

PHYSICAL CHARACTERISTICS OF WHEAT GRAINS

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ABSTRACT

Physical characteristics of wheat grains of three varieties, Giza-168, Sakha-93 (white wheat) and Banisuife-1 (durum) at different levels of moisture contents (% w.b) were investigated.

Physical characteristics included dimensions, sphericity, weight of one thousand grains, particle and bulk density, porosity, angle of repose and static coefficient of friction on four different surfaces (plywood, galvanized iron, stainless-steel and rubber-sheet) at four different levels of moisture content ranged from (9 to 18% w.b). Each of major dimensions, sphericity, weight of one thousand grains, dynamic angle of repose and static coefficient of friction appeared a linear increasing with increasing the moisture content, while both bulk and particle densities decreased linearly in the studied range. As for porosity of wheat grains of Giza-168 and Banisuife-1, it increased linearly with increasing grains moisture content while the porosity of Sakha-93 variety showed a negative relationship.

INTRODUCTION

Wheat is classified according to properties of resulting flour to hard red spring, durum, hard red winter, soft red winter and soft white wheat. Hard red spring wheat and hard red winter wheat are preferred for making bread; durum wheat is preferred for making the various types of pasta, while soft red winter wheat and soft white wheat are preferred to making the biscuits and cakes (**Ismail 2001**). Egypt produce yearly about 7.2 million ton from wheat. The total cultivated area of wheat grains in Egypt is about 2.6 million Feddan, and the average yield rate is about 2.755 ton/ Fed. (**Agric. stat. Winter crops, 2004**).

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Data on physical properties of agro-food materials are valuable because: they are needed an input to models predicting the quality and behavior of produce in pre-harvest, harvest, and post-harvest situations; and aid the understanding of food processing. (*Nesvadba, et. al. 2004*) Physical characteristics of the material such as shape, size, volume, density , surface area and coefficient of friction are important and essential engineering data in design of machine, structures, and controls; in analyzing and determining the efficiency of a machine or an operation; and in evaluating and retaining the quality of the final product (*Mohsenin, 1986*) Generally, the physical properties of grains are essential for the design of equipment for handling, harvesting, aeration, drying, storing, dehulling and processing. These properties are affected by numerous factors such as size, form, superficial characteristics and moisture content of the grain (**Baumler, E., et.al. 2005**)

The aim of this investigation was establishing a database on the physical characteristics related to handling and milling as a function of moisture content for three new varieties of Egyptian wheat grains including Giza-168, Sakha-93 and Banisuif-1.

MATERIALS AND METHODS

Seeds Samples :

Three varieties of wheat grains were selected based on their higher recent coverage area and production rate according to Ministry of Agriculture yearly Agricultural Statistics of 2004. These varieties were Giza-168, Sakha-93(white wheat) and Banisuif-1 (durum). All varieties were obtained directly after harvesting by combine machine of the 2006 crop. The samples of Giza-168 and Sakha-93 varieties were 100kg each of variety; they were procured from the experimental farm of Sakha Research Center at Kafer El Sheikh Governorate. While, sample of Banisuif-1 variety (100kg) was procured from the experimental farm of Sids Agricultural Research Center at Bani-Suif Governorate.

The wheat seeds samples were cleaned to remove all foreign materials and each variety was divided into four samples each of 25 kilograms randomly in order to obtain four different levels of moisture content. The seeds desired moisture content levels were achieved by natural drying on

the benches in laboratory room or by moistening the seeds using a calculated amount of distilled water and mixed together to achieve the desired higher moisture content level. The moistening of grains is a very sensitive and must be done under control, the rapid moistening cause grains cracks. For that, the process of moistening of several samples of wheat grains was done in steps each step rise the grain moisture content in the range of 1 % daily. The sample of wheat grains was packaging in double plastic bags and stored in cold room at $5 \pm 1 \text{ C}^\circ$ (Nelson,1980 and Sacilik,2003). Before each test or measurement, the required sample of seeds was taken out from the cold room and kept sealed in the laboratory room and was allowed to warm up to the room temperature. The moisture content of each sample was determined again before each experiment. The moisture content of seeds was determined using the standard method, (ASAE Standards,1992).

Dimensional Characteristics:

Randomly samples of one hundred seeds were taken out from each variety for each level of moisture content. The three major dimensions length (L), breadth (B), and thickness (T) of each seed in the sample were measured using the digital caliber YATO model No.YT203 with an accuracy 0.01mm.

The equivalent diameter (D_e) and sphericity (S) of seed were calculated by using the following relations (Sahay and Singh, 1994)

$$D_e = (L \times B \times T)^{1/3} \quad . \quad S = \frac{D_e}{L}$$

Weight of one thousand grains:

A randomly sample of one thousand seeds were taken by seed counter and weighed by an electric digital balance METTLER-AE200 with maximum capacity 200 g and accuracy 0.001g. The weight of each test was repeated ten replicates. (Karababa, 2005)

Bulk density:

The bulk density was determined by filling a graduated cylinder of 500 ml with the seeds from a height of 15cm at constant rate, and the base of the cylinder was tapped a dozen times on a table (Boumans,1985). Then, the cylinder was refilled again to its maximum reading (500 ml), the

sample was weighed and the bulk density was calculated (kg/m^3). Each test was done in ten replicates.

Particle density:

The particle density was determined by measuring the actual volume of a known weight of a random seeds sample. The actual volume of the seeds was determined using the toluene displacement technique (**Matouk,et,al, 2004**). The particle density for each wheat variety at each level of moisture content was including ten replicate

Angle of repose:

The angle of repose of the wheat grains was measured using the apparatus developed by **Soliman (1994)** and fabricated locally. The dynamic angle of repose was the measured angle between the horizontal and the natural slope of the seeds heap. The height of the heap was measured and the dynamic angle of repose was calculated by the following relationship

$$\theta = \tan^{-1}\left(\frac{2H}{Dp}\right) ,$$

Where : θ = dynamic angle of repose, degree.

H = heap height, cm and

Dp = platform diameter, cm.

The dynamic angle of repose for each level of moisture content of each wheat variety was including ten replicates.

3.7.Static Friction Coefficient:

A static friction coefficient measuring apparatus as described by **Soliman, N. S. 1983** was designed and fabricated as shown in figure (2) with the box dimensions 26 x 21 x 9 cm to measure the angle of static friction for grains at each moisture content level of wheat varieties on four different materialsurfaces namely plywood sheet, galvanized iron sheet, stainless steel sheet and rubber sheet. The angle of inclination (α) was recorded and the static coefficient

of friction (μ) was calculated by the

following equation $\mu=\tan \alpha$. The angle of friction (α) was measured ten times for each selected materials, each level of moisture content and for each wheat varieties

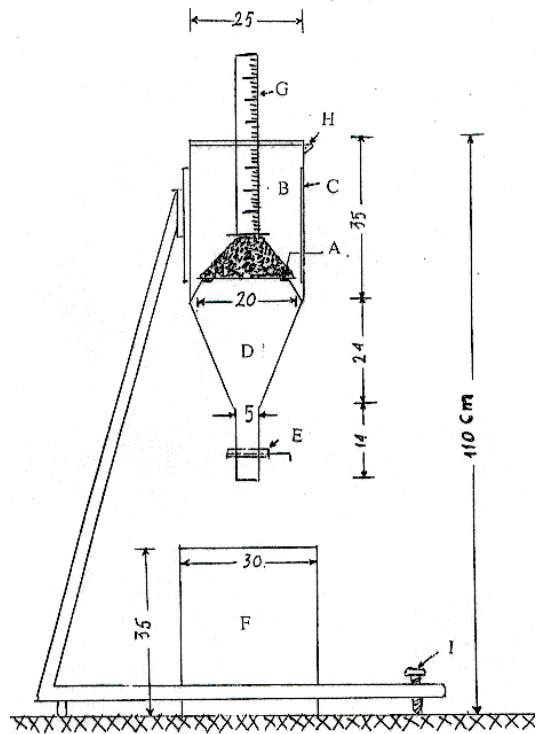


Figure (1): Angle of repose measurement apparatus

- A- Platform B - Container C- Glass window
 D- Discharge Funnel E - Sliding Gate F- Receiving Container
 G- Measuring Scale H - Water Level indicator I - Level Screw

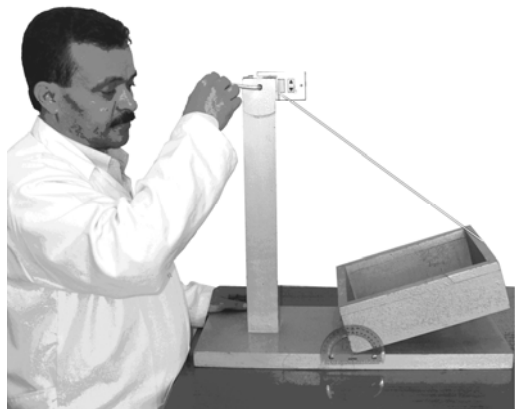


Figure (2): Static friction coefficient measurement apparatus.

RESULTS AND DISCUSSION

Firstly technological characteristics and chemical analysis of the three wheat grains varieties under study were conducted in Banisuif governorate, Sidse station, cereal technology laboratory as an average of five replicates as shown in table (1):

Table (1) :Chemical analysis and technological characteristics of studied wheat varieties.

Items	Giza -168	Sakha - 93	Banisuif-1
Transparency	7	0	41
Total Extraction	68.00	70.50	77.10
Semolina Extraction			69.0
Protein %	12.57	11.17	11.81
Ash %	2.00	1.50	1.28
Fiber %	2.30	1.60	1.35
Gluten Wet %	19.47	17.68	19.67
Gluten Dry %	6.86	5.70	6.85
Farinograph Water absorption% Consistency, minute	60.82	57.62	315

Dimensional Characteristics:

The measurements of length (L), breadth (B) and thickness (T) in (mm) of hundred grains randomly selected from each moisture level samples for the investigated grains varieties were conducted. The sphericity (S, %) of each grain were calculated.

Regression statistical analyses were conducted to clarify the relationship between each item of physical dimensions and actual moisture content. The regression appeared a linearly dependent on the moisture content. (w.b):

For Giza-168 variety:

$$L = 5.6050 + 0.0439 Mc \dots\dots\dots R^2 = 0.985$$

B	=	2.9833	+	0.0419	Mc	.....	R ² = 0.962
T	=	2.4899	+	0.0318	Mc	.....	R ² = 0.835
S	=	61.2786	+	0.1774	Mc	.....	R ² = 0.891
For Sakha-93 variety:							
L	=	5.8051	+	0.0796	Mc	.....	R ² = 0.857
B	=	2.8127	+	0.0592	Mc	.....	R ² = 0.803
T	=	2.6002	+	0.0401	Mc	.....	R ² = 0.744
S	=	59.6025	+	0.1177	Mc	.....	R ² = 0.662
For Banisuif-1 variety:							
L	=	7.0744	+	0.0473	Mc	.....	R ² = 0.965
B	=	3.1595	+	0.0293	Mc	.....	R ² = 0.836
T	=	2.9230	+	0.0262	Mc	.....	R ² = 0.820
S	=	56.1853	+	0.0730	Mc	.....	R ² = 0.765

The above equations showed that the dimensional characteristics for the studied grains increased as the moisture content was increased at the studied range.

The dimensions for Sakha-93 variety showed the highest values of change. The length changed from 6.60 to 7.20 mm, breadth changed from 3.43 to 3.80 mm and thickness changed from 3.01 to 3.31 mm for increasing grain moisture content from 9.89 to 17.51% (w.b). While, Banisuif-1 variety showed the lowest values of change. The length changed from 7.46 to 7.86mm, width changed from 3.41 to 3.66mm and thickness changed from 3.15 to 3.37mm for increasing grain moisture content from 8.70 to 17.42% (w.b).

The results showed that the relationship between dimensional characteristics and moisture content of the studied wheat grains were suggested in trend with the results of Matouk, 2004 which work on different cereals as parlay, rice, wheat and corn, Al-Mahasneh and Rababah 2006 which worked on green wheat, Soliman 1994 which measured the dimensions of different paddy rice varieties and its products and Karababa, E. 2005 which worked on popcorn.

The results indicated that Banisuif-1 variety have the highest dimensions (L, B and T) followed by Sakha-93 and the lowest dimensions was of Giza-168. While, Giza-168 variety showed the highest sphericity followed by Sakha-93 and the lowest sphericity was of Banisuif-1 variety.

Weight of 1000 grains:

The measurements of weight of one thousand grains of different wheat varieties under study were conducted in ten replicates for each moisture level. The dry matter weight of 1000 grains for wheat variety Giza-168, Sakha-93 and Bani-Suif-1 were 41.706 ± 1.05 , 49.406 ± 2.15 and 55.919 ± 1.88 g respectively. As shown in figure (3); the weight of 1000 grains appeared to be linearly dependent on the moisture content. The following linear regression equations described the relationship between weight of one thousand grains (W_{1000} - g) and their moisture contents in percent (w.b):

For Giza-168 variety:

$$W_{1000} = 40.1525 + 0.6035 \text{ Mc} \dots\dots\dots R^2 = 0.883$$

For Sakha-93 variety:

$$W_{1000} = 41.3420 + 1.1808 \text{ Mc} \dots\dots\dots R^2 = 0.957$$

For Banisuif-1 variety:

$$W_{1000} = 51.2248 + 1.0119 \text{ Mc} \dots\dots\dots R^2 = 0.946$$

Bani-Suif-1 variety recorded the highest weight of one thousand grains which varied from 60.175 to 69.125 at moisture content changed from 8.7 to 17.42 % (w.b). Sakha-93 variety recorded the medium values of weight of one thousand grains which varied from 53.13 to 62.14g for increasing grains moisture content from 9.89 to 17.51% (w.b). While, Giza-168 variety showed the lowest weight of one thousand grains which varied from 45.71 to 50.48 g for increasing grain moisture content from 9.39 to 17.25% (w.b). The results showed that the highest weight of one thousand grains was for Banisuif-1 variety followed by Sakha-93 and the lowest weight of one thousand grains was for Giza-168.

The results which obtained in this study agreed with experimental data of (*Matouk, et, al 2004*) for some Egyptian wheat varieties, (*Al-Mahasneh and Rababah 2006*) for green wheat kernels, (*Baryeh, E.A. 2002*) for millet, (*Amin et al 2004*) for lintel seeds, (*Altuntas 2005*) for fenugreek and (*Karababa 2005*) for popcorn.

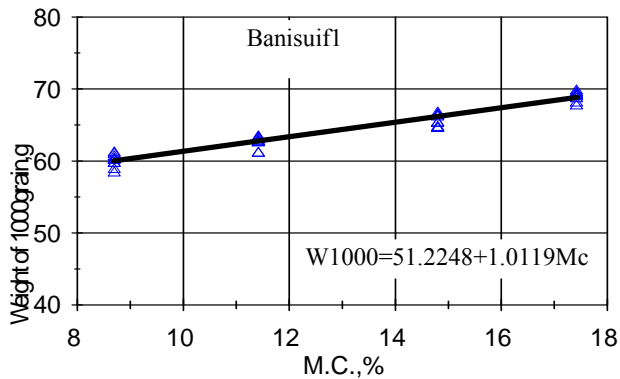
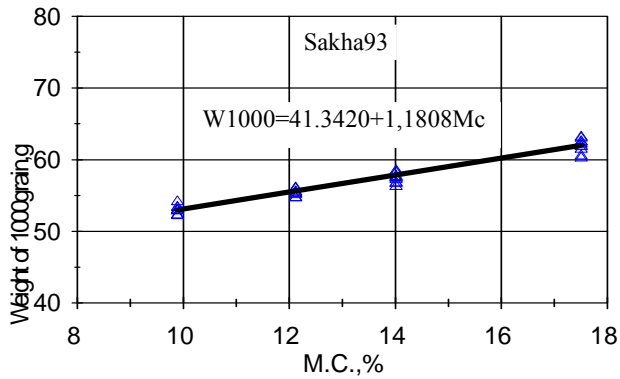
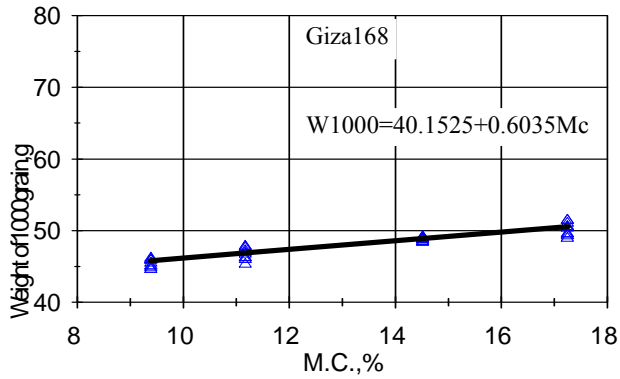


Figure (3): Effect of moisture content on weight of one thousand grains.

For Banisuif-1 variety:

ρ_b	=	976.074	-	8.6950	Mc	.....	$R^2 = 0.957$
ρ_p	=	1425.678	-	2.8256	Mc	.....	$R^2 = 0.625$
P	=	31.372	+	0.5001	Mc	.....	$R^2 = 0.987$

Bulk Density , Particle density and Porosity:

Bulk density, particle density and porosity were measured for wheat grains of the investigated varieties in ten replicate. The results as shown in figures (4, 5 and 6) were found to be dependent on moisture content. The following linear regression equations described the relationship between each of bulk density (ρ_b , kg/m³), particle density (ρ_p , kg/m³) and porosity (P, %) and the moisture content in percent (w.b):

For Giza-168 Variety:

$$\begin{aligned}\rho_b &= 891.8705 - 4.8727 \text{ Mc} \dots\dots\dots R^2 = 0.866 \\ \rho_p &= 1568.327 - 15.7885 \text{ Mc} \dots\dots\dots R^2 = 0.848 \\ P &= 43.7525 - 0.35227 \text{ Mc} \dots\dots\dots R^2 = 0.836\end{aligned}$$

For Sakha-93 Variety:

$$\begin{aligned}\rho_b &= 908.1072 - 4.2161 \text{ Mc} \dots\dots\dots R^2 = 0.756 \\ \rho_p &= 1431.787 - 4.8628 \text{ Mc} \dots\dots\dots R^2 = 0.802 \\ P &= 36.5576 + 0.08307 \text{ Mc} \dots\dots\dots R^2 = 0.855\end{aligned}$$

For Sakha-93 variety:

$$\begin{aligned}\rho_b &= 891.8705 - 4.8727 \text{ Mc} \dots\dots\dots R^2 = 0.866 \\ \rho_p &= 1568.327 - 15.7885 \text{ Mc} \dots\dots\dots R^2 = 0.848 \\ P &= 43.7525 - 0.35227 \text{ Mc} \dots\dots\dots R^2 = 0.836\end{aligned}$$

These equations showed that each of bulk density and particle density for wheat grains for the studied varieties decreased as moisture content was increased at the studied range. The porosity of Sakha-93 wheat variety has the same trend but the porosity of Giza-168 and Banisuif-1 were direct proportion with moisture content.

Banisuif-1 variety recorded the highest values of change for bulk density. It decreased from 897.40kg/m³ to 821.20 kg/m³ with the increasing of grains moisture content from 8.70 to 17.42%(w.b). While, Giza-168 variety showed the lowest values of change for bulk density. It decreased from 863.40kg/m³ to 828.20 kg/m³ with increasing of grain moisture content from 9.39 to 17.25% (w.b).

Sakha-93 variety recorded the highest values of change for particle density. It decreased from 1401.10kg/m³ to 1293.60kg/m³ with the increasing of grain moisture content from 9.89 to 17.51% (w.b). While, Banisuif-1 variety recorded the lowest values of change for particle density. It decreased from 1399.50kg/m³ to 1375.30kg/m³ with increasing of grains moisture content from 8.70 to 17.42% (w.b). Similar results reported for some Egyptian wheat varieties (*Matouk et al 2004*), hard red winter wheat (*Nelson 1980*) and green wheat kernels (*Al-Mahasneh and Rababah,2006*).

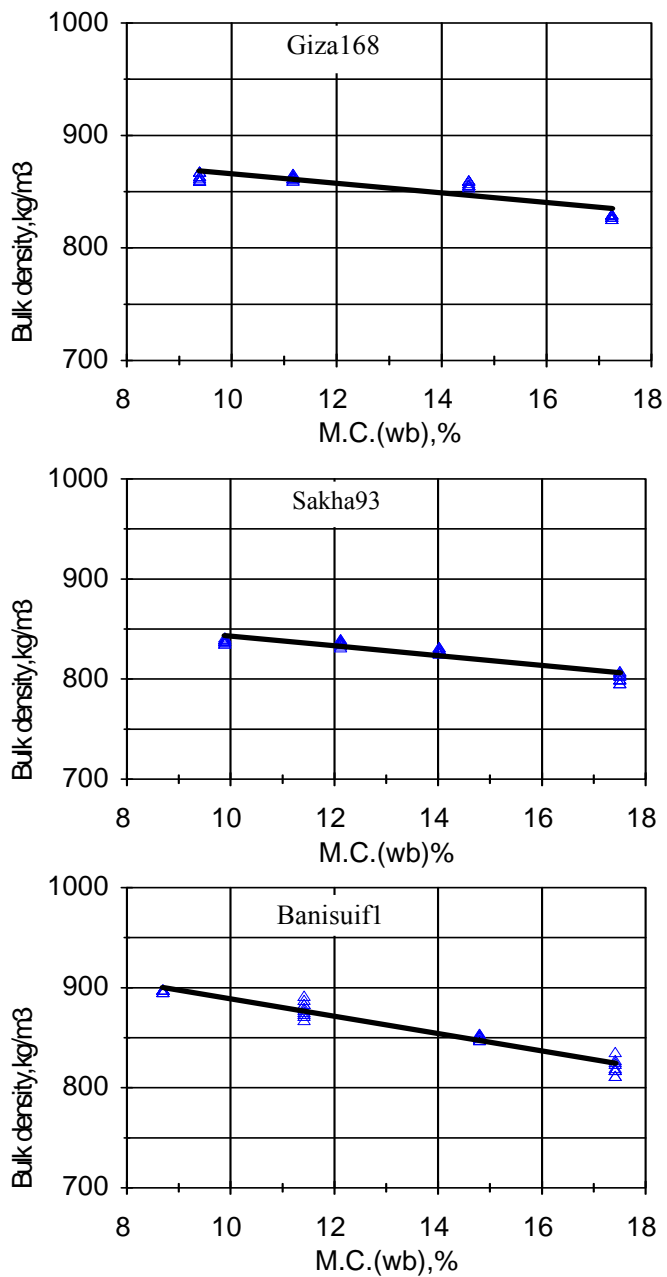


Figure (4): Effect of moisture content on bulk density of wheat grains

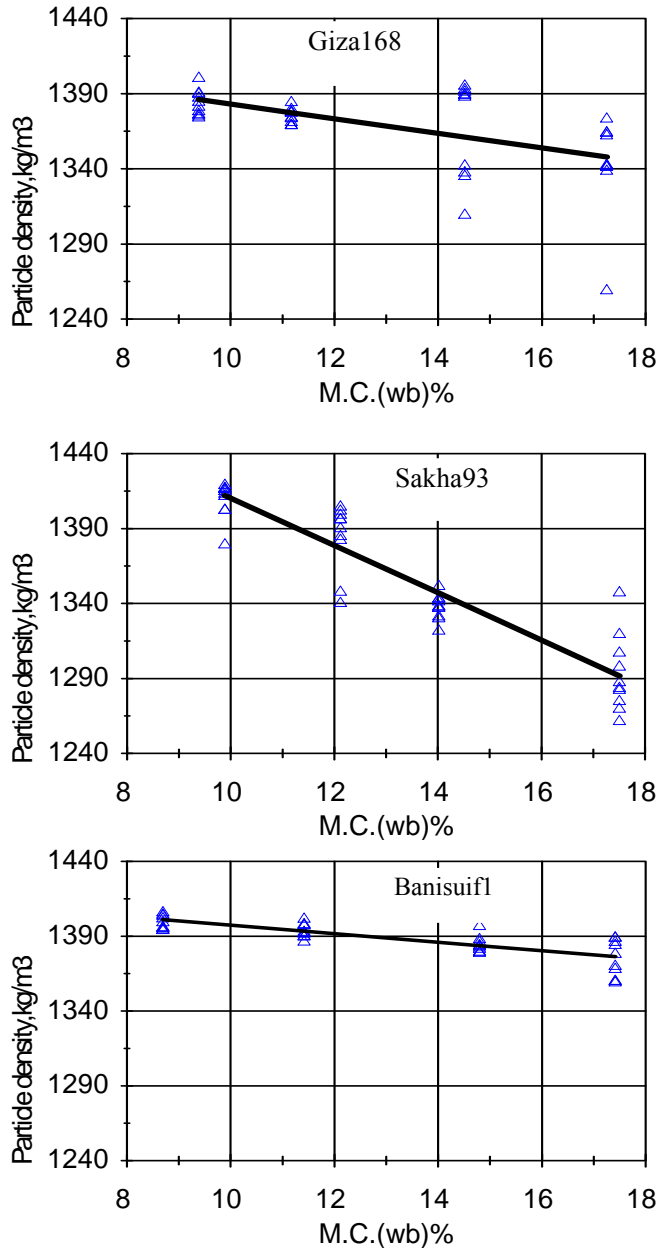


Figure (5): Effect of moisture content on particle density of wheat grains

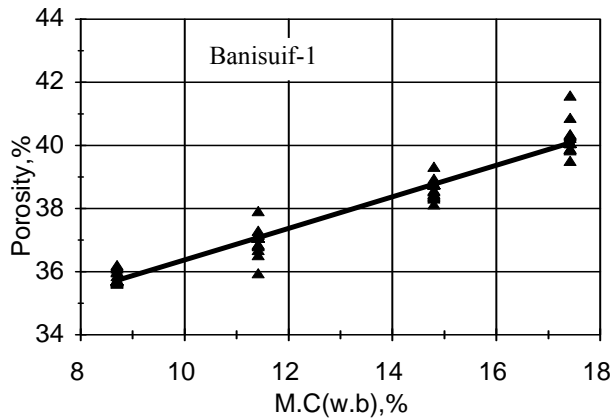
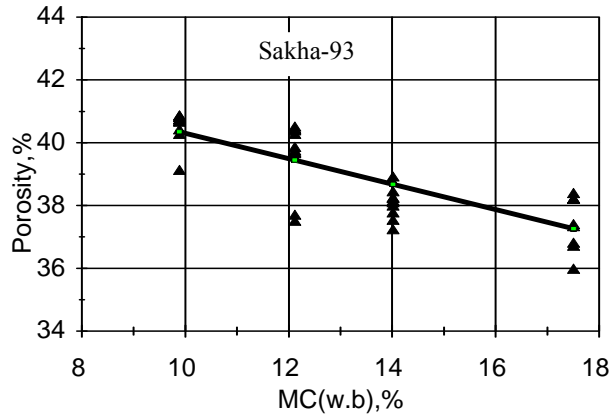
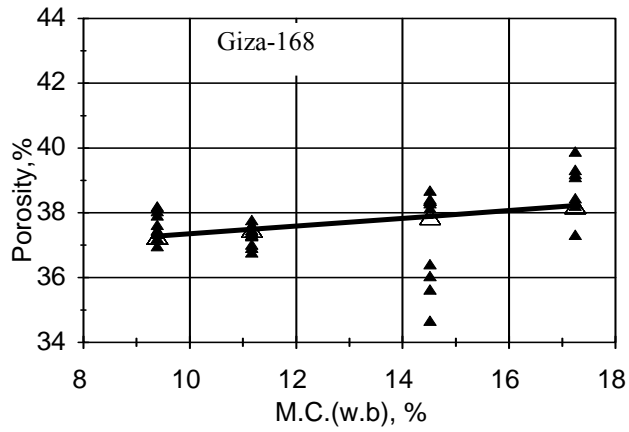


Figure (6): Effect of Moisture Content on Porosity of Wheat Grains.

Angle of Repose:

Dynamic angle of repose for wheat grains of the investigated varieties as shown in figure (7) showed linear relationship with the grains moisture content. The following linear regression equations described the relationships between the dynamic repose angle (θ) in degree and moisture content in percent (w.b):

For Giza-168 variety:

$$\theta = 24.1174 + 0.3090 \text{ Mc} \dots\dots\dots R^2=0.7069$$

For Sakha-93 variety:

$$\theta = 18.1124 + 0.6247 \text{ Mc} \dots\dots\dots R^2=0.8247$$

For Banisuif-1 variety:

$$\theta = 23.1585 + 0.2191 \text{ Mc} \dots\dots\dots R^2=0.8981$$

The above equations showed that the dynamic angle of repose increased as moisture content was increased at the studied range.

Sakha-93 variety recorded the highest values of change for the dynamic repose angle. It increased from 24.45° to 29.17° with the increasing of grains moisture content from 9.89 to 17.51% (w.b). While, Banisuif-1 variety showed the lowest values of change for dynamic repose angle. It increased from 25.10° to 27.01° with increasing of grains moisture content from 8.70 to 17.42% (w.b).

The results which obtained in this study similar to experimental data of (*soliman1994*) for paddy rice, brown rice and white rice, (*Dutta et al 1988*) for gram grains, (*Amin et al 2004*) for lentil seeds and (*Altunuts et al 2005*) for fenugreek seeds.

Static Friction Coefficient:

The static coefficient of friction for wheat grains of the investigated varieties on the selected materials surfaces including rubber, plywood, galvanized and stainless steel as shown in figures (8 to 10) appeared to be linearly dependent on the moisture content. The relationship between moisture content (w.b) and static coefficient of friction on rubber (μ_r), plywood (μ_p), galvanized iron (μ_g) and stainless steel (μ_s) can be represented by the following linear regression equations:

For giza-168 variety:

$$\begin{array}{rcll}
 \mu_r & = & 0.3362 + 0.0092 \text{ Mc} & \dots\dots\dots R^2=0.905 \\
 \mu_p & = & 0.3410 + 0.0078 \text{ Mc} & \dots\dots\dots R^2=0.8468 \\
 \mu_g & = & 0.2693 + 0.0098 \text{ Mc} & \dots\dots\dots R^2=0.9492 \\
 \mu_s & = & 0.2705 + 0.0085 \text{ Mc} & \dots\dots\dots R^2=0.8476
 \end{array}$$

For Sakha-93 variety:

$$\begin{array}{rcll}
 \mu_r & = & 0.3365 + 0.0088 \text{ Mc} & \dots\dots\dots R^2=0.7310 \\
 \mu_p & = & 0.3266 + 0.0085 \text{ Mc} & \dots\dots\dots R^2=0.8083 \\
 \mu_g & = & 0.2783 + 0.0095 \text{ Mc} & \dots\dots\dots R^2=0.749 \\
 \mu_s & = & 0.2626 + 0.0100 \text{ Mc} & \dots\dots\dots R^2=0.7914
 \end{array}$$

For Banisuif-1 variety:

$$\begin{array}{rcll}
 \mu_r & = & 0.3587 + 0.0053 \text{ Mc} & \dots\dots\dots R^2 = 0.873 \\
 \mu_p & = & 0.2887 + 0.0086 \text{ Mc} & \dots\dots\dots R^2 = 0.941 \\
 \mu_g & = & 0.3116 + 0.0064 \text{ Mc} & \dots\dots\dots R^2 = 0.909 \\
 \mu_s & = & 0.2923 + 0.0067 \text{ Mc} & \dots\dots\dots R^2 = 0.892
 \end{array}$$

The equations showed that the static coefficient of friction for wheat grains of the studied varieties increased with increasing the moisture content at the studied range on each of the four materials surfaces.

At all moisture content levels for each of the three varieties, the highest values of static coefficient of friction were on rubber followed by plywood, galvanized iron and the lowest on stainless steel.

Similar results were found by other researchers (*Helmy 1995*) for some Egyptian wheat varieties, (*Lawton 1980*) for wheat and barley grains, (*Amin et al 2004*) for lentil seeds, (*Ozarsland 2002*) for cotton seeds and (*Karababa Ersan 2005*) for popcorn kernels.

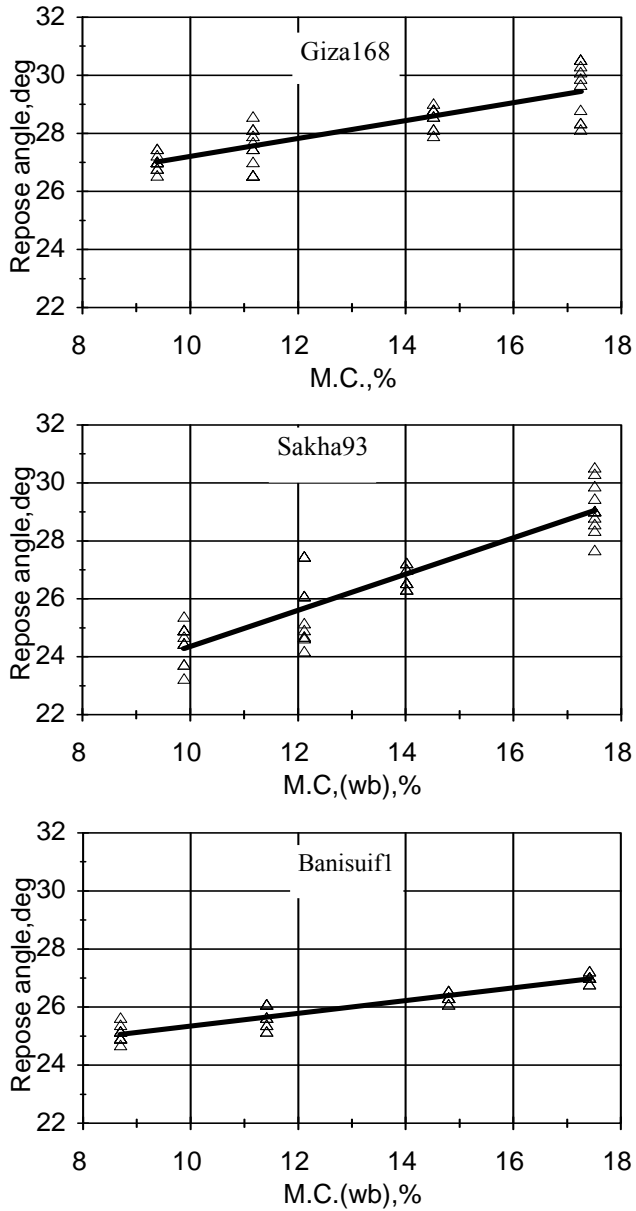


Figure (7): Effect of moisture content on dynamic angle of repose of wheat grains

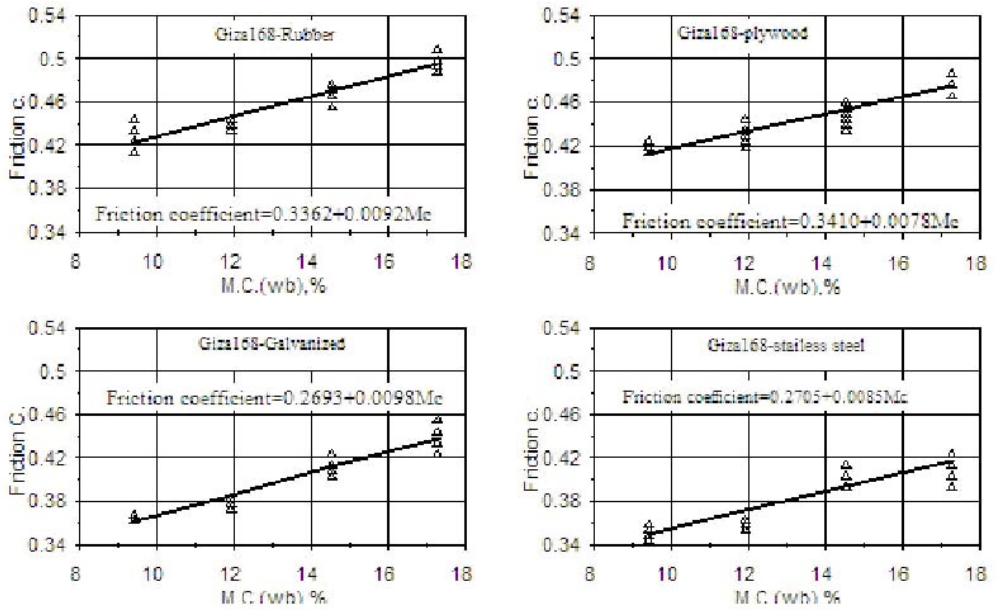


Figure (8): Effect of moisture content on the friction coefficient of Giza-168 wheat grains with the four materials

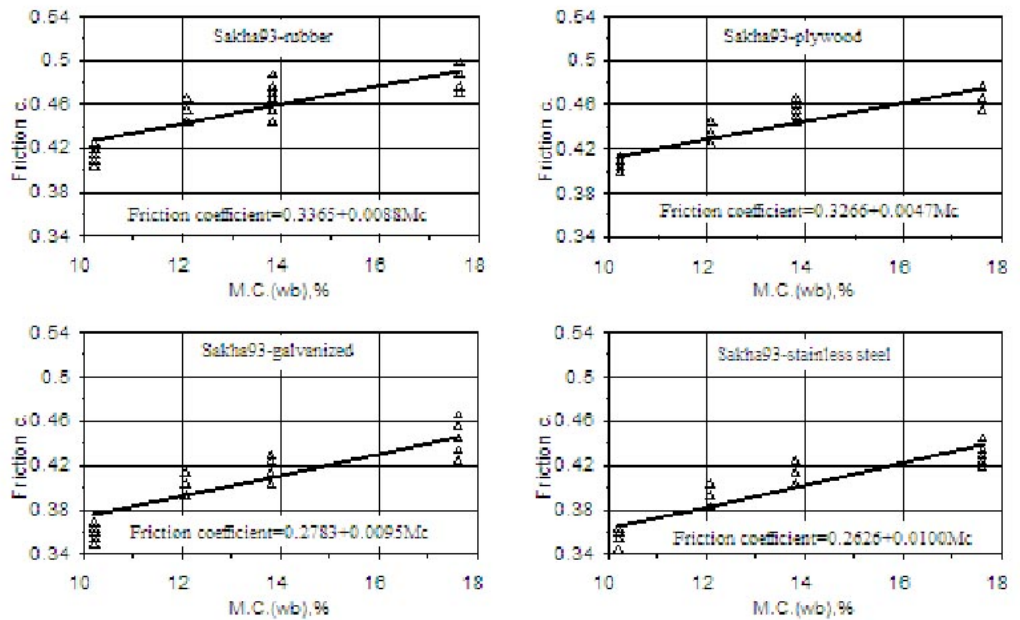


Figure (9): Effect of moisture content on the friction coefficient of Sakha93 wheat grains with the four materials

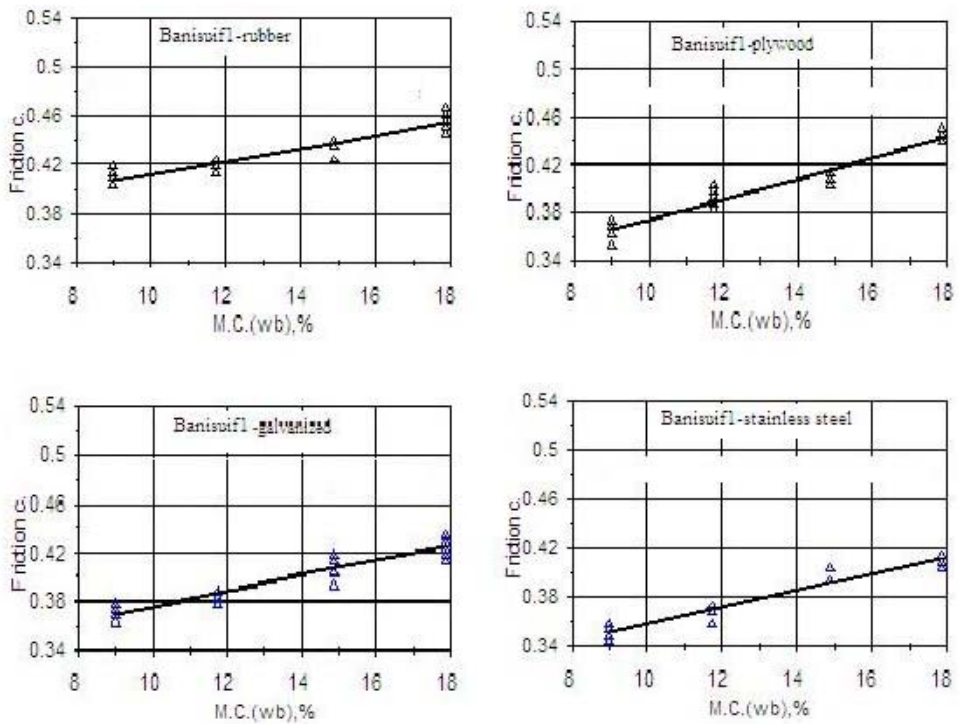


Figure (10): Effect of moisture content on the friction coefficient Banisuife -1 Of wheat grains with the four materials

CONCLUSION

The obtained results can be summarized as follows:

1. Each of physical characteristics changed with the changing of grains moisture content for the three studied varieties.
2. Grain dimensions (length, width and thickness) for the three studied varieties were increased with increasing of moisture content at the studied range. Sakha-93 variety showed the highest increase values of grain dimensions. While, Banisuif-1 variety recorded the lowest increase values. Banisuif-1 variety was had the highest dimensions and the lowest dimensions was of Giza-168 variety.
3. Weight of one thousand grains for the three studied varieties was increased linearly with increasing of moisture content. Sakha-93 variety showed the highest increase values, while, Giza-168 recorded the lowest

increase values. The highest weight of one thousand grains was of Banisuif-1 variety and the lowest was of Giza-168 variety.

4. Each of bulk density and particle density were decreased linearly with increasing of moisture content in the studied range for the three studied varieties. Banisuif-1 variety recorded the highest decrease values in bulk density, while, Giza-168 showed the lowest values. Sakha-93 variety showed the highest decrease values in particle density and Banisuif-1 variety recorded the lowest decrease values.

5. Dynamic angle of repose was increased linearly with increasing of moisture content at studied range for the three studied varieties. Sakha-93 variety recorded the highest increase values in dynamic angle of repose. While, Banisuif-1 variety showed the lowest increase values.

6. The static coefficient of friction was increased linearly with increasing of moisture content for the three studied varieties on each of the four selected materials surfaces (rubber, plywood, galvanized iron and stainless steel). At all studied moisture content levels for each of the three varieties, the highest values of static coefficient of friction was with rubber followed with plywood, galvanized iron and the lowest values was with stainless steel.

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الملخص العربي

الخصائص الطبيعية لحبوب القمح

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زاد الاهتمام بدراسة الخصائص الطبيعية للمنتجات الزراعية في السنوات الأخيرة والتي تساعد في اختيار أفضل التصميمات للأجهزة والمعدات في مراحل التداول والطحن والتصنيع (عمليات ما بعد الحصاد) وذلك بهدف تقليل فاقد الإنتاج وتحسين جودة المنتج. تهدف هذه الدراسة إلى توفير قاعدة معلومات للخصائص الطبيعية لحبوب القمح وعلاقتها بالمحتوى الرطوبي لثلاثة أصناف جديدة من القمح المصرية وهي جيزة ١٦٨ ، سخا-٩٣ ، بني سويف-١ عند أربعة مستويات رطوبة مختلفة (حوالي ٩% و ١٢% و ١٤% و ١٨%).

١- استاذ هندسة التصنيع الزراعي بكلية الزراعة جامعة الإسكندرية.

٢- استاذ مساعد الهندسة الزراعية بكلية الزراعة جامعة المنوفية - شبين الكوم.

٣- مهندس بقسم الهندسة الزراعية بكلية الزراعة جامعة المنوفية - شبين الكوم.

وتعتبر هذه الأصناف من أكثر أصناف القمح المزروعة في مصر مساحة وأعلىها إنتاجية وذلك عام ٢٠٠٤ ويستخدم أصناف القمح (جيزة-١٦٨، سخا-٩٣) في صناعة الخبز والبسكويت وصنف (بني سويف-١) قمح الديورم في صناعة المكرونة أما الخصائص الطبيعية المدروسة فكانت الخصائص البعدية وتشمل طول وعرض وسمك الحبة و الكثافة الكمية و كثافة الحبة كيلوجرام/متر^٣ و وزن الألف حبة و زاوية المكوث ومعامل الاحتكاك الاستاتيكي للحبوب علي أربعة أسطح مختلفة وهي المطاط والخشب والحديد المجلفن والصلب. ويمكن تلخيص النتائج التي توصل إليها البحث فيما يلي:

١- الخصائص البعدية:

- حبوب القمح صنف بني سويف-١ سجلت أعلى متوسطات لقيم أبعاد الحبوب (الطول والعرض والسمك) في حين كانت أقصر الأبعاد لحبوب صنف جيزة-١٦٨.

- أظهر تحليل الارتباط الخطي للنتائج أن أبعاد الحبة يزداد بزيادة المحتوى الرطوبي وأن العلاقة بين كل من طول وعرض وسمك الحبة مع المحتوى الرطوبي علاقة خطية.

أظهر صنف سخا-٩٣ أعلى المقادير في متوسط الزيادة في أبعاد الحبة حيث تراوحت الزيادة من ٦,٦٠ إلى ٧,٢٠ ومن ٣,٤٣ إلى ٣,٨٠ ومن ٣,٠١ إلى ٣,٣١ ملليمتر لكل من الطول والعرض والسمك على التوالي بزيادة المحتوى الرطوبي من ٩,٨٩ إلى ١٧,٥١ % . في حين سجل صنف بني سويف-١ أقل تغيير في متوسط أبعاد الحبة والتي تراوحت ما بين ٧,٤٦ إلى ٧,٨٦ للطول، و ٣,٤١ إلى ٣,٦٦ للعرض، و ٣,١٥ إلى ٣,٣٧ ملليمتر للسمك بزيادة المحتوى الرطوبي للحبوب من ٨,٧٠ إلى ١٧,٤٢ % أساس رطب.

٢- وزن الألف حبة:

- حبوب القمح صنف بني سويف-١ أظهرت أعلى القيم في وزن الألف حبة تلاها صنف سخا-٩٣ وكان أقلها لصنف جيزة-١٦٨.

- تحليل الارتباط الخطي للنتائج أظهر وجود علاقة طردية خطية بين المحتوى الرطوبي للحبوب ووزن الألف حبة للأصناف الثلاثة المدروسة.

- صنف سخا-٩٣ سجل أعلى زيادة في وزن الألف حبة (٥٣,١٣-٦٢,١٤ جم)، في حين أظهر صنف جيزة-١٦٨ أقل زيادة (٤٥,٧١-٥٠,٤٨ جم).

٣- الكثافة الكمية:

- أظهر تحليل الارتباط الخطي للنتائج وجود علاقة عكسية خطية بين الكثافة الكمية لحبوب أصناف القمح المدروسة ومحتواها الرطوبي.

- سجل صنف بني سويف ١ أكبر تغيير في الكثافة الكمية (٨٩٧,٤٠ - ٨٢١,٢٠ كجم/م^٣) بزيادة المحتوى الرطوبي من ٨,٧ إلى ١٧,٤٢ % بينما أظهر صنف جيزة-١٦٨ أقل تغيير في الكثافة الكمية (٨٦٣,٤٠ - ٨٢٨,٢٠ كجم/م^٣) بزيادة المحتوى الرطوبي من ٩,٣٩ إلى ١٧,٢٥ %

٤- كثافة الحبة:

- أظهر تحليل النتائج وجود علاقة عكسية خطية بين كثافة الحبة للأصناف المدروسة والمحتوى الرطوبي.

- صنف سخا-٩٣ أظهر أكبر مقادير انخفاض في كثافة الحبة (١٠, ١٤٠١-
١٢٩٣,٦ كجم/م^٣) بزيادة المحتوى الرطوبي من ٩,٨٩ إلى ١٧,٥١%، في حين أظهر صنف بني
سويف-١ أقل انخفاض في كثافة الحبة (١٣٩٩,٥٠ - ١٣٧٥,٣٠ كجم/م^٣) بزيادة المحتوى
الرطوبي من ٨,٧٠ إلى ١٧,٤٢%.

٥- زاوية المكوث الطبيعي:

- من تحليل النتائج تبين أنه توجد علاقة طردية خطية بين زاوية المكوث الطبيعي
الديناميكية للحبوب والمحتوى الرطوبي للحبوب للأصناف المدروسة.

- صنف سخا-٩٣ سجل أعلى زيادة في زاوية المكوث الطبيعي الاستاتيكية (٢٤,٤٥-
٢٩,١٧°) بزيادة المحتوى الرطوبي من ٩,٨٩ إلى ١٧,٥١%، وأظهر صنف بني سويف-١ أقل
زيادة في زاوية المكوث (٢٧,٠١-٢٥,١٠°) بزيادة المحتوى الرطوبي للحبوب من ٨,٧٠ إلى
١٧,٤٢%.

٦- معامل الاحتكاك الاستاتيكي:

- أعلى معامل احتكاك استاتيكي للأصناف الثلاثة المدروسة عند المستويات الرطوبة
الأربعة كان مع المطاط يليه الخشب ثم الحديد المجلفن وأقلها مع الحديد الصلب.

- أظهر تحليل الارتباط الخطي للنتائج أن العلاقة بين معامل الاحتكاك الاستاتيكي للحبوب
مع الأسطح الأربعة والمحتوى الرطوبي للحبوب علاقة طردية خطية.