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CHARACTERIZATION of THE PHYSICO-CHEMICAL COMPOSITION, PHYTO-CHEMICAL PROPERTIES, COOKING CHARACTERISTICS and BIOACTIVE COMPOUNDS of KONURALP RICE

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ABSTRACT
This is the first study conducted on a variety of rice (*Oryza sativa* L.) traditionally grown in the Konuralp region of the Duzce province, in the West Black Sea region of Türkiye. It investigated the physico-chemical composition, phyto-chemical properties, cooking characteristics and bioactive compounds (total phenolic content, antioxidant activity determined with the methods of $ABTS^{•+}$, CUPRAC, $DPPH^{•}$ and FRAP) of Konuralp Rice (KR) as well as *in-vitro* bioaccessibility. The proximate chemical composition of the rice was found to be as follows: the moisture content was 13.89%, the protein content was 6.48%, the total dietary fiber was 0.82%, the energy value was 323.44 kcal and the amount of starch was 59.64%. On the other hand, the phytic acid content of the sample was found to be 258.69 mg/100g. The total phenolic content of KR was found to be 2100 mg GAE/100g. The highest antioxidant capacity was found in the method of $DPPH^{•}$ for extractable (12.73 μmol trolox/g) and hydrolyzable phenolics (62.50 μmol trolox/g). The antioxidative bioaccessibility were found to be 80.19% ($ABTS^{•+}$), 27.96% (CUPRAC), 20.63% ($DPPH^{•}$) and 0.92% (FRAP). Due to the its physico-chemical and phyto-chemical properties as well as its high bioactive component content, more attention should be paid to the traditionally produced KR.
Keywords*:* Antioxidant capacity, bioaccessibility, chemical composition, cooking properties, rice, total phenolics

KONURALP PİRİNCİNİN FİZİKO-KİMYASAL BİLEŞENİ, FİTO-KİMYASAL ÖZELLİKLERİ, PİŞME KARAKTERİSTİKLERİ VE BİYOAKTİF BİLEŞENLERİ

ÖZ
Bu çalışma, Türkiye'nin Batı Karadeniz bölgesi Düzce ili Konuralp beldesinde geleneksel olarak yetiştirilen pirinç çeşidi (*Oryza sativa* L.) üzerinde yapılan ilk araştırmadır. Çalışma kapsamında Konuralp Pirincinin fiziko-kimyasal bileşimi, fito-kimyasal özellikleri, pişirme özellikleri ve biyoaktif bileşenleri (toplam fenolik içerik, $ABTS^{•+}$, CUPRAC, $DPPH^{•}$ ve FRAP yöntemleriyle belirlenen antioksidan aktivite) ile *in-vitro* koşullarda biyoalınabilirliği incelenmiştir. Analizler sonucunda Konuralp Pirincinin nem içeriği %13.89, protein içeriği %6.48, toplam diyet lifi %0.82, enerji değeri 323.44 kcal ve nişasta miktarı %59.64 olarak tespit edilmiştir. Öte yandan örneklerin fitik asit içeriği ise 258.69 mg/100g olarak bulunmuştur. Çalışmada Konuralp Pirincinin toplam fenolik madde içeriği

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2100 mg GAE/100g olarak tespit edilirken, ekstrakte edilebilir (12.73 µmol trolox/g) ve hidrolize edilebilir fenolikler (62.50 µmol trolox/g) için en yüksek antioksidan kapasite DPPH• yönteminde bulunmuştur. Antioksidatif biyoalınabilirlik değerleri ise %80.19 ($ABTS^{•+}$), %27.96 (CUPRAC), %20.63 (DPPH•) ve %0.92 (FRAP) olarak bulunmuştur. Fiziko-kimyasal ve fito-kimyasal özelliklerinin yanı sıra yüksek biyoaktif bileşen içeriğe sahip olan ve geleneksel olarak üretilmeye devam edilen Konuralp Pirincine daha fazla önem verilmelidir.
Anahtar kelimeler: Antioksidan kapasite, biyoalınabilirlik, kimyasal bileşen, pişme özellikleri, pirinç, toplam fenolikler

INTRODUCTION

Contrast to other cereals, rice is an annual cereal and hot climate cereal grown in water (Akay, 2020). Rice is a valuable seed that belongs to the grass family, and 90% of the world population relies on rice to fulfil their daily nutritional requirements (Devraj et al., 2020). While a very small part of the rice is used as a raw material in food production, most of it is consumed as cooked rice. Processed rice products can be produced in various forms including paddy, brown rice, milled rice, rice, broken rice, dry milled flour, wet-milled flour, starch (Falade and Christopher, 2015) as well as rice hull, rice bran and rice bran oil are used as a raw material in food industry (Akay, 2020).

Rice is a unique grain being colorless, having a soft flavor, a low sodium content, being easily digested carbohydrates and exhibiting hypoallergenic effects (Gujral et al., 2003). It is also a good source of thiamine, riboflavin, niacin and dietary fiber (FAOSTAT, 2010). Since rice starch is highly digestible, it can increase blood sugar satiety, which is a health problem related to diet (Mohan et al., 2010). In addition to contributing to human calorie intake, rice also contains phenolic components with proven benefits for human health (Zhou et al., 2003).

Regarding its nutritional value, traditional rice varieties have been reported to contain high levels of antioxidants, phytochemicals, phytonutrients, vitamin E, proteins and other nutrients which are important for the functioning of the immune system and boosting memory power in children. Also, it provides support against serious diseases like cancer due to their rich antioxidant and anthocyanin contents (Devraj et al., 2020).

It is very difficult to describe the quality in rice because the quality preference varies from country to country and even from region to region. The quality characteristics of rice are grouped under three main headings: physical, chemical and cooking properties. These characteristics of rice change under the influence of heredity and the environment. Physical properties, such as whiteness, grinding degree, transparency, grain sizes, foreign matter and chalking, change depending on the environmental conditions, while the chemical properties and cooking properties of rice change mainly depending on their hereditary properties (Rice Quality, 2014).

Since rice is a grain that needs water in its growing phase, the most suitable region within the Ottoman Sanjacks is the subdistrict of Konuralp. Rice agriculture has become widespread in this region and the rice obtained was classified as the Sultan's special. In the 16th century, rice consumption was very high in Ottoman Palace Cuisine (Taş, 2017). This rice variety is still traditionally grown in a small area by the local people. In this study, the aim was to determine the quality characteristics (physical, chemical and cooking) and total phenol, antioxidant capacity and bioavailability values of Konuralp Rice (KR), which is based on the Ottoman Palace Cuisine. In this way, it is aimed to understand the value of KR which has an important place in the past.

MATERIALS AND METHODS

Materials

For the present study, rice sample was obtained from a native farmer who product the rice in Konuralp-Duzce in Türkiye: 40°53′.51″ N and 31°9′.34″E. This rice type called as Kasaba Rice in locally.

Methods

Physical properties

To determine the physical properties, the undamaged rice grains were used in all analyses. Cereal weight is generally represented by 1000-kernel weight (Wu et al., 2018). Thousand kernel weight (TKW) of rice was determined using the method of Singh et al. (2005). For this purpose, milled rice was counted randomly and weighed separately. This procedure was repeated triplicate and mean of three replications was reported. The length (L), width (W) and Length/Width (L/W) ratio were determined using the method of Odenigbo et al. (2014). Accordingly, longitudinal and transverse cumulative (mm) measurements of the rice samples were taken using vernier callipers. The Length/Width (L/W) ratio was calculated by dividing the length over the width of rice grains. In presented study bulk density (BD) of rice were determined based on a protocol described by Fan et al. (1998). Broken rice grains were separated before starting the analysis. To determine the BD, rice grains were poured from a certain height and at a certain speed into a container of known volume. Then the rice grains in the container were weighed. This process was repeated in three repetitions. The bulk (mass) density of the rice samples was calculated in g/mL.

Cooking properties of Konuralp rice

Minimum cooking time was determined by the method as described by Chen et al. (2012) with minor modifications. 2.0 g of whole rice sample was boiled in 20 mL distilled water. During the cooking process, a few rice grains were removed at certain intervals and the cooking level was determined by pressing them between two glass plates. As a result of the compression, it was checked whether there was a white unfired line in the middle. It was determined as the cooking time of the rice grain when the uncooked line (no white core) disappeared. This process was repeated in three repetitions. Solid loss (cooking loss) in cooking water was determined the method as described by Oko et al. (2012) with minor modifications. 2.0 g of whole rice grain was cooked with distilled water in a boiling water bath for the minimum cooking time. The water on the cooked rice grains was removed by draining the rice grains. This cooking water was transferred to the petri dish (W_2), which was previously brought to a constant weighing weight (W_1). This petri dish was dried in an oven at 98 ^oC until it reached a constant weighing weight (W_3). The amount of solid in cooking water was calculated as:

Solid Loss=W_3-W_1

W_1= Weight of empty Petri dish

W_2 = Weight of empty dish + Dry aliquot (***W_3***)

After cooking, the elongation rate in rice grains was determined according to the method specified by Oko et al. (2012). First of all, 2.0 g of whole rice grains were taken randomly. First of all, the size of these rice grains was measured with a calliper (L_0). Later, the rice grains were cooked with 20 mL of distilled water in boiling water for the minimum cooking time and after the cooking process, the excess water was drained and the size of each cooked rice grain was measured using callipers (L_1).

Elongation Ratio=L_1-L_0

The water absorption (WA) ratio of rice grains was determined according to the method describe by Oko et al. (2012). 2.0 g of rice was cooked in 20 mL of distilled water for the minimum cooking time and the rice grains were filtered and the water on the rice was removed. The cooked rice grains were then carefully weighed. The WA ratio of rice grains was calculated as the ratio of cooked weight to uncooked weight.

Chemical compositions of Konuralp rice

Moisture (AACC Method No:44-15A), ash (AACC Method No:08-01.01), protein (AACC Method No:46-12), fat (AACC Method No:30-25.01) values of rice samples were determined by using AACC methods (AACC, 2009). The total carbohydrate (CHO) and energy values of the rice sample were determined according to FAO (2003) and they were calculated using the Atwater general factor system, according to Equations (1) and (2):

$$\text{Total CHO (\%)} = 100 - [\text{Moisture (\%)} + \text{Ash (\%)} + \text{Protein (\%)} + \text{Fat (\%)} + \text{TDF (\%)}] \qquad (1)$$

Energy (kcal) = (9 x Fat %) + (4 x Protein %) + (4 x CHO %) (2)

The macro mineral matters include potassium (K), magnesium (Mg), phosphorus (P), iron (Fe), calcium (Ca) as well as the micro mineral matters include copper (Cu), Zinc (Zn), manganese (Mn) of rice samples were determined by using ICP-AES (2100 XL; Perkin Elmer Optima, San Jose, California, USA) (TSI, 2007; NMKL, 2007). The emission intensities were obtained for the most sensitive lines free of spectral interference. The analyses were performed at the following flow rates: (a) plasma gas of 15 L/min, (b) auxiliary gas of 1 L/min, and (c) sample of 0.8 mL/min. The mineral eluates were monitored at different wavelengths: 766.5nm-K, 285.2nm-Mg, 214.9nm-P, 238.2 nm-Fe, 317.9nm-Ca, 327.4 nm-Cu, 206.2 nm-Zn, and 257.6 nm-Mn.

The phytic acid (PA) content of the rice was evaluated by a colorimetric method according to Haug and Lantzsch (1983). The PA in samples was extracted with a solution of HCl (0.2 N) and precipitated with solution of Fe III (ammonium iron (III) sulphate·12 H_2O). The absorbance was measured at 519 nm and distilled water used as blank.

Bioactive compounds of Konuralp rice

Extraction of phenolic compounds: In the presented study extractable and hydrolyzable phenolics of rice samples were extracted using the method reported by Vitali et al. (2009), with slight modifications. Briefly, 20 mL extraction solution ($HCl_{conc.}$/methanol/water=1/80/10, v/v/v) was mixed with 2.0 g of grounded rice sample and shaken with laboratory rotary shaker (Heidolph Multi Reax-Germany) at 250 rpm for 2 h at room temperature. At the end of the time the extracts were centrifuged at 3500 rpm for 10 min at 20 ^{o}C (Eppendorf Centrifuge 5430R-USA). The obtained supernatant was used as *extractable phenolics*. For hydrolyzable phenolics, after extractable phenolic extraction, the residues which combined with 20 mL of methanol/$H_2SO_{4conc.}$ (10:1, v/v) mixtures was placed in water bath at 85 ^{o}C for 20 h and then cooled at room temperature. The mixtures were centrifuged at 4 ^{o}C for 10 min at 3500*g* in a centrifuge (Sigma 3K 30). The supernatants (*hydrolyzable phenolics*) were stored at -20 ^{o}C (dark condition) until the analyses carried out. Each extraction was carried out in triplicate.

Determination of total phenolic content: Extractable and hydrolyzable phenolics were determined based on the Folin-Ciocalteu colorimetric method as described by Xu et al. (2009) with a minor modification. Total phenolic content (TPC) was calculated as the sum of extractable and hydrolyzable phenolic contents. Absorbance of samples were measured spectrophotometrically at 750 nm and the results were expressed as milligrams gallic acid equivalents (GAE) per gram of rice sample. The determination was carried out three times for each extract.

Antioxidant capacity: Due to the complexity of the composition of plant raw materials and possible reactions between them the antioxidant capacity cannot be evaluated using only one method (Valadez-Carmona et al., 2016). For this reason, in this study; the antioxidant capacity of rice sample was studied using the four distinctive methods.

ABTS$^{\bullet+}$: The estimation of 2,2´-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS$^{\bullet+}$) cation radical decolorization assay was conducted according to the method of Apak et al. (2007). The matured ABTS$^{\bullet+}$ radical solution of blue-green color was diluted with 96% ethanol at a ratio of 1:10. To 1.0 mL of the radical cation solution, 4.0 mL of ethanol were added, and the absorbance at 734 nm (UV-1800 spectrophotometer-Shimadzu, Kyoto, Japan) was read at the end of the sixth minutes. The procedure was repeated for the unknown extract by adding 1.0 mL of the radical cation solution to (x) mL of antioxidant solution and (4.0-x) mL of ethanol, and recording the absorbance readings at the end of sixth minutes. The absorbance difference was found by subtracting the extract absorbance from that of the reagent blank. This was correlated to trolox equivalent antioxidant concentration with the aid of a linear calibration curve.

CUPRAC: The cupric-reducing antioxidant capacity (CUPRAC) was performed according to method of Apak et al. (2004). Added 1.0 mL 1.10^{-2} M $CuCl_2^+$ + 1.0 mL $7.5x10^{-3}$ M neocuproine + 1.0 mL 1 M NH_4Ac + *x* mL 10^{-3} M antioxidant neutral solution + (1-*x*) H_2O:VT = 4.0 mL; measured final absorbance at 450 nm (UV-1800 spectrophotometer-Shimadzu, Kyoto, Japan). Antioxidant activity of phenolic antioxidants was calculated as trolox equivalents antioxidant capacity (TEAC values) in the CUPRAC method.

DPPH•: The 1,1-diphenyl-2-picrylhydrazyl (DPPH•) free radical scavenging assay was performed according to the modified method of Brand-Williams et al. (1995). Antioxidant solution in methanol (0.1 mL) was added to 3.9 mL of a $6x10^{-5}$mol/L methanol DPPH• solution. The extract at various concentrations was added to the reaction mixture, and the decrease in absorbance was measured at 517 nm (UV-1800 spectrophotometer Shimadzu, Kyoto, Japan) against the blank at 0 min, 1 min and every 5 min until the reaction reached a plateau.

FRAP: The ferric reducing antioxidant capacity (FRAP) assay was conducted according to the method as described by Benzie and Strain (1996). For the FRAP estimation, 3.0 mL of freshly prepared FRAP reagent (incubated at 37 ^oC) was mixed with 300 μL of distilled water and 100 μL of the test sample (or extraction solvent for the reagent blank). The test samples and blank were incubated at 37 ^oC for 40 min. At the end of incubation, absorbance was measured immediately at 595 nm (UV-1800 spectrophotometer-Shimadzu, Kyoto, Japan). The FRAP reagent was prepared by mixing 25 mL of 0.3 mol/L acetate buffer (pH 3.6), 2.5 mL of 20 mmol/L $FeCl_3x6H_2O$ and 2.5 mL 10 mmol/L TPTZ solution in 40 mmol/L HCl. Solutions of trolox dissolved in extraction solvent, ranging from 10 to 100 mol/L were used for the preparation of calibration curve. The final result was expressed as equivalent concentration (EC) the concentration (μmol trolox/g sample) of a sample in reaction mixture having the reducing ability equivalent to that of 1.10^{-3} M trolox. It is important to notice that a lower value indicates higher antioxidant activity in this case.

In-vitro bioaccessibilities of phenolics and antioxidants from Konuralp rice: For the determination of bioaccessible phenolics, the *in-vitro* digestion enzymatic extraction method was used that mimics the conditions in the gastrointestinal tract as previously described by Bouayed et al. (2012) with slight modifications. To summaries briefly, 1.0 g of ground rice sample was mixed with 10 mL distilled water and 0.5 mL of pepsin (20 g/L in 0.1 mol/L HCl) and incubated at 37 ^oC in a shaking water bath for 1 h. At the end of the time pH was adjusted to 7.2 and in this way simulation of gastric digestion was stopped. Further intestinal-simulated digestion was performed with the addition of 2.5 ml of bile/pancreatin solution (2.0 g/L of pancreatin and 12 g/L of bile salt in 0.1 mol/L $NaHCO_3$) and 2.5 mL of NaCl/KCl (120 mmol/L NaCl and 5 mmol/L KCl) and incubated in shaking water bath at 37 ^oC for 2.5 h. The sample was centrifuged at 3500 rpm for 10 min and the supernatant (dialysate) was used for determination of bioaccessible phenolics which were stored -18 ^oC until the analyses carried out. The TPC analysis was performed in the dialysate obtained as a result of simulated gastrointestinal digestion. Thus, in the dialysate sample obtained from in vitro digestion, the TPC content recovered was calculated and represented the bioaccessible phenolics. The percentage of bioaccessibility was also calculated by the ratio of bioaccessible phenolics to the TPC in the rice sample prior to digestion (Anson et al., 2009).

Bioaccessible antioxidant capacity of dialysate sample obtained as a result of simulated gastrointestinal digestion was analyzed by ABTS•+, CUPRAC (Apak et al., 2007), DPPH• (Brand-Williams et al., 1995) and FRAP assays (Benzie and Strain, 1996). The results were given as mg GAE/g for phenolic content, µmole TE/g for antioxidant capacity. Thus, the antioxidant capacity recovered in dialysate sample obtained from *in-vitro* digestion was calculated and represented the bioaccessible antioxidant capacity (Anson et al., 2009).

RESULTS AND DISCUSSIONS

Physical properties of Konuralp rice

The physical properties of the local rice samples used in the study are given in Table 1. TKW is considered as a quality characteristic of grains which is an important factor for the estimation of cereal yield, is influenced by genetic factors (Taser, 2011) as well as climatic conditions. Heredity and ecological factors are two important factors affecting TKW. In present study, as a result of the measurements, the average TKW of rice was found to be 27.4±0.08 g. Yazman (2014) determined the average amount of TKW of Baldo and Osmancık rice to be 24.85 g and 20.61 g, respectively. In the present study, TKW (27.40 g) of the rice samples was found to be higher than these values. The reason for this is that the variety investigated in the present study was a larger size than the varieties in the other studies.

Table 1. Physical properties of Konuralp rice

	Rice (*Oryza sativa* L.)
TKW (g)	27.40±0.08
L (mm)	0.30±0.01
W (mm)	0.66±0.02
L/W	2.19±0.11
BD (g/mL)	0.86±0.22

** Results are given as the average of 10 repetitions.*
TKW: Thousand Kernel Weight, L: Length, W: Width, L/W:Length/Width, BD: Bulk Density

In the present study, the length, width and L/W ratios of rice variety was determined as 0.30±0.01 mm, 0.66±0.02 mm and 2.19±0.11, respectively (Table 1). The rice variety investigated in the present study is classified as C type long grain rice, whose length 6.0≤ - ≤6.7 and L/W ratio is 2≤ - ≤3 in the TFC (2010). The L/W ratio is used to evaluate the shape of rice (Yazman et al., 2020a). While short and coarse grains are normal, long and fine grains are more fragile, so grain size and shape (L/W) are considered to be a quality feature (Taser, 2011).

In the study by Singh et al. (2005), it was reported that for 23 kinds of rice, the BD varied from a maximum of 0.88 g/mL to a minimum of 0.77 g/mL. When the BD (0.86 g/mL demonstrated in Table 1) of the rice sample investigated in this current study was compared with their study, the results were found to be similar. All in all, some of the differences in physico-chemical properties could be related to the rice samples' unique distinctive property and region differences. The variation in length, width, and L/W ratio might be due to the difference in size, shape, and moisture content that vary from one variety to another (Devraj, 2020).

Cooking properties of Konuralp rice

Commonly rice is consumed immediately after cooking with this inview its cooking properties are important. When viewed from this aspect, the consumers prefer the cooking time of the rice is short. The cooking time of the rice grain is generally determined by the loss of the opaque center in 90% of the starch in the grain (Dipti et al., 2003). In the present study, the optimum cooking time in rice sample was determined to between 15 and 20 minutes. In a similar study, Koca and Anıl (1997) reported that the optimum cooking time in rice samples varied between 19 and 24.5 minutes. The minimum cooking times of Osmancık and Baldo varieties of rice, which are preferred more by the consumers in Turkey, were reported as 16.81 and 16.11 min, respectively. In another study, Koca and Anıl (2001) reported that, there is an important and positive relationship between the quantity of protein and the cooking time. The rice water absorption ratio (WA), elongation ratio and solid loss in KR were depicted in Fig. 1.

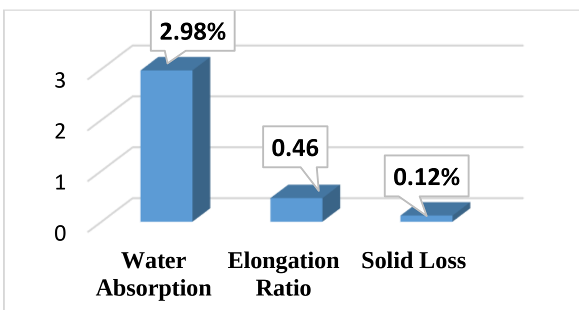

Figure 1. Cooking properties of Konuralp rice

High WA rate is an important quality criterion in terms of cooking properties. Water absorption, water holding capacity, water binding or rehydration ability can be used to explain the same criteria. The amount of WA of KR was found to be 2.98 % (Fig. 1). The average WA rate of Baldo and Osmancık rice samples was found to be 1.89 (Yazman, 2014). This variation in WA might be depend on loss of starch crystalline structure in rice samples.

In the present study the rice elongation ratio was found to be 0.46±0.05. In a study reported by Akay (2020), the elongation ratio was found to be 1.77 and 1.99 % in Baldo and Osmancık rice varieties, respectively. The outer layer which include pigments and nutrient components that supports the volume spread rather than the grain elongation can cause the decrease in elongation ratio (Devraj et al., 2020).

Solid loss in rice with cooking is an important indicator of the cooking quality of rice and indicates the amount of solid material passed to the cooking water. From Fig 1, it was observed that the solid loss 0.12% in KR sample. In study which determined the solid loss ratio for Osmancık and Baldo rice types, the values were found to be 3.90-5.16% (Yazman et al. 2020a) and 3.92-4.81% (Yazman et al. 2020b), respectively. The lower solid loss ratio can be also indicates the higher WA ratio.

Chemical properties of Konuralp rice

The chemical composition of KR was analyzed and presented in Table 2. The moisture content of KR was found to be 13.89%. The moisture content of rice is affected by many factors, such as growing conditions, storage conditions and storage time, as well as being affected by whether the product is sold packaged or unwrapped (Yazman, 2014) as well as different harvesting seasons. It has been stated in a Turkish Food Codex Rice Communique (TFC, 2010) that the moisture content of rice can be at most 14.5%. As a result of the analysis, it was determined that the moisture content of the rice investigated in current study was within the legal limits.

The ash content in food samples plays an important role in determining the level of essential minerals (Devraj, 2020). From the Table 2, it was observed that the ash content of 0.43% was similar to the amount of ash found in Osmancık rice (0.42%) and Baldo rice (0.41%) in the study conducted by Yazman (2014). It is thought that the small differences observed are due to the low or high bran amount, depending on the different degrees of peeling of the paddy sample while being processed into rice (Yazman et al., 2020a).

Table 2. Chemical composition of Konuralp rice

Chemical Composition	Rice (*Oryza sativa* L.)
Moisture (%)	13.89±0.10
Ash (%)	0.43±0.30
Protein* (%)	7.48±0.34
Fat (%)	0.50±0.14
Total Dietary Fiber (%)	0.82±0.02
Starch (g/100g)	59.64±2.24
Phytic acid (mg/100g)	252.69±3.72
Carbohydrate (%)	74.76±0.42
Energy (kcal)	323.44±0.28

**Calculated on dry matter (Nx5.70)*
**The results are given as the average of 3 repetitions.*

In current study the protein content of KR was determined to be 7.48% (Table 2). This result was similar to the findings of Yazman (2014) who determined the protein content of rice 7.98% and 7.55 %, respectively in Baldo and Osmancık varieties. Contrast to that results, Donduran (2014) reported that the crude protein ratios of paddy varieties varied between 5.64 and 8.86 %. So, it should be taken into account that the protein content may differ depending on the variety and environmental conditions.

The fat content of the KR sample was found to be 0.50% in the present study. Also, Altindag et al. (2015) determined that the fat content of rice 0.69%. The low-fat ratios detected in these studies, may be relevant with the grinding step.

The carbohydrate content of KR was found to be 74.76 % (Table 2). Kraithong et al. (2019) worked with four different rice varieties: Organic White, Brown Yasmin, Colored and Red Yasmin and determined the carbohydrate values of these rice varieties to be 85.58%, 78.19%, 77.06% and 78.07%, respectively. In another study, Reddy et al. (2017) compared the carbohydrate content of raw and polished rice. They determined the carbohydrate content of the rice to be 74.67% and 82.13%, respectively which shows similarity to this present study. In the present study, the energy value of the KR sample was calculated to be 323.44 kcal (Table 2). A similar result was found by Verma and Srivastav (2017), who calculated the amount of the energy 348.79 kcal/g in an aromatic rice variety.

Elbashir (2005) found the fiber contents of rice samples obtained from America, Pakistan, Thailand, Egypt and Sudan to be 0.48%, 0.22%, 0.35%, 0.32% and 0.30%, respectively. As previously mentioned, the Kraithong et al. (2019) study looked at four different types of rice flour: Organic White, Brown Yasmin, Colored, and Red Yasmin varieties. The researchers reported that the crude fiber amounts in the rice samples were determined to be 0.81%, 0.91%, 1.66% and 1.35%, respectively. Accordingly, the dietary fiber content (0.82%) in the present study (Table 2) was found to be similar to the fiber content of organic white rice.

The starch content of KR was found to be 59.64 % (Table 2). Elbashir (2005) reported that the starch contents of rice samples supplied from America, Pakistan, Thailand, Egypt and Sudan were 64.22%, 64.27%, 63.16%, 63.57% and 59.82%. The amount of starch in the rice supplied from Sudan (59.82%) was similar to the starch content (59.64%) of the KR in the present study.

The phytic acid is an important anti-nutritional component present in cereals and considered as a significant inhibitor of mineral absorption (Bilgicli, 2002). In the present study the phytic acid content of the KR was found to be 258.69 mg/100g. The phytic acid content of KR was similar with the results reported by Vunain et al. (2020) who determined the phytic acid content between 200.25- 204. 92 mg/100g.

Mineral constituents in Konuralp rice

The mineral constituents of the rice sample are displayed in Table 3. The macro minerals were found to be K (1524 ± 59 mg/kg), P (1042 ± 57 mg/kg), Ca (441 ± 3 mg/kg) and Mg (234 ± 1 mg/kg) in KR. The micro minerals; Zn (19.2 ± 0.9 mg/kg), Fe (13.8 ± 0.6 mg/kg), Mn (4.41 ± 0.01 mg/kg) and Cu (2.24 ± 0.01 mg/kg) were found.

Table 3. Mineral constituents of Konuralp rice

Macro Mineral (mg/kg)	K	P	Ca	Mg
	1524±59	1042±57	441±3	234±1
Micro Mineral (mg/kg)	Zn	Fe	Mn	Cu
	19.20±0.09	13.80±0.6	4.41±0.01	2.24±0.01

** Results are given as the average of 3 repetitions.*

In a study conducted by Reddy et al. (2017), K (1606.6 and 566.1 mg/kg), P (2062.1 and 718.5 mg/kg), Ca (136.2 and 53.6 mg/kg), Mg (377.2 and 106.6 mg/kg), Zn (53.9 and 24.6 mg/kg), Fe (88.8 and 26.2 mg/kg), Mn (38.8 and 20.1 mg/kg) and Cu (33.4 and 26.2 mg/kg) were detected in raw and polished rice, respectively. According to the obtained results, it was determined that the amount of some mineral materials was lower than the literature. It is thought that the reason for this is due to the different peeling processes applied during the processing of rice. In terms of mineral substance composition, it has been reported that mainly P, Mg and Ca minerals are found in rice (Rivero-Huguet et al., 2006). According to the Food and Drug Administration (FDA), the daily intake of macro minerals should be 4700, 1250, 1300 and 420 mg for K, P, Ca and Mg, respectively. This amount should be 11, 18, 2.3 and 0.9 mg for the microelements Zn, Fe, Mn and Cu respectively (FDA, 2019). Considering these amounts, it is seen that the rice used in the present study provides an important part of the daily macro and microelement needs (Table 3).

Phenolic contents and their *in-vitro* bioaccessibility

Phenolic compounds present in rice have important antioxidant activity, which has subscribed to its potential as a functional food (Rao et al., 2020). The phenolic contents and phenolic bioaccessibility values were analyzed and presented in Table 4. According to the results, the extractable phenolics, hydrolyzable phenolics and TPC were found to be 92.26, 2008.327 and 2100 mg GAE/100g, respectively.

Table 4. Total phenolics and bioavailability of Konuralp rice

	Rice (*Oryza sativa* L.)
Extractable Phenolics*	92.26±3.66
Hdyrolyzable Phenolics*	2008.33±1.17
Total Phenolics*	2100±1.13
Bioavailable Phenolics*	296.05±3.89
Bioavailability (%)	14.09±2.92

**mg GAE/100g*

** Results are given as the average of 3 repetitions.*

Adom and Liu (2002) reported that the major portion of phenolics in rice grains (62 %) existed in hydrolyzable form. In this context, results of presented study showed that the level of hydrolyzable phenolics was higher than that of extractable phenolics. Yılmaz (2019) reported that, the total phenolic content of Osmancık rice (334.54 μg GAE/g) had higher than that of the Baldo rice (301.16 μg GAE/g). Studies have shown that 70 to 90% of the phenolic substances are separated with the bran layer during the processing of the paddy crop into rice. Moreover, it was reported that the amount of phenolic substances was lower in the light-colored pericarp varieties and the amount of phenolic substance can be affected by many factors, such as the type of paddy, laboratory conditions and sample preparation conditions (Zhou et al., 2003). The bioaccessibility of the phenolic content was observed that 14.10% (Table 4). The processing and storage of food affects the flavonoid and phenolic acid content in the foodstuff.

Antioxidant capacities and *in-vitro* bioaccessibility of antioxidants

Antioxidant substances found in foods are defined as "substances that are in lower concentrations than oxidizable substrates and prevent or delay the oxidation of substrates" (Becker et al., 2004). Four different methods ($ABTS^{•+}$, CUPRAC, $DPPH^{•}$ and FRAP) were used to determine the antioxidant capacity of rice samples in the present study.

As reported by Devraj et al. (2020), traditional rice varieties are rich in antioxidant properties. In the rice sample, the antioxidant capacity ($ABTS^{•+}$) of extractable phenolic compounds in terms of Trolox Equavalent (TE) was 17.23 ± 0.61 μmol trolox/g (Fig. 2). The $ABTS^{•+}$ value of hydrolyzable phenolics was found to be 36.33 ± 2.40 μmol trolox/g. Consequently, the $ABTS^{•+}$ antioxidant capacity of hydrolyzable phenols was approximately double the $ABTS^{•+}$ values for extractable phenols.

According to the results of the CUPRAC method, the antioxidant capacity value of the extractable and hydrolyzable phenols were 3.01 ± 0.10 and 4.39 ± 1.39 μmol trolox/g, respectively (Fig. 2).

In the rice sample, the $DPPH^{•}$ antioxidant capacity of extractable phenolics was found to be 12.73 ± 0.31 μmol trolox/g (Fig. 2), while that of hydrolyzable phenols was found to be 62.50 ± 0.39 μmol trolox/g. According to these results, the $DPPH^{•}$ antioxidant capacity of hydrolyzable phenols was found to be approximately 5 times higher than that of extractable phenols. Donduran (2014) reported that the total amount of $DPPH^{•}$ of the Edirne paddy variety with high antioxidant capacity was 424.20 EC/IC50 (dw).

In some previous studies, antioxidant capacity results differed between rice varieties. It should be kept in mind that this difference may vary depending on a range of factors such as the rice variety, the harvesting period, the cultivated soil type, germination, the grain processing-polishing methods as well as the laboratory preparation time and storage time (Zhou et al., 2003).

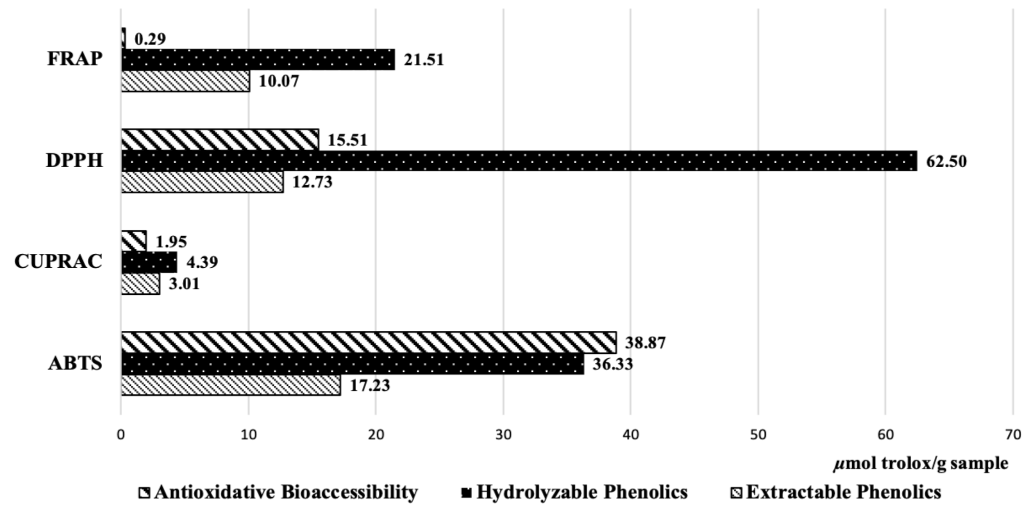

Figure 2. Extractable, hydrolyzable antioxidant capacities and antioxidative bioaccessibility of Konuralp Rice

In presented study, the FRAP antioxidant capacity of the extractable phenolic compounds was found to be 10.07± 0.41 µmol trolox/g, while that of the hydrolyzable phenols was found to be 21.51± 0.32 µmol trolox/g (Fig. 2). The FRAP antioxidant capacity of hydrolyzable phenolics were found to be about double that of extractable phenolics (Fig. 2). Similarly, in previous *in vitro* studies, hydrolyzable phenolics were found to have significantly higher antioxidant capacity than extractable phenolics (Chandrasekara and Shahidi, 2011).

CONCLUSIONS

As a result of the literature reviews, it was determined that there was no study on the physico-chemical composition, nutritional properties and cooking properties (characteristics) of *Oryza sativa* L. type rice based on the Ottoman Palace Cuisine and traditionally grown in the Konuralp-Duzce area, and therefore this study was created to do that. It has been determined that the traditionally grown rice sample has values that can compete with Osmancık and Baldo varieties of rice, which are the most preferred in Turkey, in terms of physico-chemical, phyto-chemical and cooking properties. In this sense, the TKW of the rice samples was found to be higher than Baldo and Osmancık rices. Moreover, the results obtained from the current study, that the rice used in the present study provides an important part of the daily macro and microelement needs. Besides, the results of the present study can be strong scientific proof to use this traditional rice variety as a beneficial source of antioxidant referments. This rice, which is on the verge of being forgotten and produced by the farmers only to meet their own needs, has been remembered again for the last decade thanks to the initiatives of the local government. As a result, scientific data were obtained about Konuralp Rice, which is traditionally grown in this region and whose chemical, nutritional and *in-vitro* bioaccessibility of antioxidative properties have not been determined until now. It is thought that the data obtained will be beneficial for producers, consumers and the sector.

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CONFLICT OF INTEREST

The author declares that there was no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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