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INFLUENCE OF TEMPERING TIME ON MILLING AND COOKING QUALITY OF RICE

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Abstract

The present study was carried out at the Rice Mechanization Center, Meet El-Deeba, Kafr El-Sheikh Governorate, Egypt during summer season of 1998. Several experiments were conducted to show the effect of drying parameters on the drying behavior, milling and cooking quality of rice variety Giza 177.Chemical analysis included total lipids, crude protein content, total carbohydrates, amylose, ash, alkali spreading value, gel consistency and the rice kernel elongation were determined in the Food Sci. and Technol. Dept. Lab., College of Agriculture, Kafr El-Sheikh, Tanta Univ. Rice qualities represented by percentage such as: cracks, broken milled rice, shelling efficiency, head yield and degree of whiteness were closely related to the length of tempering period and inlet air temperature. On the other hand, the highest value of shelling efficiency was 98.12 % at inlet air temperature of 80 °C and tempering period of 3 h for bed depth of 5 cm.

The results showed that the rate of drying increased with prolongation of tempering period, whereas, the minimum required time to reach 14.5 % moisture content was 30 min. at bed depth of 5 cm and inlet air temperature 80 °C with tempering period of 3 h. The maximum value of head yield was 81.24 % whereas, the crack percentage was 12.45 % and the broken milled rice was 2.91 % at inlet air temperature of 45 °C and bed depth of 5 cm for tempering period of 3 h. However, the minimum value of head yield was 74.26 % whilst, the maximum broken milled rice was 9.21% and the maximum percentage of crack was 22.62 % at inlet air temperature of 80 °C and bed depth of 5 cm under continuous drying (zero tempering).

Milled rice obtained from drying with tempering period showed a definite improvement in its cooking quality in comparison with samples dried without tempering (continuous drying). Also multiple linear regression analysis was fitted to establish relationships between the previous mentioned parameters.

INTRODUCTION

Rice is considered the most important cereal crop in Egypt. The cultivated area of rice crop in 1998 amounted to 1.482 million feddans, which produced 5.280 million tons. A large amount of the national production was locally consumed, and about 500 thousand tons were exported (RRTC, 1998). Rice is usually harvested at relatively high moisture levels from 20 to 25 % (w.b) to minimize field losses such as grain shattering, insects, birds and rodents attack. However, at these moisture levels, rough rice may suffer substantial losses both in quality and quantity. This may be due to specific changes in physical, physio-chemical and biological factors. These losses include reduction in germinability, discoloration of whole or part of the grains, reduced milling yield, unfavorable changes in cooking, eating quality and potential health hazards from mycotoxines. These losses are estimated to be about 30 % of the total production (Megahed and Krutz, 1994).

An effective solution to this problem is divided into either avoiding drying delays or extending the safe storage period of high moisture paddy by drying the grain for delaying or stopping its rapid deterioration during this period. The rate of drying increased with longer tempering times and that rice qualities such as cracking and germination were closely related to the length of the tempering period (Itoh and Terao, 1974). Sabbah (1971& 1972) studied the effect of tempering shelled corn using heated air drying and subsequent cooling experimentally by conducting experiments at 5 levels of tempering time and 3 levels of air flow rates. The results showed that tempering had significant effects on moisture removal and on cooling rate. Wasserman *et al.* (1964) showed that tempering period of 4 h was sufficient if the tempering temperature was 40.6 °C while, period of 6 h was satisfactory if the tempering temperature was 23.8 °C, when drying rice from 20 to 13 percent M.C. (w b.) in three passes with 43.3 °C air. The head yield of rice tempered cold (23.8 °C) was 2 percent lower than that of the rice tempered warm (40.6 °C).

Dermott and Evans (1978) stated that the most common method of killing microorganisms is based on the application of heat. Besides microorganisms, heating can inactivate enzymes causing deterioration during temporary or long storage periods. However, the use of heat treatment for conditioning high moisture grains to prolong their safe storage period has not been explored so far. Heating of agricultural grains for drying is an accepted practice. Recently, fluidized bed heating has been shown to be an effective means of insect disinfection in low moisture wheat. Abe *et al.* (1992) showed that the drying parameters affect the quality of the dried grain. Drying air temperature range of 45 to 50 °C, airflow rate of 0.3 to 0.5 m3 / min. kg, exposure time of 5 min. to 10 min., tempering temperature of 25 °C and tempering time of 50 min. is considered most appropriate for obtaining good quality and tasty rice. Grains must be dried promptly and fast after harvest. Grains that took time to dry to a safe moisture content usually turn out to be of poor quality.

El-Sahrigi *et al.* (1993) mentioned that the corresponding drying time to reach grain rice moisture content of 13.8% for 30,20 and 10 cm depth of grain layers was 14,12 and 7 h, respectively. Whilst, the control treatments outside the solar grain dryers (unheated air-drying) were 42,36 and 21 h for the same depth of grain layers, respectively.

Amylose content refers to the ratio of amylose to amylopectin. Among rice scientists, it is simply called amylose content. It is the first factor affecting cooking and eating qualities of milled rice. Cooked low amylose rice is sticky while, the product of high amylose will have the following characteristics according to the amylose content of milled rice Juliano *et al.* (1981):

Table 1. Rice characteristics according to amylose content of milled rice.

Class of rice	Amylose, %	Cooked product
Glutinous	0 -2	Very sticky
Low amylose	less than 19	Soft and sticky
Intermediate amylose	20-25	Soft
High amylose	25-34	Fluffy, hard

Among rice's having similar amylose content, cooked rice texture may differently exist. This may be due to the property of gelatinized starch. Rice having harder texture resulted from a harder cooled gel. A gel consistency test is developed to measure the flow characteristics of milled rice gel. The consistency of non-glutinous rice can be classified according to Juliano *et al.* (1980) as:

Table 2. Rice classification according to non-glutinous rice.

Gel consistency	Distance of gel flow, (mm.)
Hard	26-40
Medium	41-60
Soft	61-100

Juliano and Perez (1984) mentioned that the grain elongation during cooking is a desired character for rice. The chalky phenomenon presumably results from the failure of the endosperm cell wall of some varieties in direction favoring elongation, in contrast to the tendency of varieties to expand widthwise. However, the exact nature of grain elongation is not fully understood, since the composition of endosperm cell wall in selected elongating and non-elongating rice are similar.

Generally, increase in the free fatty acid in stored rice grain is a good indicator that the rice quality is deteriorating. Drying methods and conditions can accelerate the development of free fatty acid in the dried grains.

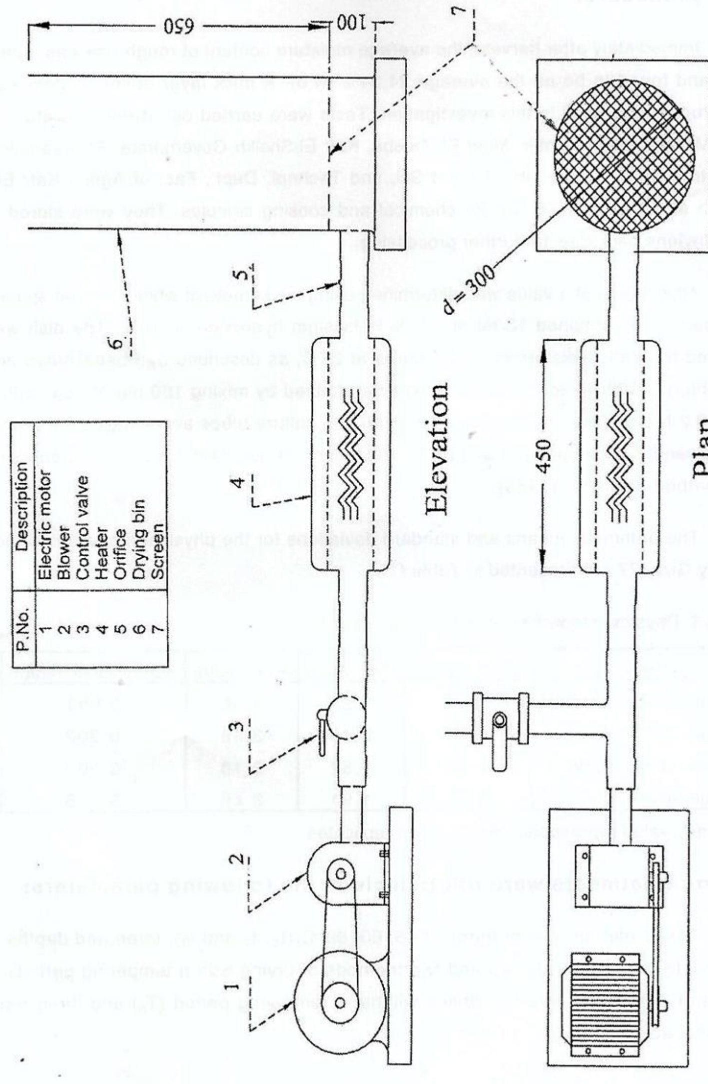
The objectives of the present study were to determine the effects of tempering time, drying air temperature and bed depth on drying rate, milling characteristics, chemical composition and cooking quality.

MATERIALS AND METHODS

Egyptian rice (*Oryza Sativa* L.) namely Giza177 (Japonica) was employed in the present study. Rice samples were obtained from the experimental farm of Rice Mechanization Center, Meet El-Deeba. A laboratory drying set up was constructed for performing drying process. Fig. (1) shows elevation and plan of the set-up. A blower driven by 0.4 kW motor at 1425 rpm was used to force the air through the dryer and the grain bed. The airflow rate was controlled manually by means of control valve. It should be noted that this system is not a thin bed drying system and should be treated as such.

Instrumentation:

A digital thermometer (model HH-26) was used to measure the drying air temperature with an accuracy of ± (1%+1°C). The required air flow rate was adjusted using (K.D.G 2000) air flow meter (model R.A.B, 14728) which measures the airflow rate directly in m^3/min. Grain moisture content was determined directly by using a kit of digital cereal moisture tester (model sp-10). After drying, samples were hulled by using a rubber roller husker (model ST-50) and then polished by using the rotary rice polisher (model RA-150). For separating the whole milled rice from the broken ones, a laboratory grader (model TRG-05) was used. The degree of whiteness was measured using whiteness meter (model c-300). Crack ratio, under a particular drying condition, was determined by inspecting a sample of the dried grain under florescent light. However, hardness of the rice kernels was tested using rigidity tester (model #174886 Kiya Seisakusho LTD). Ten kernels of good shelled rice were tested, each kernel was oriented



Dimensions in mm.

Fig. 1. A laboratory drying set up.

on its flatest surface on the bottom plate, and the manual crosshead was moved down until failure occurred. The hardness value of each sample was recorded in kilogram.

Test procedure:

Immediately after harvest, the average moisture content of rough rice was measured and found to be on the average 24.34% (w.b). A thick layer drying system was constructed and used in this investigation. Tests were carried out at the laboratory of Rice Mechanization Center, Meet El- Deeba, Kafr El-Sheikh Governorate. Rice samples, were transferred to the lab. of Food Sci. and Technol. Dept., Fac. of Agric., Kafr EL-Sheikh at Tanta Univ., Egypt for chemical and cooking samples. They were stored in polyethylene packages for further processing.

Alkali spreading value was determined using six kernels of white rice that spaced in a petri dish contained 10 ml of 1.7 % Potassium hydroxide solution. The dish was covered and left undisturbed for 23 hours at 25°C, as described by Bhattacharya and Sowbhagya (1980). Gel consistency was determined by mixing 100 mg of flour with 2 ml of 0.2 N potassium hydroxide in 13 x 100 mm culture tubes according to the procedure given by Cagampang *et al.* (1973). Elongation of rice kernel was measured using the method of Tomar (1985).

The arithmetic means and standard deviations for the physical properties of rice variety Giza177 are presented in Table (1).

Table 3. Physical properties of rice variety Giza177

Property	Mean value*	Min. value	Max. value	Standard deviation
Grain length (L), mm	5.33	5.21	5.56	0.091
Grain width (W), mm	2.86	2.45	3.48	0.302
Grain shape (L/W)	1.88	1.52	2.18	0.202
Grain index ,g	2.02	1.91	2.16	0.058

*Each value represents a mean of ten replicates

Drying treatments were run to include the following parameters:

Three inlet air temperatures of 45, 60, 80 °C (t_1, t_2 and t_3), three bed depths 5, 10 and 15 cm (d_1, d_2 and d_3) and two methods of drying with a tempering periods of 1, 2 and 3 h (T_1, T_2 and T_3), drying without a tempering period (T_o) and three replicates for each test.

After the grains were dried for 15 min., they were removed from the dryer and placed in an incubator kept at a constant temperature of 25 °C for tempering for a period of time of 1, 2 and 3 h, respectively. The effect of drying parameters such as drying temperature, tempering conditions, and bed depths on the quality of grain were examined.

Chemical composition of rice samples:

A total lipid of rice was extracted by ethyl ether using Soxhlet technique as described in the standard method of A.O.A.C. (1990). Total nitrogen of rice was determined by using micro Kjeldahl method as given by the A.O.A.C. (1990). Crude protein content of the tested rice samples was calculated by multiplying the total nitrogen by the factor of 5.95. Total carbohydrate content of rice was determined by phenol-Sulphuric acid method given by Taylor (1995). Amylose content of rice was determined according to the procedure of Juliano *et al.* (1981). Amylopectin content was calculated by the difference between 100 and amylose content. Ash content of rice was determined in an electric muffle oven at 525 - 550 °C until reaching the complete ashing following the method described in A.O.A.C. (1990).

Basic consideration used in calculation:

For each treatment a total of 100 grains of rice sample were manually dehusked. The resulting brown rice was inspected using the reflection type crack meter. The cracked grains were calculated as a percentage using the following equatin:

$$\text{Percentage of cracked grains} = \frac{n_c}{n_t} \times 100 \quad (1)$$

where :

n_c = number of cracked grains, and

n_t = total number of grains.

$$\text{The percentage of broken milled grains} = \frac{W_b}{W_B} \times 100 \quad (2)$$

Where:

W_b = mass of broken milled grains, g and

W_B = total mass of rice sample, g.

$$\text{Head yield} = \frac{W_H}{W_B} \times 100 \quad (3)$$

Where:

W_H = mass of milled grains, g.

RESULTS AND DISCUSSION

1. Moisture content:

a. Effect of drying air temperature and bed depth:

Figs. (2, 3, 4 and 5) illustrate the effect of bed depth drying, with and without tempering, on moisture reduction at three different inlet air temperatures. There was a positive effect of drying air temperature on moisture removal from rough rice. Also, it is clear that, the increase in bed depth tends to decrease both the moisture removal and drying rate.

In the same manner, the minimum required time to reach an average of 14.62 % moisture content was 30 min. at bed depth of 5 cm, inlet air temperature of 80 °C in samples with and without tempering.

b. Effect of tempering:

Results showed an increase in the rate of drying with tempering time and these agree with the result obtained by Sabbah (1972). Figs. (2,3, 4 and 5) showed that, the total amount of moisture removal in samples without tempering is less than that removed from rice with a tempering period. In the same manner, results showed that, the minimum required time to reach 14.5 % moisture content was at bed depth of 5 cm, inlet air temperature of 80 °C and tempering period of 3 h. Whilst, the maximum required time to reach an average of 14.85 % moisture content was 105 min. at inlet air temperature of 45 °C, bed depth of 15 cm in samples without tempering period (continuous drying). Also, the drying rates increased after the tempering period and this attributed to the moisture distribution within the kernel and perhaps, tempering increased the ease of drying with the second pass.

2. Milling quality:

Effects of tempering time, bed depth and inlet air temperature on milling quality were evaluated in terms of shelling efficiency, broken after milling, crack ratio, head yield, grain hardness and degree of whiteness. Table (4) summarizes the effect of the above mentioned drying parameters on milling quality.

a. Grain hardness:

Table (4) indicates the effect of inlet air temperature, bed depth and drying with and without tempering on grain rigidity. This table also, shows that the grain rigidity in-

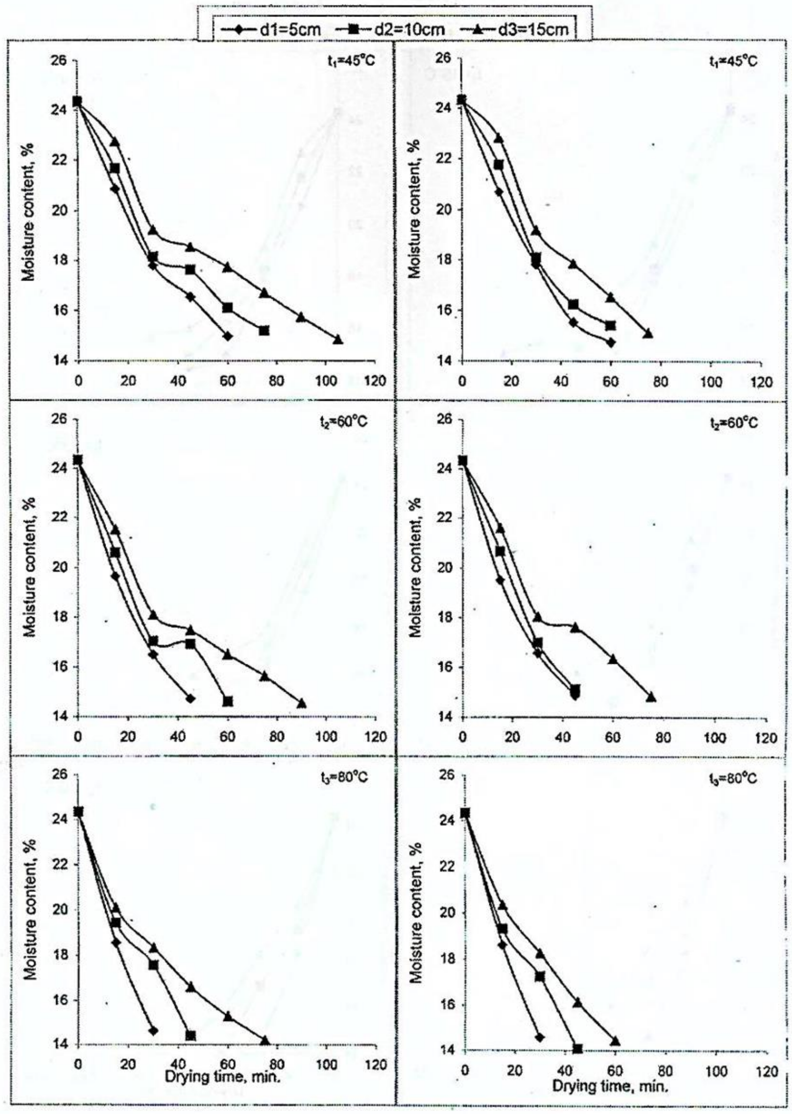


Fig. 2. Effect of bed depth and inlet air temperature on moisture reduction for continuous drying.

Fig. 3. Effect of bed depth and inlet air temperature on moisture reduction for tempering period 1 h.

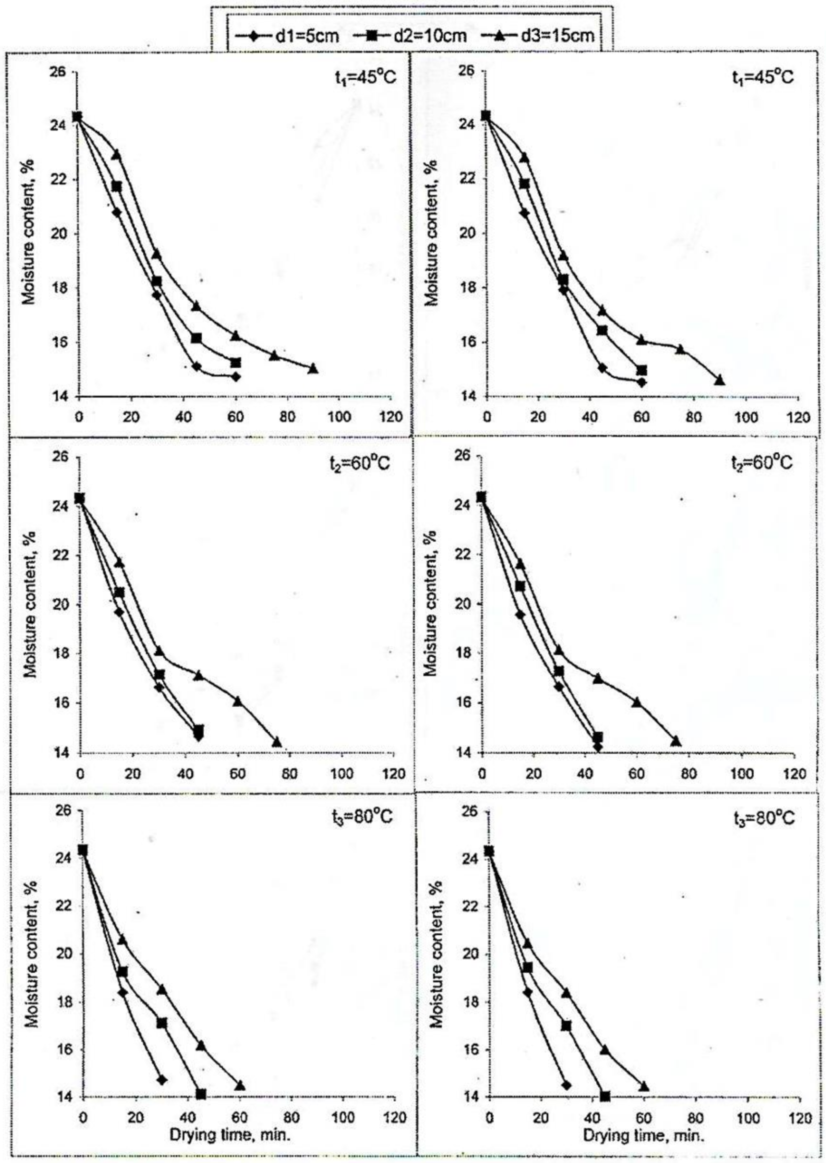


Fig. 4. Effect of bed depth and inlet air temperature on moisture reduction for tempering period 2 h.

Fig. 5. Effect of bed depth and inlet air temperature on moisture reduction for tempering period 3 h.

creases with the increase of both bed depth and tempering time. Also, the inlet air temperature increase tends to decrease the grain rigidity. It is evident that, the maximum value of grain rigidity was 56.13 N at inlet air temperature of 45 °C and bed depth of 15 cm for tempering time of 3 h.

b. Broken milled rice:

Table (4) illustrates the effect of drying parameters on the percentage of broken milled rice. It can be stated that, the same tendency was obtained as the crack for the same reason mentioned above. The highest value of broken milled rice was 9.21 % at inlet air temperature of 80 °C and bed depth of 5 cm under continuos drying (zero tempering). Whilst, the lowest value of broken milled rice was 2.61 % at inlet air temperature of 45 °C and bed depth of 15 cm for tempering time 3 h.

c. Shelling efficiency:

Table (4) and Fig. (6) show the effect of bed depth, inlet air temperature and drying with and without tempering on shelling efficiency. It can be mentioned that, the increment in bed depth tends to decrease the shelling efficiency at all inlet air temperature and tempering time. Whilst, the tempering time increase has little increase in shelling efficiency. In the same manner, there was a positive effect of inlet air temperature on shelling efficiency. It is clear that, the maximum value of shelling efficiency was 98.12 % at inlet air temperature of 80 °C and tempering time of 3 h for bed depth of 5 cm.

Equation (4) presents the calculation of shelling efficiency as a function of inlet air temperature, bed depth and tempering time in the form:

$$\eta_{Sh} = a + b(t) - c(D) + d(T) \quad (4)$$

Where:

η_{Sh} = shelling efficiency, %;

t = inlet air temperature, °C;

D = bed depth, cm;

T = tempering time, h.

d. Head yield, percentage:

Table (4) and Fig. (7) obvious the effect of drying parameter mentioned above on head yield. It can be stated that the decrement in both inlet air temperature and bed depth increases the head yield. Otherwise, the increment in tempering time in-

Table 4. Effect of tempering time, inlet air temperature and bed depth on milling quality.

Air temp., °C	Bed depth, cm	Tempering time, h	Milling quality					
			Hardness, N	Broken, %	Crack, %	Shelling eff., %	Head yield, %	Whiteness, %
45	5	0	50.15	4.35	16.22	94.12	79.53	34.21
		1	51.14	3.45	15.56	95.41	80.12	35.11
		2	52.25	3.08	14.37	95.75	80.67	35.83
		3	53.17	2.91	12.45	95.83	81.24	36.55
	10	0	51.16	4.10	15.50	93.81	79.14	34.62
		1	52.09	3.29	14.21	94.61	79.85	35.43
		2	53.45	3.00	13.29	95.44	80.32	36.16
		3	54.65	2.75	11.38	95.56	80.91	37.30
	15	0	52.44	3.82	14.37	93.45	78.76	35.19
		1	53.56	3.15	13.05	94.17	79.78	35.92
		2	54.73	2.85	12.91	94.53	80.10	36.58
		3	56.13	2.61	10.82	94.78	80.56	37.95
60	5	0	42.10	6.19	19.08	95.29	77.78	32.17
		1	43.18	5.02	17.67	96.26	77.98	33.09
		2	43.95	4.77	16.73	96.71	78.37	33.82
		3	45.28	4.36	15.05	97.35	78.53	34.57
	10	0	43.07	5.25	18.53	94.75	77.11	32.81
		1	44.30	4.87	16.90	95.45	77.65	33.65
		2	45.29	4.60	16.10	96.53	77.96	34.29
		3	47.48	4.28	14.42	97.17	78.19	35.05
	15	0	45.20	4.90	17.05	94.31	76.19	33.12
		1	46.18	4.65	16.24	94.79	76.55	33.97
		2	47.56	4.43	15.43	95.65	77.03	34.44
		3	49.30	4.09	14.02	96.73	77.38	35.39
80	5	0	38.76	9.21	22.62	96.60	75.75	30.26
		1	39.53	8.73	20.56	97.15	76.02	31.12
		2	39.87	8.15	19.45	97.78	76.18	31.89
		3	40.45	7.54	18.67	98.12	76.36	32.65
	10	0	39.29	8.35	21.46	95.34	75.10	30.63
		1	40.33	7.87	19.87	96.21	75.50	31.75
		2	40.91	7.34	19.23	96.69	75.87	32.31
		3	41.87	6.85	18.74	97.31	76.11	32.95
	15	0	41.13	7.19	20.41	94.81	74.26	31.34
		1	42.53	6.68	18.35	95.60	74.83	32.09
		2	43.09	6.41	18.01	95.92	75.09	32.65
		3	43.95	6.20	17.79	96.94	75.25	33.50

Each value represents a mean of three replicates

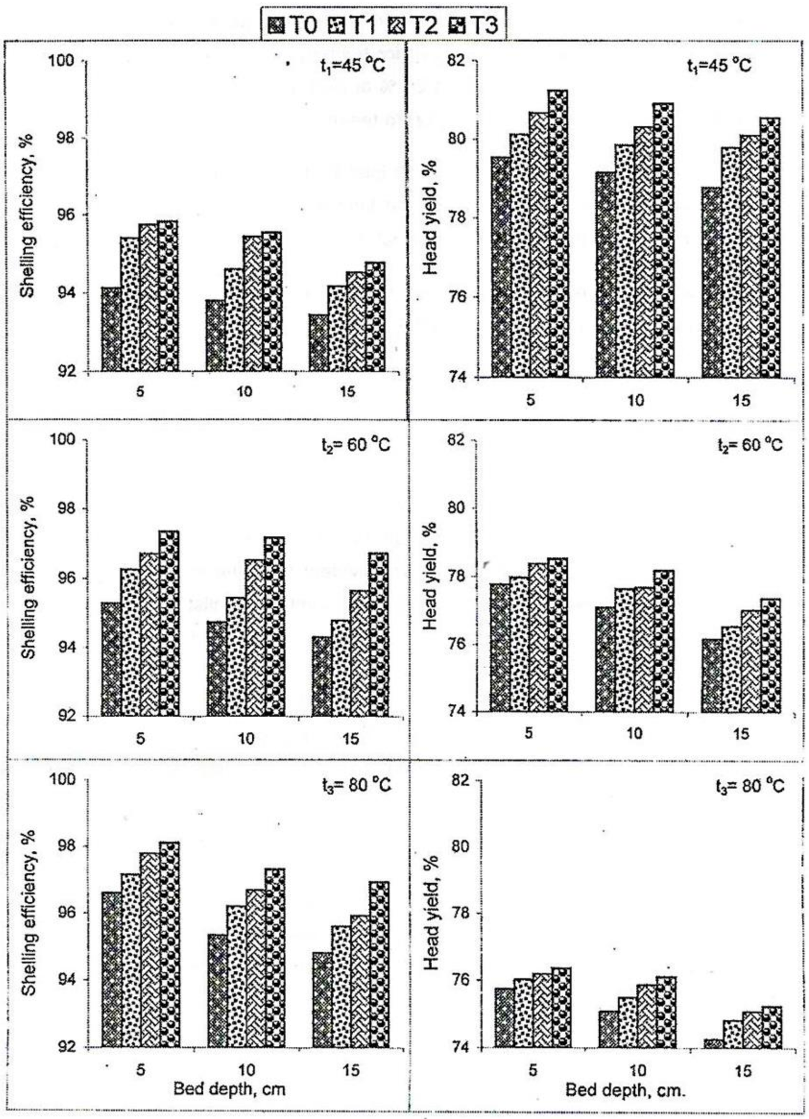


Fig. 6. Effect of bed depth, drying with and without tempering on shelling efficiency at different inlet air temperature.

Fig. 7. Effect of bed depth, drying with and without tempering on head yield at different inlet air temperature.

creases the head yield. The maximum value of head yield was 81.24 % at inlet air temperature of 45 °C and bed depth of 5cm for tempering time of 3 h. Whilst, the minimum percentage of head yield was 74.26 % at inlet air temperature of 80 °C and bed depth of 15 cm with continuous drying (zero tempering).

In regard to the analysis of variance inlet air temperature had highly significant effect on head yield. Meanwhile, tempering time had significant effect on head yield otherwise, bed depth had no significant effect on head yield.

Equation (5) illustrates the effect of inlet air temperature, bed depth and temping time on head yield percentage as in the form.

$$H_y = a - b(t) - c(D) + d(T) \quad (5)$$

Where:

H_y = head yield, %.

e. Crack percentage:

The effect of three different levels of inlet air temperature and bed depth was presented in Table (4) and Fig. (8). It was evident that, the increment in both bed depth and tempering time decreases the crack percentage. Whilst, the increase in inlet air temperature increases the crack percentage. It should be pointed out that, in drying high moisture rough rice with heated air, drying starts from the surface of the kernel and progresses inward. Drying too rapidly causes case hardening whereby the surface of the grain dries out rapidly sealing the moisture within the inner layers. The same phenomenon accounts for the development of chalky grains during milling and hence results in reduction of milling recovery quantitatively and qualitatively Abe *et al.* (1992). However, the highest value of crack was 22.62 % at inlet air temperature of 80 °C and bed depth of 5 cm with no tempering. In the same manner, the lowest value of crack was 10.82 % at inlet air temperature of 45 °C and bed depth of 15 cm and tempering time of 3 h. Statistical analysis showed that, inlet air temperature and tempering time had highly significant effect on crack percentage. However, bed depth had no significant effect on crack ratio.

Equation (6) indicated the effects of inlet air temperature, bed depth and temping time on crack percentage as in the form.

$$C_p = a + b(t) - c(D) - d(T) \quad (6)$$

Where:

C_p = crack percentage, %.

f. Degree of whiteness:

The effect of various inlet air temperatures, bed depth and tempering times on degree of whiteness were presented in Table (4) and Fig. (9). It can be mentioned that, the inlet air temperature increase tends to decrease the degree of whiteness. The reason is that higher inlet air temperature produces milled rice slightly yellowish in appearance in comparison with low air temperature. This change in color could be attributed to the non-enzymatic browning and /or the diffusion of coloring pigments of the rice hull and bran to endosperm caused by exposure of the grain to high levels of temperature. Generally, the change in grain color was less severing for milled rice produced from rough rice having higher inlet air temperature. Moreover, there were a positive effect of both bed depth and tempering time on degree of whiteness. It is clear also that, the maximum value of degree of whiteness was 37.95 % at inlet air temperature 45 °C and bed depth of 15 cm for tempering time 3 h. On the other hand, the minimum value of degree of whiteness was 30.26 % at inlet air temperature of 80 °C and bed depth of 5cm with continuos drying (zero tempering). Statistical analysis indicated that, both inlet air temperature and tempering time had a highly significant on degree of whiteness. Meanwhile, the bed depth had significant effect on degree of whiteness.

Equation (7) presents the calculation of whiteness degree as a function of inlet air temperature, bed depth and temping time in the form:

$$D_{wh} = a - b(t) + c(D) + d(T) \quad \ldots\ldots \quad (7)$$

Where:

D_{wh} = degree of whiteness, %.

The regression and correlation coefficients for degree of whiteness, head yield, crack and shelling efficiency are presented in Table (5).

Table 5. The regression and correlation coefficients for degree of whiteness head yield, crack and shelling for efficiency.

Parameters	Constant (a)	Regression coefficient			Correlation coefficient
		(b)	(c)	(d)	(r)
Shelling efficiency, %	93.0	0.05	-0.12	0.64	0.965
Head yield, %	70.17	-0.13	-0.11	0.40	0.993
Crack, %	9.55	0.17	-0.17	-0.14	0.990
Degree of whiteness, %	38.77	-0.11	0.09	0.78	0.991

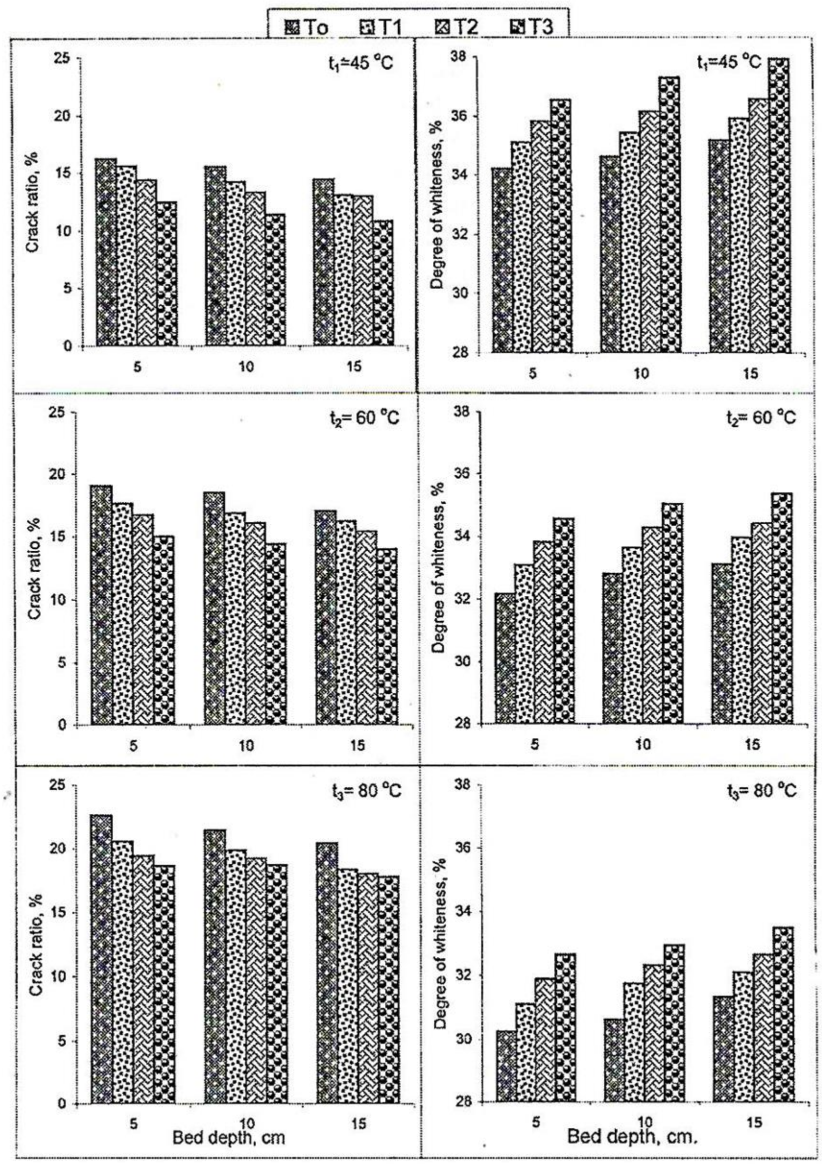


Fig. 8. Effect of bed depth, drying with and without tempering on crack ratio at different inlet air temperature.

Fig. 9. Effect of bed depth, drying with and without tempering on degree of whiteness at different inlet air temperature.

3. Chemical composition and cooking quality:

Table (6) shows the proximate chemical composition of milled rice and the above mentioned drying parameters. The increase in inlet air temperature decreases the values of crude protein content, total lipids, carbohydrate and ash. This could be attributed to the losses in rice hull and bran which contains large a mount of crude protein and minerals. In the same manner, the highest value of the above mentioned constituents were 9.21, 0.9, 94.58 and 0.711 %, respectively, at the inlet air temperature of 45 °C, bed depth of 15 cm and tempering time of 3 h. Whilst, the lowest value were 5.03, 0.24, 87.14 and 0.113 % at inlet air temperature of 45 °C, bed depth 5 cm and drying without tempering (continuous drying). Rice yield may be manipulated intentionally during milling to increase or decrease the bran content of rice. Obviously, this will affect the chemical composition of the white rice and the bran (Sotelo *et al.*, 1990).

Also, the same increase in inlet air temperature increases the amylose percentage. The highest value of amylose was 23.85 %at inlet air temperature of 80 °C and bed depth of 5 cm with continuous drying (Zero tempering). Experimental results obtained from chemical composition analysis showed that, amylose content ranged from 19.87 to 23.85 %, this means that, this variety classified soft. These findings are the same trend with those obtained by Juliano *et al.* (1981).

The cooking characteristics of heat-treated rough rice were found to be affected by inlet air temperature, bed depth and tempering time. An improvement in firmness, stickiness and elongation was observed.

Table (7) illustrates gel constituency, kernel elongation and alkali spreading value as related to inlet air temperature, bed depth and tempering time. It is clear also that, the increase in inlet air temperature increases both gel consistency and elongation. This means that, heat treatment has changed the propriety of starch granules and there by changed, the characteristics of cooked rice texture. The laboratory tests showed an increase in alkali value of dried rice in comparison to natural dried grain and the estimated gelatinization temperature has changed from 70-74 °C for continuous drying (zero tempering) to 55-74 °C for dried rough rice with tempering period these agree with the result obtained by El-Kholy (1998).

Table 6. Effect of tempering time, inlet air temperature and bed depth on chemical composition of milled rice.

Temp., °C	Bed depth, cm	Tempering time, h	Crude protein, %	Total lipids, %	Ash, %	Carbohydrates, %	Amylose, %	Amylopectin, %
45	5	0	7.22	0.60	0.177	92.24	19.87	80.13
		1	7.65	0.69	0.235	92.96	19.65	80.35
		2	7.87	0.75	0.419	93.15	19.53	80.47
		3	8.11	0.83	0.560	93.34	19.34	80.66
	10	0	7.85	0.65	0.184	92.81	19.69	80.31
		1	8.27	0.74	0.251	93.16	19.44	80.56
		2	8.41	0.80	0.456	93.34	19.22	80.78
		3	8.66	0.85	0.675	93.62	19.08	80.92
	15	0	8.15	0.69	0.192	93.13	19.33	80.67
		1	8.60	0.76	0.270	93.85	18.95	81.05
		2	8.89	0.84	0.507	94.29	18.81	81.19
		3	9.21	0.90	0.711	94.58	18.66	81.34
60	5	0	6.09	0.37	0.135	89.18	21.91	78.09
		1	6.87	0.45	0.211	89.56	21.76	78.24
		2	7.13	0.49	0.345	89.91	21.55	78.45
		3	7.45	0.53	0.500	90.24	21.44	78.56
	10	0	6.72	0.42	0.162	89.77	21.68	78.32
		1	6.95	0.48	0.246	90.12	21.45	78.55
		2	7.19	0.52	0.387	90.41	21.29	78.71
		3	7.43	0.59	0.522	90.65	21.07	78.93
	15	0	6.90	0.55	0.175	90.10	21.38	78.62
		1	7.31	0.62	0.273	90.82	21.13	78.87
		2	7.60	0.67	0.398	91.21	20.91	79.09
		3	7.83	0.74	0.539	91.54	20.72	79.28
80	5	0	5.03	0.24	0.113	87.14	23.85	76.15
		1	5.65	0.29	0.187	87.75	23.72	76.28
		2	5.98	0.34	0.265	87.96	23.59	76.41
		3	6.19	0.39	0.391	88.17	23.41	76.59
	10	0	5.80	0.30	0.145	87.52	23.64	76.36
		1	6.11	0.35	0.214	88.10	23.48	76.52
		2	6.32	0.39	0.287	88.43	23.26	76.74
		3	6.60	0.45	0.412	88.71	23.10	76.90
	15	0	6.05	0.35	0.156	88.06	23.26	76.74
		1	6.68	0.39	0.260	88.82	23.13	76.87
		2	6.94	0.46	0.345	89.13	22.98	77.02
		3	7.20	0.53	0.433	89.49	22.63	77.37

Each value represents a mean of three replicates.

Table 7. Effect of tempering time, inlet air temperature and bed depth on alkali spreading values, gel consistency and elongation ratio.

Temp., °C	Bed depth, cm	Tempering time, h	Alkali spreading value	Gel consistency, mm	Elongation, %
45	5	0	6.00	59.16	63.10
		1	5.00	57.73	62.56
		2	5.00	56.65	61.75
		3	5.00	55.50	61.08
	10	0	6.00	57.25	61.12
		1	5.00	56.09	60.25
		2	5.00	55.22	59.70
		3	5.00	54.19	58.58
	15	0	6.00	56.31	59.28
		1	5.00	55.58	58.45
		2	5.00	54.60	58.08
		3	5.00	53.45	57.87
60	5	0	7.00	57.19	65.71
		1	6.00	65.38	64.58
		2	6.00	64.26	63.78
		3	6.00	63.71	62.80
	10	0	7.00	65.11	63.44
		1	6.00	64.39	62.15
		2	6.00	63.18	61.90
		3	6.00	62.56	61.58
	15	0	7.00	64.27	62.43
		1	6.00	63.52	61.09
		2	6.00	63.01	60.78
		3	6.00	62.75	60.24
80	5	0	7.00	74.54	67.35
		1	7.00	73.07	66.19
		2	7.00	72.45	65.56
		3	7.00	71.15	64.43
	10	0	7.00	72.73	65.50
		1	7.00	71.60	64.87
		2	7.00	70.44	64.31
		3	7.00	69.38	63.60
	15	0	7.00	71.35	64.67
		1	7.00	70.28	63.50
		2	7.00	69.13	62.41
		3	7.00	68.36	61.35

. Each value represents a mean of three replicates.

CONCLUSIONS

From the obtained results the following conclusions are derived:

1. Moisture reduction and drying rate increased with longer tempering period and inlet air temperature.
2. In regard to the analysis of variance, for both inlet air temperature and tempering period had highly significant effect on shelling efficiency, crack ratio, head yield and degree of whiteness. On the other hand, the bed depth had no significant on the milling quality.
3. It can be stated that the highest value of shelling efficiency was 98.12 % at inlet air temperature of 80 °C and bed depth of 5 cm for tempering period of 3 h.
4. The results indicated also, that the maximum value of head yield was 81.24 % whereas, the minimum percentage of crack was12.45 % and the minimum broken milled rice was 2.91 % at inlet air temperature of 45 °C and bed depth of 5 cm for tempering period of 3 h.
5. Milled rice obtained from rice dried with tempering showed a definite improvement in its cooking quality in comparison to the continuous dried rice. There was a desirable characteristic of increase in texture firmness and kernel elongation with decrease in stickiness resembling the grain gelatinization and artificial aging occurred during the artificial drying.
6. It can be concluded that, the increase in inlet air temperature decreases crude protein content and increases the amylose percentage. However, there was positive effect of tempering time on crude protein content. On the other hand, the same increment in tempering period decrease the amylose percentage.

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مركز البحوث والتدريب فى الأرز (١٩٩٨). التوصيات الفنية لمحصول الأرز. برنامج الأرز – مركز البحوث الزراعية – وزارة الزراعة.

تأثير فترة الراحة على جودة ضرب وطهى الأرز

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البحث عن تحسين صفات تجفيف وتبييض الأرز هدف قومى يعمل على تعظيم إنتاجه . حيث ارتفاع نسبة التشقق والكسر أثناء عمليتى التجفيف والتبييض تمثل مشكلة كبرى لزيادة نسبة الكسر والتى قد تصل إلى أكثر من ٣٠ ٪ من الأرز الأبيض. لذلك كان هدف البحث هو دراسة تأثير فترة الراحة أثناء عملية تجفيف الأرز على الصفات التكنولوجية لعمليتى الضرب والطهى. ولتحقيق هذا الهدف تم إجراء ١٠٨ معاملة بالإضافة إلى تصنيع نموذج لمرقد تجفيف بمركز ميكنة الأرز بميت الديبة بكفر الشيخ.

وقد اشتملت الدراسة تأثير المتغيرات التالية على جودة المنتج.

أ. طريقة التجفيف (تجفيف مستمر ، تجفيف تتخلله فترة راحة لمدة ساعة ، ساعتان ، ثلاث ساعات).
ب. عمق المرقد (٥، ١٠ ، ١٥ سم)
ج. درجة حرارة هواء التجفيف (٤٥ ، ٦٠ ، ٨٠ درجة مئوية).

ويمكن تلخيص النتائج المتحصل عليها كما يلى:

١- تم الوصول إلى أعلى معدلات للتجفيف (١٤,٥ ٪) على أساس رطب عند درجة حرارة ٨٠° م وعمق مرقد ٥ سم ، وفترة راحة ٣ ساعات لمدة ٣٠ دقيقة من بداية التجفيف.
٢- بينت النتائج أن أعلى قيمة لكفاءة عملية التقشير كانت ٩٨,١٢ ٪ عند درجة حرارة ٨٠° م وعمق مرقد ٥ سم ، وفترة راحة ٣ ساعات. بينما كانت أقل كفاءة تقشير ٩٣,٤٥ ٪ عند درجة حرارة ٤٥°م وعمق مرقد ١٥ سم مع التجفيف المستمر.
٣- أظهرت النتائج أن اعلى قيمة لنسبة التصافى كانت ٨١,٢٤ ٪ ونسبة تشقق ١٢,٤٥ ٪ ونسبة تكسير ٢,٩١ ٪ عند درجة حرارة ٤٥° م وعمق مرقد ٥ سم ، وفترة راحة ٣ ساعات. بينما كانت أقل قيمة لنسبة التصافي كانت ٧٤,٣٦ ٪ عند درجة حرارة ٨٠° م وعمق مرقد ١٥ سم مع التجفيف المستمر.
٤- أوضحت نتائج التحليل الإحصائى بوجود تأثير عالى المعنوية لكل من طريقة التجفيف ودرجة الحرارة على كل من درجة التبييض ، نسبة التصافى ، نسبة الكسر ، كفاءة عملية التقشير.
٥- تم استنتاج المعادلات الرياضية باستخدام برنامج الارتباط المركب لتوصيف العلاقة بين درجة حرارة هواء التجفيف ،عمق المرقد ، طريقة التجفيف كدالة لكل من درجة التبيض ، ومعدلات التصافى ، نسبة التشقق ، كفاءة عملية التقشير.

٦- أظهرت الاختبارات المعملية لحبوب الأرز المجففة بفترات راحة تحسنا واضحا فى صفات الطهى بالمقارنة بالحبوب المجففة تجفيفا مستمرا ، حيث أدت معاملات التجفيف بفترات راحة إلى انخفاض درجة حرارة الجلتنة (.G.T) وبالتالى انخفاض زمن الطهى.

٧- أشارت الاختبارات المعملية أيضا إلى انه بارتفاع درجة حرارة هواء التجفيف تؤدى إلى انخفاض درجة لزوجة الحبوب بالإضافة إلى زيادة طول الحبة بعد عملية الطهى مما يساعد على زيادة معدل تشرب حبيبات النشا لماء الطهى وبالتالى زيادة حجم حبوب الأرز المطبوخة.