J. Agr. Sci. Tech. (2009) Vol. 11: 527-534

A Study of the Effect of Solar Drying System on Rice Quality

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ABSTRACT

A thin layer solar drying method was compared with a traditional method (sun drying) of paddy drying, with their effects on quality characteristics of two varieties of Iranian rice (Kamphiroozi and Sazandegi) studied. Solar drying process was conducted in a passive, mixed mode type solar dryer at about 50°C for 90 minutes. In sun drying method this process took 8-10 hours at a mean temperature of about 26°C. Samples were milled and polished. Quality factors including trade quality (head rice yield percent and whiteness), cooking quality (amylose content, gelatinization temperature, gel consistency, aroma and flavor) as well as nutritional quality (thiamine and lysine contents) were evaluated. For a determination of head rice yield, the percentages of de-husked and broken kernels were determined by hand-sorting of broken kernels, the calculation being done through the pertaining formula. Gel consistency was determined according to the method of Cagampang *et al.* (the consistency of milled rice paste that has been gelatinized by being boiled in dilute alkali and then cooled to room temperature). Amylose content was determined through the simplified assay method of Juliano (setting standard curve by spectrophotometer and comparing the adsorption with the sample's). Gelatinization temperature was estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% KOH for 23 hours at room temperature. Organoleptic characteristics of cooked rice (iflavor, aroma) and apparent whiteness were judged by the taste panel using sensory evaluation method in triplicate. With respect to nutritional value, lysine amino acid was determined by using biological assay and applying *Lactobacilllus delbrueckii* while thiamine being measured through thiochrome fluorescence technique. The objective of this study was to examine the influence of solar drying process on the final quality of rice kernels and to compare the effects of this method with those in the traditional method of drying (natural sun drying). Results indicated that under the conditions prevailing in solar dryer, quality factors weren't affected except for whiteness of rice that too was better than that for sun dried samples. All other quality characteristics of the final product were acceptable in comparison with those in sun drying method.

Keywords: Natural sun drying, Rice quality, Solar drying.

INTRODUCTION

To prevent rice damage following harvest of a high moisture content product, the paddy should be dried to such a level of moisture content that will enable safe storage by reducing respiration, and by a prevention of mycotoxins production. This corresponds to a moisture content of about 13-14% (w.b.), which is considered as admissible for safe storage, safe milling and subsequent safe storage as milled rice, with low fungus and insect attack, leading to a minimum deterioration of chemical components, and a minimum of subsequent loss in nutritive values [3, 9].

In commercial drying of agricultural products, heated air is usually employed. Mechanical means, especially those using hot air for fast drying of high moisture content grain are becoming increasingly popular [16]. One of the efficient techniques

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of more suitability and less damage is solar drying. Research has revealed that rough rice drying can affect quality properties of the product which in turn would affect the acceptability of the commodity by consumers at different stages of the marketing chain [17]. Therefore, with the increasing demand for better and higher quality products as well as for more efficient post harvest operations, processing methods and a prevention of product degradation can be a current challenge for rice drying industry.

MATERIALS AND METHODS

Rice Samples

Two varieties of paddy, namely Sazandegi, a long grain and Kamphiroozi, a medium grain variety were provided from Agricultural Research Centers of Isfahan and Shiraz respectively, with an initial moisture content of 20% (d. b).

Methods

Drying operation was conducted in Shiraz (29.6 degrees altitude), with on average ambient temperature of 26°C and average solar radiation during the experimental hours (10 am to 4 pm) was 800 W/m^2.

Two drying operation systems were employed:

a. Drying in a solar dryer system (Figure 1):

A mixed mode passive solar dryer was employed. In this pilot solar dryer, hot air is provided by natural convection through an air solar collector.

The drying section of that experimental dryer was a the chamber, with a tray capacity of 4 kg paddy in batch and an appropriate depth that can be regarded as thin layer, namely 2 cm [18]. It took 90 minutes to get the product to the final moisture content of about 13% (w. b.) under constant other conditions.

b. Traditional method of sun drying [10].

In most rice growing parts of Iran, rice is sun dried by being spread on the ground under direct solar radiation. This operation is likely performed in batches of roughly 4 kg of paddy. Rough rice was spread on concrete floor maintaining a 2 cm thickness of the rough rice layer. Periodic stirring of the procuct (every half an hour) was done [8]. Drying was continued till the moisture content of the kernels reached about 13% (w. b.). This duration was determined by

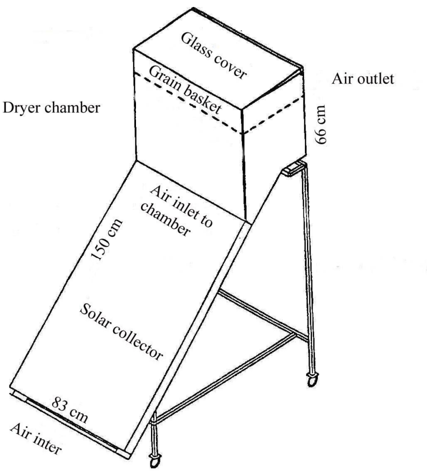

Figure1. Schematic representation of a batch type thin layer solar dryer.

intermittent sampling of the paddy and oven dry measuring of the moisture content. Moisture control curve was later drawn. The drying took about 8 hours, and then the dried rough rice kept in plastic bags and stored at 15°C for later tests.

In both methods, the drying process was done triplicated.

Milling Process

Two hundred grams of rough rice from each sample was de-husked using a rubber roller dehusker (Laboratory Rubber Rolls Unit, SATAKE RICE MECHINE, and Type-THU-Class) [13, 15, 8].

De-husked samples were polished using an abrasive type rice polisher (Rice Whitening and Cracking Machine, SATAKE Eng. Co. Ltd., Japan) [14]. Samples were grinded into flour and maintained for later quality experiments.

Quality Experiments

The percentages of de-husked and broken kernels were determined by hand-sorting of broken kernels. A kernel being 75% or more intact was considered as whole kernel [8]. Then calculation was done through the formula:

$$Head\ rice\ yield(\%) = \frac{Weight\ of\ whole\ kernels}{Weight\ of\ milled\ rice} \times 100$$

Amylose content was determined by the simplified assay method of Juliano. Rice solution prepared with ethanol and soda (1N) was boiled to being cooked. Water diluted acetic acid and iodine solution was added. Blank and standard solutions were also prepared. Light adsorption of standard samples (at 600 nm) was assessed through spectrophotometry and the standard curve prepared. Amylose content of the rice samples was determined by comparing the adsorptions of the rice solution samples with those in the standard curve [12].

Gel consistency was determined according to the method of Cagampang *et al.*. This method is based on the consistency of milled rice paste that has been gelatinized by boiling in dilute alkali and then cooled to room temperature. Tubes are laid horizontally on a table lined with millimeter graph paper and total length of the gel measured in millimeters [5, 7].

Gelatinization temperature of starch was determined by the simplified assay method of Bhattacharya. Gelatinization temperature is estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% KOH for 23 hours at room temperature. Rices with high Gelatinization temperature remain largely unaffected in the alkali solution [2].

Organoleptic characteristic of cooked rice (i. e. flavor, aroma) and apparent whiteness were assayed by the taste panel with sensory evaluation method in triplicate. Ten panelists, tested in analysis of five principle tastes and who were experts in distinction of flavor and aroma of rice were assigned to an evaluation of apparent and sensory characteristics of cooked rice. Two varieties of rice dried in the two methods were cooked in triplicate in three days. Overall rice impression, aroma, flavor and apparent whiteness were evaluated. Intensities of each of them evaluated were quantified on a 0-5 continuous scale. Panelists intensified each sensory attribute using a number between 0 and 5. The intensities of quality factors were assessed by a comparison with carefully chosen references for each attribute having the assigned intensities.

With respect to nutritional value, lysine amino acid and thiamine were determined by using biological assay and thiochorome fluorescence technique. For assaying thiamine in rice, one needs to digest it for 30 minutes and at 95-100°C in boiling water and then dilute with 0.1N HCL. Then through on oxidizing reagent thiamine is changed into thiochrome. The intensity of thiochrome fluorescence is proportional to the quantity of thiamine present and may be measured with a suitable electronic

[DOR: 20.1001.1.16807073.2009.11.5.10.7]

fluorometer. Thiamine content of the oxidized assay solution is determined by comparison of the intensity of fluorescence of the extract with that of the oxidized standard solution [11].

In a biological method for assaying lysine content, we used *Lactobacillus delbrueckii* which needs lysine for making cell wall. Standard culture medium for growing of this bacteria is prepared with different quantities of lysine. Rice samples also are prepared as culture media for bacteria. The suitable quantity of bacterium was infused into media. After incubation in 37°C, turbidity of the media may be measured by spectrophotometer and making comparisons with standard curve set. By comparing the intensity of the turbidity of the rice solutions with that of the standard curves, lysine contents of the rice samples were determined [4].

Statistical Analysis

All experiments were done in triplicate with data analyzed using MSTATC software. A completely randomized factorial design of two factors along with Dunken Test for means differences at 5% level were applied. The first factor was the drying method, (sun and solar drying) and the other one was variety in the two levels of Kamphiroozi and Sazandegi.

RESULTS AND DISCUSSION

Head Rice Yield Percent

Table 1 shows some results of the experiment.

No statistical significant difference ($P< 0.05$) was seen with respect to sun drying samples.

This result confirms findings by´ Abe *et al.* (1992) [1] and Chen *et al.* (1997) [6] related to a 45-55°C drying temperature as a higher limit for maximum head rice yield .

Table 1. Effect of variety and method of drying on head rice yield percent.

	Variety	
Method	Sazandegi	Kamphiroozi
Sun drying	80.13 a	76.51 a
Solar drying	77.3 a	78.16 a [a]

[a] In each column, the same letters indicate no significant difference at 5% level.

Gelatinization Temperature

Gelatinization temperature of starch affects the velocity of water absorption and cooking time of rice. High gelatinization temperature means higher water absorption and higher cooking time.

Table 2. Effect of variety and method of drying on gelatinization temperature

	Variety	
Method	Sazandegi	Kamphiroozi
Sun drying	4.76 bc	5.33 a
Solar drying	4.56 cd [a]	5.43 a

[a] In each column, different letters are an indication of significant difference at 5% level. Score average: 1-2<70°C; 4-5=70-74°C, 5-6>74°C.

Table 2 indicates that medium grain rice has a higher value of gelatinization temperature than long grain in all the treatments. Drying in solar dryer system resulted in a decrease of gelatinization temperature in long varieties but the difference wasn't statistically significant.

Gel Consistency

The results showed (Table 3) that the long grain and medium grain gels were in medium and hard gel range respectively.

Samples dried in sun drying method and solar dryer exhibited no significant

[DOR: 20.1001.1.16807073.2009.11.5.10.7]

difference with all samples remaining within the range.

Table 3. Effect of variety and method of drying on gel consistency, mm.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	47.00 a	30.00 c
Solar drying	47.33 a	29.00 cd [a]

[a] In each column, different letters show significant differences at 5% level.

Amylose Content

Results (Table 4) indicated that both samples were in the range of medium amylose content (21-25%).

Table 4. Effect of variety and method of drying on amylose content.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	23.23 a	21.63 cd
Solar drying	22.53 abc	21.50 d [a]

[a] In each column, different letters show significant differences at 5% level.

There was no significant difference observed within the amylose content of samples dried in sun drying and solar dryer method.

Thiamine Content

Thiamine is one of the B vitamins that is very sensitive to high temperatures. Results of this test showed (Table 5) that two varieties have different content of thiamine.

The thiamine levels in samples dried through solar dryer method show no significant differences with thiamine levels in samples dried with traditional natural drying.

Table 5. Effect of variety and method of drying on thiamine content, µg /100 g.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	167.7 ab	161.00 bc
Solar drying	170.00 a	158.00 cd [a]

[a] In each column, different letters show significant differences at 5% level.

Lysine Content

The results of lysine determination in rices subjected to different drying treatments are shown in Table 6.

Table 6. Effect of variety and method of drying on lysine content, µg/100g.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	3100 a	2960 ab
Solar drying	3150 a	2940 ab [a]

[a] In each column, different letters show significant differences at 5% level.

The lysine levels in long and medium grains were different but the difference wasn't statistically significant. With respect to the effect of drying method on lysine content, results stated that the two different methods didn't exert any significant effect on the lysine content.

Quality Characteristics of Cooked Rice

Whiteness

A group of panelists tested raw and cooked samples of rice with respect to the apparent color, aroma and flavor (Table 7).

The whiteness of cooked samples from the two different methods of drying shows a more whiteness for samples dried in solar system. In other words, drying in solar dryer

[DOR: 20.1001.1.16807073.2009.11.5.10.7]

resulted in a apparent more whiteness of rice.

Table 7. Effect of variety and method of drying on rice whiteness.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	3.5 b	3.6 b
Solar drying	4.056 a	4.3 a [a]

[a] In each column, different letters show significant differences at 5% level.

Flavor and Aroma

The results of the sensory evaluation in cooked samples subjected to different drying methods are shown in Tables 8 and 9.

Table 8. Effect of variety and method of drying on flavor of cooked rice.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	3.78 a	3.98 a
Solar drying	3.69 a	3.88 a [a]

[a] In each column, different letters show significant differences at 5% level.

Results state that samples dried in solar dryer are of the same flavor, aroma, and sensory score as the samples dried in sun drying, as judged by taste panel.

Table 9. Effect of variety and method of drying on aroma of cooked rice.

Method	Variety	
	Sazandegi	Kamphiroozi
Sun drying	3.78 a	3.89 a
Solar drying	3.6 a	3.73 a [a]

[a] In each column, different letters show significant differences at 5% level.

CONCLUSIONS

In brief, the following points can be expressed as conclusion items:

Drying rice by using a solar dryer system resulted in reasonable head rice yield, in comparison with that obtained when using sun drying.

Gel consistency and gelatinization temperature weren't affected by the method of solar drying.

Whiteness of samples dried through solar drying method was acceptable and comparable with samples dried through sun drying method.

Sensory score (aroma, flavor) of samples dried in solar dryer system was the same as that in the other method.

Amylose, thiamine and lysine contents of samples dried in solar dryer system were the same as those in sun drying method.

The two rice varieties didn't respond in the same way to the drying treatments.

Head rice yield was higher for the medium grain variety.

Gel consistency values were observed to be higher for the long grain rice.

Gelatinization temperature was higher in the case of medium grain rice.

Amylose and thiamine contents were higher for long grain variety than for the medium one.

The two varieties contained the same content of lysine.

ACKNOWLEDGEMENT

This research was conducted at Shiraz University as thesis of Master of Science. The authors are grateful to Dr. Karbassi, professor of food science and technology, Dr. Jamalian, professor of food science and technology, for their assistance during the research. They also, would like to appreciate cooperation of Agricultural Research Centers in Shiraz and Isfahan provinces.

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[DOR: 20.1001.1.16807073.2009.11.5.10.7]

مطالعهٔ تأثیر روش خشک کردن خورشیدی روی کیفیت برنج

ز. مهدیزاده و ع. زمردیان

چکیده

در این تحقیق روش خشک کردن شلتوک با استفاده از سیستم خشک‌کن خورشیدی لایه نازک با روش سنتی خشک کردن شلتوک تحت نور مستقیم خورشید که متداولترین سیستم کاربردی در مناطق معتدل است، مورد بررسی قرار گرفته و تأثیر آنها برخصوصیات کیفی دو نوع برنج ایرانی دانه بلند (سازندگی) و دانه متوسط(کامفیروزی) با هم مقایسه شدند. فرآیند خشک کردن در خشک کن خورشیدی از نوع مختلط در دمای $^{\circ}C$ ۵۰ به مدت ۹۰ دقیقه انجام شد. در مقابل روش سنتی حدود ۱۰ ساعت در دمای $^{\circ}C$ ۲۶ بطول انجامید. پس از آن نمونه ها آسیاب و سفید شدند و آزمونهای تعیین کیفیت روی آنها انجام شد. فاکتورهای کیفی مورد بررسی شامل فاکتورهای تجاری (درصد راندمان تبدیل برنج سالم و سفیدی برنج) ، فاکتورهای مؤثر در کیفیت پخت (میزان آمیلوز، دمای ژلاتینه شدن نشاسته ، قوام ژل برنج و عطر و بو) و فاکتورهای تغذیه‌ای(میزان تیامین و اسید آمینه لیزین) بودند. برای تعیین راندمان تبدیل برنج، درصد دانه‌های پوست گیری شدهٔ شکسته، بصورت دستی جداسازی شده و به کمک فرمول مربوطه درصد راندمان تبدیل تعیین شد. قوام ژل برنج مطابق روش کاگامپانگ تعیین شد که این روش بر اساس قوام خمیر برنج آسیاب شده است که بوسیلهٔ جوشاندن در محلول قلیای رقیق ژلاتینه شده و سپس در دمای اتاق سرد می‌شود. محتوای آمیلوز برنج توسط روش جولیانو به کمک دستگاه اسپکتروفتومتر و مقایسهٔ جذب نمونه‌ها با منحنی استاندارد تعیین شد. دمای ژلاتینه شدن، براساس میزان حل شدن و منتشر شدن برنج سفید شده که در محلول پتاس ۱/۷٪ به مدت ۲۳ ساعت در دمای اتاق خیسانده شده بود، تعیین گردید. خصوصیات ارگانولپتیک برنج پخته (مثل طعم و عطر) و میزان سفیدی ظاهری آن توسط آزمون چشایی توسط گروه ارزیاب حسی تعیین گردید. از نظر ارزش تغذیه‌ای ، اسید آمینهٔ لیزین بوسیلهٔ روش ارزیابی بیولوژیکی به کمک باکتری لاکتوباسیلوس دلبروکی تعیین گردید و ویتامین تیامین نیز به کمک روش فلوئورسانس تیوکروم اندازه‌گیری شد. هدف انجام این تحقیق، بررسی تأثیر روش جدید خشک کن خورشیدی در زمان کوتاه‌تر در مقایسه با روش سنتی نسبتاً زمان بر، روی کیفیت تکنولوژیکی و تغذیه‌ای دانهٔ برنج بود. در نهایت نتایج بیانگر عدم تأثیر روش خشک کردن بر فاکتورهای کیفی به جز سفیدی برنج (که در روش خورشیدی در مقایسه با روش سنتی بهتر بود) ومناسب بودن شرایط اعمال شده در سیستم در مقایسه با روش سنتی بود.

[DOR: 20.1001.1.16807073.2009.11.5.10.7]