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RICE QUALITY: GERMINATION, TRAITS, AND NUTRITIONAL ANALYSIS

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Abstract

Rice (*Oryza sativa* L.) is a crucial staple food for over half of the global population, playing a vital role in the diets of many Asian and African countries. As the third largest cereal crop worldwide, rice holds significant economic and cultural importance, especially in major producing regions like China, India etc. This review explores the origin, evolution, and global distribution of rice, with a focus on India, where diverse indigenous and high-yield varieties flourish due to the region's rich cultural history and varied climatic conditions. The review emphasizes the importance of rice quality assessment, highlighting key parameters such as germination, morphometric characteristics, cooking properties, functional attributes, and proximate composition. Germination tests are essential for evaluating seed viability and vigor, influenced by factors like temperature and stress conditions. Morphometric analysis determines grain quality, impacting milling, cooking, and consumer preferences. Cooking properties, including water uptake ratio and kernel elongation, significantly affect rice's marketability and consumer acceptability. Functional attributes like water absorption and oil absorption index are crucial for culinary versatility. Proximate composition analysis reveals rice as a rich source of carbohydrates, proteins, and fats, with variations influenced by environmental conditions. The review underscores the need for developing high-yielding, nutritious rice varieties to meet growing demand and ensure food security in the face of changing environmental conditions.

Key words: Rice (Oryza sativa L.*), proximate composition, kernel elongation, cooking properties, origin, evolution.*

Introduction

Rice (*Oryza sativa* L.), which is considered a major source of nutrient; is one of the most important dietary staple foods consumed by more than half of the global population i.e. more than 3 billion people (Lahkar and Tanti, 2017). Rice is consumed mainly in the form of whole grain. Rice the 2nd most consumed staple food appeared as a low –priced energy source providing calories to many poor people mostly in Asian and African countries. It is ranked as the 3rd largest cereal crop after maize and wheat (Lakshmi and Chamundeswari, 2021). Rice is a versatile crop that can be grown in wide agro climatic regions which makes it accessible to larger population.

Rice is composed of many important nutrient compounds and nutrient composition of rice consists of mainly carbohydrates, proteins, fats, fibre and a little amount mineral, vitamins etc. (Juliano, 1993). The

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edible part of rice grain is called caryopsis which delivers protein and ample amounts of the recommended dose of zinc and niacin (Catak, 2019). Pigmented rice is rich in bioactive agents and essential amino acids shows anti-diabetic, easy to digest fibres, anti-carcinogenic properties, anti-atherosclerosis, anti-allergic agents, gall stone alleviating and anti-inflammatory compounds beneficial for human health (Deka *et al.* 2017).

Besides consuming it in our daily diets it is used in making snack foods, brewed beverages, flour, rice bran oil, syrup and in rituals (Madhumita *et al.* 2021). Rice has a long history of being associated with cultural identities of the rice cultivating countries in the world. It also has an ample amount of economic importance globally. The global rice cultivation is assessed to be 156 million hectares and its production is estimated to be 741.5 million tonnes (FAO, 2004). Asian countries have largest share in rice production all over the world. India's rice production is estimated to be about 115.60 million tonnes for the year 2019 from the cultivated area of about 43.86 million hectares which constitutes about 21.81% of the world rice production with an average productivity of 23 thousand kg/ha (FAOSTAT, 2018).

According to UN Department of Economic and Social affairs the world population is predicted to reach 7.6 billion to 9.8 billion by 2050. Therefore, the major challenge toward the rice breeding programs is to feed the rising population by growing high yielding superior quality rice that has potential of removing hidden hunger with in limited area.

As *Oryza sativa* has a broad range of genetic variability (more than 110,000 cultivar) each with specific physiological, cooking, functional, biochemical and aroma-based qualities. Quality analysis of rice grain is essential in to meet consumer demands and for determination of market price of rice. Their demand for quality of grains is increasing. Consumers have become more quality conscious about the rice cultivars they consume. But consumer choices of rice throughout the globe is different due to varied demography and culture and end –user choice matched grain quality has more market demand hence farmers prefer cultivation of rice cultivars having more market liability.

Consumer susceptibility and market liability towards rice are dependent on various quality characteristics of grain, such as physical, chemical, cooking, and eating quality attributes or nutritional parameters (Thilakarathna *et al.* 2017). In today's world due to raising health concern and awareness of proper dietary planning has appeared as an essential topic to analyse the cooking, functional and proximate properties of rice etc. for global food security, safety and standard quality assurance.

Origin and evolution of rice

Rice is a monocotyledonous flowering plant belongs to the grass family namely Poaceace or Gramineae family. There are more than 40,000 varieties of rice has been recorded worldwide. Genus *Oryza* consists of total 25 species of rice out of these only two species that is *O. glaberrima* and *O. sativa* are utilised for human consumption and the rest are wild species. It is considered that *Oryza sativa* is domesticated from the wild grass *Oryza rufipogon* around 9000 years ago by the people of south and south-east Asia. Since then, it is serving mankind by providing around 20% of direct human calorie intake worldwide (Zeiglar and Barclay, 2008). Around more than 153 million hectares of area in the world involving more than 100 countries is used for cultivation of rice. The list of top and the largest producer countries comprises China, India, Bangladesh, Indonesia, Vietnam, Thailand, Myanmar, Philippines, Pakistan Brazil etc. Asian and African countries are not only the largest producer of rice but also the largest consumers as rice consumption in these countries exceeds around 100kg per capita annually (Zeiglar

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and Barclay, 2008).

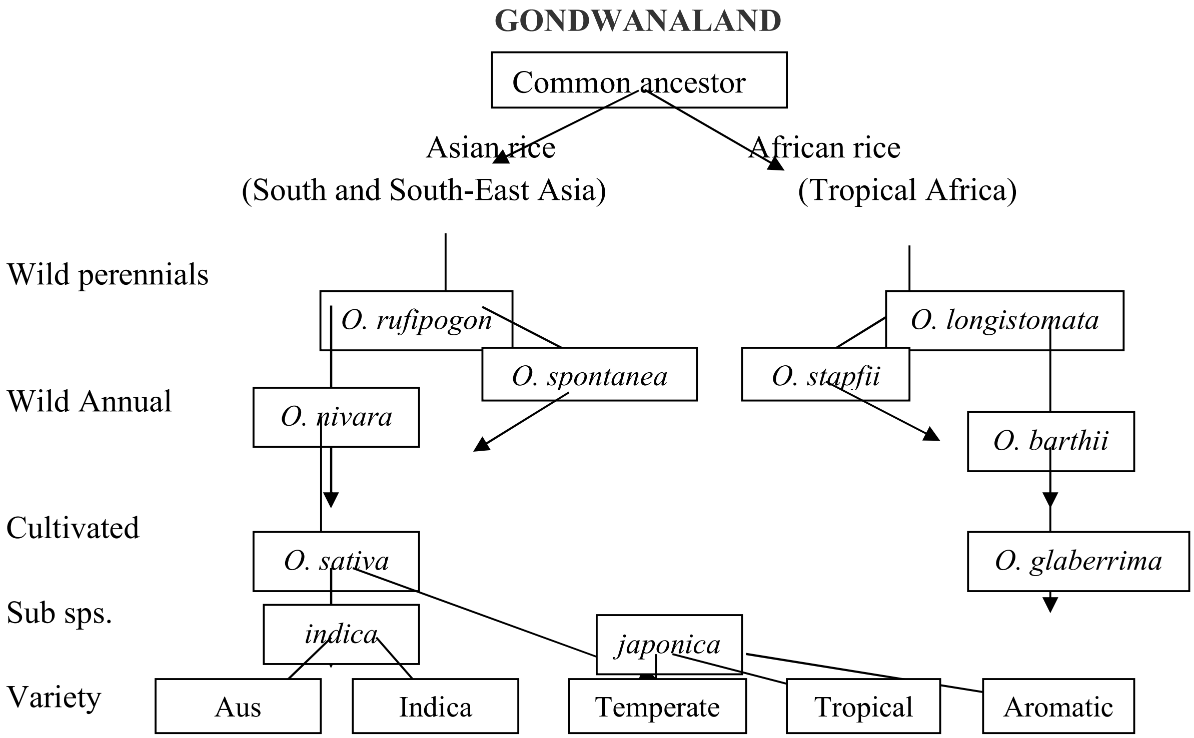

Figure 1: Schematic representation of evolution of rice (source: Khush, 2002)

Climate and Distribution of Rice

Rice is a global cereal crop which is mainly tropical plant and can also grow in sub-tropical regions. Hot and humid climate and assured supply of water is required for healthy growth of rice plant. Rice yields are largely influenced by variability in weather condition viz., maximum and minimum temperatures, rainfall, relative humidity, sunshine hours etc (Sridevi and Chellamuthu, 2015).

Rice can be grown in both dry and wet seasons. The average temperature ranges from 21-37 degree centigrade for rice growth. Rice is a semi-aquatic crop requiring saturated fields at the seedling stage and dry conditions at harvesting (Shreelatha 1989).

Rice is a widely adapted plant can grow from upland to highly submerged region under rain fed condition during monsoon. Sanchez et al. (2014) opined that optimum temperature for vegetative growth of rice is about 28 °C and optimum temperature for grain filling is about 21.7–26.7 °C. It is generally believed that higher grain yield is associated with higher incident solar radiation and higher intercepted solar radiation by rice crop canopy (Katsura *et al.* 2008). It was reported 10 per cent reduction in rice yield for 1°C increase in minimum temperature in the dry season, though the effect of maximum temperature on crop yield was not significant (Peng *et al.* 2004). Low temperature reduced the rate of grain and dry matter formation, extends the grain filling duration and delays grain maturation (Sridevi and Chellamuthu, 2015). Night temperature of less than 19 °C is the critical low temperature for inducing grain sterility in rice (Abeysiriwardena *et al.* 2002).

Poor and erratic monsoon rainfall seriously interferes with crop growth and yield. Higher relative humidity at the flowering stage under increased temperature negatively affects spikelet fertility (Yan *et al.* 2010). A relative humidity of 85-90 per cent at the heading stage induces almost complete grain

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sterility in rice at a day/night temperature of 35/30 °C.

It is estimated that about 90% of total worldwide rice is produced and consumed in Asian and African countries. Although rice is a very versatile and adaptable cereal crop ad is grown almost all over the world; however, rice is not cultivated in Polar Regions.

As per the previous studies conducted by archaeologists it is considered that the Vavilovs centre of origin of rice is the Indo-Chinese regions of Asia. The major rice growing nations of the world are China, India, Indonesia, Bangladesh, Vietnam, Thailand, Japan. India is the 2nd largest producer of rice and the major rice growing regions in India are divided as Southern region, Western region, southern region, Eastern region and North eastern region.

The North-eastern states of India, comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, lies within the international boundaries of Bhutan and China in the north, Bangladesh in the southeast and Myanmar in the west. This region constitutes the Indo-Burma biodiversity hotspot. Rice is the single most important cereal crop grown in this region. Rice is cultivated in NE India under influence of heavy rainfall on the bank of Brahmaputra River.

Production and economy of rice in India

Rice cultivation performs an extensive role in Indian subcontinent as it becomes the income source for millions of Asian people. India's rice production is estimated to about 115.60 million tonnes for the year 2019 from the cultivated area of about 43.86 million hectares which constitutes about 21.81% of the world rice production with an average productivity of 23 thousand kg/ha (FAOSTAT, 2018). Nowadays, delivering food ingredients with immense health benefits and providing food security are great global challenges. India has a long history of rice cultivation and has largest rice growing area globally, 2nd rank in rice production after China and highest export records (US Department of Agriculture; 2022-23). About 21.5% of global rice is produced from India cultivated in around 44.62 million hectares of land with annual production of 93.08 Mt with productivity of 2 tonnes per hectares. The country accounts for about 44 percent of total food grain production and play a crucial role in the country's food habit and earning source. As mentioned in the studies of Thiagranjan *et al. (*2009); India needs to increase its paddy production at the rate of 3.75 Mt per year until 2050 to meet the need of its mushrooming population and food security.

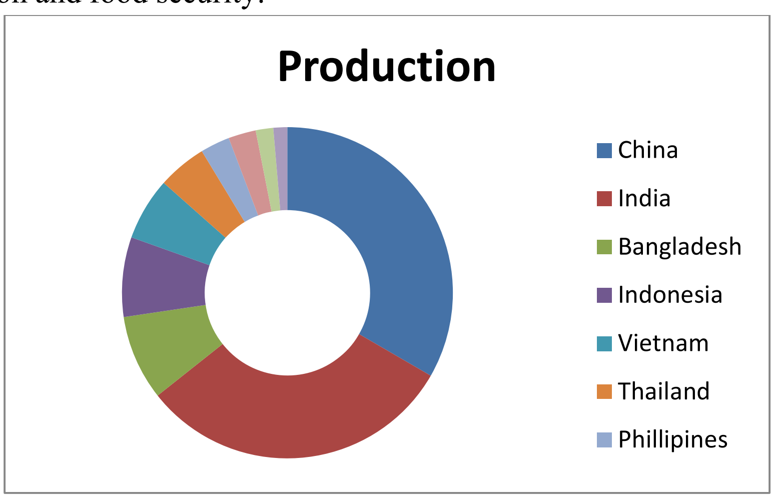

Figure 2: Pie chart representing production of rice by major rice producing countries 2022/23 (in million

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metric tonnes); Source: US Department of Agriculture 2022/23

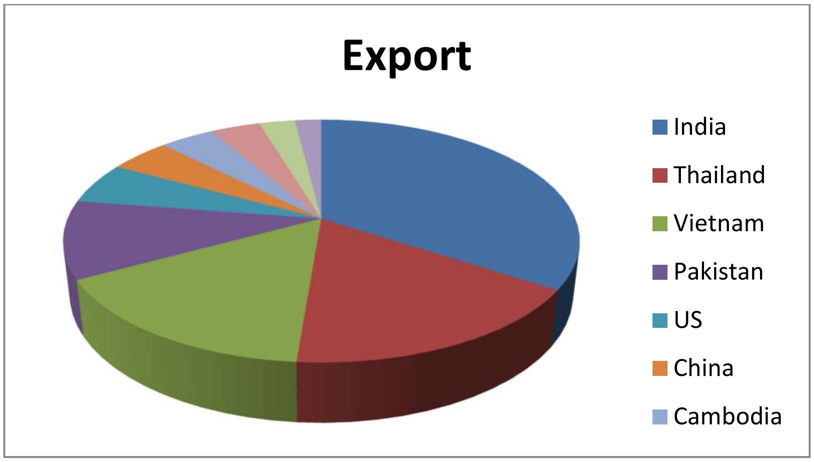

Figure 3: Pie chart showing world's biggest exporters of rice; source - US Department of Agriculture 2022/23

Structure of rice grain

The rice grain structure influences the physical and chemical properties of it. The edible part of rice grain is known as caryopsis, enfolded by husk/hull (Meera *et al.* 2021). The grain develops after completion of pollination and fertilization. The hull constitutes about 20% of rough rice weight. The dehulled rice grain appears brownish due to presence of pericarp, known as brown rice. Pericarp and aleurone layer together make the fat rich rice bran. Processing and milling of rice removes the brownish bran layer which makes rice to appear white, smooth and shiny. White rice is rich in carbohydrate. Previous studies estimated that brown rice is rich in protein, minerals, fibre, vitamins and antioxidants which makes it easier to digest and gives it a chewy texture (Bechtel & Pomeranz, 1980).

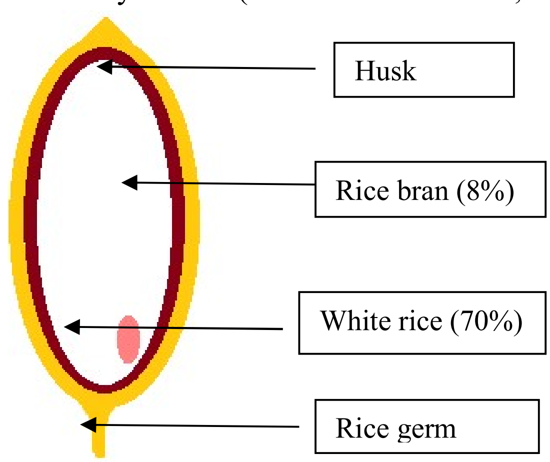

Figure 4: Structure of a rice grain

Significance of quality assessment of rice

Rice is the staple food of more than half of the global population contributing calories to 1/5th of total

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calorie intake worldwide (Smith,1998) and rice that provides 40-80% of the total calorie intake in regular Asian diet (Paramita *et al*. 2002; Singh *et al.* 2005; Hossain *et al.* 2009; Cai *et al.* 2011). As a major cereal to evaluate and analyse nutritional composition of rice is significantly important (Tan *et al.* 1999; FAO, 2004; Jiang *et al.* 2005; Dong *et al.* 2007). Rice is the third-largest food crop in the world, only after wheat and corn and it is appeared as an essential topic to analyse rice quality for improving human health utilizing food security, safety and standard quality assurance.

Across the world, rice exists in many combinations of length-width ratio, grain weight, bran colour, and endosperm chemical characteristics. End-use quality characteristics desired in some areas of the world can be entirely unacceptable to other regions. Many local rice varieties do not enter the export market other than being used close to where it is produced (Bergman, 2019). Inherent quality traits/characteristics rule rice grain quality. These quality traits are controlled by rice genotype, environmental components, and traditional practices (Kale *et al.,* 2017).

The grain quality attributes of rice that determines acceptability by the end user can be grouped into two main categories, (i) grain appearance and (ii)cooking and eating qualities (Juliano and Villareal,1993). The appearance quality is determined by grain length, breadth, length-breadth ratio, and translucency of the endosperm. The cooking and eating quality traits include volume expansion, fluffiness, cooked kernel elongation, firmness/stickiness, mouth feel and a pleasant aroma. Each of these traits is determined by the physical-chemical properties of the rice grain which in turn are genetically controlled with some modulation of expression by the growth environment. Yadav *et al.* (2007); mentioned that different rice cultivars consist of significant variations in morphological, physicochemical and cooking properties.

Parameters for quality assessment

Germination Index

Germination is the process by which plant grows from seed to a seedling. Germination test provides data of seed quality and vigour or viability of seed to predict performance in field. Germination test helps to compare performance potential or superiority of different seeds and helps in seed certification. As stated in IRRI Rice Knowledge Bank seeds with high genetic purity, high germination and vigour and of good quality i.e. disease and pathogen or damage free are taken in consideration for seed certification.

According to IRRI the germination rate is the average number of seeds that germinate over a 5- and 10-day period, helps in estimation of viability of seeds within population. Germination percentage expresses the proportion of total no of alive seeds, Seeds with more than 80% germination rate are considered good.

Previous studies found that germination rate is affected by various biotic and abiotic factors including temperature, pH, Salinity, drought etc. Wang *et al.* (2019) and Shrestha *et al.* 2022 found that the increase of temperature from 25 to 30 degree centigrade increases the germination of rice by approximately 40%. Bian (2024); mentioned that low temperature can prolong germination time of rice seed. Suriasak (2020); reported that rice exposed to high temperature during grain filling develops chalkiness and lowers grain quality and yield. Drying decreases germination rate of rice seed (IRRI).

Tiozon et al. (2023), reported that germination is a bio processing approach to increase bioavailability of nutrients in rice. They also mentioned that there is a scarcity of knowledge that how germination

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impacts nutritional components. Singh *et al.* (2022), reported that process of germination promotes nutritional complex availability and negatively interfere with digestibility of macronutrients. Xia *et al.* (2017), mentioned germination increases fibre level, stimulate bioactive compounds production such as gamma amino-butyric acid (GABA) and leads to reduced number of harmful compounds.

Nandini *et al*. (2020), during their study observed that traditional rice varieties which are native to certain place are mostly photo sensitive and more adaptive to environmental stress of that place but shows lower yield and longer duration for maturation hence most farmers prefer HYV rice cultivars.

Morphometric analysis

Rice is the most extensive cereal in human nutrition and is chosen based on grain quality. Several investigations proved that grains physical quality ultimately affects the milling and cooking quality which directly influences consumer preference (Razavi and Farahmandfar,2008). Therefore, a Comprehensive knowledge of physical and morphometric features of rice are required for designing more efficient and effective methods of harvesting, handling and it also would enable production, marketing, processing, quality evaluation and improvement (Varnamkhasti *et al*., 2007; Delshadian*et al.,* 2015; Corrêa *et al.,* 2007)

Physical and morphometric characteristics of rice grain is important as it determines consumer acceptability and helps in modelling of relevant polishing systems to achieve finer quality milled rice (Mohapatra and Bal, 2004). Also, the physical quality of rice helps to regulate the market value of paddy or rice after processing. The length, width and thickness of the rice kernel are essential to design appropriate requirements for rice milling operation and grain drying, aeration processes (Delshadian*et al*., 2015; Jouki and Khazaei, 2012).

Rice varieties are classified as long, medium and short slender, long and short bold types based on length and shape of the kernel. A length to breadth ratio of above 3 is generally considered as slender (IRRI, 1980). The analysis of L/B ratio was performed to determine the shape of individual rice grains. Researchers including Verma et al. (2013); Samal et al. (2014), reported myriad variation of L/B ratio of rice grain. Study conducted by Lodh (2002) also highlighted that rice grain quality is assessed based on grain colour, size and shape and these considered as important parameters influencing domestic consumption and international commercialization of rice. Mohapatra and Bal (2007) have studied on the physical characteristics of three Indica rice grains based on length and slender ratio. Fujita et al. (1984) reported a strong positive correlation between grain weight and grain length.

In morpho-metric character analysis length, width and thickness of grain or kernel is analysed which influences physical properties including milling and head rice recovery etc (Rehman *et al.* 2021). Morphometry study is the basic of genetic diversity analysis (Lahkar and Tanti, 2017). According to Lakshmi and Chamundeswari (2021), there is a positive co relation between raw kernel and cooked kernel i.e. kernel with more L/B ratio shows more elongation after cooking. Amount of water absorbed by rice during cooking is considered to affect kernel elongation.

A positive co relation is also observed between grain length and weight. According to Krishna *et al. (*2008*)* longer kernels exhibit more weight compared to smaller ones. 20-30gm of weight is desirable for one thousand kernels as per study conducted by Kwarteng *et al*. (2003). But the long slender grains are more susceptible to breakage than short and bold grains. Previous studies revealed that there is no relation between kernel length and breadth indicating that

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those traits are inherited separately. Rice variety that shows more lengthwise expansion than girth wise expansion is more preferable to consumer (Pathak *et al.* 2016).

Xing *et al.* (2002) stated that grain length, width and thickness are the three components to accurately determine grain shape and grain size is an important determinant of rice quality (Tan *et al.*2000). Bocevska *et al*. (2009); Moongngarm *et al.* (2010), mentioned that is reported to be influenced by various physicochemical characteristics determine the rice grain quality which in turn influences cooking behaviour as well as the cooked rice texture.

Cooking property

Rice is primarily consumed as whole grain in the form of cooked kernels. Hence, cooking quality has been given the paramount importance that ultimately influences consumer's satisfaction, acceptability and farmers choice of cultivar. Desirable softness, texture and palatability of rice kernels influence rice eating quality and end determines marketability (Meera *et al*. 2021). These qualities are primary determiner of choice controls rice price in the market (Oko *et al*. 2012). The distinction of rice cooking quality is a parameter for analysis of its total diversity inside diverse varieties. Cooking and sensory quality refers to the inclusive estimation of the colour, smell, shape, taste, palatability after cooking (Lahkar and Tanti,2017). For assessment and characterization of cooking quality of rice traits such as water uptake ratio, solid gruel loss during cooking, minimum cooking time kernel elongation ration etc are considered.

Rice can be cooked by various methods viz. pressure cooker, microwave or traditional boiling by subjecting rice kernels to surplus or restricted water content. Along with processing and milling treatment of rice kernel during cooking also shows effect on cooking and eating quality of rice (Yadav and Jindal, 2007). In current scenario people all over the world mostly prefer white polished rice over rice with bran layer as white rice takes less time for cooking and has more soft texture. Pigmented rice has hard texture, colour, chewiness and vast cooking time. Rice kernel consisting rice bran cover is less palatable which makes it less consumer viable. On the other hand, although milled rice predominant the market, the increasing health consciousness among people shifting the preference towards more superior nutrition consisting pigmented rice with good cooking attributes (Li and Gilbert, 2018).

The culinary features of rice were determined by minimum cooking time (MCT), water uptake ratio (WUR), hydration properties, loss of leached solids, grain expansion ratio and texture of cooked rice (Bergman, 2019). Cooking time of rice differs among rice cultivars and is identified by positioning the cooked rice between 2 glass slip for pressing until it becomes translucent. Tenderness and stickiness of cooked rice are determined by optimum cooking time (Shinde *et al*. 2014)

Several investigations proved that rice from different cultivars shows remarkable variation by their cooking quality and physicochemical attributes which directly persuade the consumer preferences or choice in rice selection they use. During cooking some functional changes like volume expansion and moisture absorption occurs in the rice cooking properties while, cooking time influences the moisture absorption in cooked rice and volume expansion of the rice kernel was influenced by the cooking temperature (He *et al*., 2018). Observations of various workers including Rehman *et al*. (2021) revealed that fine, slender, long grains show more lengthwise elongation after cooking, while medium and short grain milled varieties appear opaque and sticky. Longer rice shows higher water uptake, higher elongation ratio and lower gruel solid loss than the short and medium ones.

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Sandhu *et al.* (2018) in his study on *indica* rice PUSA 1121 cultivar reported that higher cooking time of rice is related to lower surface are and round shape. Gruel solid loss determines stickiness of cooked rice. They also reported that increased percentage of gruel solid loss is related to the loss of macronutrients especially lipids and proteins on granular swelling during cooking. Minimum cooking time of rice variety shows close association with its appearance, chalkiness, tenderness, textural quality, hardness, mouth feel and cohesiveness of rice variety.

Functional property

Analysis of functional characters includes study of Water Absorption Index (WAI), Swelling Power (SP), Oil Absorption Index (OAI), and Gelatinizing temperature (GT) etc. OAI reveals rice cultivar which is more suitable for food preparation as oil absorption enhances flavour and mouth feel of food. Hydration capacity and oil absorption influences commercial viability and culinary versatility of rice and are essential parameters for functional attributes assessment (Furia,1973). For hydration capacity determination water absorption index (WAI), water solubility index (WSI) and swelling power is taken under consideration. Hydration behaviour is an important parameter for cooking quality analysis of rice. Sowbhagya *et al.* (1994); mentioned that swelling and solubility of rice flour is related to hydration analysis and influence physiochemical properties such as chalkiness, amylose content and gelatinizing temperature. They also mentioned that waxy rice has more swelling and solubility in comparison to non-waxy varieties. Sowbyagya *et al*. (1994), reported correlation between swelling power and solubility with water absorption which is influenced by temperature and amylose content and hydration behaviour is influenced by physical and chemical properties of rice grain. Hussain *et al.* (2020); has observed a significant variation among rice cooking qualities of various cultivars. Rice volume expansion and hydration ratio of three cultivars varied from 3.85-3.92 mm and 228.76-284.16 g, respectively. Furia (1973), mentioned oil absorption capacity influences culinary versatility and texture of cooked rice.

Proximate composition

Rice, which is considered as a 'queen' among cereals contains myriad ingredients that provides beneficiary effect in human health system (Meera *et al.* 2021). Rice accounts for 21% of global human per capita energy, 15% of per capita protein and 21% fat supply (Maclean *et al*., 2002). Rice is a profound source of carbohydrate in the form of starch, contains fair amount of energy source but fortification enhances beneficiary elements of rice grain (Lahkar and Tanti, 2017).

Zhou *et al.* (2002), mentioned in his study that proximate composition of rice varies to a wide extend based on environmental, agronomic condition and soil fertility and evaluation of proximity of rice enhances its economic value (Otegbayo *et al*. 2001). We can assess the proximate composition of rice in various fractions including moisture, ash, crude protein, fat, crude fibre and carbohydrate content (Dong *et al.* 2007).

Verma *et al. (*2017) mentioned rice as a supplier of about 12% moisture, 70-80% carbohydrate, and few amount of digestible protein.A study conducted by Abeysekera *et al. (*2017**)**, on some indigenous rice varieties of Sri Lanka revealed significant variation of moisture content ranging from 11-12%, presence of protein content >10%, crude fat ranging from 2.18 to 4.12%; crude ash ranges from 1.30 to 1.92%, and carbohydrate 81-84%. Lipid, mineral and crude fibres are mostly confined to this pericarp. But Grist (1984); mentioned in his study that in case of milled rice there is loss of protein up to 6.0% to

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29.1%; likewise, loss of lipid is 84.00% to 86.50% crude fibre 33.3% to 81.85%, and ash content 24.15% to 70.50% depending upon the degree of milling. However, the proportion of carbohydrate increases, not due to physical increase but due to proportionate decrease of protein, mineral and lipid.

Ash is the total mineral content of food sample and analysis of ash gives us the information about the total quantity of mineral elements and inorganic components present in the food. Moisture and organic materials like protein, fat, carbohydrates are removed by oxidation or incineration using muffle furnace to obtain ash contents present in sample. Ash is later determined from loss of weight total sample after combusting at high temperature (500–600-degreecentigrade's).

IRRI analysed 2674 rice varieties of *O. sativa,* and revealed protein content of *O. sativa* rangedfrom 4.5%-15.9% (Kennedy *et al.* 2003). Rice varieties with >13% protein content is considered as high protein containing varieties. A positive correlation b/w amount of protein and ash reported by Thongbam *et al.* (2010) and negative correlation b/w fat and ash ($r=-0.899$, $p<0.001$) reported by Rasool *et al.* (2015).

The determination of the water or moisture content of a food and, conversely, of the dry matter or total solids is important not only to provide a basis for expressing the content of the other components on a wet- or dry-basis, but also as an important factor in food stability and quality. Food processing gets affected by amount of moisture present in sample hence an analysis of moisture content becomes important to predict behaviour of rice sample during processing, storage and consumption. It is believed that rice flour containing more than 12% moisture have lesser storage stability than those with a lower moisture content. Rasool *et al.* (2015) stated that non-significant variation of moisture content among rice varieties indicates that the rice cultivars either grown in same agro-climatic region or paddy stored in same area. Variation of moisture content among the cultivars studied by Rasool *et al. (2015)* ranged between 12.18 to 12.63%.

Twinomuhwezi *et al.* (2020), mentioned fat contributes to food flavour by improving lusciousness of food. Fat values vary significantly according to rice variety and it ranges from 1.72-3.37% in brown rice and 0.09-1.52% in milled rice (Wang *et al.* 2006). Study conducted by Sarma *et al*. 2023, on Bora rice revealed that amount of fat content varied from 2.7% to 1% among different cultivars. And fat among Joha rice cultivars varied from 0.61%- 2.07% as mentioned by Lahkar& Tanti (2017). Studies also revealed presence of dietary fibres presence in rice bran.

Samaranayake *et al.,* (2017) reported that the whole grain flour of the selected varieties was studied for moisture, crude fat, crude protein, crude ash, available carbohydrates, total dietary fibre and sugar contents using standard analytical techniques (n=3), while oil extracted from rice bran was studied for the fatty acid profile using gas chromatographic technique (n=3). Chaudhari *et al.* (2018); found that, the rice is most common cereal, serving as a stable food for approximately half of the global population. Over 2 billion people in Asia alone derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7–8% protein, 3% fat, and 3% fibre. Analysis of nutritive value some selected rice cultivars by Dutta *et al*. (2018), shows that protein content varied from 7.20% to 10.86%, carbohydrate from 68.05% to 81.52% and lipid content from 1.90% to 3.57% with calorific value in the range of 320.87 Kcal/100gm to 376.83 Kcal/100gm. On the other hand, dietary fibre varied from 0.92% to 1.40% while total mineral in the form of ash content varied from 0.90% to 1.43%. Rice kernels consist of about 7-17% of protein composed of essential and digestible protein, which may decrease after removing of

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the bran layer from 7-10% (Verma and Shrivastav, 2017) They also mentioned that freshly harvested rice grains contain about 80% carbohydrate which includes starch, glucose, sucrose and dextrin. Mohanty *et al*. (2011); reported that the two high protein rice cultivars viz. ARC 10063 and ARC 10075 from traditional Assam Rice Collections were found to contain about 15 – 16.42% crude protein (Nx5.95) on dry weight basis. Aishwaraya *et al*. (2017); found that total soluble protein content ranged from 7.54 g/100g to 14.54 g/100g of in the samples studied by them. Among 150 accessions, eight lines had recorded significantly higher protein content (>10.50 g/100g), 48 lines had registered moderate content (9.01 to 10.50 g/100g) and 94 lines had registered low protein content(<9.00g/100g).

Conclusion

Rice quality assessment is crucial for ensuring consumer satisfaction and meeting market demands. Factors such as germination rate, physical characteristics, cooking properties, and proximate composition play significant roles in determining the overall quality of rice. Understanding these aspects helps improve cultivation practices, processing methods, and nutritional benefits, ultimately contributing to global food security and economic stability.

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