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Effect of Milling Time on the Performance and Energy Consumption of some Short Grain Rice Varieties

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ABSTRACT

A study was carried out to test and evaluate the effect of different milling times (30, 45, 60, 75, 90 sec) on total and head rice yield, whiteness degree of milled rice, power consumption of milling process and neutrino value of milled rice. The experimental work was proceeded for four different short grain rice varieties included Sakha 101, Sakha 102, Giza 178, and Sakha super -300 using a laboratory scale friction type milling machine. The results show that, for all studied varieties the total and head rice yields decreased with the increase of milling time. Meanwhile, increasing the milling time over 60 sec increased the whitening degree in a non distinguished matter by human eyes. However, it has showed a dramatically reduction in head rice yield and neutrino constitutes of milled rice and limited reduction in power consumption. In general, milling time of 60 sec is recommended for milling process using the friction type milling machines. This level of milling time showed higher milling yield and nutrion value without noticeable reduction in milling degree and reasonable power consumption.

Keywords: rice milling, milling consumed energy, friction type milling machine.

INTRODUCTION

Rice is presently one of the most important grain in the world with one fourth of the population totally depending on it as a major stable food .Considerable research has been conducted to improve rice milling quality and cooking characteristics through plant breeding programs , improve cultural practices ,and optimization of harvesting and drying operations (LU and Siebnomergen 1995) .

Paddy or rice grain consists of husk and brown rice. Brown rice, in turn, contains bran which comprises the outer layer and the edible portion. Rice milling is removal or separation of husk (dehusking) and bran to obtain the edible portion for consumption. The process has to be accomplished with care to prevent excessive breakage of the kernel and improve recovery of paddy or rice. The extent of recovery during milling depends on many factors like variety of paddy, degree of milling required, the quality of equipments used, the operators, etc. Milling is the process where rice grain is transformed into a from suitable for human consumption, therefore, has to be done with utmost care to prevent breakage of the kernel and improve the milling recovery. Brown rice is milled further to create a more visually appealing white rice. After harvesting and drying ,the paddy is subjected to the primary milling operation which includes de-husking as well as the removal of bran layers (polishing)before it is consumed (Dhankhar 2014).

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 pure from of abrasive or friction milling in rice polishing (IRRI, 2009).

Mohapatra and bal (2004) developed a mathematical model for predicting the temperature rise and energy utilization in an abrasion milling operation and its effect on milling quality of grain. The head rice yield was co-rrelated with the final temperature of the grain .The developed model accurately predicted well the increase in bulk temperature of rice grain with milling time .Energy utilized for milling was found to be about 33%, whereas about 10% of the energy was utilized in running the temperature of the grain, and 55-60% of the total energy was utilized in running the machine in idle condition.

Mohapatra and bal (2007) studied the effect of milling on specific energy consumption of rice milled in abrasive Satake laboratory rice polisher. They concluded that, as the milling progressed the energy consumption increased with degree of milling.

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 with an increase in degree of milling and decrease of energy consumption of the friction type milling machines.

Itani *et al*., (2002) reported that the proteins, fats, vitamins, and minerals are concentrated in the germ and outer layer of the starchy endosperm. In course of milling these are removed, thus reducing the nutrition value of rice.

The current study aims at testing and evaluating the effect of different milling times on rice milling quality, energy consumption and nutrino value of different short grain rice varieties using a laboratory scale friction type milling machine. The approach led to assessment of optimum operational condition and milling time for the studied varieties.

MATERIALS AND METHODS

Four different short grain Varieties were obtained from the experimental farm of Sakha Research and Farming Center Kafr EL-Shickh gov. The selected varieties were Sakha 101,

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Sakha104, Sakha super -300 and Giza 178. The samples of each variety were cleaned and sun dried to a moisture level of 14%w.b ± 1 and stored in burlap bags until used. Before each experimental run, the rice samples were taken and the moisture content was determined using the standard oven method at 130 C° for 18 hr as recommend by (AOAC, 1990).

Rice husking and milling process:

Rice husking:

The laboratory scale rubber rolls huller (model ST-50) was used for husking different samples of the studied varieties .The machine consists of two rubber rolls rotates at different speeds with adjustable clearance between rolls. The clearance between the two rolls was adjusted to give 90% brown rice as recommended by (Dhankhar 2014). Before each run the sample was poured to the machine hopper and the chatter was opened .The grain samples were de- husked due to the pressure of the rollers movement and also to the difference in rollers speeds which causes shear stress on the husk surface induced by applying upward and down word pressure on the rough rice and friction force in opposite direction .This action causes a removal of husk from the grain.

Milling process:

In general, friction mill is suitable for Taponica varieties which are short and difficult to break. The friction type milling machine (lab. Scale) shown in Fig. (1) was used for the experimental work. The brown rice was poured into the machine from the feed hopper on the top of the machine .The brown rice is conveyed forward from the screw roll and rice is polished by the stirring frication force of the milling roll. The rotating screw roll and milling roll are covered with a hexagonal or octagonal screen. The external resistance at the outlet side (weigh resistance) provides resistance at the outlet and used to regulate the pressure in the milling chamber. The air jet is used to control rice temperature and blow off rice barns .The air jet comes from a blower via the main axis of the milling section to the outside of the screen. For all runs of milling process, three sub samples of each studied variety were used. The machine was adjusted at a roller speed of 1780 rpm and a mass of 1,500 g was placed at the mill outlet arm to give proper resistance to the outgoing grains and also create pressure inside the milling chamber as reported by (Dhankhar 2014).

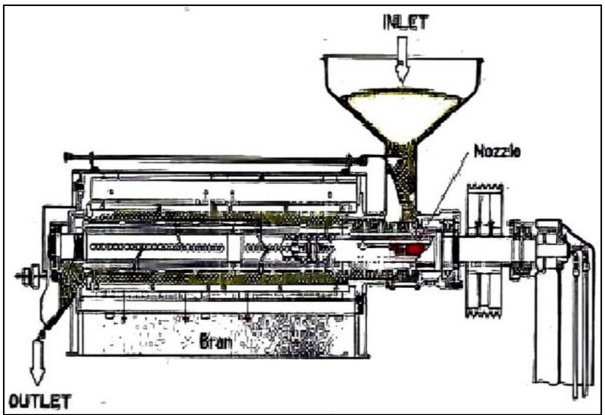

Fig. 1. Sketchmatic diagram for the friction type milling machine**.**

The brown rice of each variety was fed to the machine and when the hopper gate is opened the stop watch was started to record the milling time .The resulted white rice of each run was weighed and the broken rice was separated from the head rice using a laboratory scale rice grading machine model (Satake TRG.05A). Fig. (1) presents the structure feature of the friction type milling machine and the rice grading machine .

Test procedure and measurements:

The effect of different milling times (30, 45, 60 ,75 and 90 sec) on total rice yield, head rice yield, whitening degree of milled rice, nitrogen contents and electric power consumption for the short grain varieties Sakha 101, Sakha 104, Giza 178 and Sakha super 300 were tested and evaluated. The experimental measurements and test procedure included the following items:

Total and head rice yields:

The percentage of total and head rice yields was calculated using the following relationships:

$$\% \text{ Total rice yield} = \frac{total\ wt\ of\ milled\ rice}{wt\ of\ paddy\ sample} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\% \text{ Head rice yield} = \frac{wt\ of\ sound\ kernels}{wt\ of\ paddy\ sample} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Whiteness degree of milled rice:

Whiteness degree of milled rice was measured for each treatment using the Japanese Kett Whiteness Meter model C-300.The apparatus was calibrated using the calibration figure for white rice .The white rice sample was filled into the measuring figure and inserted into the meter tube for three minutes. Whiteness degree (unit) of the tested sample was displayed digitally into the meter screen.

Bulk temperature of milled rice:

Bulk temperature of milled rice was measured immediately after each whitening run using the infra - red spot thermometer model (HT-11).

Power consumption of the whitening process:

The electric power consumption (W/125g.paddy) for each experimental run was measured using German LVM-210/power consumption meter. The whitening machine was fixed to the power source and the power consumption meter. The stabilized reading without load power was first recorded and it was subtracted from the power data collected when the machine was running under full load for each studied variety. The samples of each variety were fed to the hopper of the machine. As the hopper gate was opened the stop watch started and the power consumption was recorded just after the sample had run through the machine for the required whitening time.

Nutrition content of milled rice:

Nutrition contents of milled rice were determined at the rice processing laboratory of Rice Research and Training Center, Sakha Agric. Res. Center (A.R.C). Protein content was estimated using the Kiel- Dahi method. Amylase content was determined by the method of (Juliano, 1971) and the lipid material was extracted from rice flour with N-Hexane as described by (Choudhury and Juliano 1980). Total content of Ca, Zn, and Mg were also determined in the digested solution using atomic absorption FMD3.

RESULTS AND DISCUSSTION

Total and head rice yield:

The percentages of total and head rice yields are presented in Figs. (2) and (3) respectively. As shown in Fig. (2), the recorded total rice yields for the tested varieties Sakha 10, Sakha 104, Giza 178 and Sakha Super- 300 were 75, 73.1, 72.9 and 73.9% respectively at the minimum milling times of 30 Sec. While, at the maximum milling time of 90 Sec., the corresponding total rice yields were 68.5, 67.2, 66.5, and 66.5% respectively. The above mentioned results reveled that, variety Sakha 101 showed the highest percentage of total rice yields at all examined milling times. Meanwhile, for all tested varieties the total rice yield (%) decreased with the increase of milling time. This may be due to higher removal rate of rice bran layers and part of the grain endosperm with the increase of milling time.

On the other hands Fig. (3) illustrates the change in head rice yield (%) as related to the milling time. As shown in the figure, variety Sakha 101 recorded the highest percentage of head rice yield, followed by Var. Sakha 104, Giza 178, and Sakha Super -300 respectively. The variation in head rice yield at similar milling times could be attributed to the changes in physical and mechanical properties of each variety. Meanwhile, the recorded head rice yields (%) at the minimum milling time of 30 Sec. were 68.4, 65.6, 64, and 63 for the tested varieties Sakha 101 , Sakha 104, Giza 178 and Sakha Super -300 respectively.While the corresponding head rice yields at the maximum milling time of 90 Sec. were 63.2, 59.3, 58.2 and 54.8 (%) respectively. This means that, with the increase of milling time, the grain exposed to more friction forces and bending stresses which increased the broken percentage and reflected in a reduction in percentage of head rice yield. However, the broken percentage is not only the factor of evaluating the performance of milling process but the whiteness degree, nutrition value, and power consumption should be also considered for assessment of the optimum milling time for the studied variety.

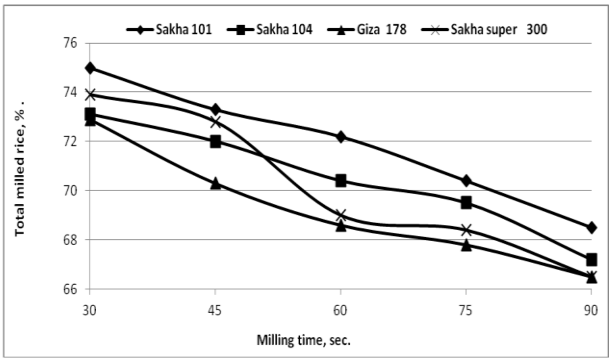

Fig. 2. Total rice yield as related to milling time for different studied rice varieties.

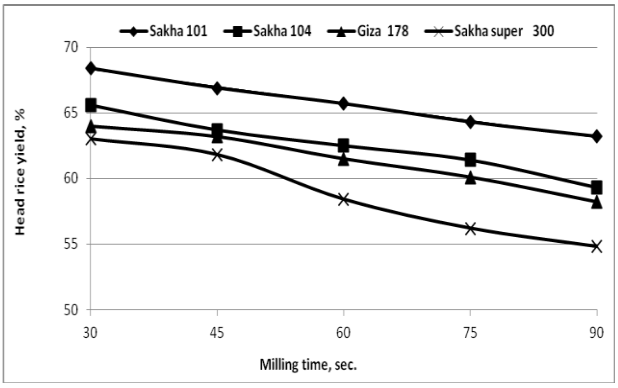

Fig. 3. Head rice yield as related to milling time for different studied rice varieties.

Rice bulk temperature:

As shown in Fig.(4), rice bulk temperature increased with the milling time for all studied varieties. The recorded rice bulk temperature ranged from (50.7 to 61°C), (43.012 to 61.921°C), (55.9 to 63.6°C),and from (45.52 to 68.242°C) for the studied varieties Sakha 101, Sakha 104, Giza178 and Sakha Super- 300 as the milling time increased from 30 to 90 Sec. respectively. In general the increase in rice bulk temperature causes a noticeable reduction in head rice yield due to heat stress and crack of kernels surface, which cause more cracked and broken kernels.

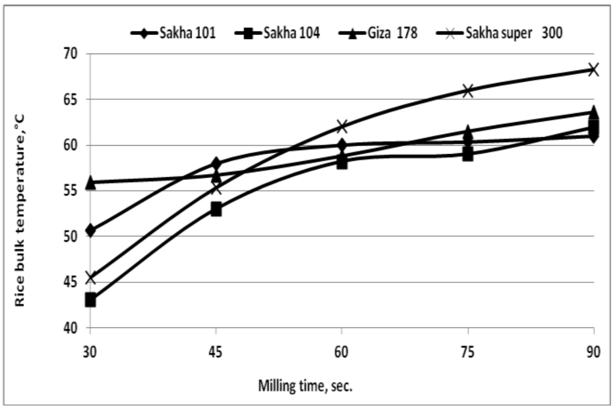

Fig. 4. Rice bulk temperature as related to milling time for different studied rice varieties.

Power consumption:

Power consumption for the milling process considered as a very important factor for optimization and economic operation of the machine. As shown in Fig. (5), power consumption of the examined friction type milling machine decreased with the increase of milling time. The recorded values of power consumption for the studied varieties Sakha 101, Sakha 104, Giza 178 and Sakha Super- 300 ranged from (240 to 122), (256 to 131), (235 to 168) and (248 to 147) (W/125g of paddy) at the minimum and maximum milling times of 30 and 90 Sec. respectively. The observed reduction in power consumption with the increase of milling time could be attributed to the working mechanism of the friction type milling machines. At the early stage of milling process, the bran removed off by the higher friction forces between grain to grain, grain and the peeling screen and grain with the revolving roll. With increasing milling time the bran layer is further removed and both the pressure and the friction forces decreased causing a relative reduction in power consumption as mentioned by (Mohapatra and Bal, 2007).

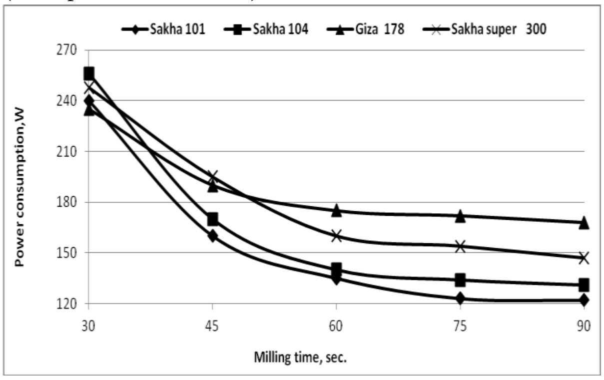

Fig. 5. Power consumption as related to milling time for different studied rice varieties using a laboratory scale milling machine.

Whiteness degree of milled rice:

The effect of milling time on whiteness degree of milled rice for different studied varieties is presented in Fig. (6). As shown in the figure, the whiteness degree of milled rice increased with the increase of milling time for all studied varieties. The recorded whiteness degree ranged from (41.971 to 46.937), (38.378 to 43.532), (33.512 to 37.912) and (36.201 to 40.633) units for the studied varieties

Sakha 101, Sakha 104, Giza 178, and Sakha Super- 300 respectively. This means that variety Sakha 101 recorded the highest whitening degree followed by Sakha 104, Sakha super 300 and G.178 respectively. The results shown in Fig.(6) revealed that, the increasing in whiteness degree starts with higher rate at the early stage of milling and declined over the milling time. As shown in Fig.(6) Over 60 Sec. milling time, the change in whiteness degree could not be distinguished by direct eye inspection or in other words, no detectable differences could be visually found for the whiteness degree at the milling times of 60,75 and 90 Sce. This means that increasing the milling time over 60 Sec, decreased the head rice yield and the nutrition value of milled rice without noticeable increase in whiteness degree.

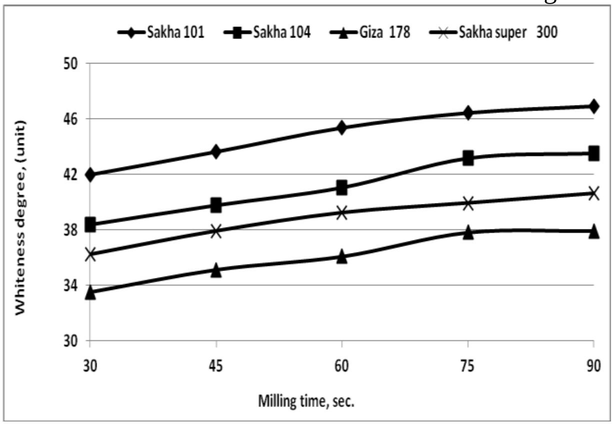

Fig. 6. Whiteness degree as related to milling time for different studied rice varieties.

Nutrition value of milled rice:

The effect of milling time on nutrion value of milled rice is presented in table (1). As shown in the table, the moisture content of all studied varieties decreased with the increase of milling time due to the increase of bulk temperature and the evaporation of moisture from milled kernels. In contrast the nutrition contents such as protein, lipids and minerals decreased with increase of milling time while the amylase content increased. The observed reduction in nutrion contents of milled kernels for different studied varieties could be attributed to the removal percentage of rice bran layers. In contrast the observed increase in amylase content may be due to the increase in starch content of milled rice. In general, the removal rate of nutrition contents is dramatically increased over the milling time of 60 Sec. for all studied varieties.

CONCLUSION

1- The total and head rice yields decreased with the increase of milling time depending upon the physical and mechanical properties of different studied varieties and the effect of both thermal and mechanical stresses on the kernels surface.

2- The bulk temperature of milled rice affecting the percentage of head rice yield, and the final moisture content of milled rice due to the thermal stress on kernels surface.

3- Power consumption of milling process decreased with the increase of milling time due to the reduction in friction forces as the milling time increased for all studied varieties.

4- Increasing the milling time over 60 sec. increased the whitening degree of milled rice in a non-distinguished matter by human eyes. However it has dramatically reduced the head rice yield and nutrion value of milled rice with limited increase in power consumption.

5- Milling time of 60 Sce. is recommended for all studied varieties to get higher percentage of head rice yield and whiteness degree and lower losses of the nutrion value of milled rice without noticeable increase in power consumption.

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تأثير زمن التبييض علي كفاءة الاداء والطاقة المستهلكة لبعض اصناف الارز قصيرة الحبة

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معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – دقي – جيزة

أجريت الدراسة لاختبار وتقييم تأثير زمن التبييض (30 , 45 , 60 , 75 ,90 ثانية) لأصناف الارز قصيرة الحبة سخا 101 , سخا 102 , جيزة 178 , سخا سوبر – 300 باستخدام الة التبييض المعملية من النوع Friction type. اظهرت النتائج إنخفاض كل من الوزن الكلي ووزن الحبوب السليمة بزيادة زمن التبييض. من ناحية اخري زادت قيم درجة التبييض لحبوب الارز بزيادة الزمن حتي 60 ثانية ثم بدأ معدل الزيادة في درجة التبييض ينخفض بصورة ملحوظة لايمكن ملاحظتها بالعين المجردة حيث تزامن ذلك مع انخفاض نسبة الحبوب السليمة ومحتوي الحبوب من العناصر الغذائية. اظهرت النتائج ايضا انخفاض قيم الطاقة المستهلك بزيادة زمن التبييض وذلك نتيجة لفقد الحبوب لجزء كبير من طبقة الرجيع خلال المراحل الاولي من عملية التبييض مما يقلل من عملية الاحتكاك وبالتالي الطاقة المستهلكة للاصناف موضوع الدراسة. وبصفة عامة اظهرت الدراسة ان زمن التبييض 60 ثانية يعتبر الزمن الامثل لعملية التبييض باستخدام الات التبييض من النوع Friction type حيث انه يعطي افضل نتائج من حيث زيادة نسبة الحبوب السليمة والمكونات الغذائية للحبة مع عدم تاثر درجة تبييض الحبوب بصورة ملحوظة بالاضافة الي الاستهلاك المناسب للطاقة .