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Differential Protein constituents and physicochemical characteristics of some rice varieties in Sindh Pakistan

I. T. ANSARI++ M. A. SAHITO, N. T. NAREJO*, I. SUHERYANI** J. H.UMRANI***
Z. A. ANSARI, M. H. CHANDIO****

Institute of Biochemistry, University of Sindh, Jamshoro, Sindh, Pakistan

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Abstract: In recent years many new rice cultivars have been introduced in the market in terms of greater yield, increased resistance to diseases and insects, greater tolerance of climate and soil conditions. Despite all these characteristics, the nutritional needs of the common man are being neglected. While the better protein and amylose/amylopectin content of rice can have a significant positive impact on public health. **Materials and Methods:** To find out the better rice variety in term of nutritional and cooking quality fourteen rice varieties, procured from Nuclear Institute of Agriculture (NIA) Tandojam, Sindh, Pakistan were analyzed for the morphological & physicochemical properties. 1000 grains weight, Length, Breadth, Elliptic factor was determined for grain types and the proximal chemical analysis such as total protein, amylose-amylopectin ratio and content of different protein fractions were obtained. **Results:** Non-Basmati rice cultivars were significantly different ($p<0.05$) from Basmati rice cultivars in physical dimensions grain length and breadth. In both Basmati and Non -Basmati rice varieties weight of 1000 seeds / g is positively correlated to breadth and negatively correlated to elliptic factor while, breadth was negatively correlated to elliptic factor in all varieties. 1000 grain weight of Non- Basmati (18.7-21.9) over Basmati (14.0-21.8) determines the quality characteristics and density of rice cultivar. The highest amylose/ amylopectin ratio was observed in Shadab while the lowest was in Mahak rice variety. The highest protein value was found in an aromatic Basmati rice variety jajai-77 (9.7% ± 0.01) & the lowest (6.86% ± 0.02) in Non-Basmati variety IR-8. **Conclusion:** The study reveals that rice varieties under study showed a significant difference from medium to long grain size as well as in their protein and amylose content. High protein and Low amylose content gives desirable feature to Basmati rice due to soft texture on cooling for longer time period, which is definitely preferred over Non- Basmati rice varieties with high amylose content.

Keywords: Rice cultivars, Morphometric, Quantification, Amylose, Protein.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the oldest cereal crop species in the world which is throughout human history has fed more people than any other food, mainly consumed by developing countries and nations in Asia. (Priya *et al.*, 2019).The first cultivation of rice was occurred around ten thousand years ago. Breeders and farmers have developed the desired characteristics of the crop since that time. Focusing on the increased rice yield was potentially appeared in the beginning of 1920s. (Kushwah *et al.*, 2015). Rice cultivars are significantly differed in their cooking, chemical and morphological properties. Many rice varieties have been subjected to mutagenesis, to improve physical and nutritional quality. A strong aroma, palatability, appearance, digestibility, expansion, and greater shelf life, of rice make it better among other rice varieties.

These elements would be potently depended on the morphological structure of the kernel and content of proteins & starch as well. (Pokhrel *et al.,* 2020).

Starch is a polysaccharide present in carbohydrates and is composed of two component amylopectin and Amylose. Rice Amylose content influences user orientation, and has achieved a great importance. Rice amylose is influenced by the difference in rice varieties including other nutrient. Low Amylose concentration of cooked rice results in soft and sticky appearance, while higher values make them less bendable. (Cameron and Wang, 2005). Most of the people of Middle East favour flaky dry rice, while the people in North China, Korea, Egypt, Japan, and Taiwan preferred sticky damp rice. (Boers *et al.*,2015).The rice varieties which expand after cooking are believed as good quality. Mostly middle

++Corresponding Author: Dr. Ibtessam Tahir Ansari Email: Ibtessam@usindh.edu.pk
*Department of Fresh Water Biology, University of Sindh, Jamshoro, Pakistan.
**Department of Pharmaceutics, Faculty of Pharmacy, University of Sindh, Jamshoro, Pakistan
***Department of Food Science and Technology, Faculty of Engineering Science and Technology, Hamdard University, Karachi.
****Director of Fisheries (Inland) Government Of Sindh, Thandisrak Hyderabad, Sindh, Pakistan

class and lower class don't observe the expansion in lengthwise or breath wise while upper class and urban people give the preference to those rice varieties which expand in lengthwise. (Ehiakpor *et al.*, 2017).

It is well known that rice with high amylose content has a lower Glycemic Index number and is more resistant to digestion. (Hu, *et al.*, 2004; Jain *et al.*, 2012). Glycemic index (GI) is related to quick effect of different foods that can be responsible to raise blood sugar level, even equated to white bread (at the index of 100) or glucose. Food with high (GI) value has a quick effect on raised blood sugar, while blood sugar with low glycemic index (GI) foods rises bit by bit. In addition to determining predilections of consuming rice, the rice glycemic index (GI) has been indicated to be influenced by the amylose concentration, and has a significant impact on human health problems. **(**Zhu *et al.*, 2012; Boers *et al.*, 2015; Zenel and Stewart, 2015; Ohtsubo *et al.*, 2016). Amylose and Amylopectin ratio can predict the glycemic index of rice. Rice with high Amylose and Amylopectin ratio is a low glycemic food which can be consumed by diabetics. Dipnaik and Kokare, 2017).

Cereal are characterized on the bases of protein content and availability of amino acids , rice protein is highly digestible &more nutrient with excellent biological value than any other cereal due to the higher concentration (~ 4 %) of lysine. (Oko *et al.* 2012b)Brown rice is better in ranks as compared to wheat in digestible energy, usage of net proteins and functional carbohydrates and rice protein also contains a rich part of lysine than sorghum, corn& wheat. (Carmencita and Carandang, 2006)Rice comprises 2, 14 & 21% fat, protein, and global energy supply, respectively. Protein content ranged from 10.2–15.9% with average of 13.6% protein content in Oryza glaberrima varieties and 4.5%-15.9% in Oryza sativa Asian rice variety. The Chinese fragrant varieties contain highest content of protein with long grain rice and showed greater value (1.7 times) than the average content of protein. While Japanese rice variety have lowest proteins(Kennedy and Burlingame, 2003).

Rice proteins are considered beneficial for human health due to its colorless appearance, rich essential amino acids composition with hypo-allergenic, and hypo-cholesterolemic properties. (Kim *et al.*, 2013a).On the basis of solubility rice proteins are divided into four classes as 4 to 10 percent albumins& globulins, 5 to 10 percent prolamin, and 80 to 90 percent glutelin, soluble in water, salt, aqueous alcohol solutions and in dilute acid or alkali respectively. Gluten accounts 80% of all rice proteins and is a larger part among all four classes of proteins. (Cagampand *et al.*, 1966; Takaiwa *et al.*, 1991).Rice varieties, Sonahri-Sugdasi, Sugdasi-Sadagu lab, Sugdasi-Ratria and Khushboo-95, bearing comparatively higher glutelin content in local varieties cultivated in Sindh.(Nadar, *et al.*, 2010).

2. MATERIALS AND METHODS

A total of fourteen rice cultivars were procured from Nuclear Institute of Agriculture(NIA) Tandojam for the analysis of physicochemical characteristics of better quality rice grains. All reagents of analytical grade were used in this study.

Physical analysis:

Manual method: The morphometric characteristics including grain length, Breadth, and elliptic factor, were measured.The rice grain was gripped vertically and horizontally between the jaws ofdigital electronic vernier calliper 0-150Mm/0-6 for the determination of length and breadth respectively and scale reading was noted. Hundred grains of the each cultivar were counted and weighed through a digital weighing balance.

Microscopic method: Stereoscopic microscope (Nikon, model SMZ1500, Japan) was used to capture pictures of 100 grains and subsequently edited with Corel Photo Paint program (Corel Draw Corporation, USA) VII.5. Thereafter it was digitally analyzed with Sigma Scan Pro program (SPSS Inc) V5.0.

Preparation of flour sample: Rice husk was separated by JLGJ4.5 Rice Huller (Shijiazhuang Sanli grain sorting machinery Co., Ltd), grinded in fine flour and then pass through 100 sieve mash

Distribution of particle size: Laser particle size distribution analyzer BT-9300H (Dandong Baxter Instrument Co., Ltd.) was used for fine grinded particle size measurement

Chemical Analysis:

Moisture, lipid, ash and protein were determined by the method AOAC (1990)

Isolation of Starch: Isolation of starch from rice samples was carried out by the method of Wani, *et al.*, 2010. 500 grams of the rice flour sample was soaked in two liter milli-Q distilled water and kept in a refrigerator at 4ºC for overnight. Homogenized in a mixer blender for five minutes 0.5 M NaOH was used to adjust pH up to 10 after ten time's dilution of the obtained slurry (V/V) and placed in sonicator for one hour. Then it was filtered with a fourfold muslin cloth and centrifuged at 4000 rpm for 30 min at 4ºC. The supernatant was removed along with brown surface layer and the sediment of white starch was washed with distilled water and centrifuged for several times. The sediment recovered as starch was dried at 45°C in a hot air oven. It was then passed through a 100-mesh sieve.

Defatting of starch sample: To minimize the lipid content of starch the samples were defatted by adding a mixture of 14 volumes methanol /ethyl ether (1:1, v/v) in it. Mixed well and allowed to stand at room temperature for 1 hour. The slurries were centrifuged at 4000rpm for 10 min at 4ºCby repeating the procedure three times to maximize the removal of lipid content (Ibáñez, *et al.*, 2007).

Determination of Amylose content: Iodine colorimetric method was used to determine amylose content as described by Juliano, 1971, while the content of amylopectin was estimated by the difference method. (Oko *et al.*, 2012a) Amylose % content was classified as low (12–20%), intermediate (20–25%), and high (25–33%) according to the suggested classification by Juliano, 1992

Extraction of the different protein fraction from rice flour: Husk was separated and grains were milled to get finerice flour. The total protein was extracted for quantification by suspending 500mg of rice flourin 1000µL of different extraction buffers overnight and mixed on an orbital shaker at 200 rpm (25˚C) for 30 minutes. The extract was then clarified at 14000 rpm (4°C) for 20 minutes. The clear supernatants obtained were used for quantification of total proteins, water soluble albumin, salt soluble globulin and alcohol soluble protein glutelin. Water soluble protein was extracted in water; salt soluble proteins were extracted in PBS while gluten was extracted in Tris-isopropanol buffer. (Tada *et al.*, 1996) Supernatant was stored at-40°C for further analysis.

Quantification of Protein:

Total protein: Total protein of moisture free rice flour sample was quantified through kjeldhal method (N=6.25) using FOSS Analytical Kjeltec™ 2300 Analyzer Unit. Different proteins fractions (albumin, globulin, prolamin and glutelin) for each rice cultivar were extracted according to the method described by Tada *et al.*, 1996 and protein content was determined in the sample extract through Bradford assay (Bradford, 1976) from the standard curve of bovine serum albumin (sigma) having linearity range with $r = 0.99$ as standard. All analysis was done in five replicates.

Statistical Analysis: All experiments were performed at least in triplicate. Data were analyzed by one-way analysis of variance (single factor) ANOVA for significant T-test ($P < 0.05$). The means were separated by the least significant difference (LSD) at 5% probability level using SAS 8.1 software. (SAS Institute Inc., NC. USA) and the coefficient of variance (CV %) was calculated as reported by Shouket *et al.*, (2007). Interrelationships among physical parameters were estimated using the Pearson correlation coefficient**(r)**.

Table 1. Physical dimension of different rice cultivars in Sindh Pakistan

Rice cultivars	weight of 1000 seeds (g)	Length (mm)	Breadth(mm)	Elliptic factor (mm)	Grain Type	Amylose classification
Non – Basmati						
IR-6	21.1 ± 0.03^{d}	6.95 ± 0.03^{h}	1.9 ± 0.1^{i}	3.65 ± 1.27^{e}	Medium	High
Shadab	18.7 ± 0.06^{i}	7.5 ± 0.05^{e}	1.8 ± 0.03^{j}	4.16 ± 0.09^{c}	Long	High
Shandar	20.8 ± 0.05^{e}	7.5 ± 0.02^{e}	2.2 ± 0.01^{e}	3.4 ± 0.02^{h}	Long	High
IR-8	23.9 ± 0.13^{a}	6.5 ± 0.05^{i}	2.5 ± 0.03^{a}	2.6 ± 0.04^{m}	Medium	High
Shua-92	20.1 ± 0.2^{g}	7.3 ± 0.18^{g}	2.1 ± 0.06^{f}	3.47 ± 0.02^{g}	Medium	High
Sarshar	21.9 ± 0.31^{b}	8 ± 0.06^{a}	2.5 ± 0.05^{a}	3.2 ± 0.05^{j}	Long	High
Basmati						
Jajai-77	17.7 ± 0.09^{j}	7.5 ± 0.04^{e}	2.5 ± 0.02^{a}	3 ± 0.03^{l}	Long	Low
Khushboo-95	17.3 ± 0.1^{k}	7.5 ± 0.02^{e}	2.26 ± 0.01^{c}	3.31 ± 0.01^{i}	Long	Low
Basmati 15-14	16.3 ± 0.1^{l}	8 ± 0.05^{a}	1.8 ± 0.01^{j}	4.44 ± 0.05^{a}	Long	Intermediate
Super Basmati	14.0 ± 0.05^{n}	7.5 ± 0.01^{e}	1.72 ± 0.01^{k}	4.33 ± 0.02^{b}	Long	Intermediate
Mehak	15.8 ± 0.07^{m}	7.83 ± 0.01^{b}	1.93 ± 0.01^{h}	4 ± 0.02^{d}	Long	Low
Sadagulab	19.6 ± 0.11^{h}	7.33 ± 0.1^{f}	2 ± 0.06^{g}	3.6 ± 0.1^{f}	Long	Intermediate
sugdasi –Ratria	21.8 ± 0.3^{c}	7.6 ± 0.03^{d}	2.23 ± 0.02^{d}	3.4 ± 0.02^{h}	Long	Intermediate
Sonehri sugdasi	20.2 ± 0.09^{f}	7.67 ± 0.01^{c}	2.4 ± 0.01^{b}	3.19 ± 0.01^{k}	Long	Intermediate

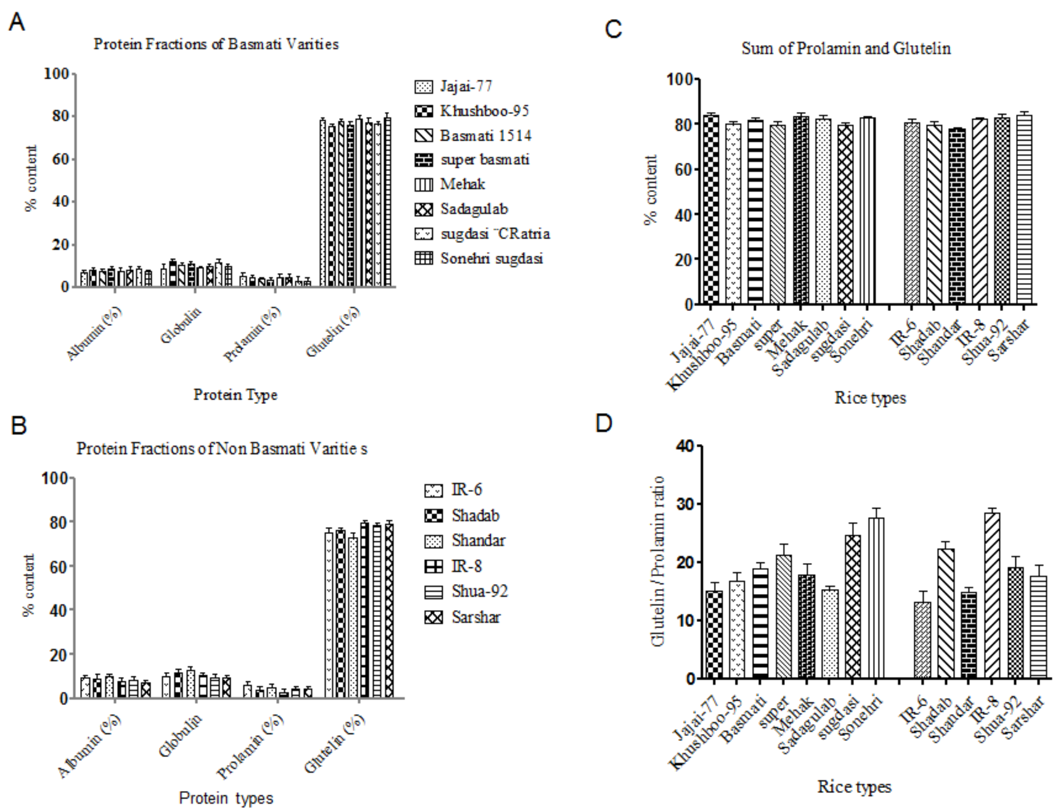
Superscript letters mean ($p<0.05$)
Means with the same letter are not significantly different

The results of physical parameters of different Non-Basmati rice varieties given in **(Table 1)** reveals that the highest grain length (8mm) was found in Sarshar which is a mutant variety of IR-8 with lowest (6.5mm) grain length. Other parameters for Non-Basmati rice varieties like grain breadth, Elliptic factor, and 1000-grain weight ranges between 1.8-2.5mm (mean 2.16mm), 2. 6-4.16 (mean 3.4),and18.7-23.9gram (mean 21g) respectively. Physical dimensions of different Basmati rice varieties, indicated that the grain length, breadth, Elliptic factor, and 1000-grain weight ranges between 7.33-8mm (mean 7.6mm), 1.72-2.5mm (2.1 mm), 3-4.4(3.6), and 14-21.8g (mean 18g) respectively.

Table 2 Pearson correlation coefficient (r) among physical characteristics of Basmati and Non- Basmati rice cultivars

	weight of 1000 seeds(g)	Length(mm)	breadth (mm)	Elliptic factor(mm)
			+	
weight of 1000 seeds/g		-0.49	0.83*	-0.95**
Length(mm)	-0.28		0.008 NS	0.42 NS
Breadth (mm)	0.62*	-0.3		-0.9**
Elliptic factor(mm)	-0.67*	0.5	-0.96**	
		++		

+ Non- Basmati, ++ Basmati
*correlated, **strongly correlated.



In both Basmati and Non-Basmati rice varieties weight of 1000 seeds / g is positively correlated to breadth and negatively correlated to Elliptic factor. While breadth is negatively correlated to Elliptic factorin all varieties **(Table 2)**

(Table 3) Proximate mean composition of rice cultivars in Sindh Pakistan Total amylose (Table 3) and protein content in 14 rice cultivars ranges from 26.2 %-30.7% & 6.86-9.67% respectively for Non -Basmati and 20.17% -24.4 % & 8.49-9.97% respectively for Basmatirice varieties.

Fig. 1. Protein constituent, g/100 g dried crude protein in different rice cultivars in Sindh Pakistan (n=5)

Different protein fractions of Basmati and Non-Basmati rice varieties such as albumin, globulin, prolamin and glutelin extracted in different buffers and quantified through standard method **(Fig. 1)**. It was observed that the percentage of albumin ranges from 6.9-9.6% (mean 8.5%), globulin 8-12.4% (mean 10.3%), Prolamin 2.8-5.7% (mean 4.3%) and glutelin 73.1-79.6% (mean 77.04%) for Non- Basmati rice varieties where as in Basmati rice varieties it varies from 7.2-9% (mean 7.94%) albumin, 9-12.1% (mean 10.4%) globulin, 2.9-5.2% (mean 4.1%) Prolamin, and 75.4- 79.8% (mean 77.6%) glutelin.

Physical parameters of rice like higher expansion volume, length, breadth, aroma of cooked rice determine the quality of rice and preferred by the people. (Custodio *et al.*, 2019). The Elliptic factor of length and breadth of grain is an important facet to define the morphology of the cultivar (Normita and Cruz, 2002) while weight of the grain provide the information regarding the density and size of the seed. Cooking quality is effected by the density of different rice grains so weight of the grain should also be uniform to determine the quality. Grain weight ranges from 14.01 to 23.9 g /1000 grains of rice varieties under study can be considered their good quality characteristics. Similar results of 1000 grains weight (11.4- 20.2g) were reported by Meena *et al*., (2010). High amylose content of grain is positively associated with the hardness of cooked rice. These will be less sticky on cooking and hardened quickly after cooling due to less amylopectin content. (Kim *et al.*, 2013a). In current studies the concentration of % amylose content of Non- Basmati (mean 26.2-30.7) and Basmati (20.17-24.4) with coefficient of variation (CV %, 5.82 & 7.3) showed a significant differences (p <0.05) which can be attributed to the genotype of the rice varieties. In addition, a high value of amylase / amylopectin ratio indicates low glycemic index and due to high ratio value, Non-basmati can be considered a low glycemic diet for diabetics.

Rice cultivars		moisture %	Ash %	Protein % (dry basis)	Starch		Amylose/ Amylopectin Ratio
					Amylose %	Amylopectin %	
Basmati	Jajai-77	9.560 ±0.63^{j}	1.06 ±0.11^{m}	9.7 ± 0.09^{b}	20.92 ± 0.26^{l}	79.08± 0.26^{c}	0.26
	Khushboo-95	9.341 ±0.48^{l}	1.65±0.22^{e}	9.97± 0.1^{a}	20.8± 0.18^{m}	79.2± 0.18^{b}	0.26
	Basmati 1514	9.817 ±0.51^{f}	1.42±0.42^{j}	9.2 ± 0.06^{h}	23.22± 0.7^{i}	76.78±0.7^{f}	0.30
	super Basmati	9.695 ±0.61^{h}	1.63 ±0.19^{f}	9.66 ± 0.1^{d}	24.4±0.23^{g}	75.6±0.23^{h}	0.32
	Mehak	10.191 ±0.9^{c}	1.39 ±0.51^{k}	8.94 ± 0.2^{i}	20.17±0.81^{n}	79.83±0.81^{a}	0.25
	Sadagulab	9.538 ±0.74^{k}	1.96 ±0.35^{a}	9.39 ± 0.08^{f}	24.04±0.52^{h}	75.96±0.52^{g}	0.31
	sugdasi Ratria	7.211 ±0.49^{n}	1.08± 0.44^{l}	8.8 ± 0.11^{j}	21.26±0.62^{k}	78.74±0.62^{d}	0.27
	Sonehri sugdasi	9.311±0.73^{m}	1.75±0.52^{d}	8.49 ± 0.07^{k}	22.18±0.6^{j}	77.82±0.6^{e}	0.28
Non – Basmati	IR-6	11.097 ±1.02^{a}	1.62 ±0.62^{g}	9.67± 0.02^{c}	28.9±0.21^{d}	71.1±0.21^{k}	0.40
	Shadab	9.771 ±0.92^{g}	1.86 ±0.91^{c}	9.57 ± 0.9^{e}	30.7±0.26^{a}	69.3±0.26^{n}	0.44
	Shandar	9.621±0.68^{i}	1.63 ± 0.90^{f}	9.22 ± 0.12^{g}	29.67±0.42^{b}	70.33±0.42^{m}	0.42
	IR-8	9.951 ± 0.9^{e}	1.94±0.51^{b}	6.86 ± 0.06^{n}	26.2±0.36^{f}	73.8±0.36^{i}	0.35
	Shua-92	10.069±1.12^{d}	1.53±0.86^{i}	7.76 ± 0.1^{m}	29.4±0.71^{c}	70.6±0.71^{l}	0.41
	Sarshar	10.263 ±1.05^{b}	1.54 ±0.81^{h}	8.06 ± 0.1^{l}	27.2±0.5^{e}	72.8±0.5^{j}	0.37

Superscript letters mean ($p<0.05$),
Means with the same letter are not significantly different.

3. <u>DISCUSSION</u>

Proteins contents vary greatly in mature rice grain (Juliano *et al*. 1968). According to analyzed data protein content comprise in between 6.86 % -9.67% in Non-Basmati and 8.49 -9.97% in Basmati rice varieties. Higher ratios of protein content in rice are more advantageous nutritionally due to good biological value. Basmati rice varieties Mehak, Khushboo-95 and Jajai-77 with high amylopectin level comprises good protein value and may play a role in human health while IR-6, Shadab and Shandar with high amylose/ amylopectin ratio can be consumed by diabetics.

Some of the Pakistani rice varieties investigated by Awan, (1996) shown 7.38 to 8.13% protein content it may be due to the difference of rice cultivars, harvested time or storage period of the varieties as it is well defined that physicochemical properties changed during the storage. (Chrastil, 1990 a,b) (Park *et al.,* 2012).Storage proteins of rice grain are classified on the bases of solubility such as albumin is soluble in water, globulin in salt solution, prolamin is soluble in aqueous alcohol solutions, and a major endospermic rice glutelin soluble in alkali or dilute acid (Osborne, 1964) (Villareal and Juliano, 1978) (Tecson *et al.* 1971) constituted equal to 70 to 80 percent of total seed proteins (Takaiwa *et al.*, 1991) (Ma, 2005). Glutelin is digestible rice seed protein thus raised the nutritional value by improving its digestibility. While low digestible prolamine is also an important objective of rice breeding to fulfill the requirement of low protein diet for the patients with kidney disease. (Jiang *et al.,* 2003)

In current study percentage of glutelin accounted 73.1-79.6% (mean 77.04%) for Non-Basmati rice varieties where as in Basmati rice varieties it varies from 75.4 to 79.8% (mean 77.6 %). Comparatively higher glutelin content in Sugdasi-Ratria, Sadagulab, Sonahri-Sugdasi and Khushboo-95 is reported by Nadar *et al.,* (2010).However, our result showed high content in IR-8, Sarshar, Mehak and Sonahri-Sugdasi there can be an involvement of many factors in variation in glutelin content like environmental circumstance, period of storage, location, soil and Nitrogen fertilizers (Igrejas, 2002)

Albumin and globulin fractions of grain protein served as the morphologic, metabolic and protective functions while Prolamin and glutenin served as storage protein. (Belderok *et al.*,2000). The comparison study of Prolamin and Glutelin for Non-Basmati and Basmati rice varieties showed the highest glutelin % in Sonehri sugdasi (79.8%) which comprises 27.5 Glutelin/ Prolamin ratio and lowest in Shandar (73.1%) with 14.9 Glutelin / Prolamin ratio. These results indicate that low amylose & high protein compositions of Basmatirice varieties are nutritionally more beneficial for human consumption. On the other hand, in Non-Basmati rice varieties IR-8 contain lowest (6.86%) protein content but the highest proportion of glutelin (79.6%) followed by Sarshar (79.3%) and Shua-92 (78.7%) which improve their digestibility & nutrient value. Generally, prolamin is less nutritious then glutelin due to lower lysine content and fewer digestibility by human (Kim *et al.*,2013b)but it also possesses some pharmacological activities (Chen *et al.,* 2010). Highest Prolamin content was found in IR- 6 while lowest was observed in IR-8. So IR-6 variety can be considered beneficial for pharmacological use.

4. CONCLUSION

Morphological characteristics such as size, shape and aroma of rice grain are the first preference in developing new varieties due to their high prices in international markets. Likewise, data of amylose and differential protein content will also be avaluable resource in developing new varieties with desired composition to enhance functional andnutritional properties. The study reveals that rice varieties under study showed a significant difference from medium to long grain size as well as in their protein and amylose content. High protein and Low amylose content gives desirable feature to Basmati rice due to soft texture on cooling for longer time period, which is definitely preferred over Non-Basmati rice varieties with high amylose content.

REFERENCES:

A.O.A.C. (1990). Official methods of analysis of the association of analytical chemists. Virginia: AOAC Inc

Awan, I. A., (1996). Physical and biochemical characterization of some of the Pakiatani rice varieties. M.Sc. (Hons.) Thesis. Dept. of Food Tech., Univ. Agric. Fsd.

Belderok, B., J. Mesdag, D. A. Donner, (2000). Bread-Making Quality of Wheat: A Century of Breeding in Europe. Kluwer Academic Publisher: Dordrecht, the Netherlands, 30–31.

Boers, H. M., J. S. ten Hoorn, D. J. Mela, (2015). A systematic review of the influence of rice characteristics and processing methods on postprandial glycaemic and insulinaemic responses. British Journal of Nutrition, 114:1035–1045.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, 72: 248-254.

Cagampand, G. B., L. J. Cruz, S. G. Espiritu, R. G. Santiago, B. O. Juliano, (1966) Studies on the extraction and composition of rice proteins. Cereal Chemistry, 43:145–155.

Carmencita D. M.,N. F. Carandang, (2006). Feeding and Economic Evaluation of Corn, Wheat, and *Sorghum* Based-Diets in Broilers. Philippine Journal of Science, 135 (1): 49-58.

Cameron, D. K. and Y. Wang, (2005). A Better Understanding of Factors That Affect the Hardness and Stickiness of Long-Grain Rice. Cereal Chemistry, 82(2):113–119

Chen, Y., Y. Chen, C. Wu, C. Yu, H. Liao. (2010). Prolamin, a rice protein, augments anti-leukaemia immune response. Journal of Cereal Science, 51: 189-197.

Chrastil, J., (1990a). Chemical and physicochemical changes of rice during storage at different temperatures. Journal of Cereal Science, 11: 71-85.

Chrastil, J., (1990b). Protein-starch interactions in rice grains. Influence of storage on oryzenin and starch. Journal of Agricultural and Food Chemistry, 38: 1804-1809.

Custodio, M. C., R. P. Cuevas, J. Ynion, A. G. Laborte, M. L. Velasco, M. Demont, (2019). Rice quality: How is it defined by consumers, industry, food scientists, andgeneticists? Trends in Food Science & Technology 92:122-137.

Dipnaik, K., P. Kokare, (2017). Ratio of Amylose and Amylopectin as indicators of glycaemic index and in vitro enzymatic hydrolysis of starches of long, medium and short grain rice. International Journal of Research in Medical Sciences, 5(10):4502-4505.

Ehiakpor, D. S., J. Apumbora, G. D. Abbeam, W. Adzawla, (2017). Households' Preference for Local Rice in the Upper East Region, Ghana. Hindawi Advances in Agriculture, 9Pp.

Hu, P., H. Zhao, Z. Duan, Z. Linlin, D. Wu, (2004) Starch digestibility and the estimated glycemic score of different types of rice differing in amylose content. Journal of Cereal Science, 40(3): 231–237.

Ibáñez, A. M., D. F. Wood, W. H. Yokoyama, I. M. Park, M. A. Tinoco, C. A. Hudson, K. S. Mckenzie, C. F. Shoemaker, (2007). Viscoelastic properties of waxy and nonwaxy rice flours, their fat and protein-free starch, and the microstructure of their cooked kernels. Journal of Agricultural and Food Chemistry, 55: 6761-6771.

Igrejas, G., H. G. Pinto, V. Carnide, J. Clement, G. Branlard, (2002) Genetical, Biochemical and Technological Parameters Associated with Biscuit Quality. II. Prediction Using Storage Proteins and Quality Characteristics in a Soft Wheat Population. Journal of Cereal Science, 36:187-197.

Jain, A., S. M. Rao, S. Sethi, A. Ramesh, S. Tiwari, S. K. Mandal, N. K. Singh, A. Singhal, N. Modi, V. Bansal, C. Kalaichelvani, (2012). Effect of cooking on amylose content of rice. European Journal of Experimental Biology, 2 (2):385-388.

Jiang, S. M., S. S. Zhu, S. J. Liu, L. Jiang, L. L. Xu, J. M. Wan, (2003). Screening and genetic analysis of rice glutelin mutant. Yi Chuan Xue Bao, 30 (7):641-5.

Juliano, B. O., (1971). A simplified assay for milled rice amylose. Cereal Science Today, 16(10):334-340.

Juliano, B. O. (1992). Structure chemistry and function of the rice grain and its fraction. Cereal Foods World. 37: 772–774.

Juliano, B. O., C. C. Ignacio, V. M. Panganiban, C. M. Perez, (1968). Screening for high protein varieties. Cereal Science Today. 13: 299-301.

Kennedy, G., B. Burlingame, (2003). Analysis of food composition data on rice from a plant genetic resources perspective. Analytical, Nutritional and Clinical Methods. Food Chemistry 80:589–596

Kim, J., B. Kim, J. Lee, D. Lee, S. Rehman, S. J. Yun, (2013a). Protein content and composition of waxy rice grains. Pakistan Journal of Botany, 45(1): 151-156.

Kim, H. J., J. Y. Lee, U. H. Yoon, S. H. Lim, Y. M. Kim, (2013b). Effects of Reduced Prolamin on Seed Storage Protein Composition and the Nutritional Quality of Rice. International Journal of Molecular Science, 14(8): 17073–17084.

Kushwaha, U. K. S., S. P. Khatiwada, H. K. Upreti, U. S. Shah, D. B. Thapa, S. R. Gupta, P. K. Singh, K. R. Mehta, S. K. Sah, B. Chaudhary, B. P. Tripathi, (2015). Modification of Rice Breeding Technology in 21st Century. International Journal of Bioinformatics and Biomedical Engineering, 1(2): 77-84.

Los Baños (Philippines): International Rice Research Institute. P15. Official Journal of Turkish Republic. 2002. September 23, No. 24885. 32Pp.

Ma, C. Y. (2005). Raman spectroscopic study of rice seed glutelin. IFT Annual Meeting. July 15-20. New Orleans, Louisana, USA.

Meena, S. K., D. Vijayalakshmi, U. Ravindra, (2010). Physical and cooking characteristics of selected aromatic rice varieties. Journal of Dairying, Foods and Home Sciences, 29(3/4): 227-231.

Nadar, K., A. Naushad, A. R. Malik, M. S. Masood, (2010). Diversity of glutelin αlpha- subunits in rice varieties from Pakistan. Pakistan Journal of Botany, 42(3): 2051-2057.

Normita, M., D. Cruz, (2002). Rice Grain quality evaluation procedures. C/O Robin Graham. A Proposal for IRRI to Establish a Grain Quality and Nutrition Research Center. IRRI. Discussion Paper Series No. 44.

Ohtsubo, K., S. Nakamura, S. Maeda1, A. Kobayashi, A. Yamazaki, S. Watanabe, (2016). Possibility of Diabetes Prevention by High-amylose Rice and Super Hard Rice. Journal of Diabetes and Obesity, 3(1): 1-7.

Oko A. O., B. E. Ubi, A. A. Efisue, N. Dambaba, (2012b). Comparative Analysis of the Chemical Nutrient Composition of Selected Local and Newly Introduced Rice Varieties Grown in Ebonyi State of Nigeria. International Journal of Agriculture and Forestry, 2(2): 16-23

Oko, A. O., B. E. Ubi, N. Dambaba, (2012a). Rice Cooking Quality and Physico-Chemical Characteristics: a Comparative Analysis of Selected Local and Newly Introduced Rice Varieties in Ebonyi State, Nigeria. Food and Public Health, 2(1): 43-49

Osborne, T. B. (1964). The Vegetable Proteins, Longmans, Green, London. V. W Padhye, and D. K. Salunkhe. 1979. Extraction and characterization of rice proteins. Cereal Chemistry, 56: 389-393.

Park, C. E., Y. S. Kim, K. J. Park, B. K. Kim, (2012). Changes in physicochemical characteristics of rice during storage at different temperatures. Research, 48: 25-29.

Pokhrel, A., A. Dhakal, S. Sharma, A. Poudel, (2020). Evaluation of Physicochemical and Cooking Characteristics of Rice (Oryza sativa L.) Landraces of Lamjung and Tanahun Districts, Nepal. International Journal of Food Science, 11Pp.

Priya, T. S. R., A.R.L. Eliazer Nelson, K. Ravichandran, U. Antony, (2019). Nutritional and functional properties of coloured rice varieties of South India: a review. Journal of Ethnic Foods, 6:11-14.

Shouket, A. M., A. S. Mahboob, A. S. Bashir, A. Afzal, (2007). Study of genetic parameter in segregating populations of spring wheat. Pakistan Journal of Botany, 39: 2407-2413.

Tada, Y., M. Nakase, T. Adachi, R. Nakamura, H. Shimada, T. Masayoshi, T. Fujimura, T. Matsuda, (1996). Reduction of 14-16 kDa allergenic proteins in transgenic rice plants by antisense gene. FEBS Letters, 391: 341-345.

Takaiwa, F., K. Oono, D. Wing, A. Kato, (1991). Sequence of three members and expression of a new major subfamily of glutelin genes from rice, Plant Molecular Biology, 17: 875-885.

Tecson, E. M. S., B. V. Esmana, L. P. Lontok, B. O. Julaino, (1971). Studies on the extraction and composition of rice endosperm: glutelin and prolamine. Cereal Chemistry. 48: 168-181.

Villareal, R. M., B. O. Juliano, (1978). Properties of glutelin from mature and developing rice grain. Phytochemistry, 17:177-182.

Wani, I. A., D. S. Sogi, A. A. Wani, B. S. Gill, U. S. Shivhare, (2010). Physico-chemical properties of starches from Indian kidney bean (Phaseolus vulgaris) cultivars. International Journal of Food Science & Technology, 45: 2176– 2185.

Zenel, A. M., M. L. Stewart, (2015). High Amylose White Rice Reduces Post-Prandial Glycemic Response but Not Appetite in Humans. Nutrients, 7: 5362-5374.

Zhu, L., M. Gu, X. Meng, S. C. K. Cheung, H. Yu, J. Huang, Y. Sun, Y. Shi, Q. Liu, (2012). High-amylose rice improves indices of animal health in normal and diabetic rats. Plant Biotechnology Journal, 10: 353–362.