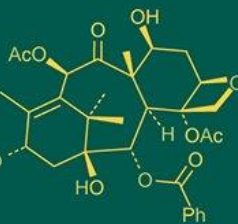
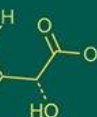
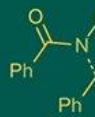


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Influence of seed coat colour on nutrient content of sorghum genotypes in storage

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Abstract

Seed storage and retention of seed viability is always an important consideration in agricultural practice. Poor storage conditions greatly affect seed vigour and viability. A laboratory experiment was conducted in the Department of Seed Science and Technology, UAS Raichur to study the storage effects on nutritive content of sorghum genotypes differing in seed coat colour during 2021-2022. The study consists of 20 sorghum genotypes of different seed coat colour which were stored for ten months in cloth bag under ambient conditions. A gradual decline in nutrient content was observed during storage. Protein content, starch content, Iron, zinc, crude fibre and tannin contents decreased significantly by during ten months of storage respectively.

Keywords: Sorghum, storage, nutrient

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench], a cultivated diploid ($2n = 20$) tropical cereal C₄ grass plant is a fifth most important cereal crop grown in the world followed by rice, wheat maize and barley. It is a monocotyledon plant of tropical origin, belonging to Poaceae family. Sorghum is called as camel of crops due to its high tolerance to water and temperature stress and also high photosynthesis efficiency. It is a warm temperate and tropical cereal and one of the most widely grown dry land food grain in India.

It is nutritionally superior to rice because of its high mineral and fibre content. Starch (60-75%) is the main component of sorghum grain, followed by proteins (7-15%), non-starch polysaccharides (2-7%) and fat (1.5-6%). The average energetic value of whole sorghum grain flour is 356 kcal/100gm (Dicko *et al.*, 2006) [3].

Seed coat is vital input in seed production. Seed coat colour is simple and excellent indicator of seed quality parameters. One of the unique features of sorghum is its variation in grain colour. The colour of seed coat of grains is most obvious physical characteristic which varies widely with white, cream, red, black *etc.* Seed coat colour is assumed to relate to tannin content and, hence, the nutritional quality of the grain.

Seed storage and retention of seed viability is always an important consideration in agricultural practice. Poor storage conditions greatly affect seed vigour. The deterioration rate depends on storage condition *i.e.*, temperature, relative humidity, seed moisture and types of storage container *etc.* Types of containers also regulate temperature, relative humidity and seed moisture content. It has been reported in the literature that fluctuation in temperature, humidity and prolonged storage result in considerable nutrient losses (Kumar and Singh, 1984) [5].

Changes in physical characteristics have also been observed during storage of cereal grains by Kent (1974). The association between the physical changes and the changes in the chemical composition of food has made the biochemical and nutritional quality control of the stored products increasing essential. The objective of the study was to investigate the effects of storage on nutritive content of sorghum genotypes differing in seed coat colour.

Materials and Methods

Seed materials

The different seed coat colour sorghum genotypes were procured from Department of genetics and plant breeding, College of Agriculture, Raichur.

The seeds were harvested in the month of February 2021 and kept for storage under ambient condition from August 2021 to May 2022 (ten months) in the cloth bag. The experiment was laid out in Completely Randomized Design with total 20 genotypes replicated four times.

Protein (%)

The protein content of seeds was estimated as per micro kjeldhal procedure as described by Jackson (1973) [4]. One gram sample was kept in the digestion flask, with a little quantity of catalyst mixture ($K_2SO_4 + CuSO_4$), 10 ml of 96 percent sulphuric acid was added and kept for complete digestion. Digested sample was distilled. The distilled amount of ammonia was titrated with 0.1 N H_2SO_4 . The nitrogen and protein content was worked out as per following formula and expressed in percentage.

$$\text{Nitrogen (\%)} = \frac{\text{Normality of } H_2SO_4 \times BR \times 0.014}{\text{Weight of sample}} \times 100$$

$$\text{Protein (\%)} = \text{percent of nitrogen} \times 5.95$$

Starch (%)

Starch was extracted by anthrone reagent as described by Clegg *et al.* (1956). It was extracted with perchloric acid after removal of sugars by extracting the sample with hot ethanol (70%). In hot acidic medium starch is hydrolysed to glucose and dehydrated to hydroxymethyl furfural. This compound on reaction with anthrone formed a green colour.

Iron and zinc estimation (mg kg⁻¹)

The content of zinc and iron was estimated using atomic absorption spectrophotometer (AAS) with zinc and iron hollow candle lamps (Jackson, 1973) [4]. The digested material with suitable dilutions was aspirated in to an AAS flame and concentration of zinc and iron was recorded in mg kg⁻¹ by referring to standard curve (Plate 4). The zinc and iron concentration was calculated using the formula.

$$\text{Micronutrient (Zn and Fe)} = \frac{\text{Concentration} \times \text{volume of extract}}{\text{Weight of the sample}}$$

Crude fibre (%)

The crude fibre content of flour sample was determined by sequential acid and alkali hydrolysis method. One gram of fresh and dried ground sample was taken in a crucible. The sample was boiled in 1.25 percent sulphuric acid and subsequently boiled in 1.25 percent sodium hydroxide solution. The sample was dried in hot air oven at 100 °C till all the moisture is evaporated (around 20 min). The weight of the crucible before ashing was noted down. The obtained dried sample was made into ash in a muffle furnace at 200 °C for 4 h. After ashing, the crucibles was cooled in a desiccator and reweighed. The residue obtained after subtraction of the ash was regarded as fibre. The crude fibre was obtained by using the following equation.

$$\text{Crude fibre (\%)} = \frac{W_1 - W_2}{W} \times 100$$

Where,

W1 = Weight of the sample before ashing (g)

W2 = Weight of the sample after ashing (g)

W = Weight of the sample (g).

Tannin (mg Kg⁻¹)

Tannin was estimated as per vanillin hydrochloride method. Extract 1g of ground seed in 50 ml methanol mix occasionally by swirling. After 20-28 hours, centrifuge and collect supernatant. Pipette out 1 ml of supernatant. Quickly add 5 ml of vanillin hydrochloride reagent. Read in spectrophotometer at 500 nm after 20 minute. Prepare the blank with vanillin hydrochloride reagent alone. Prepare standard graph with 20-100 µg catechin using diluted stock solution. From the standard graph, calculate the amount of tannin as catechin equivalent (CE) as per the absorbance values.

Data analysis

The mean data of the laboratory experiments was statistically analyzed by adopting appropriate statistical methods as outlined by Panse and Sukhatme (1985) [9]. The critical differences were calculated at one percent level of probability wherever 'F' test was found significant.

Results and Discussion

Seed coat colour effect the nutrient content of sorghum genotypes significantly during storage (Table.1).

Nutritional changes in cereal grains occurred, to various extents, during storage. It is apparent from table 1 that, significantly highest protein content was recorded in black seed coat colour genotype G₂₀ (13.15%) and the lowest was recorded in white seed coat colour genotype G₃ (11.79%) at initial month of storage. At the end of storage period, significantly highest value recorded by black seed coat colour genotype G₂₀ (12.00%) was found to be on par with G₁₇ (11.80%), G₁₈ (11.80%), G₁₂ (11.70%), G₁₅ (11.70%), G₁₆ (11.70%), G₁₀ (11.60%), G₁₁ (11.60%) and G₁₄ (11.60%) and the lowest protein content was recorded in white seed coat colour genotype (G₃) (8.93%).

The decline in protein content in unpigmented genotypes may be due to increase in moisture content. Anuradha *et al.* (2011) [1] studied different seed coat coloured cowpea genotypes and stated that, the decrease in protein content in unpigmented genotype over storage might be due to increased protein content which might have activated the proteolytic enzymes as a result of ageing effect leading to depletion of food reserves. Similar results were also found by Mokashi (2017) [8] in cowpea and Thombre *et al.* (2017) [11] in soybean. A gradual decline in level of starch content was observed in sorghum genotypes during storage. During initial storage period, significantly highest starch content was recorded in G₂₀ black seed coat colour genotype (64.50%) and the lowest was noticed in G₃ white seed coat colour genotype (58.30%). At the end of storage period, significantly highest value was recorded by G₂₀ black seed coat genotype (62.80%) and it is found to be statistically on par with G₁₇ (61.30%), G₁₈ (60.50%), G₁₄ (60.00%), G₁₅ (60.00%), G₄ (59.50%), G₅ (59.50%), G₁₉ (59.50%), G₈ (59.30%), G₁₂ (59.30%), G₇ (59.00%), and G₁₆ (59.00%). Whereas the lowest starch content was noticed in white seed coat colour genotype G₃ (54.50%).

Decline in starch content was observed with increase in storage period. The degradation in starch content may be attributed due to depletion of stored reserve over storage period and millard reactions, during which free amino groups of protein and carbonyl groups of reducing sugars form complex intermediate compounds by interacting with each other during storage. These complex structures might have inhibited the activity of proteolytic and amylolytic enzymes in unpigmented genotypes, which ultimately caused distinct reduction in starch. These results are in line with Dhanam, 2009 [2] in paddy, Mokashi *et al.*, 2017 [8] in cowpea.

The black seed coat colour genotype G₂₀ showed significantly highest iron content at initial and at end of storage period (52.88 mg kg⁻¹ and 50.19 mg kg⁻¹ respectively) followed by dark brown colour genotype G₁₇ (50.49 mg kg⁻¹ and 46.98 mg kg⁻¹). Whereas, genotype G₃ exhibited lowest iron content at initial month and at end of storage period (33.25 mg kg⁻¹ and 30.16 mg kg⁻¹ respectively).

The decline in iron content may be attributed due to fluctuation in temperature and relative humidity. Similar results were explained by, Pontieri *et al.* (2021) [10] in sorghum and Mokashi *et al.*, 2017 [8] in cowpea. They stated that decrease in iron may be due to fluctuation in temperature as well as relative humidity during the prolonged storage resulting in considerable nutrient losses.

The black seed coat colour genotype G₂₀ showed significantly highest zinc content at initial and at end of storage period

(32.24 mg kg⁻¹ and 29.98 mg kg⁻¹ respectively) which was on par with dark brown colour genotype G₁₇ (30.48 mg kg⁻¹) at initial month of storage. Whereas, genotype G₃ exhibited lowest zinc content at initial month and at end of storage period (26.12 mg kg⁻¹ and 20.79 mg kg⁻¹ respectively).

These results indicate that mineral content of sorghum was affected by both genetic and environmental factors as suggested by Dhanam, (2009)^[2] in paddy, Mokashi, (2017)^[8] in cowpea and Pontieri *et al.* (2021)^[10] in sorghum.

During initial month of storage, G₂₀ black seed coat colour genotype (2.64%) showed significantly highest crude fiber content while G₃ (2.10%), white seed coat colour genotype noticed lowest crude fiber content. After the end of ten months of storage, significantly highest crude fiber was recorded by black seed coat genotype G₂₀ (2.58%) which was on par with G₁₇ (2.53%), G₁₈ (2.51%), G₁₆ (2.48%), G₁₅ (2.44%), G₁₂ (2.37%) and the lowest was noticed by white seed coat colour genotype G₃ (1.77%).

Pontieri *et al.* (2021)^[10] suggested that the highest crude fiber content in black seed coat colour genotype might have show dependency and linear correlation with protein content of grain, hence protein content and crude Fiber are

interdependent. Increased protein content in pigmented genotypes makes them highest in crude fiber content and increased health benefits in addition to those conferred from phenolic compounds. These findings are also similar to the readings of Dhaman (2009)^[2] in paddy, Mokashi (2017)^[8] in cowpea.

Significantly highest tannin content was found in genotype G₂₀ (16.40%) and the lowest was found in white genotype G₃ (12.80%) initially. During final month of storage, tannin content was significantly highest in black seed coat genotype G₂₀ (15.90%) followed by dark brown genotype G₁₇ (15.80%). Whereas the lowest tannin content was found in white seed coat genotype G₃ (12.40%).

Darker colour genotypes showed highest tannin content than lighter coloured seeds. This might be due to presence of phenolic compounds in darker seeds coat colour genotypes which makes it antinutritional and impose resistance to mechanical damage caused by adverse environmental conditions like moisture resulting in insect resistance. Similar findings were shown by Laurena *et al.* (1984)^[6] in cowpea, Mabhuadi and Modi, (2013)^[7] in bambara groundnut and Mokashi (2017)^[8] in cowpea.

Seed coat colour	Genotypes	Protein (%)		Starch (%)		Iron (mgkg ⁻¹)		Zinc (mgkg ⁻¹)		Crude fibre (%)		Tannin (mg/100g)	
		Initial (Aug)	Final (May)	Initial (Aug)	Final (May)	Initial (Aug)	Final (May)	Initial (Aug)	Final (May)	Initial (Aug)	Final (May)	Initial (Aug)	Final (May)
White	G ₁ - IS37224	11.84	8.98	59.30	55.80	34.69	32.16	26.54	21.23	2.13	1.80	13.10	12.90
	G ₂ - M 35-1	11.90	9.95	59.80	56.00	35.45	32.91	26.89	22.19	2.20	1.84	13.90	13.20
	G ₃ - DJ6514	11.79	8.93	58.30	54.50	33.25	30.16	26.12	20.79	2.10	1.77	12.80	12.40
Pearly white	G ₄ - RSL46	11.95	10.20	62.80	59.50	38.73	34.57	26.97	22.39	2.30	1.98	14.10	13.80
	G ₅ - RSL54	11.94	9.97	63.80	59.50	37.99	34.52	26.93	22.33	2.24	1.87	14.00	13.70
Chalky white	G ₆ - RSL49	11.88	8.99	61.80	57.30	35.21	32.57	26.74	22.14	2.18	1.83	13.60	13.1
Whitish purple	G ₇ - IS3572	12.00	11.10	62.30	59.00	40.24	37.42	27.97	22.82	2.33	2.15	14.70	14.00
Purple	G ₈ - IS16310	12.10	11.20	63.30	59.30	40.35	38.96	27.98	23.54	2.39	2.18	14.80	14.30
Yellow	G ₉ - IS16006	12.12	11.20	61.50	58.30	40.48	39.98	27.99	23.56	2.41	2.22	15.00	14.70
Red	G ₁₀ - IS37247	12.45	11.60	61.80	58.80	42.97	40.47	28.91	25.43	2.49	2.34	15.40	14.90
	G ₁₁ - RSL69	12.23	11.60	59.80	57.00	40.98	37.47	28.9	24.69	2.48	2.31	15.40	14.80
Light red	G ₁₂ - RSL57	12.84	11.70	62.30	59.30	49.85	43.14	28.93	26.41	2.51	2.37	15.50	15.00
	G ₁₃ - IS37349	12.18	11.20	62.00	58.30	40.85	38.83	28.4	24.67	2.43	2.28	15.30	14.80
	G ₁₄ - IS37304	12.15	11.60	62.30	60.00	40.52	38.91	28.1	24.56	2.43	2.25	15.30	14.70
Light brown	G ₁₅ - IS37355	12.92	11.70	63.30	60.00	50.14	45.23	29.87	26.48	2.55	2.44	15.70	15.10
	G ₁₆ - IS6508	12.95	11.70	63.00	59.00	50.14	46.46	29.94	27.68	2.56	2.48	15.90	15.20
Dark brown	G ₁₇ - IS37225	13.12	11.80	64.00	61.30	50.49	46.98	30.48	28.54	2.60	2.53	16.10	15.80
	G ₁₈ - IS22436	13.00	11.80	63.30	60.50	50.18	48.50	30.23	27.98	2.58	2.51	16.00	15.60
Grey	G ₁₉ - IS2618	11.98	11.00	62.00	59.50	39.94	35.19	27.89	22.49	2.30	2.11	14.30	14.00
Black	G ₂₀ - IS25040	13.15	12.00	64.50	62.80	52.88	50.19	32.24	29.98	2.64	2.58	16.40	15.90
Mean		12.32	10.91	62.10	58.80	42.27	39.23	28.40	29.98	2.39	2.19	14.90	14.40
SEm±		0.70	0.24	0.91	1.40	1.02	0.95	0.68	0.59	0.07	0.08	0.36	0.35
CD @1%		2.63	0.68	2.97	3.98	2.90	2.70	1.93	1.67	0.19	0.22	1.01	0.98

Conclusion

Nutritional quality of cereal grains was adversely affected as a result of storage. All the nutrient content in sorghum genotypes decreased and significant losses have been occurred to various extents upon storage. In the view of these facts, it is suggested that black seed coat colour sorghum genotype is rich in nutrient content even after prolonged ten months storage and it can be stored for longer period of time.

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