Plant Archives Vol. 24, No. 1, 2024 pp. 1075-1082 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.1.149

STUDY ON COOKING QUALITIES AND ANTIOXIDANT PROPERTIES IN SELECTED TRADITIONAL RICE VARIETIES OF TAMIL NADU, INDIA

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(Date of Receiving-23-11-2023; Date of Acceptance-31-01-2024)

ABSTRACT

Cooking and physiochemical properties of rice were studied in the nine popular traditional varieties of Tamil Nadu. The objective of the study was to determine the physical characteristics of the traditional rice varieties before and after cooking and also their chemical compositions. To this objective, the physical characteristics *viz.*, kernel length and breadth, bulk density, porosity and endosperm type were recorded. The cooking and functional properties studied included length and breadth after cooking, linear elongation ratio, gelatinization temperature, water absorption ratio, anti-oxidant and phenolic content, and amylose content. Among the varieties under study, Sona Masuri and Poongar were of slender types based on the L/B ratio. The variety Poongar recorded the highest bulk density, while Sona Masuri was the least dense and Kaatuyanam was highly porous. Katuyanam, Arupatham Kuruvai and Kullakar varieties had chalky endosperm. It was found that the length-wise expansion on cooking, the most marketable quality was high in Arupatham Kuruvai, Thuya malli, Sona masoori and KarupuKavuni among all the other traditional varieties under study. In contradiction, Karunguruvai showed the highest breadthwise expansion after cooking. Gelatinization temperature estimated in terms of alkali spread value revealed that Arupatham Kuruvai, Thuya malli, Sona masoori, Kullakar, KarupuKavuni, and Kaatuyanum will have higher cooking time. Sona Masuri had the lowest water absorption ratio of 3.5 g/g, while Karupukavuni had the highest at 4.23 g/g. The varieties Poongar, Kullakar, KarupuKavuni and Kaatuyanum recorded above-average values for total phenol content and antioxidant activity. Amylose content was intermediated in the varieties MilaguSamba, Kullakar, KarupuKavuni and Karunguruvai and these varieties will be firm and fluffy on cooking.

Key words : Traditional rice, Physical properties, Functional properties, Marketable quality.

Introduction

Rice is the major staple food for India has Hindustan as its primary center of origin with a good amount of diversity. The greater population in Tamil Nadu relies on rice as a major source of food. Scientifically, rice is known as *Oryza sativa* and is mainly grown in Southeast Asian nations; it ranks third in the world in terms of production after maize and sugarcane (Bhat and Riar, 2015). Genetics, cooking quality, and other antioxidant properties are necessary for germplasm conservation (Sinha and Mishra, 2012). Such germplasm can be collected, conserved and characterized with the possibility of being used to improve the crops. All over the world, traditional rice varieties are being produced. Particularly, black rice is widely grown in Sri Lanka and some parts of India, particularly in South India and there are also modest traditional rice growing methods in the Philippines and Thailand. China leads the world in growing black rice (Ichikawa *et al.*, 2001). Rice cooking quality determines its market value and end-user preference. The quality of the grain highly depends on the acceptance of the consumer. Consumer demand for higher-quality rice has grown as more nations have become self-sufficient in the production of rice. Grain quality is determined not only by the rice type, but also by the crop production environment, harvesting, processing, and milling methods. Rice grain quality is determined by its physical and physicochemical qualities. Kernel size, shape, milling recovery, degree of milling, and grain appearance decide the physical characteristics of the grain (Cruz and Khush, 2000). Physiochemical properties govern the eating and cooking qualities of rice which include properties like amylose content, gel consistency and gelatinization temperature (Rohilla, 2000). Volume expansion upon water absorbance is yet another property that determines the end user's preference (Rebeira, 2014). As a result, eating and cooking quality can be regarded as an important inherent quality component of rice grains that must be prioritized in future rice breeding programs to suit market expectations. This research highlights the cooking qualities, physiochemical properties and other important phytochemical attributes of selected traditional rice varieties.

Materials and Methods

The investigation was carried out at Vanavarayar Institute of Agriculture in 2023 to evaluate the physicochemical and cooking characteristics of nine traditional rice varieties cultivated in Tamil Nadu to find out the better-quality characteristics and nutritional value. This study was conducted to evaluate the diversity of traditional rice grain quality based on physicochemical, cooking and nutritional properties that will provide highly important information for future rice breeding programs as well as for consumers.

Physical characteristics of selected rice varieties

Kernel length and breadth

Ten rice kernels (undamaged and sound) of selected rice varieties were analyzed for length and breadth using a Vernier caliper and expressed in mm. The length/breadth ratio was calculated by dividing the length by the breadth of rice grains (Odenigbo *et al.*, 2014).

Bulk density

To calculate the bulk density of the rice kernels, a known quantity of rice grains was filled in an aluminum container. The volume of water required to fill the remaining part of the container up to the brim was measured. The volume of the grains was determined by calculating the ratio of the weight of grains taken to the volume of water used to fill the container. This was expressed as g/cc (Bhattacharya and Sowbhagya, 1971).

Porosity

The porosity of the traditional rice varieties under study was determined by the following formula as suggested by Bhattacharya and Sowbhagya (1971).

$$\text{Porosity (\%)} = \frac{\text{True density} - \text{Bulk density}}{\text{True density}} \times 100$$

Endosperm type

The endosperm of a rice grain may be opaque or transparent due to chalkiness or waxiness resulting from the compactness of starch packing in the grain. The chalkiness of the rice is stated in terms of scores as follows.

Score	Chalkiness in the grain
0	No chalkiness
1	white belly
5	white centre
9	white back

Cooking and functional properties

Length and breadth after cooking

A handful amount of the kernels of the rice varieties were tied in a porous cloth bag and pre-soaked in water for 20 minutes and cooked for a minimum time as reported by Singh *et al.* (2005). The cooked rice kernels in this way were placed on blotting paper to drain the excess water. Ten unbroken cooked kernels from each variety were selected for measuring the length and breadth on graph paper. The measurements were replicated three times and expressed in millimeters (mm).

Linear elongation ratio

The linear elongation ratio was calculated as the ratio of the mean length of cooked rice to the mean length of milled rice. For the selected rice kernels the ratio of the mean breadth of cooked rice to the mean breadth of milled rice was expressed as Breadth wise expansion ratio (Juliano and Perez, 1984). The length-to-breadth ratio was recorded for cooked rice in three replications and the mean was reported (Singh *et al.*, 2005).

Gelatinization temperature

To calculate Gelatinization temperature two sets of six full-milled rice kernels of each variety were placed far enough on a Petri plate and 10 ml of 1.7% KOH was added. The dishes were closed and left undisturbed for 23 hours at room temperature. The disintegration of the kernels was scored according to Standard Evaluation System (IRRI, 1996) and expressed as Alkali Spreading Value.

Amylose content

Amylose content (%)	Category
>24%	High-amylose
20 – 24%	Intermediate-amylose
10 – 19%	Low-amylose
< 5%	Waxy rice

Water absorption ratio

Five grams of milled rice was taken in a beaker and soaked in water for 20 minutes and boiled for 10 minutes. The cooked rice was taken out and placed on a blotting paper to drain the excess water. The weight of the cooked rice was estimated in an analytical balance. Water absorption by weight was estimated using the formula,

$$\text{Water absorption ratio} = \frac{\text{Weight of the cooked rice}}{\text{Weight of the raw rice}}$$

Antioxidants

The antioxidants present in traditional as well as white rice varieties were assessed by the DPPH method. A 0.1 mM DPPH solution was prepared by dissolving the extracts in methanol. In a microtiter plate, 190 µl of DPPH solution along with 10 µl of extracts were added and incubated at room temperature for 30 min in dark conditions. After the incubation period, the absorbance was measured at 517 nm. For the control well, 10 µl of the extract was replaced by 10 µl of methanol. The DPPH scavenging activity was calculated by the following formula (Herch *et al.*, 2014; Rattanachitthawat *et al.*, 2010). The graph was plotted using a concentration in the X-axis and a percentage of scavenging activity on the Y-axis. The standard curve was constructed using sample.

$$\text{DPPH scavenging activity (\%)} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

Total phenolic contents

One gram of rice flour from each of the rice varieties under study was taken. To the rice flour 20ml of 80% methanol was added and incubated for 24 hours at room temperature. The extract was centrifuged at 4000 rpm for 15 minutes and the supernatants were pooled. The total phenolic content was estimated by the Folin-Ciocalteu method (Bao *et al.*, 2005). From each of the rice flour extracts 200 µl was taken and to it 1 ml of 0.5 N Folin-Ciocalteu reagent was added. The mixture was neutralized with 1 ml of 20% sodium carbonate. The optical density of the solution resulting in the formation of blue color after two hours of incubation was measured at 760 nm on a spectrophotometer. The total phenolic of the rice variety was quantified using the OD value based on the standard curve of gallic acid.

Results and Discussion

Physical properties of selected rice varieties

Length, breadth and L/B ratio

The rice varieties used in the present study are depicted in Fig. 1. The selected rice samples were analyzed for physical properties like length, breadth, L/B ratio, bulk density and porosity among the selected rice varieties and were presented in Table 1. With respect to the length and breadth, Karunguruvai showed the highest length of 5.60 mm and breadth of 2.02 mm followed by Thuyamalli's 5.52 mm length and of 2.29 mm breadth, which was significantly higher than all the varieties under study. The results opined that Kaatuyanum, Karungkuruvai, Kullakar, Arupatham Kuruvai, Thuyamalli, Karupukavuni and Milagu Samba as medium rice varieties whereas Sona Masuri and Poongar were of slender types based on the L/B ratio (Singh *et al.*, 2000). The differences in size, shape, and moisture content among varieties may account for the variations in length, breadth, and the L/B ratio. The conclusions were consistent with those of Devraj *et al.* (2019), who examined the length, breadth, and L/B ratios of traditional and chosen white rice varieties. According to Raghuvanshi *et al.* (2017), white rice will be longer than other varieties of rice.

Bulk density and porosity

The highest bulk density of 1.00 g/cc was noted in the Poongar, Kullakar and Karupukavuni varieties with the lowest bulk density of 0.66 g/cc in Sona Masuri among traditional rice varieties. The findings were in line with the work of OdenigboOdenigbo *et al.* (2014) and the difference in bulk density suggests that traditional rice types had a higher bulk density than white rice (Sona Masuri).

The porosity of both traditional and white rice types is shown in Table 1, with Kaatuyanam having the highest porosity (45.87%) and Sona Masuri having the lowest porosity (23.88%), respectively. The variance in porosity values was a reflection of bulk and actual density, which in turn depended on a number of parameters, such as grain size and other characteristics (Singh, 2003).

Endosperm type

Considering its significant impact on the eating and milling properties of rice, the chalkiness of the grain is a crucial aspect of the grain's quality. Most rice consumers essentially prefer uniform and translucent grains. Chalkiness is an opaque area in the rice grain. The Chalkiness of the varieties was studied and scored as follows (Table 1), Sona Masuri and Milagu Samba were translucent. Katuyanam, Arupatham Kuruvai and Kullakar had a white center whereas Thuyamalli, Poongar, Karupkavuni and Karunkuruvai had white back with respect to their chalkiness in the grain. It reduces the resistance of grains to forces exerted during the milling process thereby decreasing the amount of edible rice (Singh *et al.*, 2003). High temperatures during grain filling facilitate the formation of chalky grains (Fitzgerald *et al.*, 2009; Lanning *et al.*, 2011).

Fig. 1 : Traditional rice varieties under study.

Fig. 2 : Chalkiness of the endosperm in the traditional rice varieties.

Cooking and functional properties

Length, Breadth, and Linear elongation ratio after cooking

Rice grains cooking absorb water and increase in volume through an increase in length or breadth. The lengthwise increasing varieties are the most preferred ones and are regarded as high-quality premium rice. The ones with breadth-wise increase are not so desirable (Hossain *et al*., 2009).

In the present study, the lengthwise expansion of the varieties after cooking ranged from 8.3 mm to 10.8 mm (Table 2). The traditional rice varieties Arupatham Kuruvai, Thuya malli, Sona masoori, and KarupuKavuni recorded higher grain length expansion with lower breadthwise expansion after cooking. This type of cooking quality is the most preferred one by consumers. A similar report of lengthwise expansion of rice varieties after cooking has been published by Danbaba *et al*. (2011), where the length expansion ranged from 9.67 to 13.84 mm.

Among the varieties under study Karunguruvai recorded high breadth after cooking than the average and the trait ranging between 2.5 mm to 3.5 mm. In research on the cooking quality of rice Singh *et al*. (2012) have reported a range of breadth-wise expansion of rice grains after cooking as from 2.31mm to 3.02 mm.

When length and breadth are taken together as a ratio, Thuya malli, Sona masoori, Kullakar and Kaatuyanum showed a significant l/b ratio higher than the average. These values are in agreement with that of the report of Hossain *et al*. (2009). In a cooking quality study of rice, Pilaiyar (1988) has reported that l/b ratio is a better standard for estimating grain quality. These varieties with high l/b ratio after cooking are the most preferable ones by the consumers and also have a high marketable value akin to the reports of Shahidullah *et al*.

Table 1 : Physical properties of the selected rice varieties.

Variety	L	B	l/b	Bulk density (g/cm^3)	Porosity	Endosperm Type
Arupathamkuruvai	5.48*	2.09*	2.62	0.88	26.91	5
Thuyamalli	5.52*	2.29*	2.41	0.85	29.40	9
Sona masoori	5.47*	1.56	3.50*	1.00*	26.19	0
Poongar	5.68	1.79	3.17*	1.00*	23.88	9
Milagu Samba	3.74	1.74	2.14	0.88	37.76*	0
Kullakar	5.45	2.05*	2.66	1.00*	38.50*	5
KarupuKavuni	4.99	2.15*	2.32	1.00*	26.19	9
Karunkuruvai	5.60	2.02	2.78	1.00*	26.20	9
Kaatuyanum	5.54	1.86	2.97*	0.88	45.87*	5
Mean	5.27	1.95	2.73	0.94	31.21	
SE	0.20	0.08	0.14	0.02	2.53	

Table 2 : Cooking properties of the selected varieties.

Variety	L	B	l/b	WAR	Alkali spread value
Arupathamkuruvai	9.80*	3.40	2.88	3.56	Low
Thuyamalli	10.80*	3.70*	2.92	3.64	Low
Sona masoori	9.50	3.90*	2.44	3.50	Low
Poongar	9.10	3.30	2.76	3.51	Low to Intermediate
Milagu Samba	9.20	3.40	2.71	3.41	Low to Intermediate
Kullakar	9.50	2.80	3.39*	4.10*	Low
KarupuKavuni	10.00*	3.40	2.94	4.23*	Low
Karungauruvai	9.50	3.50*	2.71	3.75	Low to Intermediate
Kaatuyanum	8.30	2.50	3.32*	4.08*	Low
Mean	9.52	3.32	2.90	3.75	
SE	0.23	0.14	0.10	0.10	

Table 3 : Functional properties of the selected rice varieties.

Variety	Amylose content (%)	Total PC – mg GAE/g	Anti-oxidant activity (%)
Arupathamkuruvai	5	210.73	62.40
Thuyamalli	19	215.70	59.40
Sona masoori	18	48.70	19.60
Poongar	13	251.40*	63.87*
Milagu Samba	21*	142.90	42.31
Kullakar	20*	247.13*	73.17*
KarupuKavuni	22*	238.86*	70.72*
Karungauruvai	23*	219.60	54.80
Kaatuyanum	16	242.17*	71.70*
Mean	17.44	201.91	57.55
SE	1.86	22.05	5.73

(2009).

Gelatinization temperature

Starch in rice grains undergoes structural disintegrations when a sufficient amount of water and heat is added to it. This structural change is quantified by gelatinization which is estimated as alkali spread value. A rice variety with low alkali spread value reveals a high gelatinization temperature and vice-versa. Alkali spread value, in turn is related to the cooking time of rice also (Cuevas *et al.*, 2010). The varieties under study have been scored as in Table 2.

The varieties Arupatham Kuruvai, Thuyamalli, Sona masuri, Kullakar, Karupukavuni and Kaatuyanum reported low Alkali spread values (Fig. 3) and would have higher Gelatinization temperatures and in turn higher cooking time. The varieties Poongar, Milagu Samba and Karungauruvai showed low to Intermediate Alkali spread values. These varieties will take lesser time for cooking than the other varieties under study. In the same line of research, Tuano *et al.* (2018), reported the correlation between Gelatinization temperature and Alkali spread value in rice and Oko *et al.* (2012), reported the cooking quality of local rice varieties in Nigeria based on Alkali spread value.

Water absorption ratio

The amount of space taken up by starch when it forms a gel in water is determined by the water absorption ratio. This is dependent on the presence of hydrophilic groups and how well they can help create the gel. Selected rice varieties' water absorption ratios were examined and displayed in Fig. 4. It was noticed that Sona Masuri had the lowest water absorption ratio of 3.5 g/g, while Karupukavuni had the highest at 4.23 g/g. This variation in the absorption ratio may result from differences in the number of OH^- groups that are used to generate covalent and hydrogen bonds between the chains of starch, as well as from the loss of the crystalline structure of the starch (Gunaratne and Hoover, 2002).

Amylose content

Rice starch mainly composes of amylose and amylopectin, the important compound influencing metabolic and physicochemical properties. The proportion of amylose decides the texture of the rice grains in cooking. The rice grains with high and intermediate amylose content are firm and fluffy when cooked. The rice grains that are moist, waxy and soft have low amylose

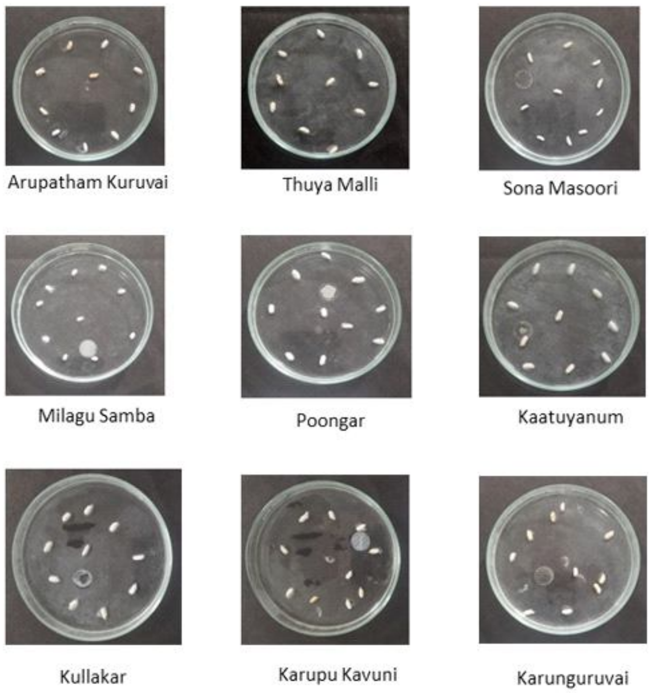

Fig. 3 : Gelatinization temperature in terms of alkali spread value using KOH.

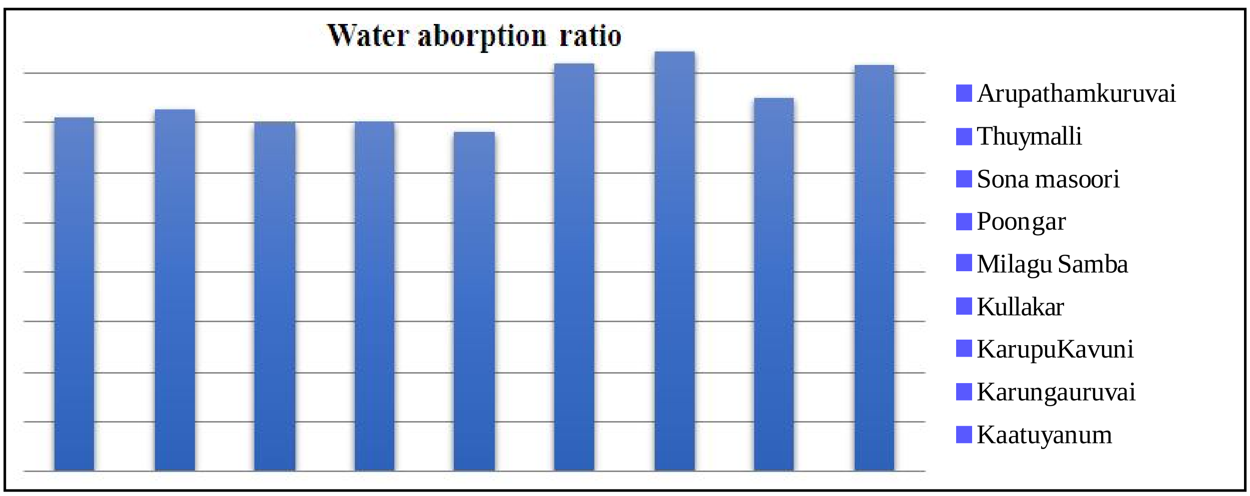

Fig. 4 : Graphical representation of water absorption ratio in the rice varieties during cooking.

content (Syahariza *et al*., 2013). The classification of the rice grains based on amylose content and stickiness is as follows: In the present study, the rice variety MilaguSamba, Kullakar, Karupukavuni and Karunguruvai showed higher amylose content than the other varieties. The results are furnished in Table 3 and interpreted as follows:

Categorization of traditional rice varieties based on amylose content

Rice variety	Catergory
Arupatham Kuruvai	Waxy rice
Thuyamalli	Low
Sona masuri	Low
Poongar	Low
Milagu Samba	Intermediate
Kullakar	Intermediate
KarupuKavuni	Intermediate
Karungauruvai	Intermediate
Kaatuyanum	Low

The varieties Arupatham Kuruvai, Thuyamalli, Sona Masuri, Poongar and Kaatuyanum are categorized as low amylose content rice varieties. These rice varieties will be sticky and waxy on cooking. The varieties with Milagu Samba, Kullakar, Karupukavuni and Karunguruvai will be firm and fluffy on cooking as they contain an intermediate amount of amylose. Similar discrimination of rice based on amylose content has also been done by Suwannaporn *et al.* (2007), Kitara *et al.* (2019) and Pranoto *et al.* (2017).

Total phenol content and anti-oxidant activity

The compounds like tocopherols, tocotrienols and phenolic compounds showing a decent amount of anti-oxidant activity have been identified in rice grains (Iqbal *et al*., 2005).

The phenolic compounds in rice are related to the darker pericarp of the rice *viz*., red and black rice (Zhou *et al*., 2004).

The current study involves the traditional rice varieties with dark pericarp ranging from light brown to dark red. The varieties Poongar, Kullakar, KarupuKavuni and Kaatuyanum recorded above-average values for total phenol content and anti-oxidant activity both together (Table 3). This indicates that phenolic content is directly related to the anti-oxidant activity. Also, all the varieties with higher values for these traits have dark-colored pericarps. Similar correlations have been reported by Chi *et al*. (2007), Jin *et al*. (2009), Rattanachitthawat *et al*. (2010), Shen *et al*. (2009) and Zhang *et al*. (2010).

Conflict of interest : The authors do not have any conflicts of interest.

Author contribution : The two authors contributed equally in the research and development of the manuscript.

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