Food Chemistry 238 (2018) 29–34

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Nutritional composition in relation to glycemic potential of popular Indian rice varieties

V.S.S. Prasad [a], A. Hymavathi [a], V. Ravindra Babu [b], T. Longvah [a,*]

[a] National Institute of Nutrition, Indian Council of Medical Research (ICMR), Jamai Osmania P.O., Hyderabad 500 007, Telangana, India
[b] Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 030, Telangana, India

ARTICLE INFO

Article history:
Received 13 December 2016
Received in revised form 17 February 2017
Accepted 23 March 2017
Available online 24 March 2017

Keywords:
Glycemic index
Glycemic load
Amylose
Resistant starch
Lalat
α-Tocopherol equivalent (ATE)

ABSTRACT

Diabetes, a chronic hyperglycemic disorder, is a public health concern in India. High glycemic carbohydrate foods are linked to higher risk of diabetes. The chemical composition and *in vivo* glycemic potential of popular Indian rice varieties namely *Jaya*, *Lalat*, *NDR-97*, *PR-113*, *Salivahana*, *Sasyasree*, *Savithri*, *Tellahamsa*, *Triguna*, *Varalu* and one hybrid *DRRH-3*, having wide agronomical and grain morphological features were studied. Nutrient composition varied prominently among different varieties. Resistant starch (RS) content (2.03–2.91%) correlated negatively with the glycemic index (GI) ($r = -0.674$; $p \leq 0.05$) and contributed for 45.5% of GI variability. *Lalat*, an aromatic traditional rice variety, with 2.91% RS and 27.9% amylose was the only one eliciting low GI of 50 and glycemic load (GL) of 13 while the rest exhibited GI ranging from 70 by *Savitri* to 80 by *Salivahana*. Identification of *Lalat* as a low GI variety is of significance in the dietary prevention and management of diabetes.

1. Introduction

The incidence of diabetes, a chronic metabolic disorder with multiple etiologies, is characterized by sustained high levels of blood sugar. About 422 million people are affected with this disease world-wide (WHO, 2016) and the numbers are projected to increase up to 642 million by 2040 (International Diabetes Federation, International Diabetes Federation, 2016). India is among the worst affected countries with 69.2 million diabetic people accounting for 8.7% of total diabetic population worldwide (International Diabetes Federation, 2016). The annual number of disability-adjusted life year (DALYs) due to diabetes increased from 4.1 to 8 million between 1990 and 2010 and is estimated to cause 0.15 trillion USD (2010) of economic loss between 2012 and 2030 in India (Bloom et al., 2014).

India is the second largest producer of rice in the world with output of 157.2 million ton paddy in the year 2014. Rice consumption in the country touched 94.9 million ton in the year 2013 (Consultative Group for International Agricultural Research, 2016) wherein rice supplied 29% of total dietary energy per capita per day. A positive association was noted between risk of diabetes and increased dietary intake of refined carbohydrates or carbohydrate rich foods that cause post-prandial hyperglycaemia. High consumption of rice which is considered to be food with high glycemic potential was found to be associated with increased risk of type II diabetes (Hu, Pan, Malik, & Sun, 2012; Nanri et al., 2010). Psaltopoulou, Ilias, and Alevizaki (2010) have shown that low glycemic diets are known to improve metabolic health indices irrespective of the amount of consumed carbohydrate. Foster-Powell, Holt, and Brand-Miller (2002) have reported a great deal of variation in glycemic response of rice with most varieties exhibiting high GI. In the context of alarming levels of diabetes in India with concomitant high rate of rice consumption, the present study was undertaken to study the compositional basis of the glycemic potential of different popular Indian rice varieties for identification of low GI rice that may help in dietary prevention as well as management of diabetes in the country.

2. Material and methods

2.1. Rice varieties and sample preparation

Milled rice samples of eleven certified and released popular rice varieties namely *DRRH-3*, *Jaya*, *Lalat*, *NDR-97*, *PR-113*, *Salivahana*, *Sasyasree*, *Savithri*, *TellaHamsa*, *Triguna and Varalu* were supplied by Indian Institute of Rice Research (Indian Council of Agricultural Research), Hyderabad, India. The heredity, morphology and ecosystem of the cultivated rice varieties are presented in Table 1. The rice samples were ground in a cyclone sample mill (UDY

* Corresponding author.
E-mail address: tlongvah@gmail.com (T. Longvah).

http://dx.doi.org/10.1016/j.foodchem.2017.03.138
0308-8146/

Table 1
Varietal, agronomical and morphological features of the selected rice varieties.

Name[1]	Central/State Release	Variety[2]	Designation	Cross combination	Year	FD[3]	Eco-System[4]	GT[5]	Yield kg/ha
DRRH-3	Central	IET 19543	DRRH 44	APMS/6A/ RPHR 1005	2009	103	IRME	MS	6500
Jaya	Central	IET 723	12306	TN1/TN141	1968	101	IRM	LB	6000
Lalat	Odisha	IET 9947	ORS 26-2014-4	OBS 677/IR 2071/Vikram/W1263	1988	95	IRME	LS	4400
NDR 97	Central	IET 9210	NDR 97	N 22/ RATNA	1992	70	RUP	LS	5000
PR 113	Punjab	IET 15100	PAU 2333-25-2	IR 8/RP2151-173-1-8// IR 8	2000	95	IRME	LS	7000
Salivahana	Central	IET 7590	RP 1057-391-1	RP 5-32/ Pankaj	1988	128	RSL	SB	5000
Sasyasree	Central	IET 2815	RP 6-516-34-1-8	IR 8/ TKM 6	1979	95	IRME	LS	2620
Savithri	Central	IET 5897	CR 210-1009	Pankaj/Jaganath	1983	120	RSL	SB	6000
TellaHamsa	Andhra Pradesh	IET 1899	C 10754	HR 12/ TN1	1971	84	IRE	LS	6000
Triguna	Central	IET 12875	RP 2542-194-301	Swarnadhan/rp 1579-38	1997	98	IRME	LS	5590
Varalu	Andhra Pradesh	IET 14848	WGL 14377	WGL 20471/CR 544-1-2	2001	63	RUP	LS	4900

Note: For crop duration from seed to seed, 30 days are added to FD.
[1] *DDRH-3* is a hybrid variety and the rest are popular varieties.
[2] IET, Initial evaluation trial.
[3] FD: Duration for 50% Flowering in days.
[4] IRME: Irrigated Mid Early; IRE: Irrigated Early; RSL: Rain-fed Shallow Low-land; IRM: Irrigated Medium; RUP: Rain-fed Up-land
[5] GT, Grain type: LS, Long-slender; MS, Medium-slender; SB, Short-bold; LB, Long-bold.

Corporation, USA) to obtain homogenous rice flour (60 mesh). The rice flours were stored in labeled airtight containers at −20 °C in deep freezer (Hoshizaki Corporation, Japan) till analysis for chemical composition.

2.2. Chemical composition of rice varieties

Official methods of analyses of Association of Official Analytical Chemists (AOAC, 1984) were followed for determination of moisture (AOAC 934.01), total ash (AOAC 942.05) and total fat (AOAC 963.15). Protein content of the rice samples is derived by multiplying gram nitrogen content estimated by micro-Kjeldahl method with conversion factor of 5.95 (Jones, 1931). Total dietary fibre was analyzed using commercial assay kit (Megazyme International, Ireland). Carbohydrate content was calculated "by difference" (FAO & WHO, 1998). Atwater conversion factors were used to derive the energy yield of the samples (Merrill & Watt, 1973). Amylose content was analyzed using commercial assay kit (Megazyme International, Ireland). Briefly, an aliquot of the test portion is dispersed in dimethyl sulphoxide and starch is selectively precipitated in ethanol, recovered and dissolved in acetate/salt solution. Then amylopectin is selectively precipitated and the amylose in supernatant was enzymatically hydrolysed to D-Glucose which is estimated by glucose oxidase/peroxidase reagent by measuring absorbance at 510 nm.

2.2.1. Mineral analyses

Dry rice flour of each variety was weighed in 0.5 ± 0.01 g duplicate aliquots, transferred into Teflon digestion tubes and 3 mL of 65% HNO_3 and 1 mL of pure H_2O_2 was added. Test portions in capped tubes were subjected to digestion in microwave oven (MARS 6, CEM Corporation). For analysis of K, Mg, Ca, Zn, Mn, Fe, Cu, Na and Al, the clear digestate is appropriately diluted with 3% HNO_3 in ultrapure water and quantified using flame atomic absorption spectroscopy (iCE 3000 Series AAS, Thermo Fisher Scientific Inc.). Linearity and detection limits were ascertained using commercial multielement standard diluted up to 5 μg/mL. Phosphorus was determined colorimetrically at 660 nm using modified Fiske and Subbarow (1925) method as described in AOAC 970.39. Trace elements (Mo, Ni, Co, Cr, Li, Cd, and Pb) were quantified simultaneously by inductively couple plasma mass spectrometry, ICP-MS (AOAC 2013.06) using 10 ppb Rhodium as internal standard. Commercial multi-element standard diluted from 0.1 μg/L to 50 μg/L was used to check linearity of ion intensities and to derive detection limits. Measurement accuracy of nutrients were checked using blanks and standard reference material (SRM) 1515 Apple leaves, 1547 Peach leaves and 1577c Bovine liver of National Institute of Standards and Technology (NIST®) and were found to be within the limits of certified range of elemental concentrations. Market rice was used as in house quality control material with every batch of analysis. Market rice does not have certified value but over time it developed its own value which served as quality control for day to day analysis.

Thiamin content in rice was estimated after conversion to thiochrome by fluorometric detection (Ramasastri, 1975). Riboflavin and Niacin were estimated by microbiological assay using *Lactobacillus casei* National Collection of Industrial Microorganisms (NCIM) 2364 (ATCC 7469) and *Lactobacillus plantarum* NCIM 2083 (ATCC 8014) as test organisms, respectively (AOAC 960.46). Pantothenic acid was analyzed by reversed phase high performance liquid chromatography (RP-HPLC) using C18 column and mobile phase (phosphate buffer, pH 2.25: acetonitrile) in the ratio of 95:5 and detected by ultra violet diode array detector (UV-DAD) at 204 nm (Woollard, Indyk, & Christiansen, 2000). Biotin was determined by ultra high pressure liquid chromatography-mass spectrometry (LC-MS) as described by Holler, Wachter, Wehrli, and Fizet (2006). Tocopherols and tocotrienols, extracted after saponification were determined by HPLC using mobile phase (hexane: acetic acid: ethyl acetate) in the ratio of 987:9:4 and detected by (UV-DAD) at 296 nm (Bonvehi, Coll, & Rius, 2000).

2.3. Cooking of rice samples and determination of available carbohydrates

The rice samples were manually cleaned free from extraneous materials, uniformly weighed and washed with deionized water. The rice samples were boiled in tap water in the ratio of 1:2 until cooked and palatable. Freshly cooked rice is hydrolyzed releasing depolymerized available carbohydrates to which Anthrone reagent was added and estimated by colorimetry as combined concentrations of free sugars at 620 nm using glucose as standard (Yemm & Willis, 1954). Resistant starch content was determined by commercial enzyme based assay kit (Megazyme International, Ireland). Briefly, 1.0 ± 0.01 g of homogenized test portion was sequentially incubated with α-amylase, protease and amyloglucosidase to hydrolyze non-resistant starch. Resistant starch was then recovered by the addition of ethanol and treated with amyloglucosidase to convert into D-glucose which is measured with glucose oxidase/peroxidase reagent.

2.4. Determination of glycemic response of rice varieties

Glycemic response measurement protocol was approved by human subject ethical review committee of National Institute of Nutrition (NIN), Hyderabad, India and each participating subject