

# COMPARATIVE OVERVIEW OF THE NUTRITIONAL PROPERTIES OF RICE (*ORYZA SATIVA* L.) LANDRACES HULLED AND UNHUSKED GRAINS (PARBOILED)

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## Abstract

Dietary regimens that are part of everyday life and habits of modern life require the inclusion of cereals with the highest percentage of vegetable fiber. Long-term digestion allows for a longer period of satiety with sufficient nutrition of the intestinal microflora, for which plant fibers are prebiotic. A hulled grain diet means the rapid utilization of carbohydrates, the rapid feeling of hunger, and insufficient energy until the next meal, and elevation of glycemia in the blood. Rice is daily present in the human diet and its inclusion should be as unhulled (parboiled) due to vegetable fibers and a balanced meal. This research includes 10 landraces from the surroundings of the largest rice-producing region of Kochani, collected from 2020-2022 from local producers. Laboratory analyses have shown significant differences in the nutritional properties of hulled and unhulled rice. Hygroscopic moisture was measured 30 days after harvest and ranged from 14.43-16.40% in hulled rice grains, where starch content was high at 62.57-73.65%, plant fiber from 2.6 to 3.06%, and total organic matter ranged from 89.99-92.19 %. In unhulled rice grains, the hygroscopic moisture is represented from 13.23 to 15.82 %, the starch significantly less compared to the hulled grains 59.23-66.29 %, and the organic matter from 84.49 to 94.35 %. Proteins are represented from 11.70 to 13.40 % and together with fats (0.4-0.9 %) were examined only in unhulled rice grains, because their content is unchanged and does not depend on the representation of vegetable fibers. The total mineral component is presented as ash, which is a higher content of 10.01 % found in the hulled rice compared to the unhulled 7.64 %. According to the obtained results, it is recommended to use unhulled rice in the diet, especially during periods when antibiotics are taken, as well as in people who have "lazy" intestines.

*Keywords:* *Oryza sativa* L., landraces, nutritional properties, hulled grains, unhulled grains.

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## 1. Introduction

Rice is a valued raw material and food all over the world. According to (Statista, 2023) starting from 2008/09 when the world production was 437.189 million metric tons to 2022/23 with 517.184 million metric tons in the global framework, the consumption of rice has increased (Sweeney, M. & McCouch, 2007). Cultural preferences in the Republic of North Macedonia, as well as in almost all Balkan countries, and in most countries in the world, are directed towards the preparation of hulled (white) rice, although according to nutritionists, it is at the top of the list of foods with a high content of starch (sugars). However, it must be noted that a large part of the nutrients are retained even after the rice has been peeled (Furong et al., 2010).

Hulled (white) rice is used much more, which has a higher glycemic index and is poor in crude fiber. In contrast, unhulled rice is rich in crude fiber (as prebiotic for the intestinal microflora), richer in minerals (manganese, iron, magnesium, phosphorus and selenium) and vitamins (B1, B3, B6, folic acid) and affects

improved digestion without to disrupt glycemic homeostasis after ingestion. Crude fiber is contained in the husk of the rice grain (Bopitiya & Madhujith, 2014) and after peeling it is removed like the rice germ. Comparatively, in unhusked rice, the protein content is 1.5 times higher and 4-5 times higher in fat and crude fiber (Longvah et al., 2022). Although the differences are great in the nutritional properties of hulled and unhusked rice, combining it with vegetables can compensate for the loss of crude fiber (Shen et al., 2009; Sompong et al., 2011). Hence, there are numerous benefits from peeled rice, such as fast digestion and a source of energy (especially before exercise), economically accessible with the lower price and simpler preparation procedure. And on the other hand, the benefits of consuming unhusked rice are numerous. In addition to being richer in phytonutrients and antioxidants (Gayacharan et al., 2019), it reduces the risk of type 2 diabetes, prevents heart attack, and has a synergistic effect on weight management and suppression of the feeling of hunger for a longer period of time and is therefore recommended exclusively as unhusked in dietary regimes. Old rice landraces can be found in reduced numbers among local farmers and households where they are still kept and cultivated (Vaughan et al., 2008). In the face of climate changes that are evident and affect reduced yields, higher susceptibility to diseases and pests (Yam et al., 2016) and cause drought, the focus can be placed on these landraces that are adapted to local conditions (biotic and abiotic factors) and easily survive, although yield is low (Hour et al., 2020). Therefore, the selection programs that obtain these hybrids and varieties use the gene pool of landraces (Garris et al., 2005) and thus produce uniform genotypes with improved adaptation mechanisms to the external environment and changes (Patra & Dhue, 2003 Metwally et al., 2010).

With the conducted research, the nutritional properties of ten rice landraces grown in the rice-producing region of Kočani were determined, with the aim of recommending them for local production, start-up mini businesses and inclusion in the assortment of products, especially in health food stores and food intended for the population who devotedly takes care of their health.

## **2. Material and methodology**

The investigated landraces belong to subspecies *O.sativa* subsp.*japonica*. Ten (10) rice landraces, originally from the Kočani region and ten (10) villages in its surroundings, were included in the research. Landraces were collected from their households, which have been maintained for more than 20 years through self-selection (Table 1). The researched parameters that define more closely the nutritional value of rice samples were analyzed three (3) days after harvest. From each landrace, 100 g of representative rice samples were taken, and ground in a hand blender, and then parameters of interest, such as starch, protein, fat, crude fiber (CF), ash, and organic matter (OM) were determined. The content of organic matter (sum of the content of starch, protein, fat, CF) and ash (100 - OM) were determined by calculation. Hygroscopic moisture (HM) was determined before grinding the samples with an automatic moisture meter 3 days after the harvest. The specified parameters were determined in samples from unhusked and hulled rice grains in the State Phytosanitary Laboratory according to accredited methods (<https://iarm.gov.mk/wp-content/uploads/2023/03/OB-05-25-LT-036>).

**Table 1.** Landraces included in research with essential details (local name, place of collecting, GPS coordinates)

Local name / Abbreviation	Place of collecting, Kočani/Name of village (locality)	Latitude	Longitude	Altitude (a.s.l.)
Zrnovski / R1	v. Zrnovci	41°51'54"N	22°26'17"E	334m
Mojanski / R2	v. Mojanci	41°52'27"N	22°22'43"E	421m
Spanchevski / R3	v. Spanchevo	41°55'53"N	22°20'48"E	320m
Sokolarski / R4	v. Sokolartsi	43°00'10"N	26°31'14"E	313m
Obleshevski / R5	v. Obleshevo	41°52'44"N	22°18'29"E	301m
Cheshinovski / R6	v. Cheshinovo	41°52'38"N	22°18'18"E	291m
Mishinski / R7	v. Mishino	42°04'22"N	22°27'15"E	1198m
Chepernenski / R8	v. Chepernik	41°55'19"N	22°41'61"E	363m
Kostindolski / R9	v. Kostin Dol	42°01'21"N	22°27'19"E	872m
Zhiganski / R10	v. Zhiganci	41°52'36"N	22°14'25"E	331m

### 3. Results

The analyzed landraces point to results that show big differences for almost all investigated parameters in husked rice. This finding does not apply to landraces where the rice grains are unhusked. In terms of hygroscopic moisture (HM), the lowest content (13.23 %) was found in P1 unhusked landraces, while in hulled grains in P9 (15.04 %) and P7 (14.75 %) landraces, which were grown at a higher altitude (R9 at 872 m, R7 at 1198 m). The content of HM in unhusked P6 landraces is high (15.82 %), and even higher and above the permissible limit values that require additional drying of rice grains in P4 hulled landraces (17.13 %) (Table 2). Both landraces grow at low altitudes, P6 at 291 m, and P4 at 313 m a.s.l. (Table 1). The total starch content varies from 67.59% in P3 to 77.65% in unhusked rice and is lower compared to the average in hulled rice ranging from 15.04% in P9 to 17.13% in P4. The concentration of proteins and fats is unchanged. In unhusked and hulled rice landraces, the proteins are the least represented in P7 (11.70 %), and the most in P10 (13.30 %). Only 0.40% is fat in P3 landraces, and almost twice as much (0.90) in P7, although it should be noted that it is also high in P5 and P8 (0.80%). The biggest motivation for researching and giving importance to unhusked rice is justified by the huge differences in CF content. Namely, in unhusked rice, the lowest content was found in P5 (14.99%), and the highest in P8 (18.52%). In hulled rice, the CF content is minimal and ranges from 2.60% in P1 to 3.60% in P10. Although they are not very large, the differences in the content of OM among the investigated landraces are still significant, so among unhusked ones they range from 86.13% in P4 to 94.35% in P9. For hulled grains, the variation is even greater and is 88.32% for P3 as the lowest to 97.49% for P10 as the highest. In P3, ash is in the highest concentration in both unhusked (15.51%) and hulled rice grain (11.68%), while the lowest was found in P9 (5.65%) unhusked grain and P10 in hulled (2.51%) (Table 2 and 3).

**Table 2.** Nutritive traits of unhusked rice landraces (L) after 3 days of harvest, in %

L (R1-10)	Moisture	Starch	Protein	Fat	CF	OM	Ash (100-o.m.)
R1	13.23	75.12	12.50	0.50	2.60	90.72	9.28
R2	14.09	77.23	11.90	0.60	2.90	92.63	7.37
R3	14.13	67.59	13.40	0.40	3.10	84.49	15.51
R4	13.82	69.83	12.80	0.70	2.80	86.13	13.87
R5	14.94	72.31	12.20	0.80	3.30	88.61	11.39
R6	15.82	75.09	13.10	0.60	3.20	91.99	8.01
R7	14.75	73.17	11.70	0.90	3.00	88.77	11.23
R8	13.83	75.28	12.80	0.80	2.70	91.58	8.42
R9	14.22	77.65	12.60	0.70	3.40	94.35	5.65
R10	15.46	73.27	13.30	0.50	3.60	90.67	9.33
x±Sx	14.43±0.06	73.65±0.04	12.63±0.05	0.65±0.24	3.06±0.10	89.99±0.03	10.01±0.03

**Table 3.** Nutritive traits of hulled rice landraces (L) after 3 days of harvest, in %

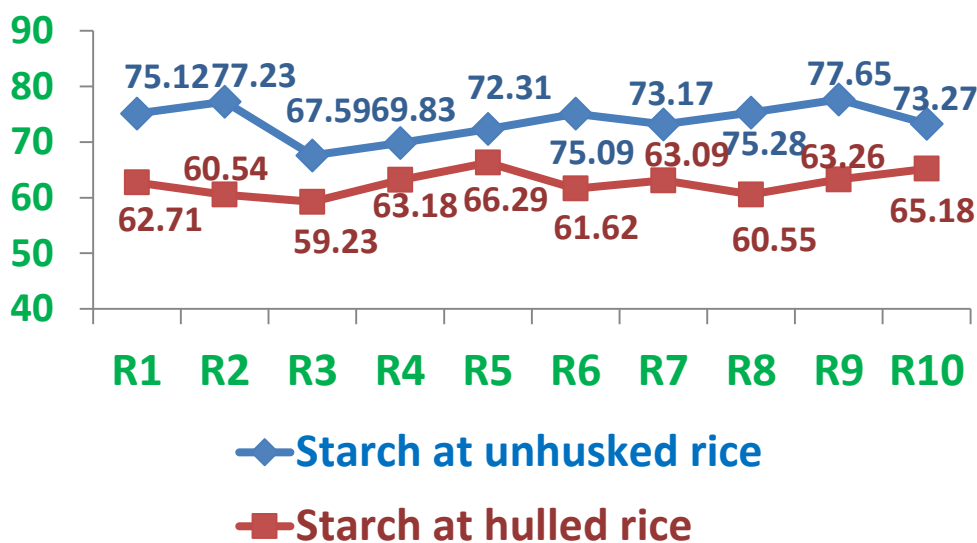
L (R1-10)	Moisture	Starch	Protein	Fat	CF	OM	Ash (100-o.m.)
R1	16.78	62.71	12.50	0.50	14.81	90.52	9.48
R2	17.92	60.54	11.90	0.60	15.34	88.38	11.62
R3	16.55	59.23	13.40	0.40	15.29	88.32	11.68
R4	17.13	63.18	12.80	0.70	16.23	92.91	7.09
R5	16.48	66.29	12.20	0.80	14.99	94.28	5.72
R6	15.27	61.62	13.10	0.60	16.18	91.50	8.50
R7	16.31	63.09	11.70	0.90	17.35	93.04	6.96
R8	15.92	60.55	12.80	0.80	18.52	92.67	7.33
R9	15.04	63.26	12.60	0.70	17.96	94.52	5.48
R10	16.62	65.18	13.30	0.50	18.51	97.49	2.51
x±Sx	16.40±0.05	62.57±0.03	12.63±0.05	0.65±0.24	16.52±0.09	92.19±0.03	7.64±0.37

#### 4. Discussion of results

The average content of HM in unhusked rice is 14.43±0.06, while in hulled rice landraces it is higher and is 16.40±0.05. In those landraces that are produced at lower altitudes, HM is higher in most cases, which is understandable due to the retention of moisture in the air. Starch, which consists of the polysaccharides amylose and amylopectin in rice grains, is the main carbohydrate component that is also a source of energy for consumers. Hulled grain rice has a high glycemic index (GI) that ranges from 40-100 (average 64), but in the cooking process it decreases by 15-20% and as such in an amount no higher than 100 g you can also find in the menu of diabetics. In these studies, a higher average content of total starch was determined in unhusked rice 73.65±0.04 than in hulled rice 62.57±0.03. Although, higher as a result of the polysaccharides present in bran rice, in combination with CF it gives a longer time of satiety and subsequent utilization of carbohydrates. On average, the concentration of proteins is 12.63±0.05, and that of fats 0.65±0.24 (Figure 1). Compared to literature data, these values are lower than in commercial varieties (Sun et al., 2020), but still higher than the

values obtained by the research of J. Yang et al., 2015. Thereby, should be considered that old preserved landraces always have a lower content of nutrients (Butardo and Sreenivasulu, 2016), but therefore have a huge value with their genotypically developed adaptive mechanisms towards unfavorable conditions that gives them an advantage in selection programs and the introduction of genes through DNA recombinant technology to obtain improved genotypes (Quek and Henry, 2016; Fu and Xue, 2010).

The average content of CF is  $16.52 \pm 0.09$  in unhusked rice grain, while significantly low in hulled rice  $3.06 \pm 0.10$ . In addition to providing satiety, it is a prebiotic for GIT microflora, and is also a source of minerals, vitamins and antioxidants (Ghorbani, 2017; Chen et al., 2022). Hence the reference of the research team to the high content of CF and the recommendation for the preparation and consumption of unhusked rice in the daily diet of any population (Chen et al., 2022) (Figure 2). As expected, OM is in higher content in unhusked rice landraces and the average representation is  $92.19 \pm 0.03$ , in contrast to  $89.99 \pm 0.03$  in hulled rice grains (Figure 3).



**Figure 1.** Comparative view of starch content at unhusked and hulled rice landraces, in %

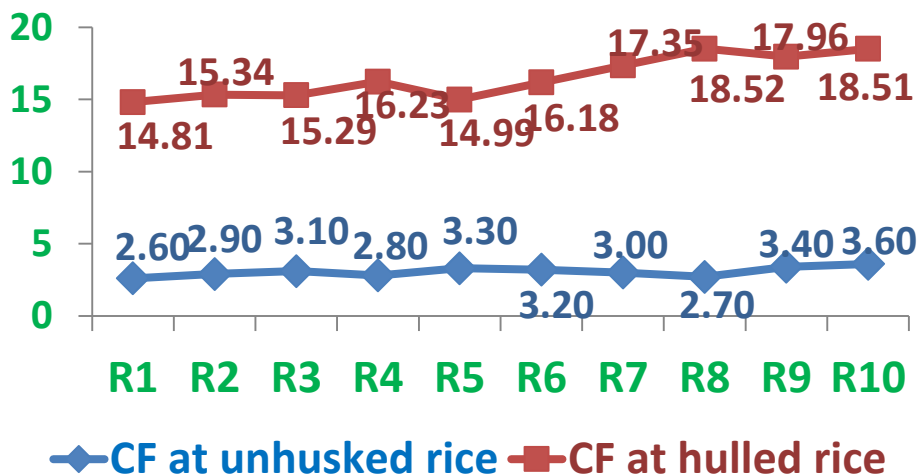


Figure 2. Comparative view of CF at unhusked and hulled rice landraces, in %

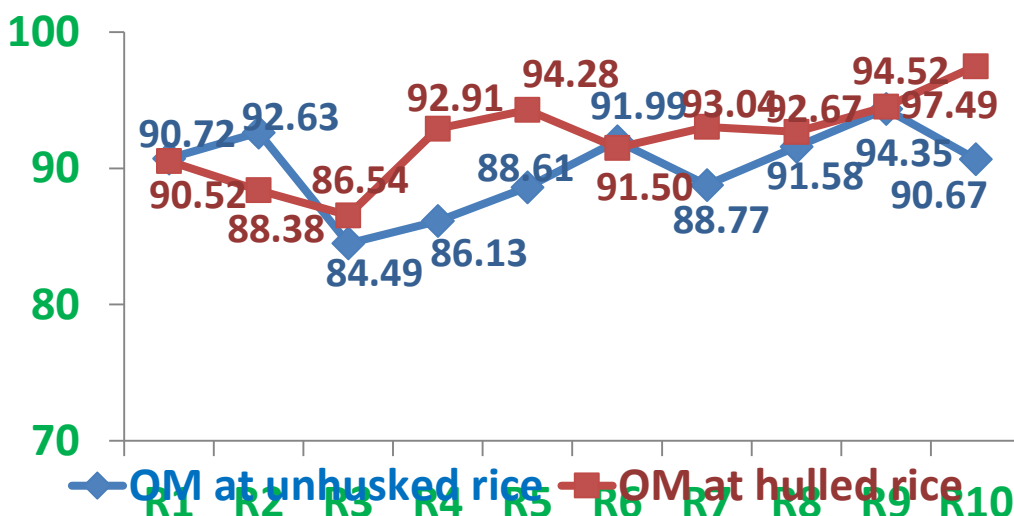


Figure 3. Comparative view of OM at unhusked and hulled rice landraces, in %

## 5. Conclusions

The conducted research provided a large amount of quantitative data on the content of nutritional components, according to which the following conclusions and a recommendation can be made:

- The content of starch in unhusked rice is significantly higher (73,65 %) than in husked rice (62,57 %), but in combination with crude fiber it gives a longer time of satiety and subsequent utilization of carbohydrates.
- The protein concentration is moderately high 12.63% and that of fats 0.65, but should be considered as valuable in breeding programs by using DNA recombinant technology to obtain more resistant genotypes.

- Crude fiber in unhusked rice is 6-7 times more abundant compared to hulled rice. High crude fiber content makes unhusked rice probiotic rice and helps maintain the intestinal microflora in good condition and number, thereby supporting and strengthening the body's immune response and improving digestion and the utilization of nutrients from the food consumed. Unhusked rice maintains the feeling of satiety for 2-3 times longer and is recommended in dietary regimes.
- From a nutritional point of view, replacing hulled/white rice with unhusked rice in the daily diet or adding rice bran to one of the meals is recommended.

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