A STUDY ON OIL AND OTHER CHEMICAL COMPOSITION OF SEEDS FOR SOME COMMERCIAL AND BROWN COLORED EGYPTIAN COTTONS

Journal

J. Biol. Chem. Environ. Sci., 2008, Vol. 3(2): 411-422 www.acepsag.org

Amal, S. M.*, Mohamed, E. M. and Mounir, M. E. ****

**Cotton Research Institute - Agricultural Research Center Egypt*

*** Food Technology Research Institute - Agricultural Research Center - Egypt*

ABSTRACT

This study was conducted to evaluate the physical and chemical properties of oil and some other chemical constituents of seeds in commercial and naturally brown colored Egyptian cottonseeds such as protein, gossypol, ash and moisture contents. The study also covered the determination of refractive index (RI) , saponification value (SV) , iodine value (IV) and the fatty acids profiles of cottonseed oils . The results revealed that brown cottonseed had lower values of oil content, protein content, refractive index, iodine value and linoleic acid percent. While it had highest gossypol content (5.33 %) compared with the white varieties. Giza 45 is consider the best Egyptian cotton varieties in seed oil content. The data also, clearly revealed that the chemical composition mostly differed significantly among the varieties, especially regarding the seed oil % the average ranged between 16.4 % to 24.22 %. Also, the results showed that refractive index and saponification values of cottonseed oil (CSO) had values which were very close to each other. Since, the iodine values (g I_2/g oil) ranged from 105.85 to 116.62 for the oil of brown cotton and Giza 85 variety respectively, which indicates that the oil of the Egyptian cottonseed belongs to the semi-dry oil category.

The fatty acids profile revealed that linoleic acid (C 18:2) was the major unsaturated fatty acid in all cottonseed oil, where it ranged from 45.50 % in brown cotton to 53.82% in Giza 85 variety. Meanwhile, Palmitic acid was the major saturated fatty acid which ranged from 22.23 % in Giza 85 to 25.57% in brown cotton, followed by stearic acid which was found at low percentages (less than 4%). In

addition, myristic acid was found in all samples except for Giza 45 (<1%).

Key words: Cottonseed, colored cotton, chemical composition, oil, Physical properties, chemical properties

INTRODUCTION

Cottonseeds are the best oil producing crop after soybean, palm tree and sunflower and the second best potential source of plant proteins after soybean. There is a mounting interest in cottonseed quality due to the worldwide demand for food, especially protein and oil .Hassan et al., (2005) evaluated the performance of four cultivars of Egyptian cotton, Giza 80, Giza 89, Giza 85 and Giza 90 for oil and protein % , and showed that Giza 85 exceeded the other varieties regarding oil content (22.28 %). On the other hand, a significant decrease was found regarding Giza 89 which gave the lowest oil content (20.56 %).

Regarding protein % character, the highest value (24.28 %) was obtained by Giza 90 among the examined cultivars, but Giza 85 and Giza 89 gave the lowest protein % (21.21% and 21.25%, respectively) and the differences between Giza 90 and both Giza 85 and Giza 89 genotypes were significant. Amal (2003) found that oil and protein % of brown cottonseed were 16.4 % and 18.7 % respectively, on average they were obviously lower than those components of either Giza 80 (21.8 % oil and 20.8 % protein) or Giza 89 (22.6 % oil and 19.9% protein), while gossypol content (mg /g) for cottonseed of brown cotton was on average 5.27 % which was higher than those of both Giza 80 and Giza 89 (4.04 % and 4.14 % respectively). Gossypol, produced in the seeds of the cotton plant, is a naturally occurring toxin that deters insect and pests.

Foodstuffs containing gossypol provided to animals would cause harmful effects such as growth depression, reproductive disease and intestinal and other internal organ abnormalities (Berardi and Goldblatt, 1980). The negative effect of gossypol on animal health has long been recognized, and the toxic effects of gossypol are much greater for non-ruminants than ruminants due to binding of free gossypol to soluble proteins in the ruminant. Therefore, free gossypol will not cause harm to animals if it is transformed into bound gossypol, because bound gossypol cannot be absorbed through digestive tract. Cottonseed oil, like most vegetable oils, is composed

mostly of triglycerides, which are three fatty acids attached to a glycerol backbone. General characteristics are shown in Tables (A) and (B). Besides triglycerides, crude cottonseed oil contains other components found in crude vegetable oils such as phospholipids, tochopherols, sterols, gossypol and cyclopropenoids.

Table (A) Some physical and chemical characteristics and fatty acids composition of cottonseed oil

Characteristic	Value
Specific gravity (25 °C)	0.016 -0.918
Iodine number	109 - 102
Refractive Index (50 °C)	1.4626 - 1.4652
Saponification number	189.4 -194.6
Acetyl value	9.7 - 12.2
Cloud point (°C)	1 - 3
Smoke point (°C)	232.2
Flash Point (°C)	343.1
Fatty acids composition (% wt):	
C14:0, Myristic	0.5 - 1.5
C16:0, Palmitic	20 - 27
C16:1, Palmitoleic	0.6 - 0.8
C18:1, Stearic	1 - 3
C18:2, Linoleic	42 - 54
C18.3, Linolenic	0.2
C20:0, Arachidic	0.2

(Cited from, Wayne 1999).

Table (B) The degree of saturation and unsaturation of fatty acid composition of some fats and oils

Oil / Fat	% Saturated	% Monounsaturated	% Diunsaturated	% Triunsaturated
Canola	6	58	26	10
Cottonseed	27	19	54	-
Safflower	9	13	78	-
Sunflower	11	20	69	-
Corn	13	25	61	1
Olive	14	77	8	1
Soybean	15	24	54	7
Peanut	18	48	34	-
Lard	41	47	11	1
Palm	51	39	10	-
Butterfat	66	30	2	2
Coconut	92	6	2	-

(Cited from, Wayne 1999).

The objective of the present study is to evaluate the physical and chemical properties of oil and some other chemical composition of commercial and naturally brown colored Egyptian cottonseeds.

MATERIALS AND METHODS

This study was carried out on naturally brown colored cotton and six commercial Egyptian cottonseed varieties i.e. Giza 45, Giza 70, Giza 86, Giza 85, Giza 89, and Giza 80. These varieties were obtained from the Cotton Research Institute, Agricultural Research Center, Giza, Egypt. The chemical composition of Egyptian cottonseeds: oil (%), protein (%), and gossypol (%) were determined according to A.O.A.C. (2000). The statistical procedures outlined by Little and Hills (1978) were applied to the data obtained in this study

Determination of Physical and chemical properties of cottonseed oil

Oil was extracted from cottonseeds after ground and soaking twice in hexane. The collected solvents were evaporated under vacuum and the obtained oil was kept at -4°C in dark bottles till analysis. Then neutralization of cottonseed oil was carried out with 16 % excess alkali. The mixture was stirred for 20 min. at 65 °C. The soap stock was removed by centrifugation at 4000 rpm, and the refined oil was washed thoroughly with cold water to get soap-free oil (Sarkar and Bhattacharyya, 1991). For bleaching, the crude cottonseed oil was stirred and heated together with 0.8 g of bleaching earth (2% wt. of oil) in a rotary evaporator at 100°C in a hot water bath under reduced pressure for 20 min. The oil then was felted to remove bleaching earth (Gnanasambandam and Proctor, 1997). Refractive index (RI), Saponification and iodine values of cottonseed oil were determined according to the method described in A.O.A.C. (2000).

Gas chromatographic analysis of cottonseed oil fatty acids

Samples of cottonseed oil, (about 10 mg), were dissolved in 2ml hexane and then 0.4ml 2N KOH in anhydrous methanol was added (Cossignani et al., 2005). After 2 min., 3ml water was added. The organic layer, separated by centrifugation, was dried over anhydrous sodium sulfate, then concentrated with a N_2 stream to about 0.5 ml for GC analysis of fatty acids methyl esters (FAME) as described below, using Agilent 6890 series GC apparatus provided with a DB-23 column (60m x 0.32mm x 0.25mm). Fatty acids products after the

previous procedures steps were dreviitised to methyl esters and directly injected into the GC. Carrier gas was N_2 with a flow rate of 2.2 ml/min, and splitting ratio of 1:80. The injector temperature was 250°C and that of FID detector was 270°C. The oven temperature settings were as follows: 150° to 225°C at a rate of 5 °C / min, and then held at 225°C for 20 min (Villeneuve et al., 2007).

RESULTS AND DISCUSSION

Chemical compositions of commercial and brown cottonseed varieties

The data of Table (1) and Figure (1) illustrate the average values of cottonseed chemical composition i.e. oil %, protein %, gossypol %, ash % and moisture % of different Egyptian cotton varieties. These data clarified that the studied chemical composition mostly differed significantly among the cotton varieties used in the study.

However, the Egyptian cotton varieties, Giza 45 and Giza 85 attained the highest values of oil % (no significant difference between them), Giza 86 gave the highest value of protein content, brown cotton had the highest gossypol content, and Giza 89 had the highest ash %, while both Giza 70 and Giza 85 gave the highest moisture content. On the other hand, the least values of oil %, protein %, and moisture % were found in brown cotton, while the least values of gossypol %, and ash % were found in Giza 86 and Giza 70, respectively.

Table (1) Average values of chemical compositions of different Egyptian cottonseed varieties

Variety	Oil %	Protein %	Gossypol %	Ash %	Moisture %
Giza 45	24.22[a]	20.62[d]	3.70[e]	4.5[d]	5.5[d]
Giza 70	20.87[d]	22.75[b]	4.36[c]	4.3[f]	7.0[a]
Giza 86	22.04[b]	23.21[a]	3.09[g]	4.9[c]	6.5[c]
Giza 85	24.11[a]	21.50[c]	4.03[d]	5.2[b]	7.0[a]
Giza 89	21.00[d]	19.92[e]	4.65[b]	5.8[a]	5.3[e]
Giza 80	21.54[c]	20.44[d]	4.13[c]	4.4 de	6.8 b
Brown cotton	16.40[g]	18.70[g]	5.33[a]	4.6 d	6.9 ab
L.S.D. 0.05	0.3073	0.2677	0.1119	0.175	0.175

L.S.D. 0.05 % = Least significant difference at 0.05 % level.
Means with the same letter (a,b,c, ...) are not significantly different.

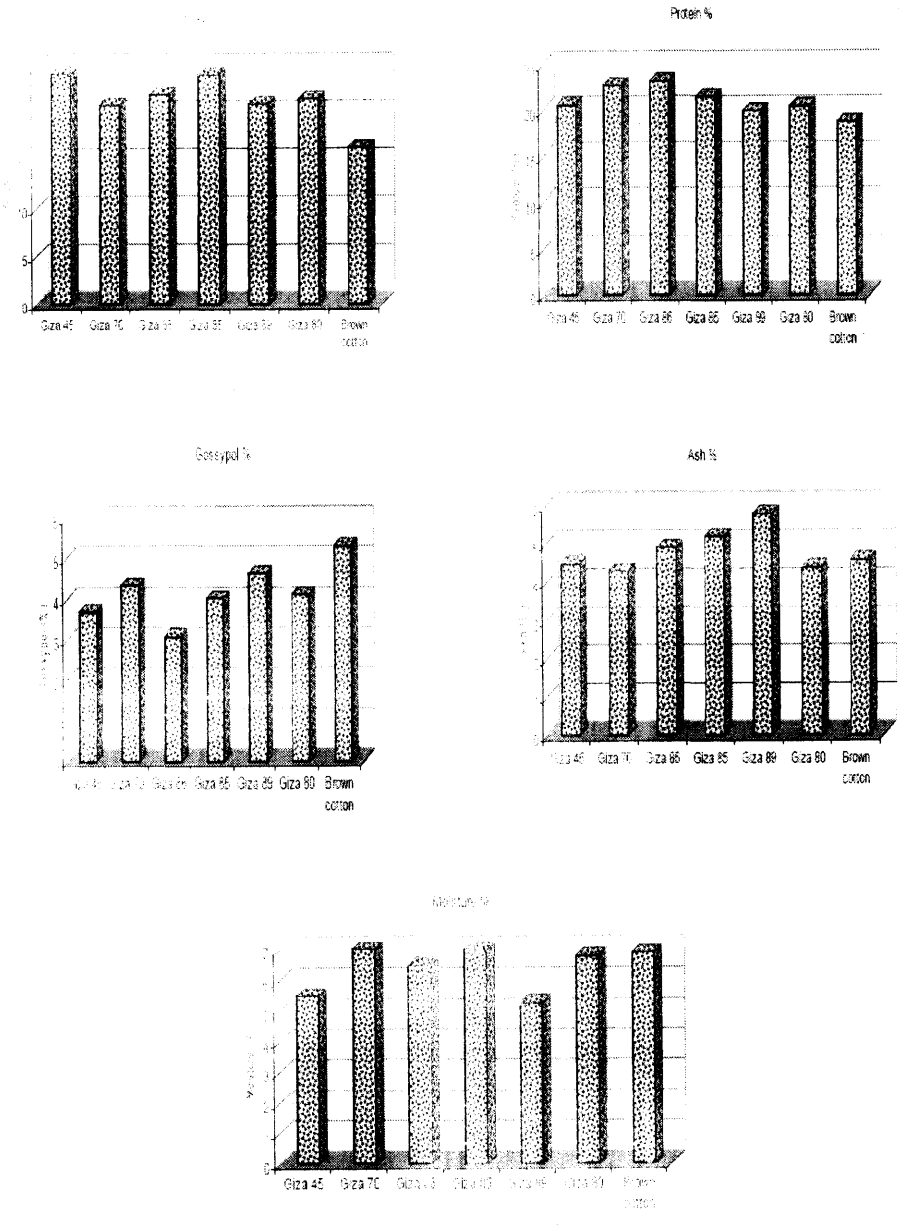

Fig. (1): The chemical compositions for different Egyptian cottonseed varieties.

It is rather interesting to note that, brown cottonseed had lower oil and protein content of 16.0 % and 18.7 % respectively along with the highest gossypol content of 5.33 % compared with the commercial varieties.

It is worthwhile to mention that Giza 45 is consider as one of the best world cottons, if not the best at all. Its fibers are known all over the world as extra-long staple and extra fine. In Addition the present study further clarified that Giza 45 is also consider the best Egyptian cotton varieties in seed oil content. So, its recommend that cotton breeders should pay more attention to develop high oil content cotton varieties, alongside high yield and high fiber quality.

Physical and chemical properties of cottonseeds oil

The extracted oil from all cottonseed types was neutralized, bleached to reach nearly 0.1% free fatty acids as (oleic acid) and zero peroxide value (meq O2/Kg oil). Refractive index at 25°C, iodine value and saponification values were determined for the above mentioned oils varieties and the obtained results are shown in Table (2)

Table (2) Physical and chemical properties of cottonseed oil for different Egyptian cotton varieties

Physical and chemical properties	Giza 45	Giza 70	Giza 85	Giza 86	Giza 89	Giza 80	Brown Cotton
Refractive index at 25°C	1.4707	1.4704	1.4706	1.4712	1.4704	1.4704	1.4699
Iodine value	112.31	109.61	111.50	116.62	110.29	109.65	105.85
Saponification value	197.17	198	197.79	197.42	197.26	198	197.17

Results in Table (2) clearly showed that each of refractive index and saponification value of cottonseed oil (CSO) had values which were very close to each other. However the iodine values (g I2/g oil) ranged from 105.85 to 116.62 for the oil of brown cotton and Giza 85 variety respectively, which indicates that the oil of the Egyptian cottonseed belongs to the semi-dry oil category (Aplewhite 1985).

It is worthwhile to mention that the changes in the physical and chemical properties (refractive index, iodine value and saponification value) of cottonseed oil could be attributed to the changes in the fatty acids percentages of the cottonseed oil of the different cotton types.

These results are in accordance with the Egyptian Standards (1993) and Codex Alimentarius (2005) for cottonseed oil.

Fatty acids of Egyptian cottonseed oil

Gas liquid chromatography technique was employed to study the composition of the cottonseed oil fatty acids. The data of the percentages of the identified fatty acids are shown in Table (3). From the Table it could be noticed that linoleic acid (C 18:2) was the major unsaturated fatty acid in all cottonseed oil, where it ranged from 45.50 % in brown cotton to 53.82% in Giza 85 variety. Meanwhile, Palmitic acid was the major saturated fatty acid which ranged from 22.23 % in Giza 85 to 25.57% in brown cotton, followed by stearic acid which was found at low percentages (< 4%). In addition, myristic acid was found in all samples except for Giza 45 (< 1%). Palmitoleic acid was found only in the oil of Giza 86, Giza 70, Giza 89 and brown cotton types. It ranged between 0.63 % and 0.98 % for Giza 86 and Giza 89 varieties respectively.

Also, it could be noticed that linolenic was found only in Giza 89 and brown colored cotton in small amounts of 0.61% and 0.84%, respectively. The percent of saturated fatty acids ranged from 24.93 % (Giza 85) to 29.50 % (Giza 89) while, the unsaturated fatty acid ranged from 70.47 % (Giza 89) to 74.95 % (Giza 85). These results are within the limits of the Egyptian Standards for the cottonseed oil (1993) and Codex Alimentarius (2005).

Table (3): Fatty acids profile of Egyptian cottonseed oil

Samples / Fatty acid	Giza 45	Giza 70	Giza 86	Giza 85	Giza 89	Giza 80	Brown cotton
Myristic 14:0	-	0.67	0.62	0.60	0.71	0.79	0.73
Palmitic 16:0	22.63	24.75	23.61	22.23	25.25	25.15	25.57
Palmitoleic 16:1	-	0.70	0.63	-	0.98	-	0.75
Stearic 18:0	3.09	2.82	2.96	2.21	2.53	2.76	3.20
Oleic 18:1	24.51	21.04	21.22	21.13	19.88	21.51	23.38
Linoleic 18:2	49.77	50.00	50.95	53.82	50.03	49.79	45.50
Linolenic 18:3	-	-	-	-	0.61	-	0.84
Saturated fatty acids	25.72	28.24	27.19	24.93	29.50	28.7	28.51
Unsaturated fatty acids	74.28	71.74	72.80	74.95	70.47	71.30	71.50

CONCLUSION

Brown cottonseed had lower values of oil content, protein content, refractive index, iodine value and linoleic acid percent. While it had highest gossypol content 5.33 % compared with the white varieties. As known Giza 45 is consider as one of the best world cottons, if not the best at all. Its fibers are known all over the world as extra-long staple and extra fine. In addition of that the present study further clarified that Giza 45 is also consider the best Egyptian cotton varieties in seed oil content.

The data clearly revealed that the chemical composition mostly differed significantly among the varieties, specially regarding the seed oil % the average ranged between 16.4 % to 24.22 % .However the economical studies referred to that for each one percent increase in seed oil , the national income would increase about more than ten million Egyptian pounds. Hence it seems rational to recommend that cotton breeders should pay more attention to develop cotton varieties of high oil content in the seeds, alongside high yield and high fiber quality.

Refractive index and saponification value of cottonseed oil (CSO) had values which were very close to each other. Since, the iodine values of Egyptian cottonseed oils belongs to the semi-dry oil category .Fatty acids profile of Egyptian cottonseed oil showed that the linoleic acid (C 18:2) was the major unsaturated fatty acid, while, the palmitic acid was the major saturated fatty acids .

REFERENCES

Amal,S. M. (2003). Study on naturally brown colored cotton. Egyptian Journal of Applied Sciences, 18 (8): 148-157, (2003).

A.O.A.C. (2000). Official Methods of Analysis of the Association of official Analytical Chemists, 17th ed., edited by W.Hormitz, A.O.A.C., Washington, D.

Aplewhite,T. H. (1985).Bailey's Industrial Oils and Fat Products. Vol. 3. Jan Wiley and Sons, Inc. New York.

Berardi. L.C., and Goldblatt ,L.A. (1980). Gossypol. In: Liener, I.E. (Ed.), Toxic Constituents of Plant Foodstuffs; Second ed. Academic Press, New York, pp. 183-237.

Codex Alimentarius (2005) Codex Standard For Named Vegetable Oils, Codex Stan 210-2005, p. 1-13.

Cossignani,L., Simonetti,M. S. and Damiani,P. (2005). Biocatalyzed acidolysis of olive triacylglycerols with 9c,11t and 10t,12c isomers of conjugated linoleic acid. Eur. Food Res. Techol.,220, 267-271.

Egyptain Standard (1993). Vegetable edible oils. Edible cottonseed oil, No.49.Egyptain Organization for Standardization and Quality Control.

Gnanasambandam, R. and Proctor, A. (1997). Soy hull as an adsorbents source in processing soy oil. JAOCS., 74 (1),685-692.

Hassan, I., Amal, S. M. and Laila, M. A. (2005). Comparative study on seed cotton yield, oil and protein contents in the seed of some Egyptian cotton cultivars grown at different locations, Egypt Journal of Agriculture Research , 83 (2): 735-750.

Little, T.M. and Hills, F.J. (1978). Agricultural Experimentation design and analysis. John Wiley and Sons. New York, Chichester, Brisbane, Toronto pp. 350.

Sarkar,S. and Battacharyya,D.K. (1991). Nutrition of rice bran oil in relation to its purification . JAOCS., 68 (12). 956-962.

Villeneuve, P., Barouh, N., Barea, B., Piombo, G., Figueroa-Espinoza, M.C., Turon,F., Pina,M. and Lago,R. (2007). Chemoenzymatic synthesis of structured triacylglycerols with conjugated linoleic acids (CLA) in central position. Food Chemistry, 100, 1443-1452.

Wayne, C. S. (1999). Cotton : Origin, history, technology and production, Chapter 4.5 (cottonseed processing). ISBN 0-471-18045-9, John Wiley & Sons. Inc. USA.

دراسة على الزيت والتركيب الكيماوى لبعض اصناف القطن المصري التجارية و القطن الملون البني

أمل صابر محمد* ، عصام محمود محمد، منير محمد عيد****

* معهد بحوث القطن - مركز البحوث زراعية

** معهد بحوث تكنولوجيا الاغذية - مركز البحوث زراعية

إنّ هدفَ هذا البحثِ إجراء دراساتٌ كيميائية مقارنة على بذور القطن المصرى البيضاء والمُلوّنة ، ودراسة خواص زيوتها الطبيعية والكيميائية . و أجريت هذه الدراسة على بذرة القطن البني و كذلك على بذور ستة أصناف من أصناف القطن المصري التجارية وهم جيزة 45، جيزة 70، جيزة 86، جيزة 85، جيزة 89، وجيزة 80. واجرى تحليل التركيب الكيميائي لهذه البذور ، حيث تم تقدير النسبة المئوية للزيت ، بروتين ، الجوسيبول و كذلك قدرت خواص الزيت الطبيعية والكيميائية مثل معامل انكسار الزيت ،و رقم التصبن و قيم الرقم اليودى و أيضا قدرت مكونات الزيت من الأحماض الدهنية .

و قد أوضحت النتائج ما يلى:

1. أنّ التركيب الكيميائيّ إختلف في الغالب بشكل ملحوظ بين الاصناف المختلفة دلالة على وجود فروق صنفية بين هذة التنوعات.
2. بذرة القطن الملون البنى وجد انها أقل الاصناف فى محتواها من الزيت والبروتينُ والرطوبة و لكنها الاعلى فى محتوى الجوسيبرل مقارنا بالاصناف البيضاء.
3. الصنف جيزة 45 المعروف بانة أحد أفضل أقطان العالم، إن لم يكن افضلهم، حيث عَرفت أليافه بانها فائقة الطول وفائقة النعومة. يعتبرُ ايضا أفضل اصناف القطن المصري في محتواها من زيت البذرة . و عموما قد تراوحت النسبة المئوية للأصناف المختلفة من 16.4 % إلى 24.22 %.
4. أظهر الصنف جيزة 86 أعلى محتوى من البروتين ، و الصنف جيزة 89 كانَ اعلى الاصناف فى محتواه من الرمادُ ، بينما الصنفان جيزة 70 و جيزة 85 أعلى الاصناف فى محتوى الرطوبة.

5. أقل قيم للجوسيبول و الرماد وجدت في بذور الصنفين جيزة 86 و جيزة 70 على التوالي.

6. ان قيم معامل الانكسار والرقم اليودى و نسبة حامض اللينوليك فى زيت بذرة القطن الملون البنى أقل مقارنه بالاصناف البيضاء. وعموما وجد أن معامل الانكسار لزيت بذرة القطن يتَراوحَ منْ 1.4699 إلى 1.4712 للصنفين جيزة 85 و جيزة 86. ووجد أيضا أن قيمة الرقم اليودَى لزيت البذرة تَراوحَ منْ 105.85 إلى 116.62لزيت الصنف جيزه 89 وجيزة 85 على التوالي، و يُشيرُ ذلك الى أنَ زيت بذرةِ القطن المصرية من انواع الزيوت النصف جافة . بينما قيم رقم التصبن لزيت بذرة القطن كانتْ تقريباً واحدة للاقطان البيضاء أو الملونة.

7. وجد أن الحامض الدهنى اللينوليك (2:18) هو الحامض الدهنى غير المشبع الاساسى فى زيت بذرة جميع أصناف القطن المصرى حيث تراوحت نسبتة من 45.50 % في القطن البنى إلى 53.82 % للصنف جيزة 85 . بينما وجد أن حامض البالميتك هو الحامض الدهنى المشبع الاساسى فى زيت بذرة جميع أصناف القطن المصرى حيث تراوحت نسبتة من 22.23 % في الصنف جيزة 85 إلى 25.57 % في القطن البنى .