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Seed coat color of Sesame (*Sesamum indicum* L.): A review

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Review

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A B S T R A C T

Sesame is an important oil seed crop for the world. Its oil content is between 45-55% and protein content is 20-25%. Approximately 3/4 of the globally produced sesame seed is processed into oil and meal. The rest is used for production of other types of foods. Sesame seed cake is generally used as feed for cattle in many countries in the world. Seed coat colour is also an important trait for commercial sesame. Color influences consumer preferences. White, black, biscuit color, light yellow, dark brown, golden and grey are the terms used to classify sesame seeds according to color globally. Here in this review, global knowledge produced in the last decade on sesame seed color is summarized.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oil seed crops worldwide (Onsaard, 2012). It contains unsaturated fatty acids in its oil (Islam et al., 2016). Sesame seed oil content is between 45-60% in its seed (Pham et al., 2010). Its oil has antioxidant properties which prevent oxidative decay and improve storage quality (Islam et al., 2016). Seeds are used for the decoration of bread, cookies and foods, and to produce paste and tahin. Sesame oil is a salad and cooking oil (Elleuch et al., 2011). Antioxidants in its oil prevent oxidative decay and it increase storage quality (Islam et al., 2016). Sesame seed protein contents is 24% (Borchani et al., 2010). Approximately 3/4 of the globally produced sesame is processed into oil and meal. The rest is used for production of other types of foods and confectionery (Kapoor et al., 2015). Sesame seed cake is generally used as feed for cattle in many countries in the world (Sarkis et al., 2014).

Seed coat colour of sesame

Seed coat colour is also an important trait as commercially for sesame (*Sesamum indicum* L.) (Pandey et al., 2013). Color influences consumer preferences (Wang et al., 2020). Oil of white sesame has been used for cooking and preparing foods for centuries (Aslam et al., 2017). History of sesame growing is very long in China where white sesames are major cultivars in field production (Zhang et al., 2010). White colored sesame seeds are potentially functional foods to treat chronic diseases (Lin et al., 2017). In addition, black sesame seeds are used for the treatment of various diseases in East Asia (Wang et al., 2020). Black sesames are more expensive than white due to the belief that black sesame are more beneficial to health than white sesame (Wang et al., 2018).

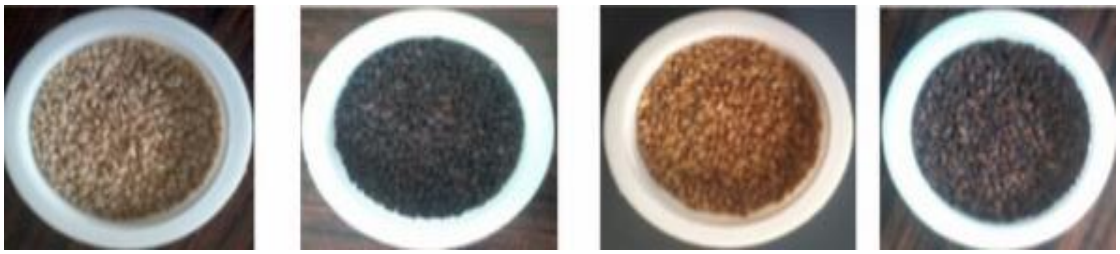

Figure. 1. Different seed coat color of sesame seed (from left to right: White, black, light yellow and dark brown) (Mishra et al., 2016)

Sesame seeds are dehulled before using by food industry due to the unwanted dark color and bitter taste of husks (Carbonell-Barrachina et al., 2009).

Table 1. Seed, capsule and flower related characteristics, states and example cultivars of sesame from India (Tripathy et al., 2019)

Characteristics	States	Example Cultivar
Seed coat color	White	TKG 21
	Grey	Uma
	Light brown	Rama
	Dark brown	Thilak
	Black	Krishna
1.000 seed weight (g)	Low <2.5	Kalika
	Medium 2.5–3	TKG 55
Seed oil content (%)	Low <45	Tilottama
	Medium 45–50	Krishna
	High >50	TKG 21
Capsule length (cm)	Short <1.5	-
	Medium 1.5–2.5	Adarsh 8, GT 2
	Long >2.5	AKT 64
Capsule arrangement	Alternate	RT 46
	Opposite	TKG 22, N32
	Cluster	G.Til-1, GT 2
Capsule number per leaf axil	1	Thilak
	More than 1	G.Til-1, GT 2
Capsule shape	Tapered	GT 10
	Narrow	TKG 21
	Oblong	Phule Til-1
	Broad oblong	-
Capsule locule number	4	TKG 22
	6	-
	8	Adarsh 8
Capsule hairiness	Absent	Rama, T 78
	Sparse	Chandana
	Dense	JCS 94, GT 2
Flower petal hairiness	Absence	-
	Sparse	RT 125
	Dense	Rajeswari
Flower petal color	White	Kalika
	Light purple	RT 54
	Dark purple	RT 103

Seed color is an important trait in sesame. It is related with biochemical properties, antioxidant content and activity of seeds and disease resistance of sesame crops (Zhang et al., 2013). Seed coat color has strong links to oil, proteins and lignans contents of sesame seeds (Wang et al., 2020). Seed color is related to protein and oil metabolism in sesame (Cui et al., 2021). In tissue culture, variation exist for callus induction and root-shoot bud formation based on seed coat color of sesame genotypes. Fresh harvested white colored thin seed coat produces higher number of multiple shoot buds compared to black/blackish brown colored thick seed coats in modified B5 growth medium (Chakraborti and Ghosh, 2010). In a study of Kim et al. (2014), protein, oil and lignan components and antioxidant properties of black and white seeds from different years and varieties were evaluated. Lignan contents were significantly different based on varieties, seed coat colours and growth years. Oil and protein showed small variations in varieties, seed coat colours and growth years (Kim et al., 2014). Sesame seed are diversified based on seed color, size and seed coat texture (Jamarkattel-Pandit, 2016) (Table 1 and 2).

Table 2. Sesame varieties released in India after year 2000, their seed colors, growth durations and oil content characteristics (Tripathy et al., 2019)

Variety (Year)	Seed colors	Duration (days)	Oil content (%)
Nirmala (2003)	Gray white seed	80–85	42–44
Prachi (2004)	Black seed	85	42–45
Gujurat Til 10 (2004)	Black seeded	92	50
Jawahar Til −12 (2004)	White seed	82–85	48–52
Amrit (2007)	Light brown seed	75–80	43–46
TKG–306 (2007)	White seeded	86–90	49–52
DSS–9 (2009)	White bold seed	85–90	48–50
Gujurat Til 3 (2009)	White bold seeded	86	47
PKV–NT–11 (2009)	White seed	88–92	50–53
RT 351 (2011)	White seed	85	50
Gujurat Til 4 (2012)	White bold seeded,	85	51
DS–5 (2012)	White bold seed	-	49–51
HT–9713 (2013)	White seeded	-	48
Kanke White (2014)	Dull white seed	85–90	50
Sweta Til (2014)	Determinate white seeded	75–80	44–49
Smarak (2014)	Golden yellow seed	75–80	44–49
Shubhra (2014)	White seed	75–90	46–52

40 samples of sesames were collected from major cultivation zones in China by Xiao-rong et al. (2017) to compare amino acid profiles of white and black sesames. Both types contained 17 essential amino acids. Arginine and glutamic acids were dominant amino acids for both sesames. Arginine and glutamic acids contents were 2.9% and 4.8% in white sesames. In black sesame, arginine and glutamic acids contents were 2.8% and 4.8%. Lysine and methionine were significantly different for both samples (Xiao-rong et al., 2017).

Sesame is in Pedaliaceae family. Its diploid chromosome number is 2n= 26. Plant is usually self-pollinated. (Golakiya, 2016). Maternal genotype is the determiner of seed color in sesame. Brown is dominant over white in sesame (Laurentin & Benitez, 2014). Knowledge on genetic basis of seed coat color is poorly understood in sesame due to its complication (Cui et al., 2021). 20 genes are associated with pigment synthesis in black sesame seeds. 10 of these are flavonoid biosynthesis and regulatory genes. These pigment synthesis related genes are also include polyphenol oxidase and isochorismate genes (Wang et al., 2020).

Figure 2. Seed color development at physiological maturity. (a) White seed, (b) biscuit color seed, (c) black seed (Tripathy et al., 2019)

Pongpraket et al., (2020) conducted a study to determine 16 mycotoxins in white and black sesame seed samples sold on market in Thailand. 22% of 200 samples were found contaminated; 2% were contaminated with multiple and 20% were contaminated with one mycotoxins. 9% of total samples were contaminated with aflatoxins and only one white and one black seed sample were exceeding the limits of European Union (2.0 μg/kg) (Pongpraket et al., 2020).

Different colour and sesame varieties were analyzed biochemically by Paroha et al., (2014). Oil content was maximum in decorticated seeds (51%) and whole seeds (47%) of white sesame seeds. Light-brown seed coat contained highest oil content (15%). Free fatty acid content in whole seeds was lowest in white seeds (0.6%) and highest in dark brown seeds (1.7%). Oxalic acid content was minimum (0.88%) in dark brown and white decorticated seeds. The highest protein was in whole (18.35) and decorticated seed (16.45%) of white. Sesamol content was maximum at white seeds (6.95 mg/kg).

2. CONCLUSION

Sesame seeds are diversified based on seed color, size and seed coat texture. Seed color is an important trait in sesame. It is related with biochemical properties, amino acid profiles, antioxidant content and activity of seeds and disease resistance of sesame crops. Seed color has effect on oil, proteins and lignans contents, antioxidant properties, consumer preferences, the potential as functional food for the treatment of various diseases, reaction to media in tissue culture. Highly diversified germplasm exist in global gene banks, research institutes, universities and commercial markets related to this trait to be utilized.

Compliance with Ethical Standards

Author Contributions

Authors contributed equally to this paper.

Conflict of Interest

The authors do not have any conflicts of interest to declare.

Ethical Approval

For this type of study, formal consent is not required.

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