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Drying Rough Rice in a Fluidized Bed Dryer

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ABSTRACT

The objective of this study was to examine the effects of the fluidized-bed drying method on the final quality of two varieties of Iranian rice, medium- and long grain. The results were compared to that of paddy drying using a traditional method. Rough rice was treated in the fluidized bed drier at 140ºC for 2 minutes. Similar samples were dried for 8-10 hrs by the traditional method. Dried samples were dehusked and polished. Quality factors, including trade quality (head rice yield percent and whiteness), cooking quality (amylose content, gelatinization temperature, gel consistency, aroma and flavor) and nutritional quality (thiamine and lysine contents), were then measured for each sample. Finally, the data was analyzed. Results show that paddy drying in a fluidized bed dryer would reduce the quality factors except for rice whiteness for which conventional drying is more acceptable. Therefore modification of fluidized-bed drying technique is recommended.

Keywords: Fluidized bed drying, Rice quality, Rough rice, Sun drying.

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INTRODUCTION

Rice is one of the major economic crops of the world and the rice market involves both consuming and producing countries.

In order to retard rice deterioration after harvest, rough rice (paddy) should be dried down to a level that will enable safe storage through reduction in respiration and prevention of mycotoxin production. This corresponds to a moisture content of about 13-14% w. b. which is considered adequate for safe storage and the milling process [2, 8].

In commercial drying of agriculture products heated air is used. Mechanical systems, especially those using hot air for rapid drying of grains high in moisture content are becoming increasingly popular [18]. Two new efficient drying techniques are the fluidized bed drying and solar drying systems. Researches show that rough rice drying can affect the quality properties of rice which, in turn, affects acceptance of the commodity by the consumers at different stages of the marketing chain [21]. Therefore, with increasing demand for better and higher quality products and for efficient operations, the processing technique and its control for minimizing product degradation is a current challenge for rice drying.

The influence of a thermal shock has been studied by Bonazzi *et al.* (1994) [2]. The results showed no loss of quality due to thermal gradients if paddy is exposed to temperature levels of 30ºC, 55ºC, 70ºC, 80ºC and 90ºC. This study showed that temperature alone cannot explain the observed quality degradation of rice during drying. Soponronnarit and Prachayavaracorn (1994) have studied a fluidized bed dryer system and their results showed that the temperature of the dryer and final moisture content of paddy should be less than 115ºC and 24-25%, respectively [17].

Taweerattanapanish *et al.* (1999) investigated the drying of paddy with a high moisture content using a fluidized bed dryer sys-

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tem. Optimum air temperature in their system was 150ºC [20].

Wiset *et al*. (2001) studied the effects of two hot air drying methods, fluidized bed drying at 90ºC for 11 minutes drying duration (single stage), and a two-stage method of drying, that is in first stage grain is dried down to 18% w. b. followed by store drying in ambient temperature. Results showed head rice yield decreased in the first method, but good head rice yield in the second one [21]. Poomsa-ad *et al*. (2001) showed that tempering treatment provided better head rice yield than treatment without tempering using the fluidization technique [13].

Soponronnarit (1999) applied three processes in a series, for moist paddy: fluidized bed drying with an inlet air temperature of 150ºC for 3 minutes, tempering in 30 minutes followed by cooling with ambient air ventilation for 20 minutes. The moisture content decreased from 33% to16.5% within about 53 minutes. The quality of paddy in terms of head rice yield and degree of whiteness was acceptable in comparison to the traditional method [16].

MATERIALS AND METHODS

Rice Samples

Samples of medium grain rough rice of the Kamphiroozi variety and long grain rough rice of the Sazandegi variety were used for all tests. The samples were provided from the farms of Agricultural Research Centers in Shiraz and Isfahan, with an initial moisture content of 20% d. b.

Methods of Drying

Two drying methods were adopted:

1. Drying in a fluidized bed dryer system (Figure 1).

The drying section of the experimental dryer was a Pyrex column 70cm in height and 8cm in diameter. Drying duration to 13% w. b. moisture content was determined with intermittent sampling of the paddy and measuring the moisture with oven. Then, a moisture control curve was drawn. Therefore, drying process was performed at a temperature of 140ºC for 2 minutes the drying duration, with an airflow rate of 500 lit min^{-1}.

2. Traditional method of sun drying [9].

About 4 kg of each paddy sample with an initial moisture content of 20% d. b. for each batch was sun dried. The rough rice was spread evenly on a concrete floor maintaining a two centimeter depth of rough rice (that is the optimum thickness for thin layer rice drying). Periodic stirring of the rice was performed every half an hour. Drying continued until a moisture content of 13% w. b. was

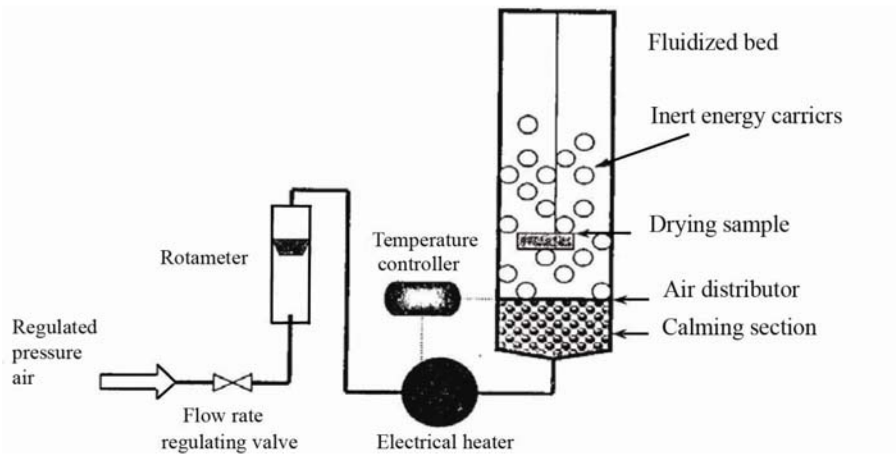

Figure 1. Schematic representation of a batch fluid-bed dryer.

established. This took 8 hours (drying duration to 13% w. b. moisture content is also determined similarly to that method). The dried rough rice sample was then kept in plastic bags and stored at 15ºC for later tests [7].

In both cases, the drying process for each variety was replicated.

Dehusking and Polishing

Two hundred grams of rough rice from each sample was de-husked using a rubber roller de-husker. (Laboratory Rubber Rolls Unit, SATAKE RICE MECHINE, and Type-THU-Class).

The percentages of de-husked and broken kernels were determined by the hand-sorting of broken kernels. A kernel having equal to or more than 75% intact was considered as whole kernel. According to the weight of whole kernels and broken kernels, the percentage of head rice yield was calculated.

De-husked samples were polished using an abrasive type rice polisher (Rice Whitening and Cracking Machine, SATAKE Eng. Co. Ltd., Japan) [12, 14, 15].

Samples were milled into flour and maintained for subsequent quality content experiments.

Quality Assessment

In addition to the head rice yield percentage, the cooking quality of rice, aroma, flavor, whiteness, and nutritional values were also evaluated. Amylose content was determined by the modified assay method of Juliano (1979) [11]. Gel consistency was determined using a technique proposed by Cagampang *et al*. (1973) and Cruz and Khush in 2000 [4, 6]. The gelatinization temperature of starch was determined by the modified assay method of Bhattacharya (1979) [1]. The organoleptic characteristics of cooked rice (i.e. flavor, aroma) and apparent whiteness were assayed by the taste panel using a sensory evaluation method in triplicate. In respect to nutritional value, lysine and thiamine were determined using biological assay and thiochorome fluorescence technique, respectively [3, 10].

The data were arranged as a factorial experiment in a randomized complete design with three replications. The means were compared by DMRT using the MSTATC software.

RESULTS AND DISCUSSION

Percentage of Head Rice Yield

The results are shown in Table 1 and Figure 2. The experimental data indicated that the head rice yield is affected by the drying system. Long and medium grain batches dried in a fluidized bed dryer from 21% d. b. initial moisture content down to 13% w. b. show a lower magnitude of head rice yield and a higher percentage of broken kernels than samples dried by the traditional method. This result is similar to the findings of Soponronnarit *et al*. (1996) [19], Taweerattanapanish *et al*. (1999) [20], Wiset *et al*. (2001) [21], and Chen *et al*. (1997) [5]. The results, however, didn't agree with those of Soponronnarit and Prachayawaratorn (1994) that showed an increase in head rice yield when applying temperatures up to 150ºC [17].

Table 1. Influence of variety and method of drying on head rice yield percentage.

Drying method	Variety	
	Long	Medium
Traditional	80.13 a	76.51 a
Fluidized bed	32.83 c	58.9 b [a]

[a] Different letters indicate significant difference at 5% level of probability.

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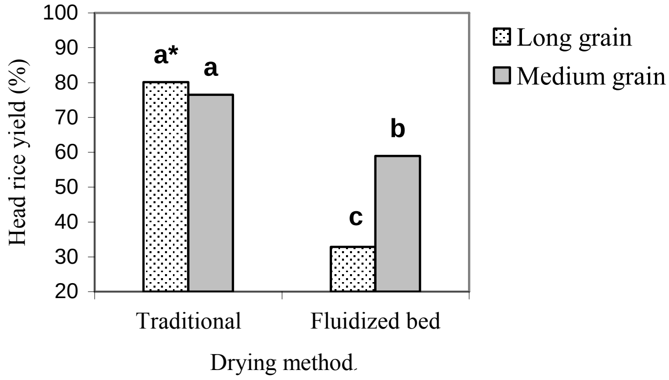


*Different letters indicate significant difference at 5% level of probability.

Figure 2. Effects of drying method on head rice yield for medium and long grain rice.

Gelatinization Temperature

The gelatinization temperature of starch affects the velocity of water absorption and the cooking time of rice. A high gelatinization temperature represents higher water absorption and a longer cooking time.

Results in Table 2 and Figure 3 show that medium grain rice has higher values of gelatinization temperature than long grain for all treatments. Furthermore, drying at high temperature (fluidized bed dryer) resulted in a decrease in gelatinization temperature for long grain varieties.

In drying rough rice at a high temperature, 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 internal pressure thus developed causes cracks to develop. As a result, penetration of moisture in the kernel is accelerated and gelatinization time decreases.

Amylose Content

Results of experiments in Table 3 and Figure 4 stated that both samples were in the medium range of amylose content (21-25%). However, the amylose content decreased when samples were dried in a fluidized bed dryer Since, at high temperatures some of the amylose is decomposed.

Table 2. Influence of variety and method of drying on the gelatinization temperature.

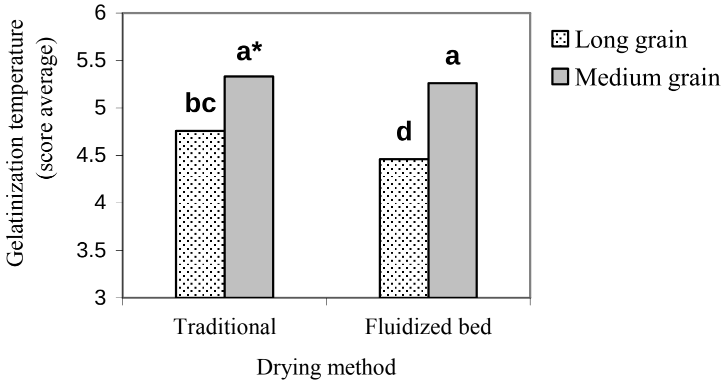
Drying method	Variety	
	Long	Medium
Traditional	4.76 bc	5.33 a
Fluidized bed	4.46 d	5.26 a [a]

[a] Different letters indicate significant difference at 5% level of probability.

Table 3. Influence of variety and method of drying on amylose content.

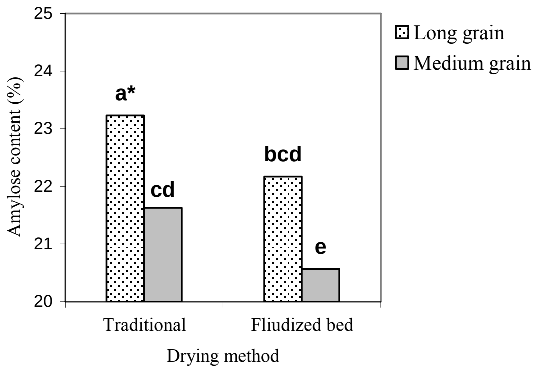
Drying method	Variety	
	Long	Medium
Traditional	23.23 a	21.63 cd
Fluidized bed	22.17 bcd	20.57 e [a]

[a] Different letters indicate significant difference at 5% level of probability.



*Different letters indicate significant difference at 5% level of probability.

Figure 3. Effects of drying method on the gelatinization temperature for medium and long grain rice. (Score average: 1-2<70ºC, 4-5=70-74ºC, 5-6>74ºC).



*Different letters indicate significant difference at 5% level of probability.

Figure 4. Effects of drying method on amylose content for medium and long grain rice.

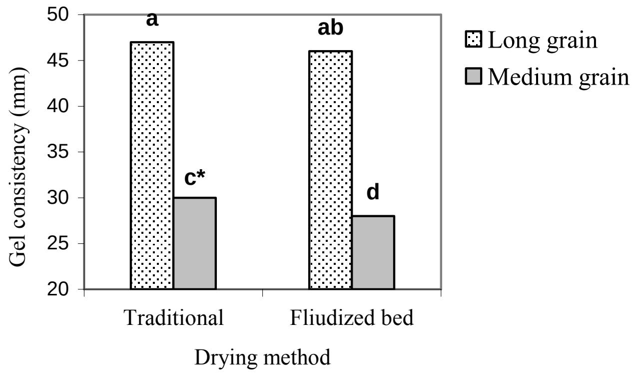
Gel Consistency

The results of this test are shown in Table 4 and Figure 5. Long grain and medium grain rice lie in the range of medium and hard gel, respectively. Samples dried in a fluidized bed dryer had the lowest value of gel consistency, but those dried by the traditional method showed no significant differences. However, all samples remained within their range. Gel consistency has a direct correlation with the amylose content of rice and with decomposition and change of amylose into smaller components at high temperature; gel consistency of rice decreases and results in a more soft gel.

Table 4. Influence of variety and method of drying on gel consistency, mm.

	Variety	
Drying method	Long	Medium
Traditional	47.00 a	30.00 c
Fluidized bed	46.00 ab	28.00 d [a]

[a] Different letters indicate significant difference at 5% level of probability.



*Different letters indicate significant difference at 5% level of probability.

Figure 5. Effects of drying method on gel consistency for medium and long grain rice.

These results show a good agreement with findings of Wiset *et al*. (2001) [21] who reported considerable loss of gel consistency in fluidized bed dryer at high temperature.

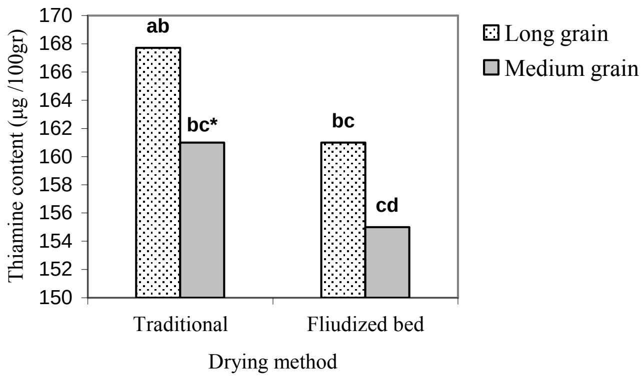
Thiamine Content

Results in Table 5 and Figure 6 show that the thiamine levels in samples dried in the

Table 5. Influence of variety and method of drying on thiamine content, µg $100gr^{-1}$.

Drying method	Variety	
	Long	Medium
Traditional	167.7 ab	161.00 bc
Fluidized bed	161.00 bc	155.00 cd [a]

[a] Different letters indicate significant difference at 5% level of probability.



*Different letters indicate significant difference at 5% level of probability.

Figure 6. Effects of drying method on thiamin content for medium and long grain rice.

fluidized bed dryer decreased, because Thiamine is one of the B vitamins with a very sensible to high temperature. In contrast to that, the samples dried using other methods show no significant differences.

Lysine Content

The results of the lysine determination in samples subjected to fluidized bed dryer and sun drying are shown in Table 6 and Figure 7. The results show that the lysine levels in samples dried in the fluidized bed dryer decreased, but the samples dried by the other method show no significant differences.

Table 6 also shows that, for the traditional method of drying, lysine content does not differ for long and medium grains, whereas for the fluidized-bed drier, the lysine content differs for the long and medium grain samples.

Quality Characteristics of Cooked Rice

Whiteness

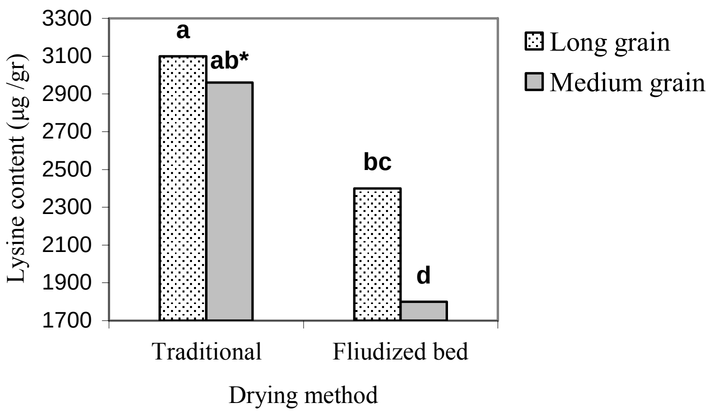
The whiteness of cooked samples from two different treatments of drying assayed by the taste panel group showed no significant difference between samples. Samples from the traditional method of drying were less glossy and more opaque than samples dried with a fluidized bed method. In other words, drying at high temperature resulted in a more apparent whiteness of rice.

These results had a good agreement with the results of Taweerattanapanish *et al.* (1999) regarding increasing rate of whiteness

Table 6. Influence of variety and method of drying on lysine content, µg gr^{-1}.

Drying method	Variety	
	Long	Medium
Traditional	3100 a	2960 ab
Fluidized bed	2400 bc	1800 d [a]

[a] Different letters indicate significant difference at 5% level of probability.



* Different letters indicate significant difference at 5% level of probability.

Figure 7. Effects of drying method on lysine content for medium and long grain.

of samples dried at high temperature [20].

Flavor and Aroma

Results of sensory evaluation of cooked samples from two different treatments showed that samples dried in a fluidized-bed had lower flavor, aroma and lower sensory scores than samples dried in a traditional manner as judged by the taste panel.

CONCLUSIONS

The results of the study showed that the following properties have been affected:

- Drying by a fluidized bed from initial moisture content of 20% d. b. to 13% w. b. at a temperature of 140ºC resulted in decreased head rice yield, while drying with a traditional method resulted in the best head rice yield.
- Gel consistency was significantly decreased by the fluidized bed dryer method with a high temperature. However, all samples remained within their range.
- Amylose content decreased when samples were dried in a fluidized bed dryer.
- The gelatinization temperature of starch significantly decreased with the method of fluidized bed dryer in the long grain variety.
- The fluidized-bed drying method resulted in a more acceptable whiteness.
- Sensory scores (odor, flavor) of samples dried at high temperature were considerably lower than those of the other method.
- Thiamine and lysine contents of samples dried at a high temperature in the fluidized bed dryer were decreased.

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خشک‌کردن برنج در سیستم خشک‌کن بستر سیال

ا. کرباسی و ز. مهدی زاده

چکیده

هدف از اجرای این تحقیق، بررسی تأثیر سیستم خشک‌کن بستر سیال بر کیفیت نهایی دو واریته برنج ایرانی دانه‌بلند و دانه متوسط بود. نتایج به‌دست آمده با نتایج حاصل از روش سنتی مقایسه شد. فرایند خشک‌کردن در روش بستر سیال در دمای ۱۴۰°C به مدت ۲ دقیقه انجام شد. خشک‌کردن نمونه‌ها به روش سنتی ۸–۱۰ ساعت زمان طی کرد. پس از آن نمونه‌ها آسیاب و سفید شدند. سپس فاکتورهای کیفی آنها شامل کیفیت تجاری (درصد راندمان تبدیل برنج سالم و سفیدی برنج)، کیفیت پخت (میزان آمیلوز، دمای ژلاتینه‌شدن نشاسته ، قوام ژل برنج و عطر و بو) وکیفیت تغذیه‌ای (میزان تیامین و اسید آمینه لیزین) آزمایش شدند. در نهایت نتایج به‌دست‌آمده آنالیز آماری شدند. نتایج نشان دادندکه دمای بالا باعث کاهش فاکتورهای کیفی برنج می‌شدند، بجز میزان سفیدی برنج که نسبت به نمونه خشک‌شده سنتی مطلوب‌تر بود. بنابراین پیشنهاد می‌شود در شرایط اعمالی سیستم خشک‌کن بستر سیال، تغییراتی صورت پذیرد.

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