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EFFECT OF MILLING MACHINE TYPE AND MILLING TIME ON FINAL QUALITY OF MILLED RICE AND PERCENTAGE OF BRAN OIL

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ABSTRACT

The aim of this study is to investigate the effects of two different types of milling machines (abrasive & friction) and five milling times (30, 45, 60, 75 and 90 sec.) on total and head rice yield, whiteness degree, bran percentage, oil percentage of the produced bran, and nutrition constitutes of milled rice. The experimental work was conducted for two different rice varieties (Short grain variety Sakha 104 and long grain variety Yasmin). The obtained results showed that, for both studied varieties, the total and head rice yields decreased with the increase of milling time. While, the abrasive type milling machine produced higher total and head rice yield in comparison with the friction type. Also for both types of milling machines, prolonged continuous milling (over 60 sec.) increased the whiteness degree of milled rice slightly, but brought about a drastic reduction in head rice yield. Meanwhile, the percentage of bran was increased while the percentage of extracted oil was decreased with the increasing of milling time for both types of milling machines and both rice varieties. Milling percentage, whiteness degree and grain transparency were increased with the increasing of milling time for both types of milling machines and both rice varieties. Also, as milling progressed from low to high degree of milling, the levels of protein, lipids, ash, and minerals decreased while the level of starch increased.

INTRODUCTION

Rice milling operations in particular, are of two types (i) abrasion milling, in which brown rice is abraded by a hard abrasive surface at high speed and low pressure between two surfaces; and (ii) friction milling in which two or three body wear take place due to the rubbing of two bodies of similar nature, under high pressure. However, there is no one form of abrasive or friction milling is using in rice polishing. (Mohabatra and Bal 2004).

Andrews *et al.,* (1992) reported that, the factors contributing to rice breakage during milling may be classified into two general categories (1) those related to the properties of the rice grain itself, and (2) those related to conditions under which the grain is milled. The properties of grain itself at the time of milling are the conditions which the rice is subjected during growing, harvesting, drying, and storage. The condition of milling affecting breakage are the type of milling machine, temperature and moisture content during milling, the degree of milling and the mechanical setting of milling machine.

Lu and Siebenmoren (1995) stated that, there was a highly significant correlation between head rice yield and the average bending force for breakage of rough rice. They also add that, thinner kernels generally fail at a lower breakage force and were in turn more susceptible to break during milling process.

Takai and Barredo (1981) investigated the milling characteristics of a friction laboratory rice mill. The results showed that, prolonged continuous milling increased the degree of polishing slightly, but caused a drastic increase in breakage. The intermittent milling permit an over milling without an increase in breakage. No reduction in the percentage of broken rice was achieved by 2-stage milling, i.e, husking by rubber roll husker and then polishing by a mill.

Andrews et al, (1992) stated that, the removal of bran layers as milling duration increases results in reduction of milled rice yield and head rice yield and an increase in degree of milling.The bran, is mainly produced during rice milling operation.

The bran is considered as an important by-product, that producing during rice milling operation, and represents 10% of the total weight of rice grain. It is rich in protein 13-16 %, oil 15-22 %, fiber 6.2-14.4 %, ash 8-17.75 %, vitamins, and trace minerals. (Daniel et al.,(1993)

Rice bran is defined as a mixture of pericarp, which is the bran layer on the surface of brown rice removed during rice milling operation, seed coat, outer endosperm, aleurone layer containing lipid and protein, and germs containing a large amount of lipid, protein, vitamin B, and vitamin E.

Although differing from the degree of milling, the ratio of rice bran to brown rice is about eight percent. Five to six percent are bran layers and two to three percent are germ. In practice, rice and small broken are mixed in bran to give a ratio of about 9%, (Hosokawa, 1994).

Rice bran, a used in different forms ranged from fuel to food, including fertilizers, pharmaceuticals, soap, and animal feed. The rice grain bran of short, medium, and long duration varieties were varied in their edible oil content.(Farinu et al., 1989; Carroll, 1990; and Saunders, 1990).

Bor (1991) reported that most of rice oil is concentrated in the pericarp, the aleurone layer, and the germ of the rice kernel. The fragments of these tissues are combined to form the by-product bran or polish after the rice is milled. The bran contains 15-20% oil while the well-polished rice (mainly endosperm) has less than 1 %.

The present study aims to investigate the effects of two different milling systems (abrasive & friction) and five milling times on total and head rice yield, whiteness degree, bran percentage, oil percentage of the produced bran, and nutrition constitutes of milled rice for the two different rice varieties (Sakha 104 and long grain variety Yasmin).

MATERIALS AND METHODS

Materials:

Rice grain:-

Two different varieties of rice grain were used during this study;

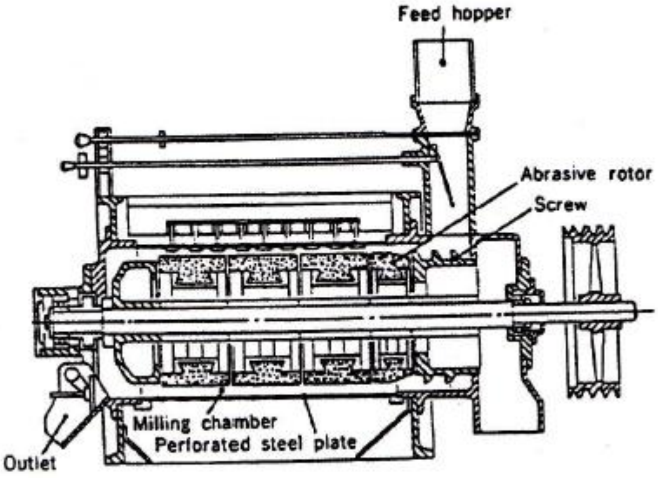
short-grain variety (Sakha 104) which was harvested at initial moisture content of 19.4% (w.b.) and long-grain variety (Egyptian Yasmin) harvested at initial moisture content of 18.6% (w.b.). After harvest, rough rice from each verity immediately transported to the laboratory and cleaned from trash and impurities. To prevent the influence of drying method on the quality characteristics of rice grain the rice samples was dried in a layer of 2 cm thickness under shade until reached the desired moisture content of 14 %. 15 kg from each variety was placed in closed plastic bags and stored until testing.

Milling machines:

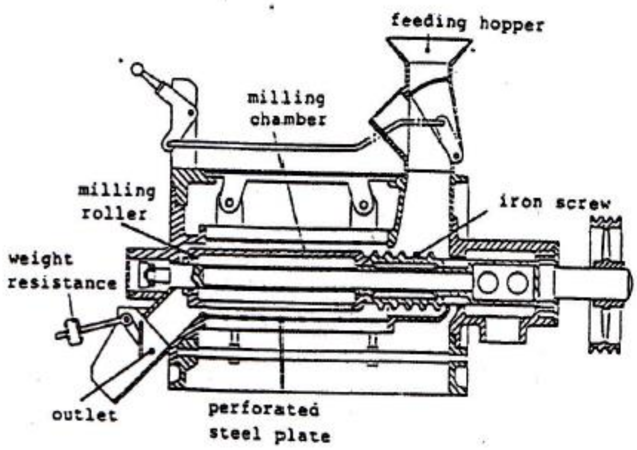
Two different types of milling machines were employed during the experimental work. The first type was abrasive system machine (model MT-05) as shown in Fig.(1). It has milling chamber that has an abrasive stone spinning in the center and a scarified metal screen on the outside. The second type was friction Type machine (model BS- 05) as demonstrated in Fig.(2). It consists of perforated concave covered by a pressure cover. The rotation of the rotor cause the bran to be removed from the kernels by the friction generated between them. The brown rice was fed to the hopper of each machine and when the hopper gate was opened immediately and the stop watch started to record the milling time and stopped just as the machine finished the run. The three sub samples of each variety were milled for either (30 – 45– 60 – 75 and 90 sec.).The resulted white rice of each experimental run was weighed and fed to the laboratory rice grading machine model (Satake TRG-05A) for separating broken kernels from head rice kernels. All of the rice bran carefully collected in a pan for the weighing process and determination of oil content.

Hulling Process:

The rubber huller (model S T- 50) was used for the hulling process of the samples. The hullers consist of two rubber rolls, one has a fixed position and the other is adjustable to obtain the desired clearance between the two rolls. The clearance between the two rolls was adjusted to give more than 90% of brown rice as mentioned by EL-Kholy (1998). The grain feed rate was kept constant for all the experimental runs. When rough rice sample (125g) was fed to the hulling machine hopper, the shutter opened, the rough rice was fed between the two rolls and the grain caught under pressure by the rubber. Because of the difference in speed of rolls, the husker was stripped of and the resulting brawn rice separately discharged and collected in a pan for the weighing process.



Cross section for the abrasive type rice whitening machine.



Cross section for the friction type rice whitening machine.

Methods:-
Experimental Measurements:
1-Total and head rice yields:

The milling quality of rough rice samples was evaluated in terms of total milling yield and the percentage of broken rice according to (Takai. and Barredo 1981) as follows:

$$\text{Head rice yield, \%} = \frac{Weight\ of\ sound\ \mathrm{ker}\,nels}{Total\ \ weight\ of\ sample}\ \ x\ \ 100 \ldots\ldots\ldots\ldots(1)$$

$$\text{Total yield, \%} = \frac{Weight\ of\ milled\ \mathrm{ker}\,nels}{Total\ \ weight\ of\ sample}\ \ x\ \ 100 \ldots\ldots\ldots\ldots(2)$$

2-Whiteness, transparency and degree of whiteness:

Whiteness, transparency and milling degree of rice samples were measured for each treatment using a Satake digital meter Model (MM-1B).

3-Determination of oil % in the rice bran :

Rice bran samples of about 30 g were dried inside the oven at 105^oC for 24 hours. To determine the percentage of oil, 5g of the dried samples was rolled inside a filtration paper (12.5 Watman) and installed inside a sokselt equipment using petroleum-ether at 40-60^oC for 16 complete cycles and then it was allowed to dry in an electric oven at 70^oC for two hours in order to evaporate the remaining solvent from the sample. The obtained samples were again weighed and the percentage of oil was calculated using the following equation:

Oil % = $(w_o / w_t) \times 100$

Where:

w_o = Weight of oil, g.

w_t = Weight the bran sample, g.

4-Nutrition constitutes of milled rice:

Protein content was estimated using the KielDahl method. Amylose content was determined by the Iodine color metric method (Juliano, 1971) and the lipid material was extracted from rice flour with N-Hexane as described by (Choudhury and Juliano(1980). Ash content of milled rice (2g) was ignited in muffle furnace at 550^oC to constant weight. Total content of Na, k, ca, Fe, Mn, Zn, Cu, and Mg were determined in the digested solution using atomic absorbtion FMD3 zeiss. Phosphorus content in the digested material was determined using microvanedate-molybdate yellow method according to (Chapman and Pratt 1978).

RESULTS AND DISCUSSION

Total and Head Rice Yields :

Figs. (1) and (2) illustrate the variations in total and head rice yields for the two studied varieties, different types of milling machines, and different milling times.

Total rice yield:-

As shown in Fig.(1), for both types of milling machines the total milling yield decreased with the increase of milling time and it was higher for the short grain variety(Sakha 104) in comparison with long grain variety Yasmin. The recorded total milling yield for the short grain variety (Sakha 104) was ranged from 72.13 to 65.92% for the friction type milling machine and it was ranged from 74.01 to 67.2 for the abrasive type. However, the total milling yield for the long grain variety (Yasmin) was ranged from 71.01 to 65.13% for the friction type milling machine and from 72.88 to 66.78% for the abrasive type.

The observed reduction in total milling yield with the increasing of milling time for the studied varieties and both types of milling machines, may be due to further milling of broken kernels with prolonged milling time which converted part of the brittle broken kernels to rice powder usually lost with the discharged bran.

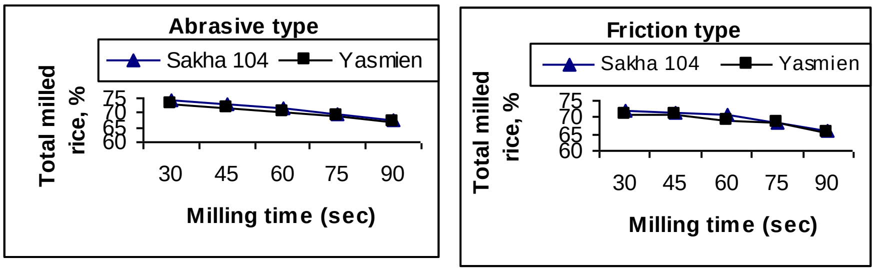


Fig. (1): Total rice yield as related to milling time for different rice varieties and different milling machines.

Hard rice yield:-

As shown in Fig. (2) the percentage of head rice yield was also decreased with the increasing of milling time, and it was higher for the abrasive milling system in comparison with the friction type, and for short grain variety (Sakha 104) in comparison with the long grain variety (Yasmin). The recorded percentages of head rice yield for the short grain variety (Sakha 104) was ranged from 61.57 to 51.36% for the frictional type milling machine in comparison with 63.39 to 53.29% for the abrasive type. On the same time, for the long grain variety (Yasmin) the recorded head rice yield was ranged from 58.51 to 50.72% for the friction type milling machine and from 64.91 to 55.75% for the abrasive type.

The results presented in Fig. (2) also show that, for both types of milling machines, the head rice yield was dramatically decreased at the first 30 sec. of milling due to the breakage of brittle kernels at this early stage of milling. While, it was slightly decreased with further increasing of milling time due to the removal of more surface bran layers which causes lower sustainability of kernels to the applied stresses as mentioned by (Andrews et al,1992).

On the same time, the results plotted in Fig.(2) show that the frictional type milling machine produced lower head rice yield in comparison with the abrasive type specially for the long grain variety (Yasmin). This may be due to the fact that, the grain milled with the frictional type milling machine receives higher pressure and more shearing and bending stresses on the starchy endosperm. While, the abrasive type milling machine can shape off the surface of rice grain which tends to bend under the higher pressure and the higher friction force of the friction type .

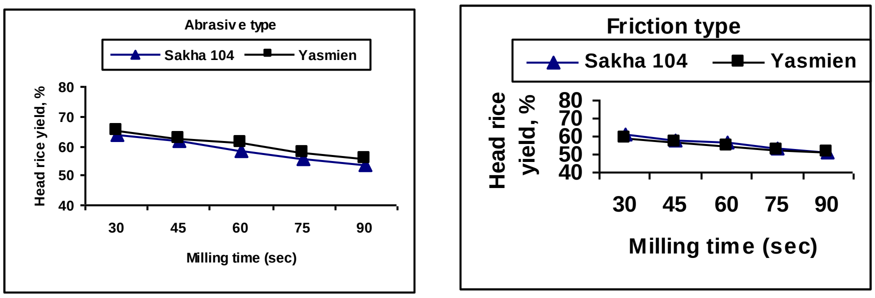


Fig. (2): Head rice yield as related to milling time for different rice varieties and different milling machines.

Rice milling degree:-

Milling degree is the degree to which the brain layer and germs eliminated from rice grain.

Fig. (3) presents the effect of milling time on milling degree of rice. As shown in the figure, milling degree of rice was increased with the increasing of milling time for both types of milling machines and rice varieties. For the friction type milling machine, the milling degree of (Sakha 104) variety was increased from 37.00 to 147% as the milling time increased from 30 to 90 sec. While, for the Egyptian Yasmin variety the milling degree of rice was increased from 22.14 to 103.8% respectively. Meanwhile, for the abrasive type milling machine, the milling degree of (Sakha 104) variety was increased from 34.16 to 138.64% as the milling time increased from 30 to 90 sec. While for the Egyptian Yasmin variety the milling degree of rice was increased from 21.00 to 87.66%.

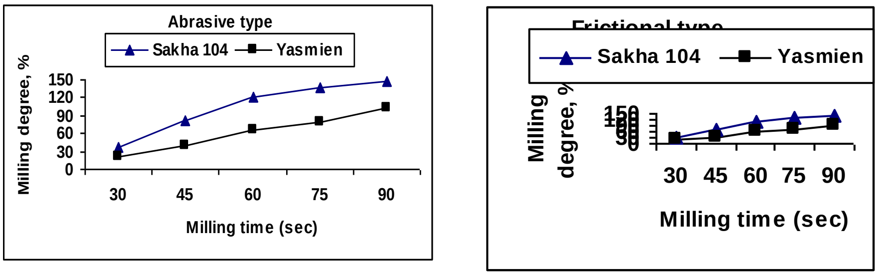


Fig.(3) Milling degree (%) of rice grain as a function of milling time for different rice varieties and different milling machines.

Rice whiteness degree:-

Rice whiteness reflects the effect of milling degree on the while color of milled kernels and is proportional with the changes in milling degree.

Fig. (4) reveals the effect of milling time on whiteness degree of milled rice. As shown in the figures, for the friction type milling machine, as the milling time increased from 30 to 90 sec. rice whiteness degree was increased from 27.53 to 50.28 units, respectively, for variety(Sakha 104) For the Egyptian Yasmin variety it was increased from 24.03 to 36.15 units respectively. However for the abrasive type milling machine, the whiteness degree of variety(Sakha 104) was increased from 28.26 to 51.10 units While, it was increased from 24.94 to 42.56 units as the milling time increased from 30 to 90 sec, respectively for the Egyptian Yasmin variety.

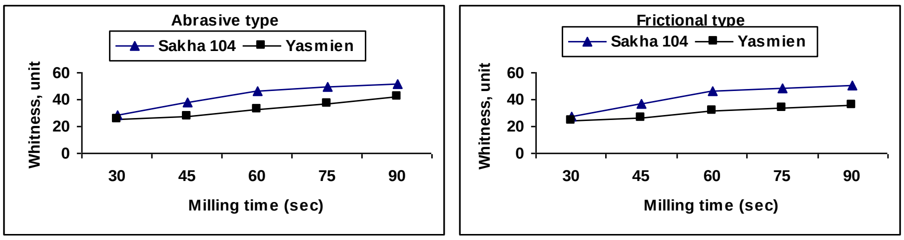


Fig. (4) Whiteness degree of rice grain as related to milling time for different rice varieties and different milling machines.

Rice transparency%:

Fig. (5) presents the effect of milling time on rice transparency. As demonstrated in the figure, for the variety (Sakha 104) milled with the friction type milling machine, transparency was increased from 1.38 to 3.12% as the milling time increased from 30 to 90 sec., respectively. While for Egyptian Yasmin variety it was increased from 1.77, to 3.42 % . For the abrasive type milling machine, transparency of variety (Sakha 104) was increased from 1.34 to 2.97% as the milling time increased from 30 to 90 sec., While, for Yasmin variety, it was increased from 1.66, 1.85 to 3.30% as the milling increased from 30 to 90 sec., respectively.

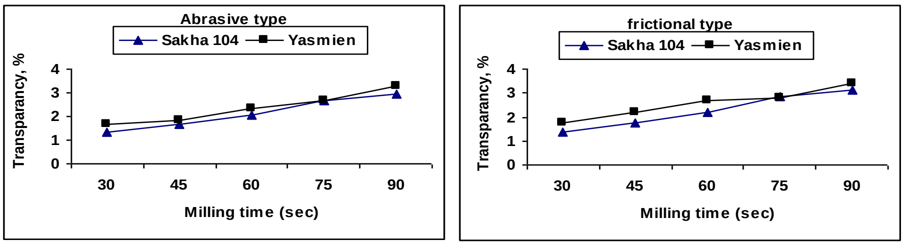


Fig. (5) Transparency, of milled rice as a function of milling time for different rice varieties and different milling machines.

Percentage of rice bran:-

Fig. (6) illustrates the effect of milling time on bran percentage of different studied rice varieties. As shown in figure, bran percentage was increased with the increasing of milling time for both types of milling machines and both rice varieties. For the friction type milling machine, rice bran of variety (Sakha 104) was increased from 3.59 to 11.14% with the increasing of milling time from 30 to 90 sec. While for Yasmin variety it was increased from 4.36 to 11.08% respectively. Meanwhile for the abrasive type milling machine, the percentage of rice bran of the Egyptian Yasmin variety was increased from 3.00 to 6.80% as the milling time increased from 30 to 90 sec., respectively. While it was increased from 4.36 to 11.08% for variety (Sakha 104).

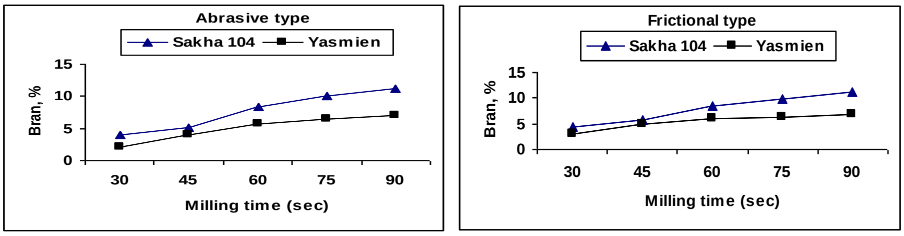


Fig. (6) Bran percentage as related to milling time for different rice varieties and different types of milling machines.

Bran oil percentage:

Fig. (7) demonstrates the effect of milling time and type of milling machine on bran oil %. As shown in the figure, bran oil % was decreased with the increasing of milling time for both types of milling machines and both varieties. This is may be attributed to the mixing of starch and small broken kernels with the rice bran as the milling time increased. For the friction type milling machine, it was decreased from 15.38 to 10.85% as the milling time increased from 30 to 90 sec for variety (Sakha 104).

While, for Egyptian variety Yasmin it was decreased from 16.84 to 13.11%, respectively. However, for the abrasive type milling machine it was decreased from 15.11 to 10.88 % as the milling time increased from 30 to 90 sec., for variety (Sakha 104). While for the Egyptian Yasmin variety it was decreased from 16.57, to 12.96% respectively. In general, oil % was higher for Egyptian Yasmin variety in comparison with (Sakha 104) variety.

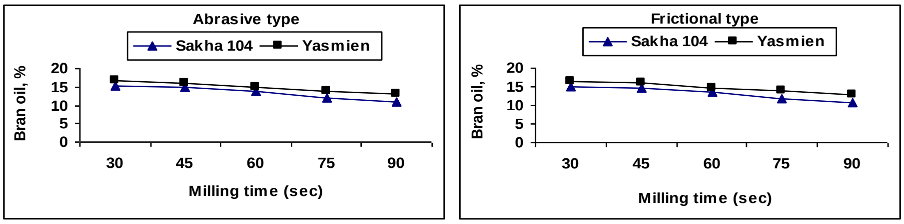


Fig.(7) Bran oil percentage as related to milling time for different rice varieties and different types of milling machines.

Nutrition constitutes of milled rice

Table (1) lists the effect of milling time and type of milling machine on moisture content, ash, protein, oil and amylase contents of different studied varieties. The results show that ash, protein, and oil contents of milled kernels using the friction type milling machine were decreased from an initial levels of 1.24 ,9.3 and 2.4% to 0.16 , 7.19 and 0.25% for variety (Sakha 104) respectively. However for variety Yasmin they were deceased from 1.18, 8.4 and 1.7% to 0.21, 6.25 and 0.39 % as the milling time increased from 30 to 90 sec., respectively. Also ash, protein, and oil contents of milled kernels using the abrasive type milling machine were decreased from an initial levels of 1.24, 9.3 and 2.4% for variety (Sakha 104) to 0.18, 7.3 and 0.30%, respectively. However for variety Yasmin they were deceased from 1.18, 8.4 and 1.7% to 0.24, 6.4 and 0.40% as the milling time increased from 30 to 90 sec., respectively. The observed reduction of ash, protein and lipids contents with the increase of milling time may be attributed to the further removal of bran layers. The table also shows that, as the milling time increased from 30 to 90 sec., the amylase content was increased from an initial levels of 20.42% to a final a level of 22.19 % and from an initial level of 20.42 % to a final level of 22.28 % for the variety(Sakha 104) milled by the friction and the abrasive milling machines, respectively. However for Yasmin variety the corresponding values were increased from 18.54 to 22.36% and from 18.54 to 20.23%, respectively. The increase of amylase content with the increase of milling time may be due to the increase of starch content in the milled rice as a result of removing more brain layer from the kernels surfacc.

Table (1): Effect of milling time and the type of milling machine on ash, protein, oil and amylase contents of milled rice.

Variety	Time, min	Ash		Protein		Oil		Amylase	
		friction	abrasive	friction	Abrasive	friction	abrasive	friction	Abrasive
Sakha 104	0	1.24	1.24	9.3	9.3	2.4	2.4	20.42	20.42
	30	0.61	0.63	8.21	8.3	1.91	2.1	21.17	21.39
	45	0.46	0.59	7.56	7.95	1.62	1.83	22.3	21.43
	60	0.25	0.27	7.4	7.7	1.38	1.5	22.35	21.79
	75	0.21	0.23	7.31	7.5	0.42	0.5	22.85	22.28
	90	0.16	0.18	7.19	7.3	0.25	0.3	22.19	22.28
Yasmin	0	1.18	1.18	8.4	8.4	1.7	1.7	18.54	18.54
	30	0.65	0.67	7.65	7.8	1.3	1.4	20.31	20.04
	45	0.6	0.62	7.31	7.6	1.1	1.25	20.72	20.15
	60	0.58	0.66	7.29	7.5	0.79	0.9	21.1	20.34
	75	0.32	0.33	7.18	7.4	0.53	0.6	21.38	20.52
	90	0.21	0.24	6.25	6.4	0.39	0.4	22.63	20.28

CONCLUSIONS

As it is obvious from the previous study and analysis:-

1-For all studied varieties, the total and head rice yield decreased with the increase of milling time. While, the abrasive type milling machine produced higher total and head rice yield in comparison with the friction type.

2- For both types of milling machines, prolonged continuous milling (over 60 sec.,) increased the whiteness degree of milled rice slightly, but brought about a drastic reduction in head rice yield.

3- Percentage of bran was increased while the percentage of extracted oil was decreased with the increasing of milling time for both types of milling machines and both rice varieties.

4- Milling percentage, whiteness degree and grain transparency were increased with the increasing of milling time for both types of milling machines and both rice varieties.
5- As milling progressed from low to high degree of milling, the levels of protein, lipids, ash, and minerals decreased while the level of analyses increased.

REFERENCES

Andrews S.B; T.J. Siebenmorgen ; and A. Mauromoustakus (1992). Evaluation of the MC Gill No.2 rice miller. Cereal Chem. 69: 35-43.

Bor, S. L. (1991). Rice oil in rice utilization. Pp 295: 311. An Avl Book published at Van Nostrand Rieinhold New York.

Carroll L. E. (1990). Functional properties and applications of stabilized rice bran in bakery products. Food Technology 77:74.

Chapman, H.D. and Pratt, P.E. (1978) " Method of analysis from soils, plant and water P.50 Univ. of California. Div. Agric. Sci. Priced Publication 4034.

Chen H.; J.J. Siebenmorgen and K. Griffin (1998). Quality characteristics of long- grain rice milled in two commercial systems. Cereal Chem. Vol. 75 No. 4 560-565.

Choudohury, N.H. and Juliano, B.O. (1980). " Lipids in developing and mature rice grain" Phytochemistry, 13, 1063-1069

Daniel, M. J.; G. Samuel ; S. Gladness ; V. Lalit ; and H. John (1993). Optimizing rice bran stabilization by extrusion cooking. Louisiana Agriculture, 36: 13-15.

El-Kholy M.M (1998). “Conditioning and aeration of high moisture paddy using different storage conditions. Un pubbished P.hd thesis. Dept. of Agric., Eng., Mansoura Univ.,

Farinu, G. D., O. G. Longe, B. L. Fetuga and S. Legel. (1989). Chemical composition of different rice processing by- products in Nigeria. Archives of Animal Nutrition 39: 867-874.

Hosokawa, A. (1994). Rice bran and rice oil technology. Prototype edition Text-Book Food Agency, Ministry of Agriculture, Orstry and Fish ries, Japan. Pp. 390-393.

Juliano, B.O. 1971. A simplified assay for milled- rice analysis. Cereal Science Today 16:334-340, 360.

Lu R. and J.J. Siebenmoren (1995). Correlation of head rice yields to select physical and mechanical properties of rice kernels. Trans. Of ASAE 38: 3, 889-894.

Mohapartra D. and S. Bal (2004). Wear of rice in an abrasive milling operation. Part I : Prediction of degree of milling. Bio-system Eng. 88 (3): 337-342.

Roide S. and Y. Nishiyama (2001). Studies on abrasive rice milling (part 2) Milling power and energy model. Journal of the Japanese Society of Agric. Machenery 63 (6): 63-67.

Saunders, R. M. (1990). Developed of new rice products as a consequence of bran stabilization. Bulletin Assocition Of Operative Millers Oct., 5559-5561.

Takai H. and I.R. Barredo (1981). Milling Characteristics of a friction laboratory rice mill. J. Agric. Eng. Res. 26, 442-448.

تأثير نوع آلة التبييض والزمن على جودة الضرب ونسبة الزيت لرجيع الكون

ياسر طلبة هنداوى و أحمد عزت خاطر
معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الجيزة.

تم دراسة تأثيرنوعين من آلات الضرب عند خمس مستويات من أزمنة الضرب على كل من نسبة التصافى الكلية , نسبة الحبوب السليمة , نسبة الضرب , درجة التبييض , نسبة شفافية الحبوب, نسبة الرجيع الناتج , نسبة الزيت فى الرجيع وكذلك التغير فى نسبة البروتين, الرماد, الدهون , الأميليز فى الحبوب المبيضة لصنفين من الحبوب سخا 104 كصنف قصير الحبة و الياسمين المصرى كصنف طويل الحبة.

وقد أمكن تلخيص النتائج المتحصل عليها فيما يلى :

1- بزيادة زمن التبييض انخفضت نسبة تصافى التبييض ونسبة الأرز السليم وكانت ماكينة التبييض بنظام Abrasive أعلى فى كلا من تصافى التبييض ونسبة الأرز السليم بالمقارنة بماكينة التبييض بنظام Friction.

2- لكلا من ماكينتى التبييض (Friction and Abrasive types) زادت درجة الشفافية على حساب انخفاض نسبة الأرز السليم عند أزمنة تبييض أعلى من 60 ثانية لكلا من صنفى الأرز.

3- زادت نسبة رجيع الأرز بزيادة زمن التبييض لكلا من ماكينتى التبيض فى حين انخفضت نسبة الزيت المستخلص بزيادة أزمنة التبييض لكلا من صنفى الأرز.

4- زاد كلا من نسبة الضرب والشفافية ودرجة التبييض لكلا الصنفين (سخا 104 , ياسمين) بزيادة أزمنة التبييض مع كلا من ماكينتى التبييض.

5- بزيادة زمن التبييض انخفضت نسبة البروتين والدهون والرماد بينما زادت نسبة الأميليز لكلا الصنفين.