

1 Sugars in Whole Sesame Seed : Effects of Cultivars, Planting Dates, and Row Spacings

2

3 . **ABSTRACT**

4 Mean contents of fructose, glucose, raffinose, stachyose, sucrose, and total sugars in
5 whole sesame seed, produced during 2011 and 2012 in mid-Atlantic region of the United
6 States, were 0.95, 1.28, 2.22, 0.14, 0.82, and 5.39 (g/100 g meal), respectively. Planting time
7 effects were significant for fructose, stachyose, and sucrose. Early planting (Late May to
8 early June) resulted in 5.4 and 34.3 percent increase in contents of fructose and sucrose,
9 respectively over late planting (Early June to mid-July). On the other hand, early planting
10 resulted in an increase of 70 percent in content of stachyose, a non-nutritive sugar. An
11 increase in row spacing from 37.5 cm to 75 cm increased the content of fructose by 24.7
12 percent but resulted in 8.1 percent decrease in content of glucose. Cultivar effects were
13 significant only for sucrose. S26 and S32 cultivars had significantly higher content over that
14 of 22K (0.89, 0.89, and 0.69 g/100 g meal, respectively). These results indicate that sugar
15 contents in sesame whole seed could be manipulated by using specific growing conditions
16 and cultivars.

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18 Keywords: *Sesamum indicum* L.; Total sugar content; Fructose content; Glucose content;
19 Sucrose content; Raffinose content; Stachyose content.

20

21 **1. Introduction**

22 Sesame (*Sesamum indicum* L. Pedaliaceae) is one of the oldest crops known to
23 humans. International demand for sesame continues to increase every year. The world's
24 traded sesame seed recently surpassed one million tons per year and was valued at
25 approximately 850 million. In the last 15 years, world trade in sesame has increased by
26 nearly 80 percent. The United States imports more sesame than it grows. In 2010, the United
27 States imported sesame seed valued at \$69.9 million which was relatively unchanged from
28 2009 [1]. This observation indicates that there is potential for enhancing sesame production
29 in the United States.

30 Due to loss of tobacco and other crops such as peanut (*Arachis hypogea* L.), the New
31 Crops Program of Virginia State University has been evaluating several summer crops that
32 can be grown in Virginia to help agricultural diversification and to enhance farm incomes. In
33 this regard, sesame (*Sesamum indicum* L. Pedaliaceae) is considered a potentially lucrative
34 crop. However, there is a complete lack of information about sesame production in this
35 region and additionally regarding composition of sesame seed produced in this region.
36 Objectives of our research effort were to determine if sesame could be successfully produced
37 in Virginia and to characterize sugar composition of sesame whole seed produced using
38 different cultivars, planting dates and row spacings.

39

40 **2. Materials and Methods**

41 2.1 Plant material

42 Five proprietary sesame cultivars (22K, S26, S28, S30, and S32) from Sesaco

43 Corporation (San Antonio, Texas, USA) were used in this study.

44 2.2 Plant production

45 This field study was conducted at Randolph Farm of Virginia State University located

46 in Ettrick, Virginia. These cultivars were planted in four-row plots with row spacings of 37.5

47 and 75 cm in an Abel Sandy Loam soil. Sesame was planted on May 23 and June 8 (PT1)

48 during 2011 and on July 17 and July 9 (PT2) during 2012 using a split-plot experimental

49 design with planting dates as main plots, row spacings as sub-plots and cultivars as sub-sub-

50 plots with four replications of a Randomized Complete Block Design. The soil received a

51 pre-plant incorporated application of approximately 2 liters of Trifluralin herbicide per

52 hectare. The experimental area received a fertilizer application of 112 kg per hectare of N, P,

53 and K. All plots were harvested manually at maturity, generally in November to December

54 of each year.

55 2.3 Determination of contents of fructose, glucose, sucrose, total sugars, raffinose, and

56 stachyose contents in whole sesame seeds

Sugars were extracted from ground sample (1 g) and analyzed by HPLC following the methods optimized by Johansen et al. [2]. Sugars in the extracts were identified by comparing their retention times with standard sugars. For quantification, trehalose was used as internal standard and the sugar concentration was expressed as g/ 100 g oil-free meal.

2.4 Statistical analysis

All data were analyzed using the Analysis of Variance procedures in version 9.3 of SAS [3]. The means were compared using Fisher's Protected Least Significant Difference at a 5% level of significance.

3. Results and Discussion

Analysis of variance (Table 1) indicated that planting dates significantly affected contents of fructose, sucrose, and stachyose; row spacings significantly affected contents of fructose and glucose; and cultivars significantly affected only the content of sucrose in whole sesame seeds.

Earlier planting (early May to early June) resulted in 0.98 g/100 g meal fructose content in whole sesame seed whereas late planting (early June to middle of July) resulted in 0.93 g/100 g meal glucose – an increase of 5.4 percent due to earlier planting. Similarly, early planting resulted in 34 percent increase in contents of sucrose over late planting (1.43 and 1.13 g/100 g meal, respectively) in whole sesame seed (Table 2). Early planting increased content of stachyose, a non-nutritive carbohydrate, 70 percent over late planting

(0.17 and 0.10 g/100 g meal, respectively). Increasing the spacing between rows from (Table 3) 37.5 cm to 75 cm resulted in an 24.7 percent increase in fructose content (1.06 and 0.85 g/100 g meal, respectively) whereas increase spacing between rows from 37.5 cm to 75 cm caused an 8.1 percent decrease in glucose content (1.33 and 1.23 g/100 g meal, respectively). Differences among five sesame cultivars were generally not significant for most sugars (Table 4). Content of sucrose in S26 and S32 cultivars were significantly higher as compared to 22K cultivar (0.89, 0.89, and 0.69 g/100 g meal, respectively).

Use of a limited number of cultivars in this study may have resulted in limited effects on contents of various sugars in whole sesame seed. However, most of the worldwide sesame production is based on use of traditional cultivars that are tall and are shattering types [4]. A major issue with sesame is the shattering habit in traditional cultivars. Shattering of capsules is not conducive to mechanical harvesting. Sesaco, a private company based in Texas (USA), has been breeding sesame to develop dwarf and shatter-resistant sesame cultivars for several years and released the first dwarf and shatter-resistant sesame cultivar in 1982 [4]. In 2010, Sesaco had more than 100,000 acres of sesame under contract production with growers in southwest Kansas, Oklahoma and central Texas. All dwarf and shatter-resistant sesame cultivars from Sesaco are proprietary. We expect that inclusion of a wider number of sesame cultivars in studies like this study would indicate an expanded range of sugar contents.

95 Our results indicated that early planting resulted in increased contents of fructose,
96 glucose, and stachyose in whole sesame seed. However, contents of total sugars and sucrose
97 were not affected by planting date indicating that sesame can be produced in Virginia by
98 using either early or late planting dates. However, early planting is expected to produce
99 sesame seeds that are sweeter over those produced by planting late. Raffinose and Stachyose
100 are considered non-nutritive and are not completely digested by human beings [5]. In recent
101 times, non-nutritive carbohydrates in food grains are receiving increasing attention due to
102 their limited digestibility and potential use in obesity reduction efforts [6].

103 With regards to identifying an optimal row spacing for sesame production in Virginia,
104 relative to sugar content of whole sesame seed, our results indicate that based on for all
105 sugars other than fructose and glucose, either a closer row spacing (37.5 cm between rows) or
106 a wider row spacing (75 cm between rows) could be used. Our objectives were to identify
107 optimal row spacing for sesame production in Virginia because farmers, generally, resist
108 purchase of new equipment when initially evaluating production of new, non-traditional
109 crops. Most Virginia farmers own soybean planters either configured for 37.5 cm or 75 cm
110 rows. Our results indicate that sesame in Virginia could be planted with existing planters.
111 Given that amount of seed for planting is small, it might be desirable to use 37.5 cm rows
112 because of weed control due to shading. On the other hand, if sesame is to be produced
113 organically via cultivation than 75 cm rows might be desirable.

114 **Conclusions**

115 Results of our study indicated that sesame could be easily produced as a commercial
116 crop in Virginia. These results also indicate that sugar contents in sesame whole seed could
117 be manipulated by using specific growing conditions and cultivars.

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119 **References**

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134 and resistant starch formation in legumes – A review. Carbohydrate Polymers 2003;
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136 Table 1. Partial analysis of variance (Mean squares) for contents of sugars

137 in seeds of five sesame cultivars grown using two planting dates and

138 two row spacings in Virginia during 2011 and 2012.

139

Variable	Years	Planting dates	Row spacings	Cultivars	R ² %	CV %	Mean
Fructose ^x	*	*	**	ns	96.4	36.9	0.95
Glucose	ns	ns	**	ns	98.2	10.2	1.28
Sucrose	ns	*	ns	*	91.6	28.7	0.82
Total sugars	*	ns	ns	ns	95.4	12.7	5.39
Raffinose	*	ns	ns	ns	96.3	11.1	2.22
Stachyose	ns	**	ns	ns	94.4	46.3	0.14

140 *, ** : Mean squares significantly different from residual mean squares at 5 and 1 percent

141 levels, respectively when tested against appropriate error mean squares as per split-

142 plot analysis.

143 x : Sugar contents as g/100 g meal.

144

145 Table 2. Effects of planting dates on contents of sugars in seeds of five sesame
146 cultivars grown using two row spacings in Virginia during 2011 and 2012.

147

Variable	Early planting (PT1)	Late planting (PT2)
Fructose ^x	0.98 a*	0.93 b
Glucose	1.43 a	1.13 a
Sucrose	0.94 a	0.70 b
Total sugars	5.29 a	5.48 a
Raffinose	2.08 a	2.37 a
Stachyose	0.17 a	0.10 b

148 x : Sugar contents as g/100 g meal.

149 * : Mean within rows followed by similar letters were not different according to LSD at 5
150 percent level.

151 Table 3. Row spacing effects on contents of sugars in seeds of five sesame
152 cultivars produced using two planting dates in Virginia during 2011 and 2012.

153

Variable	37.5 cm	75 cm
Fructose ^x	0.85 b*	1.06 a
Glucose	1.33 a	1.23 b
Sucrose	0.84 a	0.79 a
Total sugars	5.37 a	5.40 a
Raffinose	2.27 a	2.18 a
Stachyose	0.13 a	0.14 a

154 x : Sugar contents as g/100 g meal.

155 * : Mean within rows followed by similar letters were not different according to LSD at 5
156 percent level.

157 Table 4 . Cultivar differences for contents of sugars in seeds of sesame

158 produced using two row spacings and two planting dates in Virginia

159 during 2011 and 2012.

160

Variable	22K	S26	S28	S30	S32
Fructose ^x	1.12 a*	0.87 a	0.96 a	0.96 a	0.85 a
Glucose	1.24 a	1.42 a	1.30 a	1.28 a	1.16 a
Sucrose	0.69 b	0.89 a	0.81 ab	0.81 ab	0.89 a
Total sugars	5.39 a	5.58 a	5.54 a	5.28 a	5.14 a
Raffinose	2.21 a	2.28 a	2.36 a	2.13 a	2.14 a
Stachyose	0.13 a	0.12 a	0.11 a	0.16 a	0.17 a

161 x : Sugar contents as g/100 g meal.

162 * : Mean within rows followed by similar letters were not different according to LSD at 5

163 percent level.