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PHYSICOCHEMICAL PROPERTIES OF SOME DOMESTIC AND INTRODUCED RICE VARIETIES IN MACEDONIA

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ABSTRACT

Physical and chemical properties of 14 samples of crude and white rice of domestic varieties, Mesen Blatec and Prima Riska, new breed genotypes (P1 x M, P2 x M, P x MM, MBL x M, MBL x MM, 79/22-2, 78/12-3-4 and 78/12-3-5) and Italian rice varieties (Arpa, Monticelli, Onice and San Andrea) were studied. As standards the varieties Prima Riska and San Andrea were used. The best head rice yield was obtained with the genotype P x MM (63.90%). The highest thousand grain weight was yielded by the rice genotype 78/12-3-4 (paddy 42.4 g and white rice 30.0 g). The moisture, crude fat, crude protein, crude fiber and ash content showed highly significant differences among different rice varieties. Significant differences were recorded in the fiber content between different varieties of evaluated paddy rice in comparison with the standards Prima Riska and San Andrea ($p<0.05$ and $p<0.01$). There was no significant difference in fiber content in the white rice samples ($p>0.05$). The highest average protein content in paddy kernel was determined with the genotype MBL x M (8.71%), and in the white rice with the variety Onice (9.48%). The average fat content in paddy kernel ranged from 1.25% with the standard variety Prima Riska to 2.43% with the variety Mesen Blatec and in the white rice ranges from 0.17% with the genotype P1 x M to 1.03% with the one of the standard varieties San Andrea. Significant differences were recorded in the fat content between different varieties in comparison with the standards. There was no significant difference in ash content with the paddy rice and white rice samples ($p>0.05$). Further investigations are needed to evaluate the nutritional and some functional properties of these domestic and introduced rice varieties and the nutrient.

Key words: rice, physical, chemical properties.

INTRODUCTION

The rice (*Oryza sativa* L.) is one of the most important cereals in the world and represents the main food of the half of the world population (Correia et al., 2014; Thakur and Gupta, 2006; Osaretin and Abosede, 2007). In Republic of Macedonia, in the eastern region of the state along the river Bregalnica the rice is also an agricultural crop with long-lasting growing tradition (Ilieva et al., 2010). The rice production in Republic of Macedonia completely satisfies the needs for domestic market, while a certain part is intended for export (Andreevska et al., 2013).
During the rice harvest crude rice (paddy) is obtained. Unlike the other cereals (wheat, barley, maize, rye), where grains are milled into flour or feed, the rice kernel is submitted on factory finishing process for obtaining rice for consumption. Therefore the main interest for the rice producers is the yield of white rice per unit area, i.e. the obtained head rice yield of white rice during the processing of the crude rice-paddy (Andov et al., 2012; Babamiri and Asli-Ardeh, 2013; Andreevska et al., 2013; Ilieva et al., 2014). During processing of the crude rice, several rice categories are obtained: brown rice, white rice, broken rice, and the products rice bran and husks. The head rice yield (the percentage of the whole kernels of white rice) is very different with different rice varieties and genotypes grown in different management and environmental conditions. The 1000 kernel weight is an important quality property and represents primarily varietal characteristics, but depends also on the applied agro

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technique for growing on the given environmental conditions (mainly climate factors) and on other factors (Golam Sarwar et al., 1998). Also, the chemical composition of the rice kernel (such as content of protein, fat, crude fiber, ash) are also important parameters for rice quality (Yadav and Jindal, 2007). The aim of these investigations was to determine the head rice yield, 1000 kernel weight and chemical composition of the kernel of some domestic and foreign rice varieties and genotypes grown in the conditions of Republic of Macedonia.

MATERIAL AND METHODS

The rice varieties and genotypes which are the subject of the investigation presented in this paper are part of the variety collection of the Agricultural Institute in Skopje (Table 1).

Table 1. List of the tested rice varieties (*Oriza sativa* L. *japonica*)

No.	Variety	Country of origin
1.	Prima riska (st.)	Macedonia
2.	S.Andrea (st.)	Italy
3.	Mesen Blatec	Macedonia
4.	P1 x M	Macedonia
5.	P2 x M	Macedonia
6.	P x MM	Macedonia
7.	MBL x M	Macedonia
8.	MBL x MM	Macedonia
9.	79/22-2	Macedonia
10.	78/12-3-4	Macedonia
11.	78/12-3-5	Macedonia
12.	Monticelli	Italy
13.	Arpa	Italy
14.	Onice	Italy

Each variety/genotype was grown on the area of 2 m^2, with distance of 0.5 m in the plots and 1m between the plots. During the growing of the rice varieties and genotypes a standard crop management was applied. The crude rice or paddy of the investigated varieties and genotypes in the phase of full maturity was determined after the harvest was dried and stabilized at room temperature in laboratory. The head rice yield of the white rice, the whole kernels and by products at the bleaching of the paddy (broken rice, rice bran and husks) were determined by laboratory huller by bleaching of the average sample of 100 g paddy during 1.40 min. The 1000 kernel weight of paddy and white rice (the absolute kernel weight) was determined on five samples of 500 seed kernels of each sample. For performing the chemical analyses, the crude rice-paddy and white rice, were milled by laboratory mill and stabilized on room temperature. Each analysis was carried out in triplicates. The moisture content was measured applying a standard drying method for the samples in an oven at temperature of 105±5ºC, till constant weight. The total protein content was determined according to Kjeldahl method (N×5.95). The total fat content was analysed with extraction with diethyl ether according to the Soxhlet method. Ash content was determined by burning the samples in oven during 8 hours at the temperature of 600^{o}C.

RESULTS AND DISCUSSION

Physicochemical properties of a rice variety provide important facts in determining their appropriate uses (Thomas at al., 2013). The results obtained on the head rice yield of different rice varieties analysed in this study are presented in Table 2. The tested samples varied in head rice yield from 39.0 to 63.9%. The highest head rice yield (the highest percent of the whole kernels) were obtained with the genotype P x MM (63.9%), and the lowest with the genotype 78/12-3-4, (39.0%). As for the head rice yield of the varieties used as a standard, the values were for Prima Riska 50.5% and for San Andrea 41.6%. The highest percentage of the fraction of broken grains was obtained with the genotype 78/12-3-4 (20.7%), while the lowest with the genotypes P x MM (3.6%). Buggenhout et al. (2013) reported that a high percentage of broken grains is indicative of the poor milling quality, whereas a high percentage of head rice is indicative of high quality. The highest percentage of chalky grains was obtained with the varieties Arpa (7.7%) and San Andrea (6.5%), while the lowest with the genotypes 78/12-3-4 (0.2%). The chalky grains are

undesirable in all forms of rice and occur when rice is harvested at too high moisture level (Rosniyana et al., 2010). The highest percentage of bran was obtained with the genotype 78/12-3-4 (17.2%), while the lowest with the standard variety San Andrea (11.0%). As for the fraction of husks, the highest value was with the variety Mesen Blatec (22.15%), while the lowest with the genotype P2 x M (17.9%).

Table 2. Head rice yield of analysed rice varieties (%)

No.	Variety	Whole grains	Broken grains	Total (whole + Broken)	Chalky grains	Rice bran	Husks
1.	Prima riska (st.)	50.5	11.8	62.3	1.2	16.5	20.0
2.	S.Andrea (st.)	41.6	20.6	62.2	6.5	**11.0**	20.3
3.	Mesen Blatec	48.2	13.8	62.0	1.0	14.85	**22.15**
4.	P1 x M	56.2	7.2	63.4	1.1	16.4	19.1
5.	P2 x M	54.3	9.9	64.2	1.9	16.0	**17.9**
6.	P x MM	**63.9**	**3.6**	67.5	1.9	11.6	19.0
7.	MBL x M	55.2	9.7	64.9	0.6	16.0	18.5
8.	MBL x MM	63.5	3.9	67.4	1.2	13.1	18.3
9.	79/22-2	51.1	11.9	63.0	0.7	15.2	21.1
10.	78/12-3-4	**39.0**	**20.7**	59.7	**0.2**	**19.9**	20.2
11.	78/12-3-5	55.7	8.1	63.8	0.7	17.2	18.3
12.	Monticelli	60.3	4.4	64.7	0.3	14.8	20.2
13.	Arpa	55.0	4.1	59.1	**7.7**	12.3	20.9
14.	Onice	56.4	12.8	69.2	0.9	11.9	18.0
Average		**53.64**	**10.18**	**63.81**	**1.85**	**14.77**	**19.57**

In Table 3 are presented the minimal, maximal, and average values of the 1000 kernel weight of different rice varieties analysed in this study. The highest average 1000-kernel weight had the genotype 78/12-3-4 (paddy 42.4 g and white 30.0 g) and the lowest had the variety Arpa (paddy 26.4 g and white 18.4 g). The standard varieties had the highest average in Prima Riska (paddy 41.4 g and white 29.6 g) and as well as the variety San Andrea (paddy 36.0 g and white 28.2 g).

Table 3. The one thousand grain weight of analysed rice varieties (g)

No.	Variety	Paddy rice			White rice		
		Min.	Max.	Average	Min.	Max.	Average
1.	Prima riska (st.)	41.0	42.0	41.4	29.0	30.0	29.6
2.	S.Andrea (st.)	35.0	37.0	36.0	27.0	29.0	28.2
3.	Mesen Blatec	34.0	36.0	35.0	23.0	24.0	21.8
4.	P1 x M	38.0	40.0	39.0	26.0	28.0	27.0
5.	P2 x M	40.0	41.0	40.4	28.0	30.0	29.0
6.	P x MM	30.0	32.0	31.0	22.0	23.0	22.6
7.	MBL x M	39.0	40.0	39.4	26.0	27.0	26.8
8.	MBL x MM	31.0	33.0	32.2	23.0	24.0	23.6
9.	79/22-2	41.0	43.0	42.0	29.0	31.0	30.0
10.	78/12-3-4	41.0	43.0	**42.4**	29.0	31.0	**30.0**
11.	78/12-3-5	42.0	43.0	42.2	29.0	30.0	29.6
12.	Monticelli	31.0	32.0	31.4	21.0	22.0	21.8
13.	Arpa	26.0	27.0	**26.4**	18.0	19.0	**18.4**
14.	Onice	33.0	34.0	33.2	23.0	24.0	23.8

Tables 4 and 5 represent the content of moisture, fiber protein, fat and ash in paddy rice grain and white rice grain. The average moisture content of the paddy kernel (Table 4) of the investigated rice varieties and genotypes varied from 12.52% with the variety Monticelli to 13.49% with the one of the standard varieties Prima Riska. As for the moisture content in the white rice, the values were in the range of 13.64% with the genotype Mesen Blatec to 14.19% with the standard Prima Riska and Arpa. Significant differences were recorded in the moisture content between different rice varieties, evaluated in comparison with the standards Prima Riska and San Andrea ($p<0.05$ and $p<0.01$). The rough rice grains are harvested at moisture content ranging from 16% to 26% (Buggenhout et al., 2013). To avoid microbial contamination and respiration processes which can cause quality losses, they were dried to a moisture content of 12-13% (Ondier et al., 2010; Perdon et al., 2000).

Table 4. Content of moisture, crude fiber, protein, fat and ash in paddy rice grain (%)

No.	Variety	Moisture	Crude fiber	Protein	Fat	Ash
1.	Prima riska (st.)	13.49±0.39●●	9.56±0.36●●	6.44±0.08●●	1.25±0.11	4.39±0.17
2.	S.Andrea (st.)	12.89±0.05**	12.87±0.14**	6.82±0.02**	2.25±0.06**	4.50±0.57
3.	Mesen Blatec	13.08±0.19*	7.76±0.28**●●	7.88±0.08**●●	2.43±0.27**	4.76±0.30
4.	P1 x M	13.01±0.25**	11.92±0.15**●●	7.44±0.08**●●	2.23±0.17**	3.99●±0.19
5.	P2 x M	13.38±0.08●●	7.29±0.27**●●	4.62±0.17**●●	1.82±0.15**●●	3.86*●±0.05
6.	P x MM	13.16±0.13*	8.79±0.16**●●	5.50±0.15**●●	2.28±0.08**	3.89*●±0.11
7.	MBL x M	12.92±0.09**	10.63±0.06**●●	8.71±0.16**●●	1.72±0.12**●●	5.08*●±0.45
8.	MBL x MM	12.81±0.19**	12.16±0.21**●●	7.14±0.02**●●	2.16±0.09**	3.81*●±0.27
9.	79/22-2	12.91±0.32**	8.90±0.10**●●	7.01±0.05**●●	1.80±0.07**●●	4.24±0.12
10.	78/12-3-4	13.15±0.04*	7.22±0.11**●●	7.84±0.02**●●	1.56±0.12*●●	4.55±0.16
11.	78/12-3-5	13.25±0.15●	10.35±0.14**●●	7.49±0.14**●●	1.59±0.04**●●	4.24±0.10
12.	Monticelli	12.52±0.18**●	8.45±0.08**●●	8.20±0.03**●●	1.42±0.18●●	4.51±0.51
13.	Arpa	13.30±0.24●	12.09±0.20**●●	7.37±0.08**●●	1.59±0.22**●●	4.14±0.21
14.	Onice	12.63±0.13**	9.83±0.22●●	7.95±0.11**●●	2.20±0.16**	4.46±0.27
	Average	13.04	9.84	7.17	1.88	4.32
	LSD 0.05	0.31	0.33	0.17	0.24	0.47
	LSD 0.01	0.42	0.44	0.23	0.32	0.63

Values are means ± S.D.
* $p\leq0.05$; ** $p\leq0.01$; compared to standard variety Prima Riska.
● $p\leq0.05$; ●● $p\leq0.01$; compared to standard variety San Andrea.

The highest percentage of paddy crude fiber was obtained with the variety San Andrea (12.87%), while of the white rice value was obtained with the variety Arpa (0.57%) (Tables 4 and 5). The lowest percentage of the paddy crude fiber value was determined with the genotype 78/12-3-4 (7.22%), while that of the white rice with the genotype 78/12-3-5 (0.22%). Significant differences were recorded in the fiber content between different varieties of evaluated paddy rice in comparison with the standards Prima Riska and San Andrea ($p<0.05$ and $p<0.01$). There was no significant difference in the fiber content with the white rice samples ($p>0.05$).

Rice contains the lowest protein level among the cereals, thus, it is important to breed rice varieties with higher protein content and improved the nutritional quality in order to meet the consumer demands and purposes. As for the protein content, the values in paddy kernel ranged from 4.62% in the genotype P2 x M to 8.71% in the genotype MBL x M. With the white rice they ranged from 5.25% with the genotype 78/12-3-4 to 9.48% with the variety Onice (9.48%). Significant differences were recorded in the protein content between different rice varieties evaluated in comparison with the standards Prima Riska and San Andrea ($p<0.05$ and $p<0.01$).

Table 5. Content of moisture, crude fiber, protein, fat and ash in white rice-grain (%)

No.	Variety	Moisture	Fiber	Protein	Fat	Ash
1.	Prima riska (st.)	14.19±0.03$^{••}$	0.51±0.27	5.93±0.14	0.30±0.02$^{••}$	0.29±0.02
2.	S.Andrea (st.)	13.99±0.02**	0.36±0.08	6.58±0.15	1.03±0.14**	0.43±0.14
3.	Mesen Blatec	13.64 ±0.05**$^{••}$	0.36±0.05	7.60±0.33**$^{••}$	0.27±0.16$^{••}$	0.25±0.03
4.	P1 x M	13.85 **$^{••}$	0.34±0.10	5.62±0.40$^{••}$	0.17±0.04$^{••}$	0.24±0.00
5.	P2 x M	13.94 **	0.39±0.10	5.64±0.26$^{••}$	0.27±0.02$^{••}$	0.16±0.13
6.	P x MM	13.91**	0.42±0.04	5.70±0.26$^{•}$	0.35±0.05$^{••}$	0.27±0.03
7.	MBL x M	13.66**$^{••}$	0.24±0.10	6.53±0.32	0.23±0.02$^{••}$	0.27±0.06
8.	MBL x MM	13.85** $^{•}$	0.39±0.10	7.75±0.05**$^{••}$	0.33±0.02$^{••}$	0.26±0.12
9.	79/22-2	14.03**	0.41±0.03	8.18±1.16**$^{••}$	0.30±0.02$^{••}$	0.32±0.01
10.	78/12-3-4	13.82** $^{••}$	0.42±0.29	5.25±0.19*$^{••}$	0.34±0.23$^{••}$	0.28±0.03
11.	78/12-3-5	14.02**	0.22±0.11	6.70±0.13*	0.29±0.04$^{••}$	0.23±0.03
12.	Monticelli	13.85 ** $^{••}$	0.32±0.20	7.67±0.10**$^{••}$	0.82±0.13**$^{••}$	0.27±0.14
13.	Arpa	14.19$^{••}$	0.57±0.29	8.37±0.21**$^{••}$	0.40±0.03$^{••}$	0.30±0.03
14.	Onice	13.90 *	0.49±0.03	9.48±0.43**$^{••}$	0.62±0.07**$^{••}$	0.31±0.01
Average		13.92	0.39	6.93	0.41	0.28
LSD 0.05		0.10	0.00	0.65	0.15	0.00
LSD 0.01		0.14	0.00	0.88	0.20	0.00

Values are means ± S.D.
* $p \leq 0.05$; ** $p \leq 0.01$; compared to standard variety Prima Riska
$^{•}$ $p \leq 0.05$; $^{••}$ $p \leq 0.01$; compared to standard variety San Andrea

Investigations of Andreevska and Ilieva (1999) have shown that the protein content with different rice varieties is very variable and ranges from 6.72% to 10.12% in the paddy kernel and from 6,31% to 10,29% in the brown rice kernel.

The average fat content in the paddy kernel ranged from 1.25% with the standard variety Prima Riska to 2.43% with the variety Mesen Blatec (Table 4). The high level of fat content in paddy rice kernel is mainly contributed by the oil presents in the bran layer (Rosniyana et al., 2010). Our obtained results are significant in comparison with the standard Prima Riska except with the variety Monticelli. In comparison with the standard San Andrea the results were significant only for the genotype P2 x M, MBL x M, 79/22-2, 78/12-3-4 and 78/12-3-5, Monticelli and Arpa. In the white rice kernel the fat content ranged from 0.17% with the genotype P1 x M to 1.03% with one of the standard varieties San Andrea (Table 5) (Rohman et al., 2014; Sujatha et al., 2004). Significant differences were also recorded in the fat content between different varieties of the evaluated paddy rice in comparison with the standards Prima Riska and San Andrea ($p<0.01$). The highest ash content in paddy kernel was found with the genotype MBL x M (5.08%), and the lowest with the genotype MBL x MM (3.81%, Table 4). As for the white rice kernel, the highest ash content was determined with the varieties San Andrea (0.43%), and the lowest one with the genotype P2 x M (0.16%, Table 5). The comparison of the kernel composition of the paddy and white rice showed that the mineral content was decreased in polished rice kernel (Abbas et al., 2011).

CONCLUSIONS

The physical characteristics, such as the head rice yield, whole grains, broken, chalky and thousand grain weight varied among different rice varieties. The best head rice yield was obtained with the genotype P x MM (63.90%). The highest thousand grain weight was found in the rice genotype 78/12-3-4 (paddy 42.4 g and white 30.0 g). The moisture, crude fat, crude protein, crude fiber and ash content showed highly significant differences among different rice varieties. Significant differences were recorded in the fiber content

between different varieties of evaluated paddy rice in comparison with the standards Prima Riska and San Andrea ($p<0.05$ and $p<0.01$). There was no significant difference in the fiber content of the white rice samples ($p>0.05$).The highest average protein content in paddy kernel was determined with the genotype MBL x M (8.71%), and in white rice kernel with the variety Onice (9.48%). The average fat content in the paddy kernel ranged from 1.25% with the standard variety Prima Riska to 2.43% with the variety Mesen Blatec. In the white rice kernel it ranged from 0.17% with the genotype P1 x M to 1.03%. Significant differences were recorded in the fat content between different rice varieties in comparison with the standards. There was no significant difference in the ash content of the paddy rice and white rice samples ($p>0.05$). Further investigations are needed to evaluate the nutritional and some functional properties of these domestic and introduced rice varieties.

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