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Variation in Physio-Chemical Characteristics, Mineral Concentrations and Cookability of Rice Marketed in Jordan

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Abstract: Five kilograms of different rice brands from different origins were purchased from Jordanian outlets. All rices were examined for their physical characteristics, chemical composition, minerals concentration and cookability. The results showed that Sella Basmati (India) had the lowest percentage of broken rice kernels (0.4%) whereas Sun Bird (Egypt) had the highest value (11.5%). Water absorption varied significantly and the highest water absorption value was for Ruzzana (95.9%) and the lowest was for Sun Bird rice brand (32.6%). Cooking time of all rice brands varied significantly and ranged from 23.7 (Ruzzana) to 10.3 min. (Amber). Higher levels of proteins (25.2%) were found in Sella Basmati. The loss of nutrients is due to rice brand genetic variation and soaking in warm water for one hour before cooking. This study emphasized that soaking rice grains in worm water before cooking is an important factor in reducing the concentration of nutrients and minerals in all investigated rice brands.

Key words: Rice brand, chemical composition, physico-chemical characteristics, Jordan

Introduction

Rice is a staple food for over half the world population. Both wild rice (*Zizania aquatica* L.) which was originally consumed by native Americans as a staple food in northern United States and southern Canada and the cultivated or milled rice (*Oryza sativa* L.) belong to the *Gramineae* family. *Z. aquatica* is mainly used in gourmet food products such as soup, stuffings and meat dishes due to its price, color, flavor and texture (Lorenz, 1981; Oelke *et al*., 1997). *O. sativa* has been adapted and consumed by humans for almost five thousand years (Zhou *et al*., 2002). Rice is ranked as the worlds' number one human food crop (Itani *et al*., 2002). The average rice production in the world during 1997-1999 amounted to 585 million metric tons, nearly all used for human consumption (FAO, 2000; White, 1994).

The average production of wheat and corn during the same time period amounted to 596 and 600 million tons, respectively, considering 20% of wheat and 60% of corn went to animal feed. Recently, rice consumers as in Japan and other countries, have been requesting a wide range of added values for this staple food. These characteristics include food texture (stickiness, hardness), rice nutrients and constituents (protein, amylose allergens) and aroma, color, size and shape of the rice kernel. There are a number of different markets for rice, a small amount of rice crop is used to make ingredients for processed foods and as feed, but the bulk is consumed as cooked rice. Zhou *et al.* (2002) reported that different properties define rice kernel eating quality. The eating quality is determined by physicochemical properties (Chrastil, 1990; Chrastil, 1992; Chrastil, 1994; Noomhorm *et al*., 1997; Perdon *et al*., 1997; Champagen and Betle, 1999), mainly water absorption, cooking quality, whiteness and dullness and gelatinization of starch. On the other hand Lisle *et al.* (2000) found that neither amylose content, amylopectin structure and protein composition explained the difference in cooking quality of rice.

Jordan imports rice from different countries without any quality preference. Therefore, the objectives of this investigation are to determine the physico-chemical characteristic of rice marketed in Jordan and to investigate the gross chemical composition, mineral concentrations and cooking time.

Materials and Methods

Twelve brands of rice were included in this investigation. One package (containing 5-15 kg) of each brand of rice was purchased from the city of Amman outlets. The purchasing was repeated three times at one month time interval, each purchase is considered one replicate. Amber rice was bought from Iraqi markets, it is an Iraqi produce. Rice packages were transferred to the lab. Labeled and kept in nylon bags at 4°C until analysis time. The following tests were performed on each rice sample.

Physical kernel characteristics

One hundred kernel weight: one hundred rice grain were counted manually, the average of three repeats for each replicate was recorded.

Table 1: Country, value in JD (Jordanian Dinar) and quantities of imported rice during 1995-2003 ($ = 0.7 JD)

Country of Origin	Imported Rice (Value in million JD)	Imported Rice (Million Metric Ton)
Saudi Arabia	0.07	0.16
Egypt	25.78	106.6
Turkey	0.01	0.02
India	5.02	15.74
Pakistan	1.56	3.12
Uzbekistan	0.01	0.02
Singapore	0.07	0.22
Thailand	0.75	32.23
Vietnam	0.27	1.26
China	5.44	20.28
Japan	0.9	2.76
Australia	47.45	162.84
EEC	0.02	0.07
United Kingdom	0.02	0.09
Italy	8.85	28.97
Spain	3.64	12.13
France	0.28	0.42
Netherlands	0.02	0.6
USA	73.11	229.55
Grand Total	179.99	6170.8

Hectoliter weight: A standard USDA hectoliter was used to determine the weight of one liter.

One hundred kernel volume: A random one hundred rice grain were immersed in a graduated cylinder and the displaced volume was recorded.

Broken kernel percent: One hundred gram rice were weighed. The broken kernels were separated manually and weighed, their percentage was calculated.

Chemical composition: About 200 g of each rice brand were pulverized using a lab. sample grinding mill, the powder was passed through a 0.5 mm sieve and collected in nylon bags and used for chemical and mineral analysis. Moisture, ash, protein (N×6.25), crude fiber and crude fat were determined according to AOAC (1984) procedure. Carbohydrate content was calculated by difference.

Mineral analysis: Ca, Na, K, Mg, Mn, Cu and Fe concentrations were determined according to the procedure outlined by Ereifej and Gharaibeh, 1993. Atomic absorption spectrophotometer was used. Phosphorus levels were determined according Fiske and Subbarow (1925). Mineral concentration values were computed on dry weight basis.

Water absorption: About one hundred gram of rice grain were soaked in warm distilled water for one hour. The rice samples were reweighed and the percent water absorption was calculated.

Cooking time: The soaked rice samples were covered with warm water and cooked. At five minutes interval rice grains were taken out and pressed by thumbs, until the grain was easily smashed. The cooking time was recorded.

Statistical analysis: The collected data were subjected to statistical analysis. Means were separated and compared, the least significant difference between the means was computed according to Steel and Torrie 1982.

Results and Discussion

Data on imported rice are shown in Table 1. Jordan mainly imports large amount of rice from USA followed by Australia and Egypt. The average annual cost between 1995-2003 is about 25.5 million J.D ($ 36.4 million) which shows the economic importance of imported rice to be of high quality.

Table 2 shows data on color, grain length, country of origin, weight of 100 kernel, weight of 1000 kernel, broken grain, water absorption, hectoliter and cooking time. The percentages of broken grain were 11.5% for Sun Bird (Egypt) and the lowest percentage is (0.4%) for Sella Basmati (India). More over, no significant variation in percentage of broken rice between all types of rice tested at p = 0.05 except for Abu bent and Sun white brands which had the lowest percentage of broken grains 1.9% and 1.6% respectively.

Water absorption showed significant variation and ranged from 25 to 32% (at p = 0.05). Ruzzana imbibed high amount of water (95.9%) as compared with all rice brands, the lowest water absorption value was for Sun Bird (23.6%). Sella Basmati required the highest cooking time (23.7 min) and Amber the lowest (10.3 min), all other rices required cooking time ranging from 13.7 min to 21.3 min. The low variation of cooking time (minutes) between all brands could be related to the soaking treatment time (60 min) before cooking. Some types of rice, Sun Bird, Sos rice, Dux rice and La cigala showed significant variation in cooking time. However, the water absorption was variable between brands of rice. The cooking quality of rice was determined on the basis of the variety and its physicochemical properties, mainly amylose content as reported previously (Sujatha *et al.*, 2004), as well as, cooked rice is composite food consisting of different biopolymers, including starch and proteins along with moisture as plasticizer (Ahmed *et al.*, 2007).

The analysis of chemical composition of raw rice (Table 3) showed that Sella Basmati contains the highest amount of protein (25.2%) and Royal Umbrella had the lowest protein content (15.2%). On the other hand, the fiber content of all rice brands ranged from 2.9% (Royal Umbrella) to 1.4% (Sos Rice) while the Ash content ranged between 0.8 and 0.4%. Concerning fat content of rice brands, Sella Basmati rice had the highest fat content (3.4%) and Amber had the lowest fat value

Table 2: Physical characteristic and cooking time of raw rice marketed in Jordan▼

Commercial Rice Brand	Color	Grain length	Country of Origin	Weight of 100 Grain (g)	Weight of 1000 Grain (g)	Broken Grain (%)	Water Absorption (%)	Hectoliter (g/l)	Cooking Time (min)
Harvest	White	Medium	USA	2.0^{ab}	20.6^{ab}	6.0^{bcd}	30.4^{ed}	869.9^{abc}	17.7^{c}
Ruzzana	Gold	Long	Saudi Arabia	1.7^{f}	17.0^{abc}	4.8^{ecd}	95.9^{a}	833.0^{e}	21.3^{b}
Sella Basmati	White	Long	India	1.5^{h}	23.7^{a}	0.4^{f}	49.2^{c}	810.0^{gf}	23.7^{a}
California	White	Medium	USA	2.1^{a}	21.2^{ab}	3.4^{def}	32.0^{ed}	861.1^{cd}	20.3^{b}
Sun Bird	White	Medium	Egypt	2.0^{bc}	19.6^{abc}	11.5^{a}	23.6^{e}	859.7^{d}	15.3^{de}
Sun White	White	Medium	Australia	2.0^{ab}	20.4^{abc}	1.6^{ef}	32.5^{ed}	869.5^{abc}	18.3^{c}
Abu Bent	Gold	Long	USA	2.1^{a}	21.0^{ab}	1.9^{ef}	59.6^{b}	816.1^{f}	20.3^{b}
Sos Rice	White	Long	Spain	1.6^{g}	15.7^{bc}	3.7^{ed}	27.5^{ed}	827.0^{e}	14.7^{de}
Dux Rice	White	Medium	Spain	1.8^{de}	18.3^{abc}	8.2^{b}	25.0^{ed}	862.3^{bcd}	14.7^{de}
La Cigala	White	Medium	Spain	2.0^{bc}	19.7^{abc}	3.3^{edf}	31.3^{ed}	876.1^{a}	15.3^{de}
Royal Umbrella	White	Long	Thailand	1.8^{ef}	17.5^{abc}	4.4^{ed}	31.8^{ed}	878.7^{a}	13.7^{e}
Amber	Brown	Long	Iraq	1.3^{i}	13.5^{c}	8.0^{bc}	33.4^{d}	806.2^{g}	10.3^{f}
LSD $p \geq 0.05$				0.11	6.85	3.25	9.22	9.54	1.82

▼Values are average of three replicates; *Values followed by the same letter are not significantly different at $p \leq 0.05$

Table 3: Chemical composition of uncooked rice marketed in Jordan▼

Rice Brand	Carbohydrate (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)
Harvest	82.5^{c}	3.1^{ab}	0.5^{bcd}	2.3^{abc}	20.2^{abc}
Ruzzana	88.6^{ab}	2.4^{bcd}	0.8^{a}	1.9^{abc}	18.3^{bc}
Sella Basmati Rice	88.3^{ab}	3.4^{a}	0.7^{ab}	1.8^{bc}	25.2^{a}
California	90.5^{ab}	2.3^{bcde}	0.6^{abc}	1.9^{abc}	20.0^{abc}
Sun bird	90.4^{ab}	2.1^{cdef}	0.4^{d}	2.1^{abc}	19.2^{bc}
Sun white	89.2^{ab}	2.1^{cdef}	0.4^{d}	2.4^{abc}	18.9^{bc}
Abu bent	87.5^{abc}	1.6^{efg}	0.7^{ab}	1.5^{c}	19.3^{bc}
Sos Rice	91.0^{a}	1.7^{defg}	0.6^{abcd}	1.4^{c}	17.0^{bc}
Dux Rice	84.9^{bc}	1.9^{cdefg}	0.7^{ab}	1.9^{abc}	21.7^{ab}
La Cigala	90.5^{ab}	2.5^{bc}	0.5^{bcd}	2.8^{ab}	22.7^{ab}
Royal Ambrella	90.5^{ab}	1.5^{gf}	0.4^{dc}	2.7^{ab}	15.2^{c}
Amber	88.3^{ab}	1.1^{g}	0.6^{abcd}	2.9^{a}	18.3^{bc}
LSD $p \leq 0.05$	5.66	0.77	0.22	1.07	5.84

▼Values are average of three replicates and calculated on dry weight basis; *Values followed by the same letter are not significantly different at $p \leq 0.05$

Table 4: Chemical analysis of cooked rice marketed in Jordan▼

Rice Type	Carbohydrate (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)
Harvest	74.0^{abc}	1.0^{a}	0.3^{bc}	1.5^{a}	10.1^{a*}
Ruzzana	76.6^{ab}	0.8^{a}	0.7^{a}	1.0^{b}	8.9^{b}
Sella Basmati Rice	69.0^{c}	1.4^{a}	0.4^{abc}	1.0^{b}	10.4^{a}
California	75.1^{abc}	0.8^{a}	0.4^{abc}	1.0^{bc}	7.4^{c}
Sun bird	76.2^{ab}	0.9^{a}	0.2^{c}	0.9^{bc}	7.7^{c}
Sun white	76.2^{ab}	0.6^{a}	0.4^{abc}	1.0^{bc}	8.9^{b}
Abu bent	76.9^{ab}	0.8^{a}	0.6^{abc}	0.7^{cd}	10.5^{a}
Sos Rice	79.4^{a}	0.5^{a}	0.3^{abc}	0.8^{bc}	7.4^{c}
Dux Rice	73.9^{abc}	0.5^{a}	0.3^{abc}	0.3^{e}	8.9^{b}
La Cigala	71.6^{bc}	0.8^{a}	0.5^{abc}	0.3^{e}	8.0^{bc}
Royal Ambrella	80.2^{a}	0.5^{a}	0.5^{abc}	0.3^{e}	8.2^{bc}
Amber	77.1^{ab}	0.7^{a}	0.6^{ab}	1.0^{bc}	11.0^{a}
LSD $p \leq 0.05$	6.97	1.3	0.4	0.3	1

▼Values are average of three replicates and calculated on dry weight basis; *Values followed by the same letter are not significantly different at $p \leq 0.05$

(1.1%). Sos rice found to contain the highest level of carbohydrate (91.0%) and Harvest the lowest carbohydrate content (82.5%).

Data on the effect of cooking on the chemical composition of rice brands are shown in Table 4. The protein content found to range from 7.4% for California rice to 11% for Amber rice, fiber also varied significantly and ranged from 03% to 1.5%. Ash, fat and carbohydrate were also varied significantly. The cooked rice significantly lost some nutrients (proteins, lipid,

Table 5: Mineral analysis of uncooked rice marketed in Jordan (mg/100g)$^{▼}$

Commercial Rice Brand	Ca	Na	K	Mg	Mn	Cu	Fe	P
Harvest	43.0^{e*}	37.3^{cabd}	60.5^{ed}	40.5^{b}	0.7^{a}	1.0^{e}	$5.5b^{ac}$	0.7^{bc}
Ruzzana	116.9^{a}	51.8^{ab}	103.2^{a}	50.1^{ba}	0.8^{a}	0.9^{dec}	6.1^{bac}	0.9^{abc}
SellaBasmati	73.4^{cd}	46.8^{cab}	84.5^{b}	52.8^{ba}	0.3^{a}	0.8^{de}	5.8^{bac}	0.8^{abc}
California	79.3^{c}	41.0^{cab}	63.1^{d}	45.4^{ba}	0.6^{a}	0.9^{dec}	5.8^{bac}	0.7^{bc}
Sun Bird	31.3^{ef}	53.0^{a}	51.8^{g}	60.7^{a}	0.5^{a}	0.8^{dec}	10.0^{a}	0.7^{bc}
Sun White	96.6^{b}	34.8^{cdb}	59.0^{edf}	41.0^{b}	1.0^{a}	0.8^{e}	5.5^{bac}	0.7^{bc}
Abu Bent	65.3^{d}	50.5^{ab}	84.4^{c}	62.9^{a}	0.9^{a}	1.1^{bdac}	7.7^{ba}	1.0^{abc}
Sos Rice	31.5^{f}	37.1^{cabd}	55.0^{gf}	53.2^{ba}	0.5^{a}	1.0^{bdec}	6.4^{bac}	0.6^{bc}
Dux Rice	102.9^{b}	35.5^{cdb}	37.1^{h}	44.1^{ba}	0.9^{a}	1.35^{ba}	4.2^{bc}	1.2^{ab}
La Cigala	27.2^{f}	35.0^{cdb}	46.3^{i}	46.5^{ba}	1.0^{a}	1.4^{a}	2.7^{c}	0.8^{bc}
Royal Umbrella	42.4^{e}	31.7^{cd}	26.6^{j}	36.7^{b}	0.6^{a}	1.1^{bdac}	4.2^{bc}	0.7^{bc}
Amber	73.3^{cd}	34.0^{cdb}	62.9^{egf}	52.5^{ba}	0.5^{a}	1.3^{b}	4.8^{bc}	1.4^{a}
LSD $p \geq 0.05$	13.15	9.82	5.46	19.58	1.45	0.35	4.90	0.61

$^{▼}$Values are average of three replicates and calculated on dry weight basis; *Values followed by the same letter are not significantly different at $p \leq 0.05$

Table 6: Mineral analysis of cooked rice marketed in Jordan (mg/100g)$^{▼}$

Commercial Rice Brand	Ca	Na	K	Mg	Mn	Cu	Fe	P
Harvest	32.5^{bc*}	23.2^{cde}	40.6^{efd}	16.3^{cd}	0.6^{ab}	0.8^{ab}	1.9^{abc}	0.7^{bc}
Ruzzana	73.3^{a}	41.5^{a}	94.8^{a}	31.2^{a}	0.5^{ab}	0.8^{ab}	2.0^{abc}	0.9^{bc}
Sella Basmati	39.9^{bc}	41.3^{ab}	71.2^{bc}	23.2^{abc}	0.3^{b}	0.5^{ab}	2.5^{a}	0.8^{bc}
California	19.0^{bc}	40.1^{abc}	43.4^{def}	16.7^{cd}	0.5^{ab}	0.5^{b}	1.6^{abc}	0.7^{bc}
Sun Bird	29.7^{bc}	45.2^{a}	50.7^{cde}	18.7^{cd}	0.4^{ab}	0.7^{ab}	1.5^{abc}	0.7^{bc}
Sun White	17.3^{c}	26.0^{cde}	43.6^{edf}	23.2^{abc}	0.7^{ab}	0.7^{ab}	1.3^{bc}	0.7^{bc}
Abu Bent	45.4^{b}	43.7^{a}	77.8^{ab}	26.5^{abc}	0.7^{ab}	0.7^{ab}	2.3^{ab}	1.0^{ab}
Sos Rice	26.2^{bc}	26.5^{bcde}	36.7^{ef}	17.0^{dc}	0.4^{ab}	0.5^{ab}	1.2^{bc}	0.6^{bc}
Dux Rice	44.1^{bc}	35.1^{abcd}	34.1^{ef}	19.7^{bcd}	0.5^{ab}	0.6^{ab}	1.0^{c}	0.9^{abc}
La Cigala	26.5^{bc}	27.0^{bcde}	28.8^{cdef}	23.6^{abc}	0.6^{a}	0.6^{ab}	1.6^{abc}	0.7^{bc}
Royal Umbrella	31.3^{bc}	26.8^{bcde}	23.6^{f}	11.0^{d}	0.5^{ab}	0.6^{ab}	2.0^{abc}	0.7^{bc}
Amber	12.8^{a}	15.0^{e}	56.6^{bcd}	30.0^{ab}	0.4^{ab}	1.1^{a}	2.2^{ab}	1.4^{a}
LSD $p \geq 0.05$	27.779	20.38	25.96	20.98	0.72	0.61	1.10	0.51

$^{▼}$Values are average of three replicates and calculated on dry weight basis; *Values followed by the same letter are not significantly different at $p \leq 0.05$

carbohydrate and minerals), this is expected because rice usually is soaked with warm water for nearly one hour. These values showed in Table 4 found to be comparable with the values reported by Perdon *et al.* (1999). Reports showed that, rice is affected by factors such as variety, amylose content, gelatinization temperature (Del Mundo *et al.*, 1989; Juliano and Perez, 1983) processing factors (Rousset *et al.*, 1995) and cooking method (Perdon *et al.*, 1999). Rice lipids are usually stable in the intact spherosomes in the cell. However, when the lipid membrane is destroyed by phospholipase, physical injury or high temperature, lipid hydrolysis is initiated by the action of lipases (Takano, 1989). Therefore, cooking temperature of rice treated in this study could be an important factor of lipid loss after cooking.

Data on minerals analysis of cooked rice are shown in Table 5. Calcium content varied significantly and ranged from 116.9 mg/100g for Ruzzana Sella to 31.1 mg/100g for Sunbird. Minerals Ca, K, Mg, Mn, Cu, Fe and P were also found to vary significantly.

The effect of soakin and cooking on minerals was obviously occurred (Table 5 and 6). The mineral composition of grain rice brands were highly reduced. The reason for mineral loss could be due to leaching water soluble minerals and enhancement of temperature during soaking before cooking. These findings are in agreement with the data published by Juliano and Perez (1983). Moreover, the concentration for cooked and uncooked rice found to be comparable with the values reported by Perdon *et al.* (1999) as well as by Juliano and Perez (1983).

In conclusion, we found that the marketed rice brands in Jordan varied significantly in their physical characteristics, chemical composition, mineral concentrations and cooking time. It was found that Amber rice required 10.3 min to cook very well, whereas the Indian Sella Basmati required almost 24 min, all other rice brands required intermediate time to cook very well. The loss in protein, carbohydrate, ash and fiber is due to variety of rice and soaking in warm water before cooking.

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