02	20.50±0.13	21.75±0.29
Emulsion stability (%)	22.43±0.01	23.69±0.21	22.90±0.41

*All results are mean ± standard deviation for three replicates

Table 4.4: Particle size distribution of Composite Flour Blends

Particle size	CFB 1 (WSP)	CFB 2 (SWP)	CFB 3 (PSW)
16 mesh size (%)	3.76±0.01	3.50±0.26	3.21±0.43
36 mesh size (%)	61.23±0.04	64.87±0.11	65.50±0.61
60 mesh size (%)	27.08±0.01	26.32±0.21	25.50±0.02
85 mesh size (%)	6.57±0.02	5.78±0.13	5.45±0.29
100 mesh size (%)	3.19±0.01	2.65±0.21	2.31±0.41

4. 3 Nutritional Quality of Composite Flour Blends

4.3.1 Proximate Composition

The result of proximate composition of CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (PSW) are presented in Table 4.5.

4.3.1.1 Moisture content

The average moisture content of CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (PSW) was 12.05±0.05, 11.08±0.02 and 12.07±0.09 per cent, respectively. These values were slightlylower than given by **ISI (1980)** i.e.13 per cent moisture on dry weight basis. **Longvah *et al.* (2017)** reported 11.10 and 8.97 per cent moisture in whole wheat and pearl millet,which is comparable to obtained values.

Table 4.5 Proximate analysis of Composite Flour Blends (per 100g)

Parameters	CFB 1WSP	CFB 2SWP	CFB 3PSW
Moisture (%)	12.05±0.05	11.08±0.02	12.07±0.09
Crude protein (%)	22.16±0.09	25.34±0.05	22.22±0.07
Crude fat (%)	3.05±0.14	3.09±0.01	3.07±0.01
Total ash (%)	2.78±0.05	2.85±0.23	2.86±0.26
Crude fiber (%)	12.21±0.01	12.43±0.04	12.17±0.03
Carbohydrates (%)	56.34±0.01	50.01±0.01	53.98±0.01
Energy (kcal/100g)	343.5±0.26	378.5±0.47	332.2±0.43

4.3.1.1 Crude Protein

The values for crude protein content of composite flour blends i.e. CFB 1(WSP), CFB 2(SWP) and CFB 3(PSW) were 22.16±0.09, 25.34±0.05 and 22.22±0.07 per cent respectively. The crude protein of CFB 2 (SWP) was highest among all three. The proteincontent of all the composite flour blends is higher than that of **ISI (1980)** i.e. 17 per cent. **Longvah *et al.* (2017)** reported the total crude protein of 10.57 and 10.96 per cent in whole wheat flour and pearl millet respectively which are much lower than obtained values.

4.3.1.2 Crude fat

The values for crude fat content of three composite flour blends were 3.05±0.14, 3.09±0.01 and 3.07±0.01 per cent in CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (SWP), respectively. The crude fat content of CFB 2 (SWP) was highest of all the three (9.79). These values were less than reported values of wheat flour and pearl millet as Longvah*et al.* (2017) gave of 1.53 and 5.43 per cent respectively.

4.3.1.3 Total Ash

The values for total ash content of CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (PSW) were 2.78±0.05, 2.85±0.23 and 2.86±0.26 per cent, respectively. CFB 2 (SWP) exhibitedhighest ash content among all the three. These values were slightly higher than the values given by **ISI (1980)** i.e. 2.5 per cent. **Longvah *et al.* (2017)** reported the total ash for whole wheat flour and pearl millet as slightly lower i.e. 1.28 and 1.37.

4.3.1.4 Crude fibre

The values for crude fiber for CFB 1 (WSP), CFB 2 (SWP) and CFB 3(PSW) were12.21±0.01, 12.43±0.04 and 12.17±0.03 per cent respectively.

4.3.1.5 Carbohydrate by difference

The values of CFB 1 (WSP), CFB 2 (SWP) and CFB 3 (PSW) were 56.34±0.01,50.01±0.01 and53.98±0.01 per cent, respectively. **Longvah *et al.* (2017)** reported the carbohydrate content of whole wheat and pearl millet as 64.17 and 61.78 per cent which were higher than the values of blends.

4.3.2 Physiological Energy Value

The energy values for CFB 1(WSP), CFB 2 (SWP) and CFB 3 (PSW) were 343.5±0.26, 378.5±0.47 and 332.2±0.43 kcal per 100 g against 320.26 and 347.99 kcal per 100 g of whole wheat flour and pearl millet respectively as reported by **Longvah *et al.* (2017).**

5. CONCLUSION

Diet is known to play a pivotal role in Diabetes Mellitus specifically in Non- Insulin Dependent Diabetes. Millet based foods with characteristic low glycemic index are used as major tools in diet to help in management of hyperglycemia in diabetic subjects.Therefore, the present study was an effort in the direction of producing low cost, nutritious and low glycemic index food products suitable for home preparation and commercial production.

The three Composite flour blends namely CFB 1(WSP) incorporating whole wheat, sorghum and pearl millet in the ratio of 40:30:30, CFB 2(SWP) with sorghum, whole wheat and pearl millet in the ratio of 40:30:30 and CFB 3(PSW) with pearl millet,sorghum and whole wheat in the ratio of 40:30:30 were prepared and their products i.e. biscuits, instant upma mix and chapatti were prepared for examining the suitability in diabetic diet. These were evaluated for nutritional quality, sensory quality characteristics and glycemic response in normal subjects. Also, the biscuits and instant upma mix were evaluated for storage stability.

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