Review Article

Nutritional Composition of Yellow Pericarp Sorghum (*Sorghum bicolor* L. Moenech): A Review

ABSTRACT

Sorghum is a gluten-free cereal and forms the staple diet of a majority of the populations living in the semi-arid tropics. Sorghum grain contains pigmented pericarp (i.e., red, yellow, brown) and non-pigmented pericarp (i.e., white). Sorghum grains with yellow pericarp have greater demand in the market owing to its nutritional importance, good roti making quality and keeping quality. From a nutritional perspective, a major advantage of sorghum as a healthy and nutritious crop is its higher proportion of slowly digestible and resistant starch components compared with other staple cereal crops. The nutritional composition of *Sorghum bicolor* grain includes energy (193 cal), moisture content (52%), protein (7.1 g), fat (0.6 g), carbohydrates (39.8 g), fiber (0.9 g), calcium (10 mg), iron (3.5 mg), and niacin (1.7 mg). Yellow pericarp sorghum has a greater protein level (12-13%) than white sorghum (10-11%). Sorghum is a good source of minerals and vitamins and mostly located in aleurone layer and germ. It is an important source of B vitamins except for vitamin B_{12} and vitamin A. Yellow coloured sorghum grain is rich in beta carotene, leutin and zeaxanthin. Yellow pericarp sorghum is characterized by high carbohydrate, carotenoid, and manganese (Mn) contents. Yellow pericarp sorghum is rich in flavanones and has slightly higher total phenolic contents than white sorghum. The objective of this review paper is to provide a comprehensive understanding of nutritional composition of yellow pericarp sorghum with reference its to nutritional composition and to demonstrate the potential for incorporation of yellow pericarp sorghum in predominant cropping systems to popularize it and improve livelihoods.

Keywords: Yellow pericarp Sorghum, Nutritional composition, Minerals, Vitamins

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench), also known as Jowar in India, is a staple food for millions of people living in the semiarid tropics of Asia and Africa. It is the fifth most significant cereal crop in the country and accounts for around 16% of global sorghum production. India provided 13% of the world's sorghum area (40.97 M ha) and 8% of the world's sorghum production (59.76 M t) in 2019-2020. It is grown for food, animal feed, fodder, and, more recently, biofuel. In India, Rajasthan State is the largest sorghum grower and producer followed by Uttar Pradesh and Maharashtra. The crop is cultivated over an area of 13.64 lakh ha with a production of 4.80 M t and productivity of 998 kg ha^{-1} (Agricultural Statistics at a Glance, 2021). In Telangana, it is cultivated in 56,000 ha with production of 1.60 lakh tonnes and productivity of 790 kg ha^{-1}. Out of the total cultivated area under sorghum in Telangana, 60% accounted is under rainfed condition. Whereas in Andhra Pradesh, it is cultivated in 1.20 lakh hectares with production of 4.10 lakh tonnes and productivity of 3428 kg ha^{-1}.

India's sorghum production is dominated by high-yielding white sorghum hybrids, and new production technology have resulted in an increase in output from a gradually shrinking cultivation area. Recent market demand has increased for sorghum grains with yellow pericarp due to their nutritional value, good roti-making and preserving qualities. Yellow sorghums are typically tall (≥2.5 m) statured as against the white sorghum (2.0 m) and are susceptible to lodging, when raised under improved management practices during *rabi* and summer. Hence, they are invariably cultivated during *kharif* season. Currently cultivated sorghum cultivars with yellow pericarp are low-yielding local land races. Yellow pericarp sorghums are generally raised in patches in tribal areas of Telangana during *kharif* for subsistence with minimum management practices resulting in low yields and susceptibility to pests and diseases. However, keeping in view the consumer's preference recently high yielding sorghum (both grain and fodder) cultures with yellow pericarp were developed by RARS, Palem, Telangana, India.

2. Physical characteristics of white and yellow pericarp sorghum

Sorghum grain is composed of naked caryopsis, which consists of pericarp, endosperm, and germ. The sorghum kernel is a caryopsis in which the pericarp is completely connected to the endosperm. Variations exist in sorghum owing to the difference in the colour of the pericarp. Sorghum grain contains pigmented pericarp (i.e., black, red, yellow, brown) and non-pigmented pericarp (i.e., white). Anerao *et al.* (2022) determined physical properties of different sorghum varieties such as thousand kernel weight, and thousand kernel volume and found that white sorghum recorded higher thousand kernel weight and thousand kernel volume as compared to yellow sorghum. These results were in close resemblance with the results reported by (Gürsoy & Güzel, 2010). Anerao *et al.* (2022) also reported that seed shape of both yellow and white sorghum genotypes was round and was in line with the results obtained by Mabelebele *et al.* (2015).

Fig. 1. Images of yellow sorghum (left) and white sorghum (right) seeds

Table 1: Differences between Yellow and White Sorghum

Characters	**Yellow Sorghum**	**White Sorghum**
Glume colour	Yellow	White
Protein content	12 – 13%	10 – 11%
Seed Shape	Round	Round
Plant height	≥2.5 m	2.0 m
Duration	95- 105 days	100-105 days
Ear head	Compact and Symmetric	Loose or semi compact
Pest and Disease incidence	Comparatively less	More
Cost	Rs 49/kg	Rs 35/kg

Yield	18-20 q/ha	20-25 q/ha

Table 2: Nutritional composition of sorghum grain (per 100g)

Ingredient	Quantity
Protein (%)	4.40 – 21.10
Lysine (%)	0.30 – 0.90
Carbohydrates (g)	55.60 – 75.20
Amylose	21.20 – 30.20
Fat (g)	2.10 – 7.60
Crude fibre (g)	1.00 – 3.40
Ash	1.30 – 3.30
Minerals (mg/100 g)	
Calcium (g)	11.0 – 586.0
Phosphorus (mg)	0.90 – 20.0
Vitamins (mg/100 g)	
Thiamine	0.24 – 0.54
Niacin	2.90 – 6.40
Riboflavin	0.10 – 0.20
Anti-nutritional factors	
Tannin (%)	0.1 – 7.22
Phytic Acid (mg/100 g) as Phytin Phosphate	875.00 – 2211

Source : Makokha *et al.,* 2002

3. Chemical composition and nutritive value of white and yellow pericarp sorghum

Sorghum is a gluten-free grain that is rich in antioxidants, vitamins, magnesium, phosphorus, potassium, calcium, iron, protein, and fibre. However, Yellow Sorghum contained a reasonably high amount of these vitamins and minerals (Mohammed *et al.,* 2019).

3.1. Carbohydrates

Carbohydrates make up the largest proportion of sorghum's nutritious components. The carbohydrates in sorghum consist of starch, soluble sugar, and fibre. Non-structural carbohydrates in sorghum (sugars, starch, and fructosans) and structural carbohydrates are distinguished in sorghum (cellulose, hemicelluloses and pectin substances). Anerao *et al.* (2022) reported relatively higher carbohydrate values in yellow pericarp sorghum variety (73.53 %) as compared to white sorghum variety (72.36%). Similar results were obtained by Longvah *et al.* (2017). In the same study no significant differences were observed in crude fibre content. In a study conducted by Mohammed *et al.* (2019), both the carbohydrate content and crude fibre content did not differ significantly between yellow and white pericarp sorghum.

Sorghum has a significant amount of slowly digested starch (SDS), which has a functional quality and delays the digestion and absorption of carbs in the colon. This component is extremely advantageous for diabetics. Grain starches are relatively more difficult to digest than cereal grains. According to reports, sorghum grain has the lowest raw starch digestibility because endosperm proteins hinder starch accessibility. However, yellow sorghum has less fiber content and higher starch digestibility as compared to white sorghum (Arun *et al.,* 2009). Foods with a low Glycemic index help slow absorption of carbohydrates and prevent extreme blood glucose fluctuation. White jowar (flour) has a lower glycemic index (49.85) than yellow jowar (flour) (52.56), according to Vahini and Bhaskarachary (2013).

3.2. Proteins

The second significant component of sorghum grains is proteins. It is known that the protein concentration of sorghum fluctuates along with its amino acid profile. In addition to genetic considerations, environmental variables may contribute to the considerable variance in protein content among organisms (Geleta et al., 2005). Sorghum's protein content is comparable to that of wheat and corn. Significant proportion of sorghum protein is prolamin (kaffirin), which has the unique property of being less digestible than other grain proteins after boiling, which may be advantageous for the health of specific dietary groups. Compared to white sorghum, yellow sorghum has a greater protein level (12-13%) than white sorghum (10-11%). Mohammed *et al.* (2019) reported higher protein content in yellow sorghum (11.57%) as compared to white sorghum (9.57%). The results obtained were similar to the findings of Chavan *et al.* (2015).

3.3. Dietary fibre

Sorghum also contains between 9.7 and 14.3 grammes of dietary fibre, which acts as a bulking agent, cholesterol-binding agent, increases transit time, and retards carbohydrate absorption (Narasinga Rao, 2003), which has a significant positive effect on preventing and managing diseases such as constipation, irritable bowel syndrome, and obesity. Anerao *et al.* (2022) reported that crude fibre content did not differ significantly between yellow and white pericarp sorghum. These results were in agreement with Mohammed *et al.* (2019) who also noticed no significant differences in crude fibre content of white and yellow pericarp sorghum

3.4. Total Soluble sugars

Total soluble sugars are largely responsible for the good taste of roti prepared from sorghum (Nirmal et al., 2017). Anerao *et al.* (2022) noticed higher total soluble sugars of 1.65% in white sorghum which was followed by yellow pericarp sorghum which recorded a lower amount of total soluble sugar. Nirmal *et al.* (2017) also reported similar results.

Table 3. Differences in nutritional composition of yellow pericarp sorghum and white sorghum varieties

S No	Genotype/ Variety	Protein (%)	Fiber (%)	Total sugars (g/100g)	Reducing Sugars	Glume Color
Yellow pericarp sorghum						
1.	PYPS-2	12.02	1.25	2.76	0.279	Yellow
2	PYPS-8	13.52	1.37	3.65	0.26	White with red glume
3	PYPS-13	12.77	1.54	3.42	0.514	Creamy white
4	PYPS-14	13.17	1.54	2.81	0.375	White
5	PYPS-19	13.34	2.31	4.56	0.708	White with black glume
6	PYPS-28	13.43	1.85	3.03	0.499	Creamy white
White Sorghum Checks						
1	SPV-462	10.10	2.61	2.61	0.411	White
2	PSV-56	8.52	1.83	3.04	0.481	White

Source: RARS, Palem, Telangana

4. Mineral composition of white and yellow pericarp sorghum

Sorghum is a rich source of minerals and vitamins, the majority of which are found in the aleurone layer and germ, which are essential to the human diet. Therefore, the consumption of sorghum through a variety of products with added value will contribute to the supply of important minerals in the human body. Anerao *et al.* (2022) reported that white sorghum recorded higher amount of phosphorus content (490.55 ppm) than yellow sorghum (390.21 ppm). Whereas, yellow sorghum recorded higher potassium content (61ppm) and the white sorghum having the least potassium content (53ppm) in a study conducted by Mohammed *et al.* (2019). The values obtained from this study were found to higher than that reported by Leder (2004). A higher level of calcium content was found in the yellow pericarp sorghum which is (27.86 ppm) which was followed by white sorghum (18.71 ppm). With respect to micro nutrients, yellow pericarp sorghum showed higher iron content (5.27 ppm) as compared to white sorghum (4.33 ppm) (Anerao *et al.,* 2022). Whereas, yellow pericarp sorghum recorded lower zinc content (5.27 ppm) as compared to white sorghum (4.33 ppm).

5. Vitamin composition of white and yellow pericarp sorghum

Sorghum is an important source of B vitamins except for vitamin B_{12} (Gazzaz *et al.,* 1989). Yellow coloured sorghum grain is rich in beta carotene, leutin and zeaxanthin. The vitamin content of sorghum is not up to the recommended dietary allowance (RDA) recommended by WHO. Mohammed *et al.* (2019) observed that yellow pericarip sorghum recorded higher vitamin B_1 (Thiamine), B_3 (niacin) and B_6 (pyridoxine) than white sorghum. White sorghum does not contain vitamin A, While, yellow pericarp varieties contain small amounts of Beta carotene a precursor of Vitamin A.

6. Total phenolic content of white and yellow pericarp sorghum

The primary polyphenols in sorghum grain, such as phenolic acids and tannins, are considered to operate as antioxidants and play a crucial role in enhancing the immune system (Hassan et al., 2021). It is rich in phenolic compounds, including as phenolic acids, flavonoids, and condensed tannins, which exhibit antioxidant capability and possible health advantages (Alferi *et al.,* 2017). Yellow pericarp sorghum is rich in flavanones and has slightly higher total phenolic contents than white sorghum (Dykes *et al.,* 2011). Anerao *et al.,* 2022 noticed that yellow pericarp sorghum recorded higher total phenolic content (289.20 mg/100g) than white sorghum (157.63 mg/100g). The grain color is one of the reasons that results in the TPC differences among these varieties, however the variation in brewing sorghum grains may come from other reasons, such as the strain and growing environment.

Almond *et al.* (1979) observed relatively similar dry matter, crude protein and amino acid content in both yellow and white sorghums but white sorghum had markedly higher tannin content. The presence of tannins in the grain contributes to the low digestability of sorghum in comparision with other cereals. The concentration of tannins in yellow sorghum ranges from 0.2 to 0.5 % whereas that of white sorghum varieties can reach 3%. Tannins not only reduce palatability but also effect feed intake and growth as they reduce amino acid digestibility. On the other hand tannins found in sorghum contain antioxidants that protect against cell damage, reduce disease and aging.

7. Conclusion

Based on the different reviews examined it can be said that yellow pericarp sorghum has relatively higher percentage of most of the nutrients as compared to white sorghum. Yellow sorghum contained higher amount of proteins and minerals like calcium, potassium, iron etc. Thus yellow pericarp sorghum can serve as important nutritious cereal and the area under it can be increased by introduction of yellow sorghum in predominant cropping systems in different parts of India and yellow sorghum can also be used to make different value added products to fetch more benefits.

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