QUALITY EVALUATION OF NEWLY RELEASED KAU RICE (*Oryza sativa* L.) VARIETIES AND THEIR SUITABILITY FOR TRADITIONAL FOOD PRODUCTS

By

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DECLARATION

I, hereby declare that this thesis entitled **"Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products"** is a bonafide record of research work done by me during the course of research and that this thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled **"Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products"** is a bonafide record of research work done independently by **Mrs. CHANDHNI A. A.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to her.

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ABBREVIATIONS

AOAC	- Association of Official Analytical Chemists
g	- Gram
mg	- Milligram
ml	- Millilitre
µg	- Microgram
%	- Per cent
WAI	- Water Absorption Index
WSI	- Water Solubility Index
UR	- Unroasted
R	- Roasted
w. r. t.	- With respect to

Introduction

INTRODUCTION

'Rice is vitality, rice is vigor too and rice indeed is the means of fulfillment of all ends in life. All gods, demons and human beings subsist on rice'

(Krishi-Parashara)

Rice is the staple food of more than half of the world's population. Every third person on earth eats rice every day in one form or another. Rice is the other name for food in Asian countries. Rice has become the 'Grain of Life' for 2.4 billion Asians, as Asia accounts for 92 per cent of world's rice production and 90 per cent of global rice consumption. Rice is cultivated in 157 million ha in the world, of which 90 per cent of the area is in Asia. Rice (*Oryza sativa L.*) is the most versatile cereal crop that provides 21 per cent of global human per capita energy and 15 per cent of per capita protein. India has the largest acreage of 44 million ha under rice with a production of 100 million tonnes (FAO STAT, 2013).

Rice based systems are pivotal for food security, poverty alleviation and improved livelihood. Rice is a symbol of cultural identity and global unity as many religious observances, festivals, customs, cuisine and celebrations are connected with rice. It is foreseen that world population may exceed 8 billion by 2025 and about 765 million tonnes of rice will be needed to meet the demand of the growing population (Premkumar *et al.*, 2012).

Rice (*Oryza sativa L.*) belongs to the family *Poaceae* and the tribe *Oryzeae*, which consists of 12 genera including the genus *Oryza*, with specific differences among their morphological and genetical traits (Subramaniam, 2012). Rice in India is cultivated under the widest range of growing conditions namely upland hills of Himalayas in Kashmir to low-lying *Kuttanad* areas of Kerala (Boopathi *et al.*, 2012).

India alone has 1,00,000 traditional varieties still in use by farmers around the country and another 3,00,000 have become extinct (Vivekanandan, 2012).

Red rice consumed by Keralites is characterized by a red bran layer in which most of the micronutrients are concentrated and a red tinge remains even after high degree of milling. The colour of the bran ranges from light to dark red. Coloured rice have been preferred in the past for their special features such as medicinal value and exclusive taste. In India, red rice have occupied a special position since time immemorial (Ahuja *et al.*, 2007). A number of red grained varieties were cultivated in Kerala, Tamil Nadu, Karnataka and the north eastern states with areas having unfavourable conditions such as deep water, drought, sandy soils, salinity, and cold conditions. A great diversity in cultivars exists among red rice. The states of Kerala possess a rich variability of genetic resource in red rice (Adheena and Elsy, 2012). They are glutinous and non glutinous, scented and non-scented, late and early maturing and short and long grained. The introduction of high-yielding varieties with the advent of green revolution and the market demand of white rice have resulted in a drastic reduction of the area under red rice in India.

Rice grain quality has become an important issue affecting domestic consumption and international trade of rice. Marketing potential of red rice can be widened with identification of the nutritional benefits among health conscious consumers. Intrinsic properties like amylose, gelatinization temperature and gel consistency determine the market quality of rice as well as its products (Lodh, 2002). Consumers concept of grain quality involves grain appearance, size and shape of the grain, behaviour upon cooking, taste, tenderness and flavour of cooked rice. Cultivars with different grain qualities are also required for medicinal, ceremonial, and end use specific production purposes. The better understanding of the factors that contribute to the overall grain quality of rice is vital in rice breeding programmes. Such knowledge is necessary to meet the growing global demand for high quality rice and thereby generating higher export revenues. Determination of grain quality features is imperative in adoption of newly released varieties as well for defining their suitability for products.

Hence, the present study on red rice entitled 'Quality evaluation of newly released KAU rice *(Oryza sativa L.)* varieties and their suitability for traditional food products' has been undertaken with the following objectives.

1. To evaluate the physical, cooking, biochemical, nutritional, organoleptic and keeping qualities of newly released KAU rice varieties.
2. To assess the suitability of these varieties for preparation of selected traditional food products.

Review of literature

2. REVIEW OF LITERATURE

Literatures pertaining to the study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' are reviewed under the following headings.

2.1 Rice – 'The grain of culture'

2.2 Diversity in rice varieties

2.3 Quality attributes of rice varieties

2.4. Rice based traditional food products

2. 1 Rice – 'The grain of culture'

Rice (*Oryza sativa L.*) is the grain of culture which shaped our history, tradition, diet and economy of billions of people. Rice has played a significant role in framing the culture as well as the economy of many societies. Rice is known as the grain of life and is synonymous with food for Asians (Fresco, 2005 and Ahuja *et al.*, 2008). In Asian countries rice is not just a cereal, it is the root of civilization.

Rice has been grown in Asia for at least 10,000 years and it has richly influenced the cultures and lives of billions of people. Our myths, beliefs, festivals, traditions, rituals and languages are associated with rice cultivation practices (Gomaz, 2001 and Chatry, 2001). Our proud heritage that transcends ethnicities and conventional cultures are evolved from the depth green fields. Rice is depicted as an important food crop which feed majority of the people in the world (Rangasamy *et al.*, 2012). According to Sathyan (2012), rice is life for more than half of the humanity in the world.

The use of rice, dates back to *puranic* period. References regarding the use of red, black and wild *nivara* rice appear in the Agni Purana (900 AD) and the *Vishnu Purana* (200 AD) (Kumar, 1988 and Sensarma, 1992). According to Hindu mythology rice is depicted as a heavenly gift and is positioned as an essence of life by Buddist culture. It was narrated in different mythologies that Lord Krishna and Sribhudda were pleased with rice delicacies. In India, rice is associated with prosperity and is used for worshiping the Hindu Goddesses Lakshmi and Durga (Sharma, 2003).The history of rice goes back to 130 million years and excavations by archaeologists have found rice dating back to 2000 BC from Mohanjodaro, Lothal and Rangpur. Rice has been planted before 5,500 years ago (around 2960 BC) (Katewongsa, 2005).

Red rice varieties were used as food in India, China, Korea, and Japan since more than 3,000 years (Ahuja *et al.*, 2007). Description about the medicinal and nutritive qualities of *njavara* rice was found in various ancient treatises of Ayurveda such as *Ashtanga Hrudayam* (Vagbhatta, *circa* 400–500 A.D.) (Mohanlal, 2011). Rice is first mentioned in the Yajur Veda (c. 1500-800 BC) and frequently referred in Sanskrit texts. According to Sandhu and Diwaker (2014) rice is depicted as a symbol of prosperity and fertility.

Rice was treated as a spiritual commodity and there was no ritual without rice. In India, this grain is anchored in various traditions related to birth-to-death cycle. According to Chandran (2009) rice is used in different auspicious days of our life like *annaprasanam, vidya-arambham,* marriage and also during funeral ceremony. Thus, rice is well integrated into every stage of our life cycle. Hence ancient people considered rice as their life.

Rice is the predominant cereal that feeds the world with 600-800 millon tonns produced annually (FAOSTAT, 2009). Rice has turned to be the most significant food crop of the world providing the calorific requirements of the majority of the population. Rice is cultivated in 157 million ha in the world of which 90 per cent of the area is in Asia which also accounts for 90 per cent of the total global rice production (Rangasamy *et al.,* 2012). Sandhu and Diwaker (2014) reported that, more than 430 million metric tons of rice was consumed worldwide.

Gurinder *et al.* (2006) reported that, rice is the mainstay of diet of approximately 55 per cent of people and 70 per cent of population depend on rice production for their livelihood. In the Indian subcontinent, rice is cultivated in more than a quarter of the cultivated land. Rice is a very essential part of the daily meal in the southern and eastern parts of India (Ahuja *et al.*, 2007).

Nayak *et al.* (2014) reported that, globally India stands first in rice area and sècond in rice production.

According to the USDA (2013) India was the world's largest rice exporter in 2012-2013 with exports of around 10.9 million tons. FAO has estimated India's 2014 aggregate paddy rice production at around 157.5 million tons (FAO, 2014).

Rice plays a fundamental role in world's food security and socio-economic development. Rice is a major cereal crop in the developing world. It is consumed as a staple food by over one-half of the world's population with approximately 95% of production in Asia (Paramitha *et al.*, 2002 and Singh *et al.*, 2003). It is the livelihood of millions of rice producers, processors and traders worldwide (Fresco, 2005). It is the staple food for more than 65 per cent of the Indian population. Being a source of livelihood for about 100 million rural households, it has become a major agriculture and economic product for the people all over the world (Ahuja *et al.*, 2007).

2. 2 Diversity in rice varieties

Oryza sativa is the species of rice cultivated worldwide. The asian domesticated rice, *O. sativa* strains are classified into two ecotypes, *indica* and *japonica*. The third ecotype *javanica* has also reported (Cheng *et al.*, 2003 and Garris *et al.*, 2005). Historians believe that the *indica* variety of rice was first domesticated in the area of Eastern Himalayas. The *japonica* variety, domesticated from wild rice in southern China which was introduced to India (Ahmad, 2014).

Rice (*Oryza sativa L.*) belongs to the family *Poaceae* (*Graminae*) and the tribe *oryzeae*, which consists of 12 genera including the genus *Oryza,* with specific differences among their morphological and genetic traits (Subramaniam, 2012).

Rice has the most diversified crop species due to its adaptation to wide range of geographical ecological and climate regions. According to Vivekanandan (2012) India alone has 1,00,000 traditional varieties still in use by farmers around the country and another 3,00,000 have become extinct.

In the traditional rice growing areas of Asia, rice of various colours like red, purple, black, brown, yellow, and green have been known and grown. Coloured rice has been preferred in the past for their special features such as medicinal value and exclusive taste. Ahuja *et al.* (2007) indicated that red rice occurs as wild, weedy or cultivated types and the red kernels are covered with dark or light coloured husk. The author also mentioned that flavoured, black rice were the favorate of the royals of

China, while red rice were preferred by people in many parts of India, Sri Lanka, and Bhutan.

Susruta (c. 400 BC), *Charaka* (c. 700 BC), and *Vagbhata* (c. 700 AD), the well-known Ayurvedic practitioners of historic period considered red rice (*raktashali*) as the best among the *shali* varieties of rice. The *Garuda Purana* gives the details of the medicinal uses of red *shali* as a destroyer of the three *doshas*. *Mahashali* is referred to as highly restorative (Kumar, 1988). The author also reported that, mentions about red rice was found in the Buddhist scripture *Milinda Panha*, which dates back to the reign of the Greek king Manadros (*Milinda*in Sanskrit) of 1st century BC. Krishnamurthy (1991) reported that the author of *charakasamhitha* and other later authorities classify the *raktashali* or *lohatshali* rice with red husk and grain as the best for medicinal purposes. In *Kashyapiyakrishisukti*, one of the first Indian treatises on agriculture, the compiler Kashyapa (c.800 AD) describes various *shali* rices namely *shali*, *kalama*, and *sambaka* type (Ayachit, 2002). Red rice was highly valued as they had the power to redress the imbalance in the *tridosha* which are the basic operating principles that govern the psychobiological aspect of the body (Ahuja *et al.*, 2007).

India is home to wide varieties of rice cultivars. To feed the ever increasing population, release of rice varieties and hybrids of high yield potential is given prime importance. Apart from different traditional rice varieties, in last three decades 632 varieties were developed and released for commercial cultivation in India (FAO, 2002). Samba Mahsuri (BPT 5204) is an elite fine grain type rice variety which is grown extensively in India which contributing to 1/3 rd of country's rice production (Kumar *et al.*, 2012). Three out of the best varieties in the country namely *Samba Masuri* (BPT 5204), *Swarna* (MTU 7029) and *Vijetha* (MTU 1001) were released by Acharya N. G. Ranga Agricultural University. A high yielding, fine grain variety possessing premium grain and cooking quality, named as improved *Samba Mahsuri* (RP Bio 226) was released by Directorate of Rice Research.

Patani of Maharashtra and *Jatu* and *Matali* of Kulu valley are famous red rice varieties of Himachal Pradsh (Ahuja *et al.*, 2007).The variety from Maharashtra, *Ratnagiri* 4 is a midlate duration (125-130 days), mid tall in height and high yielding variety (Apte *et al.*, 2012).

Gangavati Sona (GNV-05-01) is a high yielding paddy variety for irrigated ecosystem of Northern Karnataka (Ibrahim *et al.*, 2012).

Rice varieties developed by Perunthalaviar Kamaraj Krishy Vigyan Kendra, Pudhuchery are Puduvai Ponni (PY-1), Punithavathi (PY-2), (Bharathidasan (PY-3), Jawahar (PY-4), Aravindar (PY-5), Subramania Bharathi (PY-6) and Annalakshmi (PY-7) (Purushothaman *et al.,* 2012). *Kavuni* is a traditional rice variety from *Tamilnadu*, known for its anti-diabetic properties (Valarmathi *et al.*, 2012).

Kerala is well known for the rich genetic diversity of the traditional rice varieties grown in various seasons and in different agro-climatic conditions. Rice varieties cultivated and practices of cultivation in Kerala are unique and need special attention. Kerala has been identified as the portable centres of origin of *Oryza sativa* due to the vast diversity of land races and occurrence of wild races (Rosamma *et al.*, 2003).

Around 60 rice varieties has been released by the Regional Agricultural Research Sation, Pattambi. *Eravappandi*, Ptb-19, Ptb-21 (*Thekkan*), PTB-33 (*Arukkarayi*) have International reputation due to their disease resistance capacity. The improved local strains and high yielding red rice varieties are released by the

Regional Agricultural Research Station, Pattambi are *Aryan* (Ptb 1), *Ponnaryan* (Ptb 2), *Eravapandy* (Ptb 3), *Vellari* (Ptb 4), *Veluthari Kayama* (Ptb 5), *Athikkiraya* (Ptb 6), *Parambuvattan* (Ptb 7), *Thavalakkannan* (Ptb 8), *Thekkancheera* (Ptb 10), *Thekkan Chitteni* (Ptb 11), *Kayama* (Ptb 13), Jeddu Halliga (Ptb 17), *Eravapandy* (Ptb 18), *Athikkirayan* (Ptb 19), *Vadakkan Chitteni* (Ptb 20), *Thekkan* (Ptb 21), *Velutha Vattan* (Ptb 22), *Cheriya Aryan* (Ptb 23), *Chuvanna Vattan* (Ptb 24), *Thonnooran*(Ptb 25), *Chenkayama* (Ptb 26), *Kodiyan* (Ptb 27), *Kattamodan* (Ptb 28),*Karutha Modan* (Ptb 29), *Chuvanna Modan* (Ptb 30),*Elappapoochampan* (Ptb 31), *Aruvakkari* (Ptb 32), *Arikkirai* (Ptb 33), *Valiya Champan* (Ptb 34), *Annapoorna* (Ptb 35), *Jyothi* (Ptb 39), *Sabari* (Ptb 40), *Bharathy* (Ptb 41), *Rasmi* (Ptb 44), *Matta Thriveni* (Ptb 45), *Nila* (Ptb 48), *Aathira* (Ptb 51), *Aiswarya* (Ptb 52), *Mangala Mahsuri* (Ptb 53), *Karuna* (Ptb 54), *Harsha* (Ptb 55) and *Varsha* (Ptb 56) (Rosamma *et al.*, 2003 and KAU, 2012).

Annapoorna (Ptb-35) is the Asia's first high yielding short duration variety. *Jyothi* was released in 1974 and is the most commonly used rice variety of Kerala state. *Matta Triveni* (Ptb-45) a high yielding variety was released in 1990. *Kanchana* (Ptb-50), *Athira* (Ptb-51), *Aishwarya* (Ptb-52) are high yielding varieties released from RARS Pattambi. *Kanchana* (Ptb-50) is a rice variety released in 1993 and *Mangalamashoori* (Ptb-53) is a highly yielding variety released in 1998. *Harsha* (Ptb-55) is also a high yielding variety suitable for upland cultivation. *Samyuktha* (Ptb-59) is a high yielding variety for *kootumundakan* system of farming. *Vaishak* (Ptb-60) is released in 2010 and is suitable for upland cultivation (KAU, 2012).

Jyothi is a high yielding red rice variety (PTB 39) and is mainly consumed as a staple food in Kerala in the form of table rice (Nair *et al.*, 2005). *Matta* of Kerala is a famous red rice variety (Ahuja *et al.*, 2007). The most popular rice variety of the State is *Uma* (MO.16) developed by Rice Research Station, Moncompu followed by

Jyothi, developed from the Regional Agricultural Research Station, Pattambi. The other varieties popular in the State in the order of their preference are *Aiswarya, Kanchana, Aathira, Matta Triveni, Harsha, Vaishak, Bhadra, Krishnanjana, Makom* and *Gouri* (Kumari, 2012).

Pokkali rice have red kernelled bold grains and are tolerant to water-logging, salinity, and acidity. High genetic diversity exists within the *pokkali* varieties. *Pallippuram Pokkali, Kuzhippalli Pokkali* and *Vettikkal Pokkali* are grown in different regions. Other saline resistant varieties of the tract include *Cheruviruppu, Chettiviruppu, Kuruka* and *Anakodan.* Varieties like *Orumundakan, Eravapandy, Orpandy* and *Orkayama* etc, are photosensitive and are grown during the second crop season (Kumari, 2007). Adheena and Elsy (2012) have reported that the traditional *Pokkali* varieties like *Chettivirippu, Chootupokkali* and *Pokkali* are introduced from Kerala.

'*Njavara*' rice (*Oryza sativa L.*) is a medicinal red rice variety endemic to Kerala in India. Morphologically '*Njavara*' is similar to ordinary rice with husk colour varying from golden yellow to brownish black (Menon, 2004). Two types of *Njavara* have been identified, the white glumed and black glumed, both of which are used in Ayurvedic treatments (Kumari, 2007 and Mohanlal, 2011).

Chennellu and *Kunjinellu* are varieties indigenous to North Kerala. *Kunjinellu* is a variant of red coloured grain. *Chennellu* with bright red grains, grown as an upland variety in parts of Kannur district (Kumari, 2007). Traditional rice varieties like *Kamadara, Mukinnaveluthu, Dhandan, Jeerakashala, Vettuveliyari, Churulakkari, Sampathalan, Vazhakkannan,* were reported to be traditionally cultivated in Kerala (Nair, 2013).

Erumakkari and *Karuthachembavu* are the traditional rice varieties indigenous to South Kerala. *Karuthachambavu* has black grains, blackish red kernels and black endosperm. *Annoori*, a wild species of rice is used by the *kani* tribes for treatment of small pox. *Kavunginpoothala*, a rice variety indigenous to Palakkad District is given to diabetic patients to reduce discomfort (Kumari, 2007). *Kuthiru, Orkayama, Karivennali, Pokkali, Kolivalan, Malayudumban, Orkayama* were rice varieties mentioned in Krishigeetha (Kumar, 2008).

Kuthiruvithu, Kochumundon and *Mundon* are the saline tolerant varieties of the Kaipad system of Kannur District (Kumari, 2007). *Ezhome-1* and *Ezhome-2* were released as Kaipad varieties for commercial cultivation in saline prone Kaipad ecosystem in the state of Kerala. The donor parent of the variety *Ezhome –1* is *Kuthiru* and that of *Ezhome -2* is *Orkayama*. *Ezhome –1* is a long duration variety with 135 -140 days duration, and *Ezhome -2* is a medium duration variety of 120 -122 days duration (Vanaja and Mammootty, 2010).

Traditional varieties like *Mundakan, Karamundakan, Karimundakan, Vellamundakan, Athikkirazhi mundakan* and *Oarumundakan* are photosensitive, tall *indica* varieties possessing tolerance to salinity, popularly grown during the Mundakan (second crop) season in *Onattukara* ecosystem (Kumari, 2007).

2. 3. Quality attributes of rice varieties

Being a major cereal grain, evaluating the nutritional and cooking qualities of rice has been given highest priority. Rice is the only cereal crop consumed mainly as whole grain and quality considerations are much more important than any other food crop (Paramita *et al.*, 2002 and Hossain *et al.*, 2009). Rice grain quality is influenced by various physicochemical characteristics that determine the cooking behaviour as well as the cooked rice texture (Bocevska *et al.*, 2009 and Moongngarm *et al.*, 2010). Awasthi *et al.* (2011) observed significant variation in the physical characteristics, chemical composition and antimicrobial activity in the marketed rice brands available in Bangalore.

Rice variety, drying and storage conditions, rough rice moisture content, amylose content, starch type, degree of milling, water to rice ratio, cooking methods, pre-cooking and post-cooking processing are the deciding factors for the cooking and textural characteristics of rice (Mohapatra and Bal, 2006). In *japonica* rice eating countries, low amylose, short grain is preferred. In *indica* rice consuming countries, long grain with intermediate amylose and gelatinization temperature is preferred (Hossain *et al.*, 2009). Ashogbon and Akintayo (2012) also indicated that varietal and cultivar differences can be considered as the major factor behind differences in cooking behaviour of rice. Babu *et al.* (2012) indicated that grain quality characteristics like milling percentage, grain appearance, cooking quality and nutritional components are very important in rice.

Nandini (1995) observed a higher head rice yield in traditional varieties. The highest rice yield was observed for variety *Chuvannari, Thavalakannan* followed by *Vyttila-3*. Lakshmi (2011) and Sathyan (2012) observed a head rice recovery of 62.16 per cent and 33.66 per cent in parboiled as well as raw rice of *Jyothi*.

Rice varieties are classified as short, medium or long grains by rough kernel dimension ratio (Slaton *et al.*, 2001). Rice buyers, millers and consumers, judge the quality of the uniformity of its size and shape as well as the appearance and overall size-shape relationship (Armstrong *et al.*, 2005). Consumers preference varies based on the type of rice and their origin (Azabagaoglum *et al.*, 2009 and Musa *et al.*, 2011). A study conducted by Sugeetha (2010) among eight pre-release rice cultures of KAU for various quality attributes found that the mean length of grain was found to be highest for MO8-20-KR (6.88 mm) and lowest for MO-87-5 (5.60 mm). The width was found to be highest for the variety OM-3 (2.73) and lowest for MO-95-1 (2.29) variety.

In a study on new rice type genotypes, it was found that kernel length/width ratio of cooked rice ranged from 2.04 to 3.95 and 2.39 to 5.07 respectively (Sandeep and Zaman, 2003; Hossain *et al.*, 2009 and Danbaba *et al.*, 2011). Highest length and breadth ratio was recorded for the local white rice (3.75) whereas, the lowest ratio was recorded for brown rice (2.09) (Thomas *et al.,* 2013). Lakshmi (2011) reported that parboiled *Jyothi* rice variety have grain length of 6.70mm, grain width of 2.50mm and length and breadth ratio of 2.66 and is of long medium. Sathyan (2012) observed grain length of 6.65 mm, grain width of 2.20 mm and length and breadth ratio of 3.02 in *Jyothi* variety which specifies the grain as long slender.

Nandini (1995) observed that among 60 rice varieties, thousand grain weight of husked rice was found to be higher in hybrid derivatives of rice *Reshmi* and *Vyttila-3.*Singh *et al.* (2003) found that the thousand kernel weight of translucent grain was significantly lower than chalky grains obtain from different varieties. According to Sugeetha (2010), the highest value for thousand grain weight for raw rice was recorded for M-108-262-1 (23.34 g) variety.

Parboiled *Jyothi* rice has grain weight of 26.56 g and grain volume of 3 mm^3 (Lakshmi, 2011). Sathyan (2012) observed *Jyothi* rice have a grain weight of 25.67 g and grain volume of 25.8 mm^3.

The physiochemical properties of six different rice varieties from Malaysia were evaluated by Thomas *et al.* (2013) and it was found that glutinous rice had the highest thousand kernel weight (19.43 g) followed by Bario rice (19.23 g) and brown rice (18.66 g) respectively. The lightest thousand kernel weight was recorded for the white rice variety (16.97 g).

According to Lakshmi (2011) and Sathyan (2012) bulk density of 0.84 g/ ml was observed in parboiled as well as in raw rice of *Jyothi* variety. Thomas *et al.* (2013) reported that bulk density was highest in brown rice (0.86 g/ml), followed by glutinous rice (0.83 g/ml) and Bario rice (0.82 g/ml) among six rice varieties of Malaysia.

The water absorption index of 17.60 and 22.07 was noticed in parboiled as well as raw rice of *Jyothi* variety (Lakshmi, 2011 and Sathyan, 2012). The authors also found water solubility index of 0.20 and 0.12 in parboiled and raw rice of *Jyothi* variety.

Aroma of cooked rice is an important attribute of rice as it determines the market price of the rice and shows the local and national identity (Melissa *et al.*, 2009).

According to Tan *et al.* (1999) cooking quality of rice is directly related to the physical and chemical characteristics of the starch in the endosperm and amylase and amylopectin ratio. In a study conducted by Thomas *et al.* (2013), brown rice took longest cooking time of 31.67 minutes than white rice varieties.

Sugeetha (2010) reported the highest cooking time of 48.16 minutes in MO-87-5 and lowest of 32.33 minutes in MO-2. Lakshmi (2011) observed cooking time of 44.67 minutes in parboiled *Jyothi*. According to Sathyan (2012) *Jyothi* obtained cooking time of 29.33 minutes.

Rice texture is affected by factors such as variety, amylose content, gelatinisation temperature, processing factors and cooking method. Cooked rice with low amylose is soft and sticky, while rice with high amylose is firm and fluffy (Perdon *et al.,* 1999). Rice texture is a key indicator of rice quality as it affects by acceptance of cooked rice by consumers (Lyon *et al.,* 2000). Texture of cooked rice is affected by milling and duration of cooking. Lightly milled rice samples resulted in lower moisture uptake of rice during cooking, thus harder cooked rice. Longer cooking duration results in greater moisture uptake of rice, producing softer cooked rice (Saleh and Meullenet, 2007).

Cooking and eating qualities of rice is directly associated with the amylose content (Hamaker and Griffin, 1990). Nandini (1995) observed that hybrid derivatives had higher amylose content and traditional rice varieties had lower amylose content. Lii *et al.* (1996) reported that amylose content is considered as the single most important characteristic for predicting cooking and processing behaviours of rice. Amylose content is directly related to the water absorption, volume expansion, fluffiness and separability of cooked rice (Delwiche *et al.,* 1996). The relative amount of amylose and amylopectin affect the unique physical and chemical properties of starch (Slattery *et al.*, 2000). Amylose content as well as gelatinization temperature and gel consistency can highly influence cooking and eating qualities of rice (Paramita *et al.*, 2002). Rice with high amylose content are hard and dry in texture compared with rice with lower amylose content (Aliawati, 2003). Kishine *et al.* (2008) reported that *Nerica* rice varieties of Africa had high amylose content. '*Njavara*' and '*Jyothi*' have been reported to have similar amylose content of 23 per cent (Deepa *et al.,* 2008). Sathyan (2012) reported that germinated *Jyothi* rice have amylose content of 24.50 per cent. According to Thomas *et al.* (2013) the lowest amylose content of 3.36 per cent was found in brown rice followed by black rice (5.11%) with the highest (27.71%) in white rice.

Water uptake ratio is an important parameter which affects the cooking quality. If the bulk density is higher, then correspondingly water uptake ratio will also be high. This has been attributed to the compact structure of a rice variety (Horigane *et al.*, 2000 and Mohapatra and Bal, 2006).

When a disorganised cellular structure is present in the grain, soft cooked grains can be obtained (Lisle *et al.*, 2000). Optimum water uptake ratio on cooking is an important parameter for a variety, as yield of cooked rice is directly proportional to water uptake ratio. Rice with high water binding capacity normally yields soft textured cooked product. Higher water binding capacity, swelling ratio, peak viscosity and reduced optimum cooking time have been observed with higher degree of milling (Mohapatra and Bal, 2006).

Nandini (1995) reported that among 60 rice varieties of Kerala CSRC collection, *Matta Triveni* and *Aranmula* local were found to be having water uptake ratio of 5.25. The highest water uptake of 1.52 was reported in OM-4 and the lowest of 1.40 in M-108-262-1 variety among eight KAU varieties (Sugeetha, 2010). In an varietal evaluation study using six different rice varieties, Thomas *et al.* (2013) observed highest water uptake ratio for brown rice (3.95) and lowest for glutinous rice (2.33).

Nandini (1995) reported volume expansion ratio of 6.25 in *Aranmula* local and CSRC collection. Lakshmi (2011) reported that parboiled *Jyothi* rice have water uptake of 6.16 ml/ g and volume expansion ratio of 5.50 per cent. Sathyan (2012) reported that germinated *Jyothi* rice have a water uptake of 4.33 ml/ g and volume expansion ratio of 4.08 per cent.

Quality attributes of four Pakistani coarse rice varieties were studied by Anjum *et al.* (2007) and reported that volume expansion ratio and water absorption ratio of 3.15 and 2.31 respectively in rice variety *Sarshar* (3.15 and 2.31). In a study conducted by Sugeetha (2010) it was found that KAU variety MO8-20-KR obtained the highest volume expansion ratio of 5.35.

Nandini (1995) reported that highest elongation ratio of 1.93 in CO-25 variety. Gujral and Kumar (2003) reported that volume expansion and water absorption increased during cooking of Basmathi type rice variety. According to Sugeetha (2010) the highest elongation ratio of 1.68 was obtained in MO6-10-KR variety and the lowest in MO-4 (1.51) variety. Lakshmi (2011) mentioned that parboiled *Jyothi* rice had grain elongation ratio of 1.43 per cent and Sathyan (2012) observed grain elongation ratio of 1.80 per cent in *Jyothi* rice variety.

Cooking time is directly affected by gelatinisation temperature of starch and protein (Kaur *et al.,* 1991). According to Bandayopathyay and Roy (1992) the gelatinisation temperature influences the cooking behaviour. IRRI (2004) reported that, in many rice growing countries there was a distinct preference for rice with intermediate gelatinisation temperature. Sugeetha (2010) reported that highest gelatinization temperature of 66.88 was observed in MO8-20-KR variety when compared to the other seven varieties. Sabouri *et al.* (2012) reported that gelatinisation temperature is associated with amylose content. Rice varieties with high gelatinisation temperature generally have low amylose content.

Lakshmi (2011) and Sathyan (2012) observed a gel length of 37.66 mm and 48.10 mm in parboiled and raw rice variety *Jyothi*. Oko *et al.* (2012) assessed different rice varieties of *Nigeria* and reported that Faro 15 (I) and E4077 were harder than others. When cooked, rice types with hard gel consistency harden faster than those with a soft gel consistency. The author also reported that the rice with soft gel consistency cook more tenderly and remain soft even upon cooling.

Patinol *et al.* (1999) indicated that the moisture content is a major factor affecting the milling quality of rice. If the moisture content is too low or too high, there will be a decline in the milling recovery and head rice. It also influences the colour and cooking behaviour of rice.

Nandini (1995) reported that the moisture content of 3.12 per cent in traditional variety *Kuruwa*. Belsnio (2003) reported that high moisture in the grain directly reduces the grade of rice. This is a critical factor affecting the keeping properties of grain during storage and also on the milling quality and yield. According to Roy *et al.* (2008) the moisture content of cooked rice influences its hardness and adhesion. Paddy with a moisture content of 10 to 14 per cent and high purity is suitable for production of good quality milled rice (IRRI, 2009). The physicochemical properties such as moisture content, hardness and stickiness of cooked rice, affect the eating quality of rice. Sugeetha (2010) reported that MO-87-5 and MO-95-1 are having moisture content of 13.40 per cent among other six varieties of KAU. According to Oko and Ugwu (2011) *Sipi* variety contained the highest percentage moisture content of 18 per cent while Canada variety has the lowest percentage moisture content of 3.67 per cent. Lakshmi (2011) and Sathyan (2012) reported moisture content of 12.10 per cent in parboiled and 12.67 per cent in raw rice of *Jyothi* rice variety respectively.

Freshly harvested rice grains contain about 80 per cent carbohydrates which include starch, glucose, sucrose and dextrin (Yousaf, 2000).

Nandini (1995) assessed calorific value of 17 rice varieties of Kerala and reported that traditional varieties of rice gave higher values for calories. The highest value of 358 Kcal was noticed in traditional variety *Thekkancheera*. According to Gopalan *et al.* (2012) milled rice had carbohydrate content of 78.2 g.

Sugeetha (2010) reported that among eight rice varieties of KAU, highest energy value of 386.17 Kcal was obtained in MO8-20-KR variety. Sandhu and Divakar (2014) reported that rice is a nutritional staple food which provides instant energy, as it is the most important component in rice (starch). Rice has the highest energy digestibility because of its low dietary fibre and tannin content.

Sugeetha (2010) evaluated the starch content of eight varieties of KAU and found the highest starch content of 76.25 per cent in MO8-20-KR variety. A starch content of 75.13 per cent and 79.61 per cent was observed in parboiled and raw rice of *Jyothi* variety (Lakshmi, 2011 and Sathyan, 2012).

Rice protein consists of four fractions such as albumin, globulin, glutelin and prolamin. Globulin (about 12%) and glutelin (about 80%) are the major proteins and albumin (about 5%) and prolamin (about 3%) are the minor ones (Juliano, 1994). Nandini (1995) observed a high protein content of 10.75 in a hybrid rice variety *Ramya*. Shih and Daigle (1999) reported that the protein and starch found in rice are both hypoallergenic and easily digestible. Bean and Nishita (2000) indicated that rice protein is high in nutritional quality among the cereal proteins because it is rich in essential amino acid lysine. Yousaf (2000) reported that the protein content ranged from 7.0 to 10.8 per cent in milled rice in which 70 to 80 per cent is glutein. The *in* *vitro* protein digestibility of rice was found to be 87.6 to 91.8 per cent. Anjum *et al.* (2007) reported that crude protein content in different rice varieties of Pakistan ranged from 7.80 to 8.80 per cent and the highest value of protein content was found in *Sarshar* varieties. Protein is the most abundant component in rice grain next to starch and its nutritional quality depends on its amino acid composition and digestibility (Xie *et al.*, 2008). According to Manay and Shadaksharaswamy (2008), milled rice contained 6.9 per cent protein.

The amino acid profile of rice is high in glutamic acid and aspartic acid, but low in lysine (Nadia *et al.*, 2009). In a study conducted by Oko and Ugwu (2011) among five rice varieties from different places, it was found that *Awilo* rice had the highest protein content (6.22%).

Sugeetha (2010) reported that OM-2 obtained the highest protein content of 8.17g/100 among different Kerala rice varieties. In a study conducted by Lakshmi (2011) protein content of 7.55 per cent was recorded in parboiled *Jyothi*. Sathyan (2012) reported a protein content of 8.11per cent in *Jyothi* rice variety. In a study conducted by Thomas *et al.* (2013) using 6 rice varieties 'Black rice' variety was found to have the highest protein content of 8.16 per cent.

Rice fat consists of unsaturated fatty acids (Chen and Chang, 1998). Hoseney (1998) indicated that the lipid content decreases when the rice is milled, as the lipids are more concentrated in the peripheral part of the grain. Milled rice has an average of 0.3 to 0.5 per cent lipids. Sugimoto *et al.* (1998) evaluated the lipid content of six varieties of brown rice and milled rice and it ranged from 2.1 to 3.2 per cent and 0.61 to 0.95 per cent, respectively. Anon (2001) reported a fat content of 0.54 per cent in milled rice.

Anjum *et al.* (2007) evaluated 6 Pakistani varieties and found that the fat content ranged from 5.16 to 6.14 per cent with the highest content in *IRRI*-6. Lakshmi (2011) reported that parboiled *Jyothi* rice variety has fat content of 1.30 per cent. According to Sathyan (2012) *Jyothi* rice variety has a fat content of 1.92 per cent. A study conducted by Thomas *et al.* (2013) among six different rice varieties from Malaysia reported highest fat content of 1.74 per cent in brown rice variety.

Rice is a good source of insoluble fibre. Nandini (1995) reported that among seventeen selected rice varieties of Kerala, the crude fibre content was found to be higher in traditional varieties when compared to hybrid derivatives. The variety *Kutticheradi* have high amount of crude fibre content of 0.51per cent. Srilakshmi (2003) mentioned that the fibre content in rice is mainly hemicelluloses made up of pentoses, arabinose and xylose. The total dietary fibre content in *Njavara* was 34.44 per cent and it was found to be significantly higher than *Jyothi* and *IRRI*-8. Crude fibre content ranged from 2.17 to 2.57 per cent in different rice varieties showing highest value of fibre content in *IRRI*-6 (Ahuja *et al.*, 2007 and Deepa *et al.*, 2008).

Manay and Shadaksharaswamy (2008) reported that rice is a moderate source of fibre and the fibre content varied from 0.2 to 1.0 per cent. Among eight rice varieties from KAU, Sugeetha (2010) found a highest fibre content of 0.29 per cent in MO-95-1 variety. In a study conducted by Lakshmi (2011), parboiled *Jyothi* rice variety obtained a fibre content of 0.83 per cent. According to Gopalan *et al.* (2012) milled rice had 0.2 per cent fibre. Sathyan (2012) noticed a fibre content of 1.07 per cent in *Jyothi* rice variety. Brown rice contain higher proportions of dietary fibre compared to fully polished or white rice (Babu *et al.*, 2009). Black rice is also known to be a good source of fibre (Thomas *et al.*, 2013).

Sugeetha (2010) observed highest calcium content of 12 mg/ 100g in MO8-20-KR among seven KAU varieties in the study. Lakshmi (2011) and Sathyan (2012) reported that a calcium content of 6.50 mg/ 100g and 5.94 mg/ 100g in parboiled and raw *Jyothi* variety respectively.

Menon (2004) reported that the high thiamine content in *Njavara* rice could be useful in treating muscle weakness, neuritis and other symptoms related to deficiency of vitamin B_1. Sugeetha (2010) reported that when compared to eight KAU rice varieties, MO-95-1 obtained the highest thiamine content of 0.29 mg/ 100g and MO-2 variety obtained the lowest of 0.05 mg/ 100g. Thiamine content of 0.24 mg/ 100g was observed in parboiled *Jyothi* (Lakshmi, 2011). Sathyan (2012) observed a thiamine content of 0.05 mg/ 100g in *Jyothi* rice variety.

Rice is the cereal lowest in iron content and aromatic rice had higher iron content (Gregorio *et al.*, 2000). Rood (2000) reported high iron content in the Chinese red rice varieties 'Bloody Sticky' and 'Dragon Eyeball'. Parboiled *Jyothi* rice variety have an iron content of 1.97 mg/ 100g (Lakshmi, 2011). In a study conducted by Sathyan (2012) iron content of 1.94 mg/ 100g was reported for *Jyothi* rice variety. Gopalan *et al.* (2012) indicated that rice is generally poor in iron content.

Highest zinc content was found in bran and lowest was found in polished rice (Sotelo *et al.,* 1990). The highest iron and zinc content of 1.94 mg and 2.97 mg respectively were found in *IRRI*-6 (Ahuja *et al.*, 2007). *Nerica* rice varieties of Africa have high micronutrients like iron and zinc ranging between 21.1 mg/ kg^{-1} to 25.3 mg/ kg^{-1} for iron and 53.2 mg/ kg^{-1} to 48.7 mg/ kg^{-1} for zinc in upland rice (Somado *et al.*, 2008).

According to Nandini (1995) hybrid rice varieties have higher value for minerals *viz.*, phosphorus, iron and calcium. Phosphorus content was found to be high in *Jayathi* (155.50) variety, highest calcium in *Kavunginpoothala* (11.11) variety and highest Iron content in *Hrswa* (3.42). Sugeetha (2010) reported that highest total mineral content 0.93 per cent was observed in MO8-20-KR variety. Lakshmi (2011) observed phosphorus content of 161.83 mg/ 100g in parboiled *Jyothi* variety. Sathyan (2012) reported that germinated *Jyothi* rice have phosphorus content of 158.60 mg/ 100g.

According to Manay and Shadaksharaswamy (2008), mineral matter in rice varied from 0.8 to 2.0 per cent. Niacin content in milled rice is found to be 1.0 mg (Manay and Shadaksharaswamy, 2008). According to Gopalan *et al.* (2012) niacin content in milled rice as reported by is 1.9 mg.

2.4. Rice based traditional food products

India is the home for ageless culinary art, and had a rich heritage of a wide variety of traditional foods. Traditional foods are an expression of culture, history and lifestyle (Paramita 2002 and Slimani *et al.*, 2002). Traditions, region and culture linked to the food products were considered as important quality features (Holt and Amilien, 2007). Food choices and food habits are an outcome of cultural heritage and economic and social factors (Aneena, 2009). Every community in India had their own and distinct food ethos. Preferences regarding the taste, texture, colour and stickiness of the rice varieties highly differ among consumers of different cultures. Dry flaky rice is eaten in South Asia and the Middle East. Moist sticky rice is presented in Japan, Taiwan Province of China, the Republic of Korea, Egypt and northern China. Red rice is preferred throughout southern India.

Rice is eaten as whole grain and red rice are considered highly nutritive and medicinal in India. (Rani and Krishnaiah, 2001). In India, rice consumption is generally accomplished in various forms like whole cooked grain, where rice is served normally in two ways, raw rice and parboiled grains (Prashant and Prasad, 2012).

Rice is mainly used as table rice. Among 60 rice varieties of Kerala thirty-five varieties were homogeneous with respect to quality attributes such as appearance, colour, flavour, texture and taste for the preparation of cooked rice (Nandini, 1995). Subbulakshmi (2005) reported that the cooked rice kept overnight in water was consumed as a delicious breakfast item by South Indians after mixing with curd. The author also reported that hybrid derivatives such as *Bharathy, Jayathi, Jyothi, Kanakom, Neeraja, Swarnaprabha, Vyttila-1* and *Vyttila-3* and traditional varieties such as *Aruvakkari, Aryan, Chenkayama, Chuvannamodan, Elappapoochemban, Kattamodan, Thrissur local-1, Thekken, Vadakkenchittani, Vellari* and *Veluthavattan*and other improved varieties such as *CO-25* and *Mashuri* were found to be highly suitable for the preparation of cooked rice using raw rice. Divakar and Francis (2010) evaluated the suitability of seven KAU rice varieties for the preparation of traditional dishes and indicated that the variety *Karuna* is the most favourable for table rice.

The rice flours and starches are important ingredients in both traditional and novel foods prepared across the world (Villareal *et al.,* 1993). Physiochemical properties of the starch changes when thermal treatment occurs during the processing of the pregelatinized rice flour. Pregelatinized rice flour used in the food industry as a bulking or thickening agent and also to improve the texture of the finished product (Lai, 2001). Rice flour can be used in many applications like snack processing to increase the crispiness of chips and to decrease hardness of crackers. Rice flour can improve the texture of the product, reduce the breakage, and extend the shelf life of breakfast cereals. The particle size of the rice flour greatly affects cooking time of the product. Rice starch is very fine in nature and is usually less than 16 microns in size (Bond, 2004). The author also reported that rice flour and starches are used to make new and better gluten free food products. Cultivar differences, starch component, the milling methods, and the pre-treatments of either rice or flour greatly influence the processing quality of rice flour.

Indigenous fermented foods with rice have been prepared and consumed for thousands of years, and are strongly linked to cultural and tradition. *Iddli* and *dosa* are the two important South Indian breakfast items prepared using cereal-pulse combination (Subbulakshmi, 2005). *Iddli* is a fermented food widely consumed in India and Srilanka. *Iddli* is made from rice and dehusked blackgram dhal, soaked, ground, fermented and steamed (Manoharan and Prathapkumar, 2014).

According to Prashant and Prasad (2012) rice is the main base for preparation of many indigenous fermented food products like *idli, dosa, uttapam, sake* an alcoholic beverage, sweets (*anarasa, khir*), *khichadi, pulav,* puffed and extruded products.

Nandini (1995) indicated that for fermented and steamed food preparations, varieties like *Annapoorna, Aruna, Jayathi, Neeraja, Nila, Pavizham, Reshmi, Swarnaprabha, Swarnamodan, Vyttila-1* and *Vyttila-3, Chenkayama, Cheriya Aryan, Chitteni, Aryan, Chuvannamodan, Chuvannari Thavalakannan, CO-25* and *Mashuri* were found to be highly suitable. Varieties like *Hraswa, Triveni, Kutticheradi* and *Thrissur local-1* were also found to be suitable for the preparation of *iddli.*

Cereal based fermented foods like *nan, roti* and *and rana* pancake made from rice flour and legume were the traditional foods consumed by Pakistanis (Shah, 1986).

Dhokla is a fermented food prepared from rice and Bengal gram (Steinkraus, 1997). *Vattayappam* is a popular traditional rice based fermented dish prepared by the Christian community of Central Travancore in Kerala and has scared tradition of being prepared during Christmas and on Ester eve (Emmanuel, 2006). Rice beer is a fermented rice product prepared by many tribal communities residing in the North-Eastern states of India (Jeyaram *et al.,* 2008).

Puttu is a traditional breakfast preparation of Kerala and glutinous rice is preferred in making *puttu*in South India (Arumugasamy *et al.*, 2001). *Puttu* and *appam* are traditional rice flour based products. *Iddli* and *dosas* are delicacies also made from rice flour batter. Kunhimon (2010) reported that among *puttu, appam* and *unniappam* prepared using rice flour and bamboo seed, rice flour obtained a highest score for overall acceptability with a mean score of 8.48, 7.58 and 8.26 respectively. Lakshmi (2011) reported that products prepared from parboiled *Jyothi* rice namely *kozukatta, iddli, idiyappam* and *puttu* using parboiled unroasted rice flour obtained a high mean score for different quality attributes.

Puttu prepared from rice is a famous traditional breakfast food of Kerala (Kadaloor, 2007). Sathyan (2012) reported that products prepared from *Jyothi* rice namly *kozhukatta* and *unniyappam* scored highest mean score for different quality attributes. Productes like *puttu* and *idiyappam* using roasted rice flour of *Jyothi* also obtained a high mean score.

Nandini (1995) reported that the highly acceptable varieties such as *Neeraja, Swarnamodan, Vyttila-1, Vyttila-3, Chenkayama, Chitteni, Kattamodan, Kavungin Poothala, Vellari, Veluthavattan*and *Co-25* were suitable for powdering and are suited for steamed preparation like *puttu*. For the baked preparation *appam*, varieties such as *Vyttila*-1, *Kavunginpoothala, Vellari* and CO-25 were found highly suitable. Divakar and Francis (2010) found that *Swetha* and *Ashwathi* were the most acceptable for rice flour based traditional preparations.

Traditional rice based festive foods of Kerala included *vishu kanji* and *vishukatta* prepared of Hindu communities, *neychoru* and *biriyani* of Muslims and *achappam, kuzalappam* and *vattayappam* of Christians (Shyna and Indira, 2003).

Pal kanji is another traditional cereal and milk based Kerala delicacy prepared with milk, and rice (Achuthan and Emmanuel, 2006). *Kanji* is a typical traditional food used by people of Kerala from time immemorial (Kadaloor, 2007 and Lalithambika, 2007).

According to Steinkraus (1997), beaten rice is a very popular Indian traditional product consumed either as snack after toasting or frying or as a breakfast dish after soaking in water and seasoning with spices and vegetables. A variety of popped or puffed rice like *khull, khoi, aralu* and *nelpori* are consumed as snack items by all segments of the Indian population. Popped products were generally used as snack foods either after spicing or sweetening (Srivastava and Batra, 1998). Rice and finger millet based traditional foods like *arsha, dhuska, chhilka, pua, letto, dumbo, lath* and *roti* are relished by the *Munda*, and *Oraon*tribes of Eastern India (Lakra *et al.*, 2006).

Materials and Methods

3. MATERIALS AND METHODS

The study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' was carried out with the objective of evaluating the physical, biochemical, nutritional, cooking and organoleptic qualities of newly released KAU rice varieties. The study also aimed to assess the suitability of these rice varieties for the preparation of selected traditional food products.

The materials used and the methods followed in the present study are given under the following headings.

3.1. Collection of rice varieties
3.2. Processing of rice varieties and preparation of rice flour
3.3. Quality evaluation of rice varieties
3.4. Shelf life studies of rice and roasted rice flour
3.5. Preparation of traditional food products with rice and rice flour
3.6. Organoleptic evaluation of traditional food products prepared with rice
3.7. Statistical Analysis

3. 1. Collection of rice varieties

Newly released KAU red rice varieties namely *Ezhome*-1 and *Ezhome*-2 were collected from College of Agriculture, Padannakkad. *Prathyasha* (MO-21) from Rice Research Station, Mancompu. *Vyttila*-8 from Rice Research Station, Vyttila and *Vaishak* (PTB- 60) from Regional Agricultural Research Station, Pattambi.

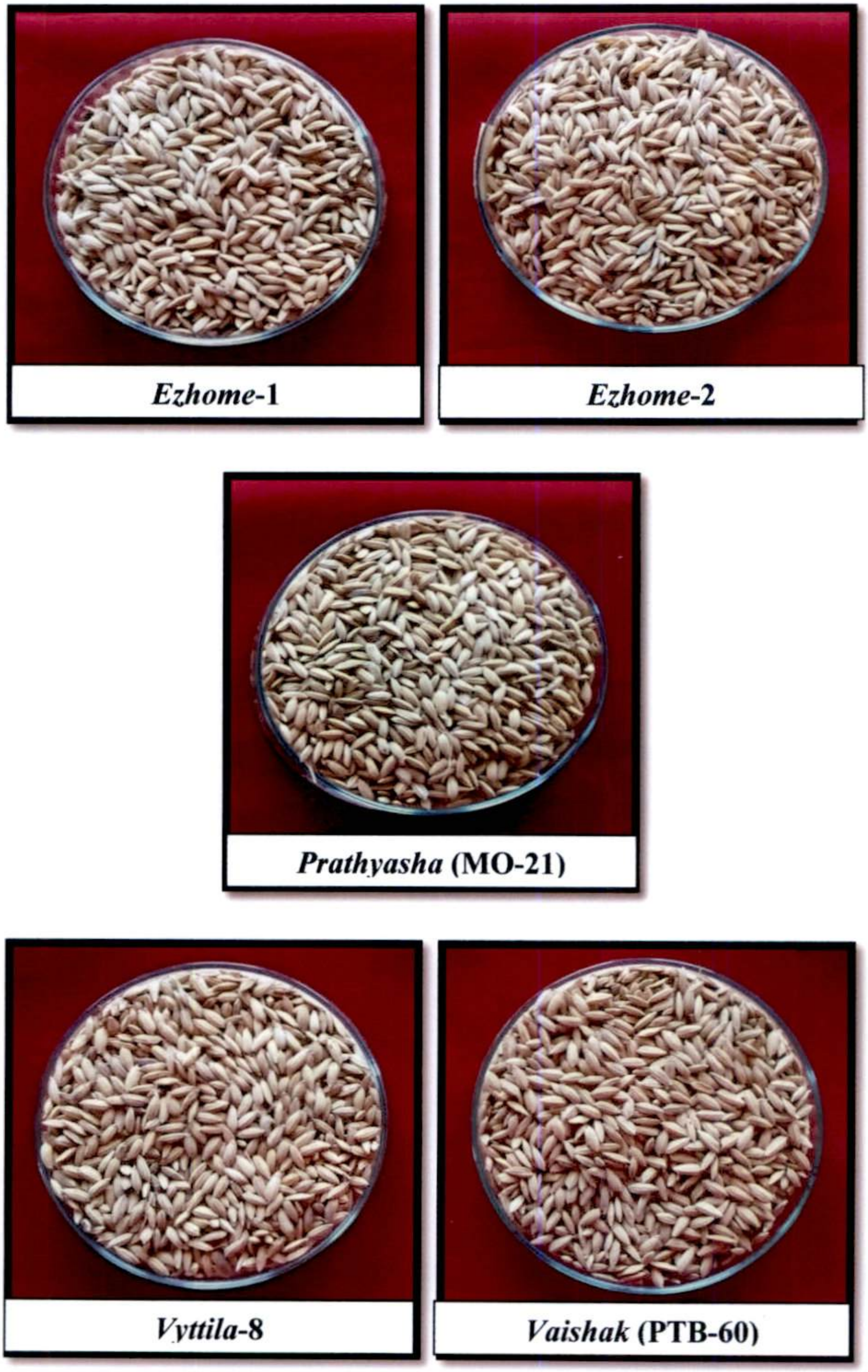


Plate 1a: Rice varieties selected for the study

Plate 1b: Rice varieties selected for the study

Commonly used red rice varieties *Jyothi* and *Uma* were collected from Agricultural Research Station, Mannuthy served as control. The collected rice varieties are shown in Plate 1a and 1b.

Ezhome rice varieties *Ezhome*-1 and *Ezhome*-2 are high yielding, and non-lodging, organic red rice varieties, for the saline prone Kaipad rice fields of Kerala. These new seed varieties have been developed by the Kerala Agricultural University with the participation of farmers of Ezhome panchayath. *Prathyasha* (MO-21), a short duration rice variety of paddy developed by the Rice Research Centre at Mankombu, is suitable for double cropped of wet lands of Kuttanad. *Vyttila*-8 is a saline-resistant variety, developed by the Rice Research Station, Vyttila of the Kerala Agricultural University. It is cultivated in the backwater nourished coastal areas of central Kerala and is resistant to water salinity. *Vaisakh* (PTB-60) was developed by the Regional Agricultural Research Station (RARS), Pattambi. It is a semi tall, short duration variety with good grain yield and is suitable for direct seeding in upland situation.

3. 2. Processing of rice varieties and preparation of rice flour

A part of the collected paddy was used for evaluating physical qualities and for preparing rice flakes. The rice samples were milled in a local mill, before assessment of organoleptic qualities of cooked rice and suitability of rice for product development. The milled rice samples along with the controls were packed in air tight glass containers and stored for six months under ambient conditions.

Milled rice was soaked in cold water for 4 to 6 hours and water was drained. The soaked rice was spread over a clean cloth to remove excess water. Rice was powdered and sieved using a fine sieve. A portion of the powdered rice flour was used unroasted while the rest was roasted for ten minutes.

Unroasted rice flour was used for quality evaluation and for preparation of traditional products like *appam, unniyappam.* Food products like *puttu* and *ada* were prepared using roasted rice flour. Both unroasted and roasted rice flour was used for evaluating physical qualities. Roasted rice flour samples along with the controls were packed in air tight glass containers and stored for six months under ambient conditions.

3. 3. Quality evaluation of rice varieties

Various quality parameters like physical qualities, cooking qualities, biochemical and nutritional qualities were assessed. The organoleptic qualities of cooked rice and shelf life qualities of rice varieties were also evaluated.

3. 3. 1. Physical qualities of rice varieties

Paddy was dehulled with a laboratory sheller (RETC drier manufactured by ENGART Engineering Services Maharashtra, model number: NF 268). Weighed quantity of paddy was poured into the hopper for dehulling. The resulting brown rice was weighed to obtain the percentage of hull and brown rice (Khush *et al.,* 1979). The brown rice was again milled in a laboratory polisher (Mac Lawkin (Godrej.com) Jupiter Scientific Company, Tamil Nadu Model No:LK 1140) for 30 seconds with the prescribed added weight (500g) on the pressure cover, followed by a second milling for another 30 seconds without the weight. The fraction removed in the first milling was considered as bran and that after the second milling, as polish.

The milled rice sample was collected in a thick paper bag and sealed immediately. The rice was allowed to cool before weighing. This procedure minimises grain cracking during cooling (Adair 1952). The data obtained from milling of paddy was used for determining the physical qualities like milling percent, head rice recovery, thousand grain weight, volume weight, grain shape and grain size.

3. 3. 1. 1. Milling per cent

Milling per cent include the weight of head rice and broken rice and is calculated as follows.

$$\text{Milled rice (\%)} = \frac{\text{Weight of milled rice}}{\text{Weight of paddy}} \times 100$$

3. 3. 1. 2. Head rice recovery

Whole grains (head rice) were separated from the milled rice with a winnower. The resulting head rice was weighed to get head rice recovery (Adair, 1952).

$$\text{Head rice recovery} = \frac{\text{Weight of head rice}}{\text{Weight of paddy}} \times 100$$

3. 3. 1. 3. Thousand grain weight

This was measured by the method of Redding *et al.* (1991). It involved the counting and weighing of 1000 randomly selected unpolished brown rice kernels.

3. 3. 1. 4. Volume weight

Volume weight was measured as described by Ali *et al.* (1993). A 500 ml graduated cylinder was filled with a known amount of water (100 ml). Thousand grains of milled rice kernels were dropped into the cylinder. Tapped the cylinder to remove any air bubbles attached to the rice grains and recorded the total volume (rice + water). From this, the initial volume of water is subtracted to get the volume of rice and expressed as mm^3.

3. 3. 1. 5. Grain shape and grain size

Grain appearance depends upon the size and shape of the kernel. Length and width of grain were measured using grain vernier and using the following scale, grain size and shape was determined. For size: extra long, >7.50 mm; long, 6.61 to 7.50 mm; medium, 5.51 to 6.60 mm and short, <5.50 mm was used. For shape, based on length-to-width ratio grain was classified as slender, >3.0; medium, 2.1 to 3.0; bold 1.1 to 2.0 and round, < 1.0 (IRRI, 2002).

3. 3. 2. Cooking qualities of rice

Cooking and eating characteristics of rice are largely determined by the properties of the starch that makes up ninety per cent of milled rice. Hence, cooking qualities of milled rice were evaluated.

3. 3. 2. 1. Preparation of cooked rice

Rice varieties were cooked by straining method suggested by Saleh and Meullener (2007). Rice was measured and washed with cold water repeatedly and strained. Put a fairly large quantity of water in a big pan and bring to the boil. Add the known quantity of rice into the boiling water. After cooking, rice water was drained. The cooked rice samples were compared with the control. The evaluation was carried out in the morning using score card by a selected panel of ten judges.

3. 3. 2. 1. 1. Selection of judges

A series of organoleptic trials were carried out using simple triangle test at laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellanick (1985).

3. 3. 2. 1. 2. Preparation of score card

Score card containing five quality attributes namely appearance, colour, flavour, texture and taste were prepared for the evaluation of the products. Each of the above mentioned qualities were assessed by a nine point hedonic scale. Overall acceptability was computed separately using the average of above mentioned five quality attributes. The score card prepared given in Appendix I.

3. 3. 2. 2. Gelatinisation temperature index

An estimate of the gelatinisation temperature was indexed by the alkali digestion test suggested by Little *et al.* (1958). It is measured by observing the degree of spreading of individual milled rice kernels in a weak alkali solution (1.7% KOH). Six whole-milled kernels without cracks were selected and placed in a petridish. Ten ml of 1.7 per cent potassium hydroxide (KOH) solution was added. The samples were arranged to provide enough space between kernels to allow for spreading. The petridishes were covered and incubated for 23 hr at 30°C in an oven. Starchy endosperm was rated visually to index the degree of spreading in alkali.

Rice with a low gelatinisation temperature disintegrates completely where as rice with an intermediate gelatinisation temperature shows only partial disintegration. Rice with a high gelatinisation temperature remains largely unaffected in the alkali solution.

3. 3. 2. 3. Cooking time

Optimum cooking time was estimated by the method outlined by Juliano and Bechtel (1985). In a 250 ml beaker, about 100 ml-distilled water was boiled (98 ± 1°C) and 10 g of head rice sample was dropped into it. Measurement of cooking duration was started immediately. After 10 minutes and every minute thereafter, one or two grains of rice were removed and pressed between two clean glass plates. Cooking time was recorded when at least 90 per cent of the grains no longer had opaque core or uncooked centres. The rice was then allowed to simmer for about another two minutes to ensure that the core of all grains had been gelatinised. Optimum cooking time included the additional two minutes of simmering.

3. 3. 2. 4. Water uptake

Water uptake was estimated by the method outlined by Zhou *et al.* (2007). A known weight of milled rice grains (10g) was cooked with excess cooking water (100 ml) in a beaker. The excess residual cooking water was withdrawn using a pipette after the cooking process and the volume was measured. Water uptake capacity of the cooked rice grain was calculated from the difference between the total cooking water and residual cooking water after the cooking process and expressed as milli litre per gram of grain.

3. 3. 2. 5. Volume expansion

Volume expansion was estimated by the method suggested by Pillaiyar and Mohandas (1981). It was determined from the ratio between the cooked volume of rice to that of uncooked rice. The volume of the 10 milled kernels was noted initially and after cooking in a graduated test tube. The volume expansion is calculated from the ratio between cooked volume to the uncooked volume.

$$\text{Volume expansion ratio} = \frac{\text{Cooked volume}}{\text{Uncooked volume}}$$

3. 3. 2. 6. Amylose content

Amylose content was determined by the method suggested by Sadasivam and Manikkam (1992). To 100 mg of powdered rice sample, 1ml of distilled ethanol and 10 ml of 1N NaOH were added and kept overnight and the volume was made up to 100 ml. The extract (2.5ml) was taken and added about 20 ml of distilled water and three drops of phenolphthalein. Then 0.1N HCl was added drop by drop until the pink colour disappears. To this, 1ml of iodine reagent was added and the volume was made up to 50 ml. The intensity of the colour developed was read at 590 nm in spectrophotometer. The amylose present in the sample was estimated from standard graph prepared using serial dilution of standard amylose solution and expressed in percentage.

3. 3. 2. 7. Gel consistency

Gel consistency was measured as suggested by Cagampang *et al.* (1973). All the rice samples for measuring gel consistency were stored in the same room for 2 days so as to equalize the moisture content of the grain. Whole milled rice grains were ground to give a fine flour (100 mesh). Hundred milli gram of the powder was weighed into test tubes. Ethyl alcohol (0.2 ml of 95 per cent) and 2.0 ml of 0.2 M KOH were added with a pipette. The contents were mixed well. The test tubes were covered with glass marbles (to prevent steam loss and to reflux the samples). The samples were cooked in a vigorously boiling water bath for eight minutes, until the tube contents reached 2/3 the height of the tube. The test tubes were removed from the water bath and left to stand at room temperature for five minutes. The tubes were cooled in an ice-water bath for 20 minutes and laid horizontally on a laboratory table, lined with a graph paper. The total length of the gel was measured in millimeter from the bottom of the tube to the gel front.

Gel consistency of rice varieties were classified as:

Soft	> 61 and above
Medium	41-60
Medium hard	36-40
Hard	26-35

3. 3. 2. 8. Grain elongation

The method suggested by Azeez and Shafi (1966) was followed for evaluating the degree of elongation of cooked rice grains. The elongation test consists of taking 25 whole milled kernels in a beaker that were soaked in 20 ml of distilled water for 30 minutes. The samples were placed in a water bath and the temperature was maintained at 98°C for 10 minutes. The cooked rice was transferred to a petridish lined with filter paper. Ten cooked whole grains were selected and measured by placing it linearly on a graph paper. The proportionate elongation was the ratio of the average length of cooked rice grains to the average length of raw rice grains.

3. 3. 2. 9. Keeping quality of cooked rice

To determine the keeping quality of rice, a known amount of cooked rice sample is kept in ambient condition. Changes occurred in cooked rice like off flavour, texture and discolouration during a keeping period of 24 hours were observed. Time taken for the spoilage of cooked rice is noted.

3. 3. 3. Chemical and nutritional qualities of rice

Chemical and nutritional qualities of milled rice were assessed using standard procedures. Analysis was carried out in triplicate samples for the following constituents initially.

3. 3. 3. 1. Moisture

Moisture content of rice was estimated by the method of A.O.A.C. (1980). To determine the moisture content, five gram of rice was taken in a petridish and dried in a hot air oven at 60°C- 70°C, cooled in a desiccator and weighed. The process of heating and cooling was repeated until a constant weight was achieved. The moisture content was calculated from the loss in weight during drying and expressed in percentage.

$$\text{Moisture} = \frac{(\text{Initial weight of moisture cup} + \text{Sample}) - (\text{Final weight of moisture cup} + \text{Dry sample})}{\text{Weight of the sample}}$$

3. 3. 3. 2. Total carbohydrate

The total carbohydrate content was analysed colourimetrically using anthrone reagent (Sadasivam and Manikam, 1992). Powdered rice sample of 0.1 g was hydrolysed with 5 ml of 2.5 N HCl and then cooled to room temperature. Later the residue was neutralized with solid sodium carbonate until the effervescence ceases and the volume was made up to 100 ml and centrifuged. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green to dark green colour was read at 630 nm.

A graph was prepared using serial dilutions of standard glucose. From the standard graph the amount of total carbohydrate present in the sample was estimated and expressed in grams.

3. 3. 3. 3. Starch

The starch content was estimated colorimetrically using anthrone reagent (A. O. A. C, 1980). The rice grains were powdered and the rice powder (0.5g) was extracted with 80 percent ethanol to remove sugars. Residue was repeatedly extracted with hot 80 percent ethanol to remove sugars completely. The residue was dried over a water bath and 5 ml of water and 6.5 ml of 52 per cent perchloric acid were added and extracted at $0^{o}C$ for 20 minutes. The supernatant was pooled and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to 1 ml with water and 4 ml of anthrone reagent was added, heated for eight minutes, cooled and read the OD at 630 nm in a spectrophotometer.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was obtained and multiplied by a factor of 0.9 to arrive the starch content.

3. 3. 3. 4. Energy

The energy content was worked out from the amount of total carbohydrate, protein and fat present in the sample.

Total carbohydrate, protein and fat were estimated by the method as described in 3. 3. 3. 2, 3. 3. 3. 5 and 3. 3. 3. 6. Finally multiply the amount of total carbohydrate, protein, and fat by 4, 4 and 9 respectively. Then the results are added together to get the energy. Energy content was expressed as kilo calorie (Kcal).

$$\text{Energy (Kcal)} = (\text{CHO} \times 4) + (\text{Protein} \times 4) + (\text{Fat} \times 9)$$

3. 3. 3. 5. Protein

Protein content was estimated by the method of A.O.A.C (1980). Rice (0.2g) was digested with 6 ml Con. H_2SO_4 after adding 0.4 g of $CuSO_4$ and 3.5 g K_2SO_4 in a digestion flask until the colour of the sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. The distillate was collected in 20 per cent boric acid containing mixed indicator and then titrated with 0.2 N HCl, to determine the nitrogen content. The nitrogen content obtained was multiplied with a factor of 6.25 to get the protein content and was expressed in grams.

3. 3. 3. 6. Fat

Fat content of rice was estimated by the method of A. O. A. C (1955). Five gram of rice was powdered and taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for six hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled, and ether was removed by heating and weight was taken. The fat content was expressed in grams.

3. 3. 3. 7. Fibre

Crude fibre was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978). Two gram of rice was powdered and boiled with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide for 30 minutes. Again, it was filtered through a muslin cloth and washed with sulphuric acid, water and alcohol. The residue was transferred to a pre weighed ashing dish, dried, cooled and weighed. The residue was then ignited for 30 minutes in a muffle furnace at 600°C, cooled in a dessicator and reweighed. The fibre content of the sample was calculated from the loss in weight on ignition and expressed in grams.

3. 3. 3. 8. Thiamine

Thiamine content was estimated by the method suggested by Sadasivam and Manikam (1992). Five gram of sample was finely ground and taken in a 250 ml conical flask. Slowly added 100 ml of 0.1N sulphuric acid without shaking and kept overnight. After shaking vigorously, filtered through Whatman No.1 filter paper and discarded the first 10-15 ml of the filtrate. Pippetted out 10 ml of the extract into 100 ml separating funnels. Pippeted out 10 ml of the working standard and added 3 ml of 15 per cent NaOH into each separating funnel immediately, followed by four drops (0.2ml) of ferricyanide solution. After shaking gently for exactly 30 seconds, 15 ml of isobutanol was added rapidly from a quick delivery burette. Stopped immediately and shook vigourously for 60 seconds and allowed the layers to separate. Drained off the bottom layer carefully and added one spatula of sodium sulphate directly into the separating funnel, stoppered and swirled gently to clarify the extract. The clear extract was collected from the top into a clean dry test tube and read at an exitation wave length of 365 nm and emission wave length of 435 nm, exitation band pass and emission band pass of 10 nm and sensitivity set at the 500 v in a spectroflurometer. The thiamine content was expressed as mg per 100 g of the sample.

3. 3. 3. 9. Calcium

Calcium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982). The diacid was prepared by mixing 70 per cent perchloric acid in the ratio 9:4. Two gram of rice sample was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer. Calcium content was expressed in mg per 100 g of the sample.

3. 3. 3. 10. Zinc

The zinc content of the sample was estimated by atomic absorption sepctrophotometric method using the diacid extract prepared from the sample (Perkin- Elmer, 1982). The diacid solution was directly read in atomic absorption spectrophotometer to find the zinc content and expressed in mg per 100 g of sample.

3. 3. 3. 11. Iron

Iron content of the sample was estimated by atomic absorption sepctrophotometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982). The diacid solution was directly read in atomic absorption spectrophotometer to find the iron content and expressed in mg per 100 g of sample.

3. 3. 3. 12. Phosphorus

The phosphorus content was analysed colorimetrically as suggested by Jackson (1973), which gives yellow colour with nitric acid vandate molybdate reagent. To 5 ml of predigested aliquot, 5 ml of nitric acid vandate molybdate reagent was added and made up to 50 ml with distilled water. After 10 minutes, the OD was read at 420 nm.

The content of phosphorus present in the sample was estimated from the standard graph prepared using serial dilution of standard phosphorous solution and expressed in mg per 100 g.

3. 3. 4. Physical qualities of rice flour

Rice was soaked in cold water for 4 to 6 hours and water was drained. The soaked rice was spread over a clean cloth to remove excess water. Rice was powdered and sieved using a fine sieve and roasted for ten minutes (Pasricha and Rebello, 1977). A portion of powdered rice flour is kept as unroasted. Following physical qualities of unroasted and roasted rice flour were studied.

3. 3. 4. 1. Bulk density

The bulk density of rice flour was determined by the method described by Okaka and Potter (1977). Fifty gram sample was put into a 100 ml graduated cylinder. The cylinder was tapped 50 times and bulk density was calculated as weight per unit volume of sample.

3. 3. 4. 2. Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI of flour were determined by the method of Anderson *et al.* (1969). The ground flour sample (2.5g) was mixed with 30 ml distilled water using a glass rod and cooked at 90^0C for 15 minutes in a water bath. The cooked paste was cooled to room temperature and transferred to centrifuge tubes and centrifuged for 10 minutes. WAI and WSI were calculated by the expressions.

$$\text{WAI} = \frac{\text{Weight of the sediment}}{\text{Weight of the dry solids}}$$

$$\text{WSI} = \frac{\text{Weight of the dissolved solids in supernatant}}{\text{Weight of the dry solids}}$$

3. 3. 4. 3. Retrogradation property

Retrogradation property was evaluated by the method suggested by Singh *et al.* (2005). Flour paste (9%) were heated to 90^0C for 20 minutes and then cooled. These cooked rice flour paste were stored for 3, 6, 9 and 12 days at 4^0C. Syneresis was measured as percentage amount of water released after centrifugation in 15 minutes.

3. 4. Shelf life studies of rice and roasted rice flour

Rice and roasted rice flour were packed in air tight PET containers and stored for a period of six month under ambient conditions. The microbial qualities and presence of storage pests were evaluated initially and at monthly intervals for a period of six months.

3. 4. 1. Microbial enumeration of rice and roasted rice flour

The total microbial count in milled rice and roasted rice flour was enumerated in each month for a period of six months using serial dilution and plate count method as described by Agrawal and Hasija (1986). One gram of the rice sample was added to 9 ml sterile water and agitated for 20 minutes. One ml of this solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4} and 10^{-5} dilutions were also prepared.

Enumeration of total microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungus and sabouraud's dextrose agar media for yeast, which was obtained from Himedia Lab, Mumbai. The dilution used for bacteria was 10^{-5} and for fungi and for yeast 10^{-3} dilution was used.

3. 4. 2. Insect infestation in rice and rice flour

The presence of storage insects were assessed in each month by visual observation and by examining the rice and rice flour under microscope.

3. 5. Preparation of traditional food products with rice and rice flour

Rice flakes were prepared from paddy and *iddli* was prepared using milled rice. Traditional products like *appam* and *unniyappam* were prepared using unroasted rice flour, *puttu* and *ada* were prepared with roasted rice flour by standard procedure.

The procedures adopted for preparation of traditional rice products are given in Appendix II.

3. 6. Organoleptic evaluation of traditional food products prepared with rice

Organoleptic evaluation of rice products was carried out by preparing rice flakes, *iddli, appam, unniyappam, puttu* and *ada* by standard procedures. The products prepared from newly released rice and rice flour were compared with similar products prepared from rice varieties which were kept as control. The organoleptic evaluation was carried out in the morning time using score card by a selected panel of ten judges as mentioned in 3. 3. 2. 1. 1 and 3. 3. 2. 1. 2.

3.7. Statistical Analysis

The observations recorded were tabulated and the data was analyzed statistically using complete randomized design (CRD). The data on physical qualities of different rice varieties were analyzed statistically using one way ANNOVA. The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance (W) and total index score was worked out.

Result

4. RESULTS

The results of the study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' are presented under the following heads.

4. 1. Quality evaluation of rice and flour of rice varieties

4. 1. 1. Physical qualities of rice

4. 1. 2. Cooking qualities of rice

4. 1. 3. Chemical and nutritional qualities of rice

4. 1. 4. Physical qualities of unroasted and roasted rice flour

4. 1. 5. Storage qualities of rice and roasted rice flour

4. 2. Acceptability of traditional food products

4. 2. 1. Organoleptic evaluation of rice and rice based products

4. 2. 2. Organoleptic evaluation of rice flour based products

4. 1. Quality evaluation of rice and flour of rice varieties

4. 1. 1. Physical qualities rice

Physical qualities like milling per cent, head rice recovery, thousand grain weight, volume weight, grain shape and size of rice varieties were evaluated and are presented in Table 1a and 1b. The results pertaining to the physical qualities are as follows.

4. 1. 1. 1. Milling per cent

The milling per cent among newly released rice varieties varied from 64.07 per cent in *Prathyasha* (MO-21) to 77.83 per cent in *Ezhome*-2. The rice varieties

Vyttila-8, *Ezhome*-1 *and Vaishak* (PBT-60) obtained a milling per cent of 74.10 per cent, 72.03 per cent and 69.93 per cent respectively.

Control varieties *Jyothi* and *Uma* obtained a milling per cent of 73.8 per cent and 72 per cent respectively. The relative milling per cent of selected rice varieties with respect to *Jyothi* and *Uma* were woked out separately. The relative milling per cent with respect to *Jyothi* and *Uma* was the highest in *Ezhome*-2. Among different rice varieties, the milling per cent of *Ezhome*-2 was found to be the highest (77.83) and was adjudged as the best variety. There were no varieties which had a milling per cent on par with that of *Ezhome*-2. The second highest milling per cent among newly released rice varieties was observed in *Vyttila*-8 (74 %). *Prathyasha* (MO-21) recorded the lowest milling per cent of 64.07 and it was found to be lower than the milling per cent of control variety *Jyothi* (73.8 %). The milling percent of *Uma* (72%) was found to be on par with that of *Ezhome*-1.

4. 1. 1. 2. Head rice recovery

The head rice recovery of rice varieties was assessed. The highest head rice recovery among newly released rice varieties was observed in *Vyttila*-8 (57.45 %) followed by *Ezhome*-1 (55.49 %), *Vaishak* (PTB-60) (54.09 %) and *Prathyasha* (MO-21) (52.80 %). The lowest head rice recovery among newly released rice varieties was obtained for *Ezhome*-2 (49.48 %).

The control varieties *Jyothi* and *Uma* obtained head rice recovery of 41.08 per cent and 49.75 per cent respectively. The relative head rice recovery with control varieties was also determined. *Vyttila*-8 obtained the highest relative head rice recovery of 139.84 with respect to *Jyothi*. The head rice recovery of *Ezhome*-2 was on par with that of control variety *Uma*.

Table 1a: Physical qualities of rice varieties

Rice varieties	Milling per cent (%)	Relative milling per cent w.r.t Jyothi	Relative milling per cent w.r.t Uma	Head rice recovery (%)	Relative head rice recovery w.r.t Jyothi	Relative head rice recovery w.r.t Uma
Ezhome -1	72.03 (8.51)	97.58	100.02	55.49 (7.48)	135.08	111.52
Ezhome – 2	77.83 (8.85)	106.81	109.48	49.48 (7.07)	120.46	99.45
Prathyasha (MO-21)	64.07 (8.03)	86.81	88.98	52.80 (7.30)	128.53	106.12
Vyttila-8	74.10 (8.63)	100.40	102.91	57.45 (7.61)	139.84	115.46
Vaishak (PTB-60)	69.93 (8.39)	94.75	97.12	54.09 (7.38)	131.68	108.72
Jyothi	73.80 (8.61)	100	102.50	41.08 (6.44)	100	82.56
Uma	72.00 (8.51)	97.56	100	49.75 (7.08)	121.12	100
CD	**0.4052**			**0.3428**		

Figures in parenthesis are SQRT ($\sqrt{x+1/2}$) transformed values

4. 1. 1. 3. Thousand grain weight

Thousand grain weight of rice varieties was assessed. Among newly released rice varieties, the thousand grain weight was found to be the highest in *Vaishak* (PTB-60) (20.68 g) followed by *Ezhome*-1 (20.38 g), *Vyttila*-8 (19.08 g), *Ezhome*-2 (18.6 g). The lowest thousand grain weight was noticed in *Prathyasha* (MO-21) (17.41 g).

Control rice varieties *Jyothi* and *Uma* recorded thousand grain weight of 19.98 g and 16.38 g respectively. The relative thousand grain weight with respect to *Jyothi* and *Uma* were the highest for *Vaishak* (PTB-60) followed by *Ezhome*-1. The critical difference in thousand grain weight among newly released varieties were assessed and found that the thousand grain weight of *Vaishak* (PTB-60) is on par with that of *Ezhome*-1.

4. 1. 1. 4. Volume weight

Volume weight of newly released rice varieties varied from 12.81 mm^3 in *Ezhome*-2 to 14.6 mm^3 in *Vaishak* (PTB-60). The volume weight of *Ezhome*-1, *Prathyasha* (MO-21) and *Vyttila*-8 were 12.96 mm^3, 13.55 mm^3 and 14.03 mm^3 respectively.

Control rice varieties *Jyothi* and *Uma* obtained volume weight of 12.33 mm^3 and 12.85 mm^3 respectively. When compared with *Jyothi*, the highest relative volume weight was observed in *Vaishak* (PTB-60) (118.70 mm^3). Among newly released rice varieties, the relative volume weight with respect to *Uma* was lowest in *Ezhome*-2 (99.70 mm^3). The relative volume weight of all other varieties was found to be lower than *Vaishak* (PTB-60). The critical difference among volume weight of different rice varieties were found to be statistically insignificant.

Table 1b: Physical qualities of rice varieties

Rice varieties	Thousand grain weight (g)	Relative thousand grain weight w.r.t Jyothi	Relative thousand grain weight w.r.t Uma	Volume weight (mm)	Relative volume weight w.r.t Jyothi	Relative volume weight w.r.t Uma
Ezhome -1	20.38 (4.57)	102	124.42	12.96 (3.66)	105.37	100.9
Ezhome – 2	18.6 (4.37)	93.09	113.56	12.81 (3.64)	104.15	99.7
Prathyasha (MO-21)	17.41 (4.23)	87.14	106.29	13.55 (3.74)	110.16	105.44
Vyttila-8	19.08 (4.42)	95.5	116.48	14.03 (3.80)	114.07	109.2
Vaishak (PTB-60)	20.68 (4.60)	103.5	126.26	14.6 (3.88)	118.7	113.6
Jyothi	19.98 (4.52)	100	121.98	12.3 (3.57)	100	95.7
Uma	16.38 (4.10)	81.99	100	12.85 (3.65)	104.5	100
CD	**0.0303**			**NS**		

Figures in parenthesis are SQRT (√x+1/2) transformed values

NS: Not significant

4. 1. 1. 5. Grain size and shape

Grain size of rice varieties in terms of grain length, grain width and L/B ratio is presented in Table 2. Among newly released rice varieties, the length of rice grain was found to be the highest in *Ezhome*-1 (4.95 mm) and the lowest in *Prathyasha* (MO-21) (4.33 mm). The grain length of *Ezhome*-2, *Vaishak* (PTB-60) and *Vyttila*-8 were found to be 4.35 mm, 4.44 mm and 4.46 mm respectively.

The grain length of 5.4 mm was observed in control variety *Jyothi* and 3.99 mm in *Uma* variety. The relative grain length with respect to *Jyothi* was in the range of 80.19 mm to 91.67 mm in different rice varieties. The grain length of all the newly released rice varieties was higher than the grain length of *Uma* (3.99 mm). Among newly released rice varieties, the highest grain length was noticed in *Ezhome*-1. But when compared with control rice varieties, the maximum grain length was observed in *Jyothi* (5.4 mm). The critical difference in grain length was assessed and found that the grain length of *Vyttila*-8 is on par with that of *Vaishak* (PTB-60).

The grain width was found to be the highest in *Vaishak* (PTB-60) (1.86mm) followed by *Ezhome*-1 (1.84 mm), *Vyttila*-8 (1.82 mm), *Ezhome*-2 (1.21 mm) and *Prathyasha* (MO-21) (1.21 mm).

The control variety *Jyothi* and *Uma* obtained grain width of 1.82 mm and 1.79 mm respectively. The relative grain width with respect to *Jyothi and Uma* was in the range of 66.48 mm to 103.91 mm in different rice varieties. The critical difference among grain width of different rice varieties were determined and found that the grain width of *Ezhome*-1 and *Vaishak* (PTB-60) was on par with that of *Vyttila*-8 and *Jyothi* respectively.

Table 2: Grain quality attributes of rice varieties

Rice varieties	Grain length (mm)	Relative grain length w.r.t Jyothi	Relative grain length w.r.t Uma	Grain width (mm)	Relative grain width w.r.t Jyothi	Relative grain width w.r.t Uma	L/B ratio	Interpretation
Ezhome -1	4.95 (2.33)	91.67	124.06	1.84 (1.53)	101.09	102.79	2.3	Bold medium
Ezhome – 2	4.35 (2.20)	80.56	109.02	1.21 (1.31)	66.48	67.59	3.59	Slender long
Prathyasha (MO-21)	4.33 (2.19)	80.19	108.52	1.21 (1.30)	66.48	67.59	3.57	Slender long
Vyttila-8	4.46 (2.22)	82.59	111.78	1.82 (1.52)	100	101.68	2.45	Bold medium
Vaishak (PTB-60)	4.44 (2.22)	82.22	111.28	1.86 (1.53)	102.19	103.91	2.4	Bold medium
Jyothi	5.4 (2.43)	100	135.34	1.82 (1.52)	100	101.68	3	Slender long
Uma	3.99 (2.11)	73.89	100	1.79 (1.51)	98.35	100	2.22	Bold medium
CD	**0.0606**			**0.0303**				

Figures in parenthesis are SQRT (√x+1/2) transformed values

Grain shape was determined by considering the L/B ratio of milled rice. The L/B ratio of different rice varieties varied from 2.3 to 3.59. Among newly released rice varieties, the highest L/B ratio was found in *Ezhome*-2 (3.59) followed by *Prathyasha* (MO-21) (3.57), *Vyttila*-8 (2.45), *Vaishak* (PTB-60) (2.4) and *Ezhome*-1 (2.3). Based on the L/B ratio, grains were classified as slender long, bold medium and round short. *Prathyasha* (MO-21) and *Ezhome*-2 obtained L/B ratio of 3.57 and 3.59 respectively and were classified as slender long grain rice. *Ezhome*-1, *Vyttila*-8 and *Vaishak* (PTB-60) rice varieties were classified as bold medium grain rice. Control varieties *Jyothi* and *Uma* were classified as slender long and bold medium respectively.

For most of the physical quality parameters, raw rice of newly released varieties were found to be superior.

4. 1. 2. Cooking qualities of rice

Cooking qualities of the raw rice namely, the sensory qualities, gelatinization temperature index, cooking time, water uptake, volume expansion, amylose content, gel consistency and grain elongation were analysed among the newly released rice varieties and was compared with the control varieties. The results are as follows.

4. 1. 2. 1. Sensory qualities of the cooked rice

The mean scores of different quality attributes of cooked rice are given in Table 3. In cooked rice, the mean score for appearance varied from 7.00 to 7.30 with a mean rank score in the range of 2.90 to 4.05. *Ezhome*-2, *Ezhome*-1 and *Vyttila*-8 obtained a mean score of 7.30 with a mean rank score of 3.60, 3.70 and 4.50 respectively. The control varieties, *Jyothi* and *Uma* obtained a mean score of 8.00 and

7.70 with a mean rank score of 5.55 and 4.70 respectively. Among different rice varieties, the highest mean score for appearance was observed in *Jyothi* with a mean rank score of 5.55.

The mean score for colour of the cooked rice varied from 6.50 to 7.00 with a mean rank score of 3.45 to 5.10. *Ezhome*-1 and *Vaishak* (PTB-60) obtained a mean score of 6.90 and 6.80 with a mean rank score of 4.45 and 4.40 respectively. The control varieties, *Jyothi* and *Uma* recorded a mean score of 6.60 and 6.50 with a mean rank score of 3.75 and 3.40. Among different rice varieties, the highest mean score for colour was observed in *Vyttila*-8.

In cooked rice, the highest mean score of 7.20 for flavour was noticed in *Vaishak* (PTB-60) with a mean rank score of 5.50 among the newly released rice varieties. *Vyttila*-8 and *Ezhome*-2 obtained the same mean score of 6.70 with a mean rank score of 4.05 and 4.00 for flavour. *Ezhome*-1 and *Prathyasha* (MO-21) recorded a mean score of 6.60 and 6.50 with mean rank score of 3.70 and 3.40 respectively. For flavour, *Jyothi* and *Uma* obtained a mean rank score of 4.00 and 3.35 with a mean score of 6.70 and 6.50. Among different rice varieties *Vaishak* (PTB-60) obtained the highest mean score for flavour.

Among newly released rice varieties, the lowest mean score of 6.80 for texture of cooked rice was observed in both *Prathyasha* (MO-21) and *Vaishak* (PTB-60) with a mean rank score of 2.70 and 3.05 respectively. The highest mean score 7.60 was observed in rice variety *Ezhome*-2 followed by 7.20 both in *Ezhome*-1 and *Vyttila*-8. Mean score of 7.80 and 7.50 with a mean rank score of 5.30 and 4.25 were noticed in control varieties *Jyothi* and *Uma.* Among different rice varieties under the study, *Jyothi* obtained the highest mean score of 7.80 for texture.

The highest mean score of 7.80 for taste of cooked rice was noticed in *Ezhome*-2 with a mean rank score of 4.95, among newly released rice varieties. *Prathyasha* (MO-21) and *Vaishak* (PTB-60) obtained a mean score of 7.20 for taste, with a mean rank score of 3.15 and 3.25 respectively. Control varieties *Jyothi* and *Uma* obtained a mean score of 8.10 and 7.60 with a mean rank score of 5.65 and 4.15 respectively for taste. Among different rice varieties, the highest mean score for taste was noticed in the variety *Jyothi*.

The mean scores for overall acceptability of the cooked rice varied from 7.10 in *Prathyasha* (MO-21) to 7.40 in *Ezhome*-2 with a mean rank score in the range of 3.15 to 4.20. Cooked rice prepared from *Jyothi* rice variety obtained the highest mean score for overall acceptability when compared to other rice varieties. The cooked rice prepared with different rice varieties are presented in Plate 2a and 2b.

Significant agreement among the judges was noticed in the evaluation of different quality attributes like appearance, flavour, texture and taste of cooked rice of different rice varieties. No agreement among the judges was noticed in the case of colour and overall acceptability of cooked rice prepared with different rice varieties.

An index was worked out for each variety using mean rank scores obtained through Kendall's test for all the five parameters (Appearance, colour, flavour, texture and taste) as W_1X_1+ W_2X_2+ W_3X_3+ W_4X_4 and W_5X_5 where W_1, W_2, W_3, W_4 and W_5 were weights assigned to the different ranks under taste, texture, flavour, colour and appearance as 5, 4, 3, 1.5 and 1.5 respectively. The weights were assigned logically. The attributes of weight assigned will in no way alter the sequential ordering of the varieties. The total index obtained for selected rice varieties are given along with the mean scores.

Table 3: Mean scores for different organoleptic qualities of cooked rice

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	7.30 (3.70)	6.90 (4.45)	6.60 (3.70)	7.20 (3.85)	7.40 (3.65)	7.30 (3.85)	11.39
Ezhome – 2	7.30 (3.60)	6.50 (3.45)	6.70 (4.00)	7.60 (4.85)	7.80 (4.95)	7.40 (4.20)	13.34
Prathyasha (MO-21)	7.20 (3.50)	6.50 (3.45)	6.50 (3.40)	6.80 (2.70)	7.20 (3.15)	7.10 (3.15)	9.43
Vyttila-8	7.30 (4.05)	7.00 (5.10)	6.70 (4.05)	7.20 (4.00)	7.10 (3.20)	7.20 (3.50)	11.57
Vaishak (PTB-60)	7.00 (2.90)	6.80 (4.40)	7.20 (5.50)	6.80 (3.05)	7.20 (3.25)	7.20 (3.65)	11.18
Jyothi	8.00 (5.55)	6.60 (3.75)	6.70 (4.00)	7.80 (5.30)	8.10 (5.65)	7.80 (5.05)	**15.08**
Uma	7.70 (4.70)	6.50 (3.40)	6.50 (3.35)	7.50 (4.25)	7.60 (4.15)	7.60 (4.60)	11.99
Kendall's W	****0.236**	**0.152[NS]**	***0.189**	****0.225**	****0.266**	**0.102[NS]**	

Figures in parenthesis are mean scores

*Significant at 10% level and ** Significant at 5% level

NS: Not significant

Ezhome-1

Ezhome-2

Prathyasha (MO-21)

Vyttila-8

Vaishak (PTB-60)

Plate 2a: Cooked rice prepared with raw rice of different varieties

Jyothi	*Uma*

Plate 2b: Cooked rice prepared with raw rice of different varieties

The scores of total index obtained for different varieties were considered for determining the suitability of selected varieties for table rice. Among different rice varieties, the highest total index of 15.08 was obtained by control variety *Jyothi* for cooked rice. Newly released rice varieties obtained lower total index than control varieties and among those cooked rice, *Ezhome*-2 obtained the highest total index (13.34). Control rice variety *Jyothi* was found to be the most suitable for the preparation of cooked rice.

4. 1. 2. 2. Gelatinisation temperature index

Newly released rice varieties along with control were subjected to the alkali digestion test and were visually observed to evaluate the degree of disintegration in alkali. After the stipulated time of observation, little effect was observed among newly released rice varieties. All the rice varieties were found to be of high gelatinisation index.

It was found that the control rice varieties *Jyothi* and *Uma* were completely disintegrated in alkali after the stipulated time of observation and were found to be of intermediate gelatinisation temperature index. The gelatinisation temperature index of different rice varieties are presented in Plate 3.

4. 1. 2. 3. Cooking time

Cooking time of rice varieties is presented in Table 4a. The cooking time taken by different rice varieties varied from 18.51 minutes in *Prathyasha* (MO-21) to 24.75 minutes in *Ezhome*-2. *Vyttila*-8, *Vaishak* (PTB-60) and *Ezhome*-1 obtained a cooking time of 22.39 minutes, 23.83 minutes and 24.45 minutes respectively.

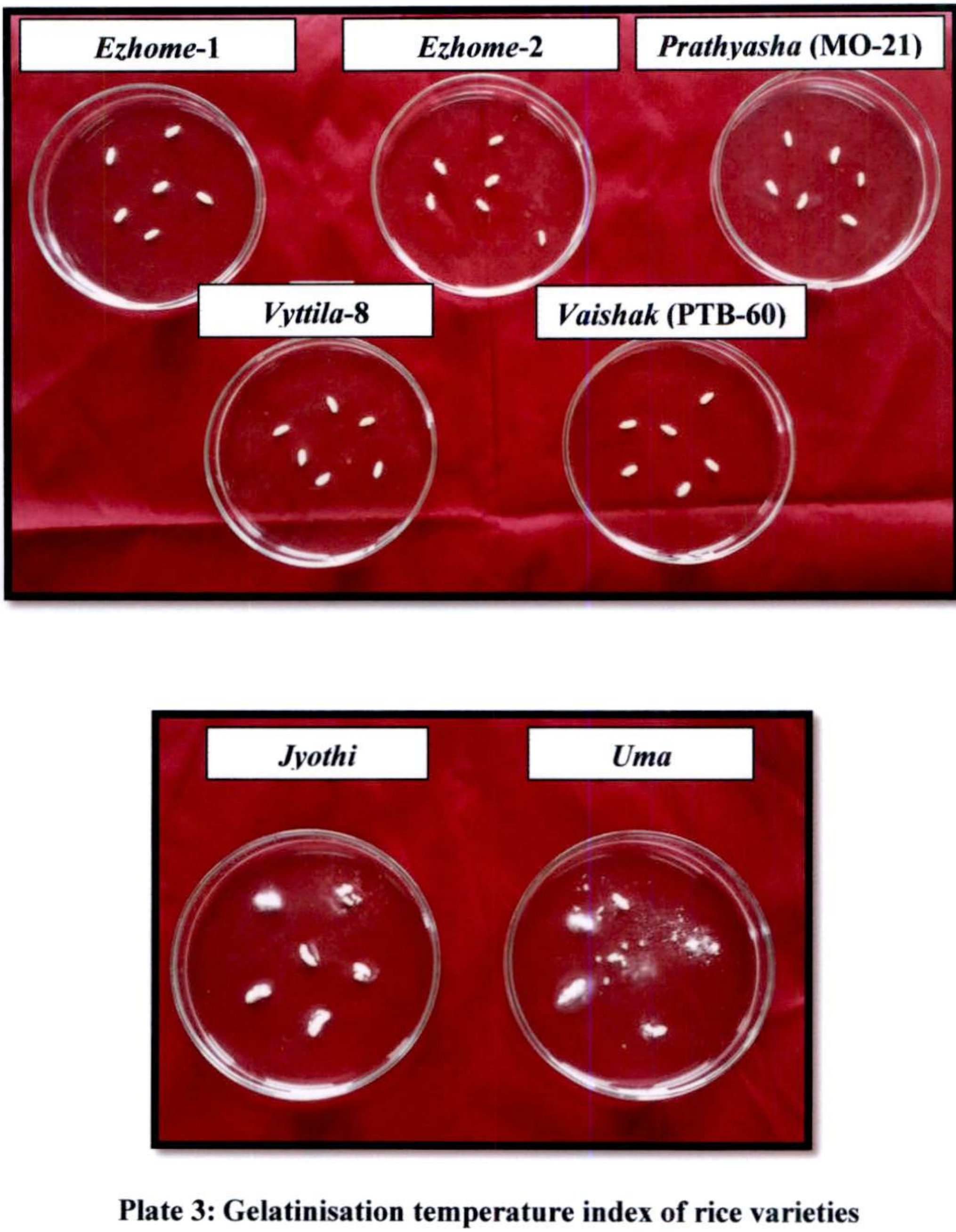


Plate 3: Gelatinisation temperature index of rice varieties

The cooking time obtained for control variety *Jyohti* and *Uma* were 22.20 minutes and 22.42 minutes respectively. The critical difference of different rice varieties was assessed and found that the cooking time of *Ezhome*-2 is on par with *Ezhome*-1. The critical difference of *Vyttila*-8 was found to be on par with that of control varieties *Jyothi* and *Uma.*

4. 1. 2. 4. Water uptake

The water uptake by rice while cooking is presented in Table 4a. Among newly released rice varieties, the highest water uptake of 5.74 ml/ g was observed in *Ezhome*-2 rice variety followed by 4.86 ml/ g in *Vyttila*-8, 3.81 ml/ g in *Vaishak* (PTB-60), 3.72 ml/ g in *Prathyasha* (MO-21) and 3.47 ml/ g in *Ezhome*-1.

Among different varieties under study, *Jyothi* obtained the lowest water uptake of 3.3 ml/ g and *Uma* obtained the highest value of 6.42 ml/ g. The relative water uptake ratio with respect to *Jyothi* was higher than 100 in all newly released varieties. When compared with *Uma,* the relative water uptake is in the range of 54.05 to 89.4 in newly released rice varieties. The critical difference among water uptake ratio of different rice varieties was assessed. Water uptake ratio of *Prathyasha* (MO-21) was found to be on par with that of *Ezhome*-1. No varieties were on par with that of control variety *Uma* with respect to water uptake.

4. 1. 2. 5. Volume expansion

Volume expansion ratio of rice varieties were determined and enumerated in Table 4a. The highest volume expansion ratio of 5.60 was noticed in *Ezhome*-2 and the lowest of 4.50 in *Vyttila*-8 among newly released rice varieties. The volume

Table 4a: Cooking qualities of rice varieties

Rice varieties	Cooking time(min)	Relative cooking time w.r.t Jyothi	Relative cooking time w.r.t Uma	Water uptake (ml/g)	Relative water uptake w.r.t Jyothi	Relative water uptake w.r.t Uma	Volume expansion	Relative volume expansion w.r.t Jyothi	Relative volume expansion w.r.t Uma
Ezhome -1	24.45 (4.99)	110.13	109.05	3.47 (1.99)	105.15	54.05	5.18 (2.38)	92.17	85.33
Ezhome – 2	24.75 (5.01)	111.30	110.17	5.74 (2.49)	173.90	89.40	5.60 (2.46)	99.64	92.25
Prathyasha (MO-21)	18.51 (4.36)	83.40	82.56	3.72 (2.05)	112.73	57.94	4.49 (2.23)	79.89	73.97
Vyttila-8	22.39 (4.78)	100.90	99.86	4.86 (2.31)	147.28	75.70	4.50 (2.23)	80.07	74.13
Vaishak (PTB-60)	23.83 (4.93)	107.34	106.29	3.81 (2.07)	115.60	59.35	4.78 (2.29)	85.05	78.74
Jyothi	22.20 (4.76)	100	99.02	3.3 (1.94)	100	51.40	5.62 (2.47)	100	92.58
Uma	22.42 (4.78)	100.90	100	6.42 (2.63)	194.50	100	6.07 (2.56)	108.00	100
CD	**0.1516**			**0.1516**			**0.1819**		

Figures in parenthesis are SQRT ($\sqrt{x+1/2}$) transformed values

expansion ratio of *Prathyasha* (MO-21), *Ezhome*-1 and *Vaishak* (PTB-60) were found to be 4.49, 5.18 and 4.78 respectively.

The volume expansion of control varieties was higher than that of newly released rice varieties. Control varieties *Jyothi* and *Uma* obtained volume expansion ratio of 5.62 and 6.07 respectively. Relative volume expansion ratio of *Ezhome*-2 with respect to control varieties *Jyothi* and *Uma* was found to be 99.64 and 92.25 respectively. Volume expansion ratio of *Ezhome*-2 was found to be on par with that of *Jyothi*. None of the varieties were found to be on par with that of control variety *Uma*.

4. 1. 2. 6. Amylose content

The amylose content of rice varieties were assessed and are given in Table 4b. The highest amylose content among newly released rice varieties was observed in *Ezhome*-2 (15.61 %) followed by *Ezhome*-1 (15.31 %), *Vaishak* (PTB-60) (14.49 %), *Vyttila*-8 (11.86 %) and *Prathyasha* (MO-21) (10.20 %).

The amylose content of control rice varieties *Jyothi* and *Uma* were 22.17 per cent and 23.32 per cent respectively. The relative amylose content of the newly released rice varieties with respect to control varieties was lower and found to be in the range of 43.74 to 70.38. *Uma* obtained the highest amylose content among all rice varieties. The critical difference among amylose content of different rice varieties were assessed and it was found that the amylose content of *Ezhome*-1 was on par with that of *Ezhome*-2. The amylose content of *Jyothi* was found to be on par with that of *Uma* variety. None of the varieties were found to be on par with that of *Prathyasha* (MO-21).

Table 4b: Cooking qualities of rice varieties

Rice varieties	Amylose content (%)	Relative amylose content w.r.t Jyothi	Relative amylose content w.r.t Uma	Gel consistency (mm)	Relative gel consistency w.r.t Jyothi	Relative gel consistency w.r.t Uma	Consistency
Ezhome -1	15.31 (3.97)	69.036	65.633	57.16 (7.59)	153.6559	207.8545	Medium
Ezhome – 2	15.61 (4.01)	70.389	66.919	29.89 (5.50)	80.34946	108.6909	Hard
Prathyasha (MO-21)	10.20 (3.27)	46.009	43.741	145 (12.06)	389.7849	527.2727	Soft
Vyttila-8	11.86 (3.51)	53.479	50.8431	132 (11.51)	354.8387	480	Soft
Vaishak (PTB-60)	14.49 (3.85)	65.338	62.117	56.91 (7.57)	152.9839	206.9455	Medium
Jyothi	22.17 (4.76)	100	95.070	37.2 (6.13)	100	135.2727	Medium hard
Uma	23.32 (4.88)	105.18	100	27.5 (5.28)	73.92473	100	Hard
CD	**0.1924**			**0.3639**			

Figures in parenthesis are SQRT ($\sqrt{x}$+1/2) transformed values

4. 1. 2. 7. Gel consistency

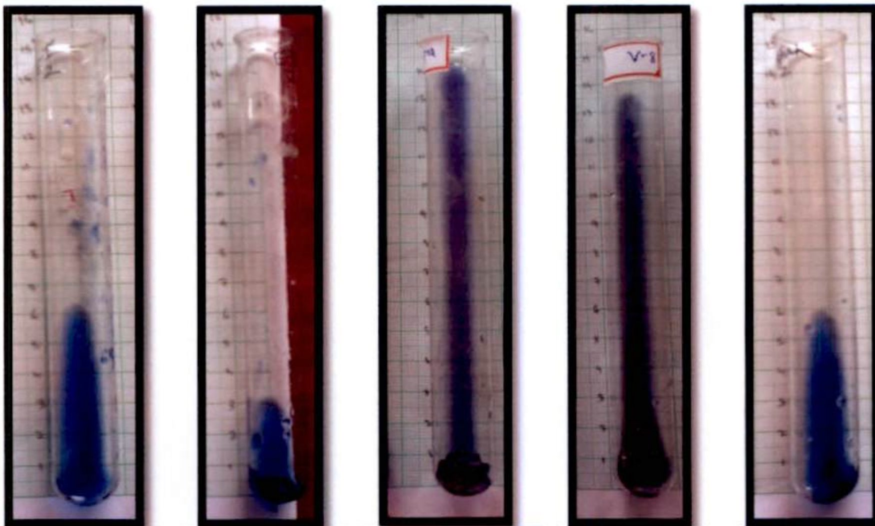
Gel consistency of rice varieties were determined by measuring gel length and furnished in Table 4b and in Plate 4. Among newly released rice varieties maximum gel length of 145 mm was noticed in *Prathyasha* (MO-21) followed by *Vyttila*-8 (132 mm), *Ezhome*-1 (57.16 mm) and *Vaishak* (PTB-60) (56.91 mm). The lowest gel consistency among newly released rice varieties was observed in *Ezhome*-2 (29.89 mm).

Gel length of 37.2 mm and 27.50 mm were noticed in control rice varieties *Jyothi* and *Uma* respectively. Gel consistency was found to be the highest in *Prathyasha* (MO-21) which was on par with that of *Vyttila*-8. The gel consistency of *Vaishak* (PTB-60) was on par with that of *Ezhome*-1. In the present study, the lowest gel consistency was observed in control rice variety *Uma*. None of the variety was found to be having gel consistency on par with that of *Uma*.

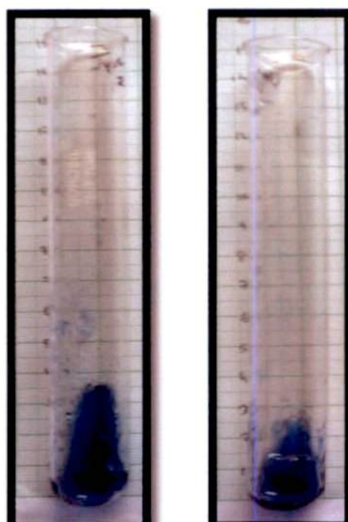
4. 1. 2. 8. Grain elongation

Grain elongation ratio of rice varieties is presented in Table 4c. Among newly released rice varieties, maximum grain elongation ratio of 0.9 was observed in both *Ezhome*-2 and *Prathyasha* (MO-21). Both *Vaishak* (PTB-60) and *Ezhome*-1 obtained the lowest grain elongation ratio of 0.72 among newly released rice varieties.

The control varieties obtained a grain elongation ratio of 0.99 (*Jyothi*) and 0.81 (*Uma*). Among different rice varieties under the study, the highest grain elongation was noticed in control variety *Jyothi* (0.99). The critical difference among grain elongation of different rice varieties were assessed and found that the grain elongation of control variety *Uma* was found to be on par with that of newly released



***Ezhome*-1** | ***Ezhome*-2** | ***Prathyasha* (MO-21)** | ***Vyttila*-8** | ***Vaishak* (PTB-60)**



Jyothi | ***Uma***

Plate 4: Gel consistency of rice varieties

Table 4c: Cooking qualities of rice varieties

Rice varieties	Grain elongation	Relative grain elongation w.r.t Jyothi	Relative grain elongation w.r.t Uma	Keeping quality (hr)	Relative keeping quality w.r.t Jyothi	Relative keeping quality w.r.t Uma
Ezhome -1	0.72 (1.10)	72.7	88.9	11.62 (3.481)	98.6	99.4
Ezhome – 2	0.9 (1.18)	90.9	111.1	12.01 (3.537)	101.9	102.7
Prathyasha (MO-21)	0.9 (1.18)	90.9	111.1	11.24 (3.421)	95.4	96.1
Vyttila-8	0.81 (1.14)	81.8	100	12.58 (3.617)	106.8	107.6
Vaishak (PTB-60)	0.72 (1.10)	72.7	88.9	12.60 (3.620)	106.9	107.8
Jyothi	0.99 (1.22)	100	122.2	11.78 (3.505)	100	100.8
Uma	0.81 (1.14)	81.8	100	11.69 (3.491)	99.2	100
CD	**0.003**			**0.1678**		

Figures in parenthesis are SQRT (√x+1/2) transformed values rice variety *Vyttila*-8. The critical difference among grain elongation ratio of *Ezhome*-2 was on par with that of *Prathyasha* (MO-21).

4. 1. 2. 9. Keeping quality

Keeping quality of cooked rice was assessed the observations is given in Table 4c. It is observed by keeping the cooked rice for 24 hours under ambient conditions. Among newly released rice varieties maximum keeping quality up to 12.60 hours was noticed in *Vaishak* (PTB-60) and minimum of 11.24 hours in *Prathyasha* (MO-21). The cooked rice became mushy and sticky after the keeping period. None of the varieties had keeping quality on par with that of *Vaishak* (PTB-60).

The keeping quality in control rice varieties *Jyothi* and *Uma* ranged between 11.78 hours and 11.69 hours, which was lower than the keeping quality of most of the newly released rice varieties. The relative keeping quality with respect to *Jyothi* and *Uma* was in the range of 98.6 to 114.1 in different rice varieties. The critical difference in keeping quality among different rice varieties were determined. It was found that keeping quality of *Ezhome*-1 and *Ezhome*- 2 was on par with that of control varieties *Jyothi* and *Uma.* None of the varieties was found to be on par with that of *Prathyasha* (MO-21).

Cooking qualities of newly released rice varieties were found to be comparable with that of control varieties.

4. 1. 3 Chemical and nutritional qualities of rice

Chemical and nutritional qualities of rice varieties like moisture, starch, protein, fat, energy, fibre, thiamine, calcium, zinc, iron and phosphorus were evaluated. The results on the chemical and nutritional qualities of different raw rice varieties are presented in Table 5.

4. 1. 3. 1. Moisture

The moisture content of rice varieties was assessed and found that among newly released rice varieties the highest moisture content of 11.6 per cent was observed in *Ezhome*-1 and also in *Prathyasha* (MO-21). The lowest moisture content of 8.5 per cent was noticed in *Ezhome*-2. *Vaishak* (PTB-60) and *Vyttila*-8 obtained moisture content of 10.6 per cent and 10.4 per cent respectively.

The moisture content obtained for control rice varieties *Jyothi* and *Uma* were 10 per cent and 10.3 per cent respectively. It was found that the moisture content of *Ezhome*-1 was on par with that of *Prathyasha* (MO-21). The moisture content of none of the varieties was on par with that of *Ezhome*-2.

4. 1. 3. 2. Total carbohydrate

The total carbohydrate content of rice varieties was assessed and found that among newly released rice varieties the highest carbohydrate content of 81.43 g was observed in *Ezhome*-2 followed by 78.37 g in *Ezhome*-1, 78.24 g in *Vaishak* (PTB-60) and 78.07 g in *Vyttila*-8. The lowest carbohydrate content of 71.01 g was noticed in *Prathyasha* (MO-21).

Carbohydrate content obtained for control rice varieties *Jyothi* and *Uma* were 75.60 g and 71.45 g respectively. The critical difference in carbohydrate content among different rice varieties were assessed and found that the carbohydrate content of *Ezhome*-1 was on par with that of *Vyttila*-8 and *Vaishak* (PTB-60). The carbohydrate content of none of the varieties was on par with that of *Ezhome*-2.

4. 1. 3. 3. Starch

The starch content of rice varieties was assessed and found that among newly released rice varieties, the highest starch content of 68.6 g/ 100g was noticed in *Ezhome*-2, and the lowest of 51.5 g/ 100g in *Prathyasha* (MO-21). *Vyttila*-8, *Vaishak* (PTB-60) and *Ezhome*-1 possessed a starch content of 55.8 g/ 100g, 61.5 g/ 100g and 62.1 g/ 100g respectively.

Starch content of 63.1 g/ 100g and 61.2 g/ 100g was observed in control rice varieties *Jyothi* and *Uma*. Among different rice varieties under the study, the highest starch content was observed in *Ezhome*-2 and none of the varieties were found to be having starch content on par with that of *Ezhome*-2. Starch content of *Ezhome*-1 was found to be on par with that of control variety *Jyothi*.

4. 1. 3. 4. Energy

The energy content of rice varieties was assessed and found that among newly released rice varieties, the highest energy content of 363.55 Kcal was noticed in *Ezhome*-2. Rice varieties *Vyttila*-8, *Vaishak* (PTB-60) and *Ezhome*-1 obtained energy content of 345.71 Kcal, 351.07 Kcal and 353.57 Kcal respectively. The lowest energy content of 318.70 Kcal was noticed in *Prathyasha* (MO-21) variety.

Control rice varieties were found to be having an energy content of 335.81 Kcal *(Jyothi)* and 319.71 Kcal (*Uma*) respectively. Energy in *Vaishak* (PTB-60) was on par with that of *Ezhome*-1. The statistical analysis revealed that the critical difference observed in energy content of different rice varieties namely *Ezhome*-1, *Vaishak* (PTB-60), *Vyttila*-8, *Jyothi* and *Uma* were on par with that of *Ezhome*-2. *Prathyasha* (MO-21) rice variety, in which the lowest energy content was noticed was found to be on par with the energy content of control rice variety *Uma*.

4. 1. 3. 5. Protein

The protein content of rice varieties were determined and found that the highest protein content of 8.95 g/ 100g among newly released rice varieties was noticed in *Ezhome*-2 and the lowest of 7.0 g/ 100g in *Vyttila*-8. *Prathyasha* (MO-21), *Vaishak* (PTB-60) and *Ezhome*-1 obtained a protein content of 7.5 g/ 100g, 8.1 g/ 100g and 8.75 g/ 100g respectively.

Protein content of 7.5 and 7.7 g/ 100g was noticed in control rice varieties *Jyothi* and *Uma*. The statistical analysis revealed that protein content of *Prathyasha* (MO-21) was on par with that of control rice variety *Jyothi*. It was also observed that the protein content of *Ezhome*-2 was on par with that of *Ezhome*-1.

4. 1. 3. 6. Fat

The fat content of rice varieties was assessed and found that among newly released rice varieties, the highest fat content of 0.71 g/ 100g was obtained in *Vaishak* (PTB-60) variety and the lowest fat content of 0.3 g/ 100g in *Ezhome*-2. *Prathyasha* (MO-21) and *Vyttila*-8 obtained a fat content of 0.53 g/ 100g each and 0.64 g/ 100g was noticed in *Ezhome*-1.

Jyothi and *Uma* rice varieties obtained a fat content of 0.42 and 0.35 g/ 100g respectively. The statistical analysis revealed a significant difference in fat content with respect to the variety. Among newly released rice varieties, the highest fat content was observed in *Vaishak* (PTB-60) (0.71 %). The fat content of *Ezhome*-1 was found to be on par with that of *Vaishak* (PTB-60). *Ezhome*-2 possessed the lowest fat content of 0.3 g/ 100g and that of the control variety *Uma* (0.35 g/ 100g) was found to be on par with this

4. 1. 3. 7. Fibre

The fibre content of rice varieties were estimated and found that he highest fibre content of 0.7 g/ 100g was noticed in *Ezhome*-1 followed by 0.64 g/ 100g in *Ezhome*-2, 0.35 g/ 100g in *Prathyasha* (MO-21) and 0.26 g/ 100g in *Vyttila*-8 among newly released rice varieties. The lowest fibre content of 0.08 g/ 100g was recorded in *Vaishak* (PTB-60) variety.

Fibre content of 0.18 and 0.2 g/ 100g was noticed in *Jyothi* and *Uma* respectively. On adjudging the values, fibre content of *Ezhome*-1 was found to be on par with that of *Ezhome*-2. The critical difference in fibre content of *Prathyasha* (MO-21) was found to be on par with that of *Vyttila*-8. The fibre content of *Vaishak* (PTB-60) was found to be on par with that of control varieties *Jyothi* and *Uma*.

4. 1. 3. 8. Thiamine

The thiamine content of rice varieties were determined and found that the highest thiamine content of 0.07 mg/ 100g among newly released rice varieties was noticed in *Vaishak* (PTB-60). Both *Ezhome*-1 and *Ezhome*-2 recorded a thiamine content of 0.06 mg/ 100g for each and 0.03 mg/ 100g for *Prathyasha* (MO-21). The lowest thiamine content of 0.02 mg/ 100g was observed in *Vyttila*-8.

Thiamine content was 0.05 mg/ 100g in *Jyothi* and 0.04 mg/ 100g in *Uma* respectively. The thiamine content of different rice varieties indicated that the values obtained for *Ezhome*-1 was on par with that of *Ezhome*-2 and also with that of control variety *Jyothi*. Considerable variation in thiamine content was not observed among different rice varieties.

4. 1. 3. 9. Calcium

The calcium content of rice varieties was determined and found that among newly released rice varieties, the highest calcium content of 6 mg/ 100g was noticed in *Prathyasha* (MO-21) and the lowest of 4.92 mg/ 100g in *Ezhome*-1 variety. Calcium content of *Vaishak* (PTB-60), *Ezhome*-2 *and Vyttila*-8 rice varieties were 4.94 mg/ 100g, 5.27 mg/ 100g and 5.7 mg/100g respectively.

Comparatively higher calcium content was observed in both control varieties *Jyothi* (6.6 mg/ 100g) and *Uma* (5.26 mg/ 100g). Among different rice varieties under the study, *Jyothi* obtained the highest calcium content of 6.6 mg/ 100g. None of the rice varieties showed calcium content on par with that of control variety *Jyothi*. The calcium content of *Ezhome*-2 was found to be on par with that of *Uma*. *Ezhome*-1 recorded a calcium content on par with that of *Vaishak* (PTB-60).

4. 1. 3. 10. Zinc

The zinc content of rice varieties was assessed and found that among newly released rice varieties, the highest zinc content of 1.31 mg/ 100g was observed in *Ezhome*-2 followed by *Vyttila*-8 (1.28 mg/ 100g), *Prathyasha* (MO-21) (1.17 mg/ 100g) and *Ezhome*-1 (1.08 mg/ 100g).

In control rice varieties, zinc content of 1.11 mg/ 100g (*Jyothi*) and 1.07 mg/ 100g (*Uma*) was recorded. Among different varieties, the lowest zinc content of 1.01 mg/ 100g was noticed in *Vaishak* (PTB-60). The zinc content of *Ezhome*-1 was found to be on par with that of control varieties *Jyothi* and *Uma*. The critical difference among zinc content of different varieties revealed that none of the varieties obtained zinc content on par with that of *Ezhome*-2.

4. 1. 3. 11. Iron

The Iron content of rice varieties was determined and found that among newly released rice varieties, the highest iron content of 0.61 mg/ 100g was noticed in *Prathyasha* (MO-21) variety and the lowest of 0.41 mg/ 100g in *Ezhome*-1 followed by *Vyttila*-8 (0.44 mg/ 100g), *Vaishak* (PTB-60) (0.47 mg/ 100g) and *Ezhome*-2 (0.51 mg/ 100g).

Iron content of control rice varieties were 0.56 mg/100g (*Jyothi*) and 0.56 mg/ 100g (*Uma*) respectively. Iron content of none of the varieties was found to be on par with that of *Ezhome*-2. The iron content of *Jyothi* variety was found to be on par with that of *Uma*.

4. 1. 3. 12. Phosphorus

The phosphorus content of rice varieties was assessed and found that among newly released rice varieties the highest phosphorus content of 135.41 mg/ 100g was noticed in *Ezhome*-2. *Vyttila*-8, *Prathyasha* (MO-21) and *Ezhome*-1 rice varieties obtained phosphorus content of 95.87 mg/100g, 122.87 mg/100g and 128.17 mg/100g respectively. *Vaishak* (PTB-60) variety was found to be having the lowest phosphorus content of 90.29 mg/100g.

Table 5: Chemical and nutritional qualities of selected rice varieties (per 100g)

Rice varieties	Moisture (%)	Total carbohydrate (g)	Starch (g)	Energy (Kcal)	Protein (g)	Fat (g)	Fibre (g)	Thiamine (mg)	Calcium (mg)	Zinc (mg)	Iron (mg)	Phosphorus (mg)
Ezhome -1	11.6 (3.48)	78.37 (8.88)	62.1 (7.91)	353.57 (18.81)	8.75 (3.04)	0.64 (1.06)	0.7 (1.09)	0.06 (0.74)	4.92 (2.32)	1.08 (1.26)	0.41 (0.95)	128.17 (11.34)
Ezhome – 2	8.5 (3.01)	81.43 (9.05)	68.6 (8.31)	363.55 (19.08)	8.95 (3.07)	0.3 (0.89)	0.64 (1.06)	0.06 (0.74)	5.27 (2.40)	1.31 (1.34)	0.51 (1.08)	135.41 (11.65)
Prathyasha (MO-21)	11.6 (3.47)	71.01 (8.45)	51.5 (7.16)	318.70 (17.86)	7.5 (2.82)	0.53 (1.01)	0.35 (0.92)	0.03 (0.72)	6 (2.55)	1.17 (1.29)	0.61 (1.05)	122.87 (11.10)
Vyttila-8	10.4 (3.31)	78.24 (8.87)	55.8 (7.50)	345.71 (18.60)	7.0 (2.74)	0.53 (1.01)	0.26 (0.87)	0.02 (0.72)	5.7 (2.49)	1.28 (1.33)	0.44 (0.97)	95.87 (9.81)
Vaishak (PTB-60)	10.6 (3.33)	78.07 (8.86)	61.5 (7.87)	351.07 (18.75)	8.1 (2.93)	0.71 (1.10)	0.08 (0.76)	0.07 (0.75)	4.94 (2.33)	1.01 (1.22)	0.47 (0.98)	90.29 (9.52)
Jyothi	10 (3.24)	75.6 (8.72)	63.1 (7.93)	335.81 (18.33)	7.5 (2.82)	0.42 (0.95)	0.18 (0.82)	0.05 (0.74)	6.6 (2.66)	1.11 (1.26)	0.57 (1.03)	133.2 (11.56)
Uma	10.3 (3.29)	71.45 (8.47)	61.2 (7.85)	319.71 (17.89)	7.7 (2.86)	0.35 (0.92)	0.2 (0.83)	0.04 (0.73)	5.26 (2.40)	1.07 (1.25)	0.56 (1.03)	101.35 (10.08)
CD	**0.1213**	**0.4171**	**0.3712**	**0.8799**	**0.1198**	**0.0489**	**0.0303**	**0.003**	**0.0303**	**0.030**	**0.060**	**0.4246**

Figures in parenthesis are SQRT ($\sqrt{x+1/2}$) transformed values

A phosphorus content of 133.2 mg/ 100g and 101.35mg/ 100g was noticed in control varieties *Jyothi* and *Uma* respectively. On analysis of the critical difference in phosphorus content among different varieties, *Ezhome*-2 was found to be on par with that of control rice variety *Jyothi*.

Newly released rice varieties were found to be superior in nutritional qualities when compared with control varieties.

4. 1. 4. Physical qualities of unroasted and roasted rice flour

Unroasted and roasted flour prepared from rice varieties were evaluated for various physical characteristics like bulk density, water absorption index, water solubility index and retrogradation property. The results are as follows.

4. 1. 4. 1. Bulk density

Bulk density of unroasted and roasted rice flour from rice varieties is given in Table 6. In the case of unroasted rice flour, the highest bulk density of 0.73 g per ml was noticed in *Ezhome*-2 and followed by 0.71 g per ml in both *Vyttila*-8 and *Vaishak* (PTB-60). The lowest of 0.70 g per ml was observed in *Ezhome*-1 and *Prathyasha* (MO-21) rice variety.

In case of roasted rice flour, among the newly released rice varieties the highest bulk density of 0.61 g per ml was observed in *Prathyasha* (MO-21) and *Ezhome*-1 followed by 0.54 g per ml in *Ezhome*-2. The lowest bulk density of 0.53 g per ml was noticed in both *Vyttila*-8 and in *Vaishak* (PTB-60).

The control rice variety *Jyothi* obtained bulk density of 0.63 g per ml in unroasted rice flour and 0.54 g per ml in roasted rice flour. *Uma* obtained bulk density of 0.71 in unroasted rice flour and 0.62 in roasted rice flour. Newly released rice variety *Ezhome*-2 obtained the highest bulk density for unroasted rice flour. Compared to the newly released rice varieties, control variety *Uma* obtained the highest bulk density in the case of roasted rice flour.

The critical difference among bulk density of different rice varieties was assessed. In the case of unroasted rice flour, the bulk density of *Ezhome*-2 was on par with that of *Vyttila*-8, *Vaishak* (PTB-60) and *Uma*. The bulk density of roasted rice flour of *Ezhome*-1 was found to be on par with that of *Prathyasha* (MO-21) and *Uma*. Considerable variation was not observed in bulk density of both unroasted and roasted rice flour of different rice varieties.

4. 1. 4. 2. Water absorption index

Water absorption index of unroasted and roasted flour from rice varieties is given in Table 6. In the case of unroasted rice flour, the highest water absorption index was observed in *Ezhome*-1 (23.78) and the lowest of 22.67 in *Vaishak* (PTB-60) variety. Unroasted rice flour of *Ezhome*-2, *Prathyasha* (MO-21) and *Vyttila*-8 obtained a water absorption index of 23.74, 23.21 and 22.98 respectively. Water absorption index of 25.46 and 25.45 was observed in unroasted rice flour of control varieties *Jyothi* and *Uma*.

Water absorption index of roasted rice flour of newly released rice varieties was highest for *Ezhome- 2* (23.90) followed by *Prathyasha* (MO-21) (23.08), *Vyttila*-8 (22.83), *Vaishak* (PTB-60) (22.34) and *Ezhome*-1 (22.17). Roasted rice flour of *Jyothi* and *Uma* varieties obtained a water absorption index of 24.65 and 25.11

respectively. Compared to the control varieties, newly released rice varieties obtained a lower water absorption index in both unroasted and roasted flour.

Water absorption index of unroasted rice flour of *Vyttila*-8 was found to be on par with that of *Ezhome*-1 and *Ezhome*-2. Roasted rice flour of *Prathyasha* (MO-21) was found to be on par with that of *Ezhome*-2. Among selected rice varieties, the water absorption index of unroasted and roasted rice flour of none of the varieties was on par with that of control varieties *Jyothi* and *Uma*.

4. 1. 4. 3. Water solubility index

Water solubility index of unroasted and roasted flour from rice varieties are given in Table 6. In the case of unroasted rice flour, the highest water solubility index of 0.73 was observed in *Vyttila*-8 and the lowest of 0.34 in *Ezhome*-1 rice variety. Water solubility index of 0.55, 0.60 and 0.61 were noticed in *Prathyasha* (MO-21), *Ezhome*-2 and *Vaishak* (PTB-60) respectively. Unroasted rice flour of all newly released rice varieties, except that of *Ezhome*-1 showed higher water solubility with respect to control varieties *Jyothi* and *Uma.*

In roasted rice flour of newly released rice varieties, the highest water solubility index of 0.81 was noticed in *Ezhome*-2 followed by *Prathyasha* (MO-21) (0.40), *Vaishak* (PTB-60) (0.65) and *Ezhome*-1 (0.79). Among different rice varieties, the lowest water solubility index for roasted rice flour was noticed in *Vyttila*-8 (0.28).

Control varieties *Jyothi* and *Uma* recorded a water solubility index of (0.49 and 0.42) and (0.42 and 0.68) for unroasted and roasted rice flour respectively. The critical differences in water solubility index of unroasted as well as roasted flour of newly released varieties were assessed and found that it was statistically insignificant.

Table 6: Physical qualities of roasted and unroasted flour of rice varieties

Rice varieties	Bulk density (g)		Water absorption index		Water solubility index	
	Unroasted	Roasted	Unroasted	Roasted	Unroasted	Roasted
Ezhome -1	0.70 (1.09)	0.61 (1.05)	23.78 (4.92)	22.17 (4.76)	0.34 (0.98)	0.79 (1.13)
Ezhome – 2	0.73 (1.10)	0.54 (1.02)	23.74 (4.92)	23.90 (4.93)	0.60 (1.05)	0.81 (1.13)
Prathyasha (MO-21)	0.70 (1.09)	0.61 (1.05)	23.21 (4.86)	23.08 (4.85)	0.55 (1.02)	0.40 (0.92)
Vyttila-8	0.71 (1.10)	0.53 (1.01)	22.98 (4.84)	22.83 (4.83)	0.78 (1.10)	0.28 (0.87)
Vaishak (PTB-60)	0.71 (1.10)	0.53 (1.01)	22.67 (4.81)	22.34 (4.77)	0.61 (1.05)	0.65 (1.07)
Jyothi	0.63 (1.06)	0.54 (1.02)	25.46 (5.09)	24.65 (5.01)	0.49 (0.99)	0.42 (0.95)
Uma	0.71 (1.10)	0.62 (1.05)	25.45 (5.09)	25.11 (5.06)	0.42 (0.96)	0.68 (1.08)
CD	**0.003**	**0.003**	**0.2351**	**0.2329**	**NS**	**NS**

Figures in parenthesis are SQRT ($\sqrt{x+1/2}$) transformed values

NS: Not significant

4. 1. 4. 4. Retrogradation property

Retrogradation property of unroasted and roasted flour prepared from rice varieties were studied by evaluating the synerisis percentage is presented in Table 7.

Among unroasted rice flour prepared with different rice varieties, *Ezhome*-1 obtained the highest synerisis percentage during 3rd day of observation, which increased gradually on 6th, 9th and 12th day. During 3rd day, the lowest synerisis percentage was observed in unroasted rice flour of *Uma* variety. Except in *Ezhome*-2, unroasted rice flour of all other varieties showed a gradual increase in synersis percentage from 3rd day to 12th day of study. At the end of 12th day of study, the highest synerisis percentage was noticed in unroasted rice flour of *Vyttila*-8 and the lowest in that of *Uma*.

Among roasted rice flour of different varieties, *Ezhome*-2 obtained the highest synerisis percentage at 3rd day of study and the lowest in *Vaishak* (PTB-60). At the end of 12th day of study, the highest synerisis percentage was noticed in *Ezhome*-1 and the lowest in *Prathyasha* (MO-21). Except in roasted rice flour of *Ezhome*-2 and *Prathyasha* (MO-21), in all other varieties a gradual increase in synersis percentage from 3rd day to 12th day was observed. Physical properties of rice flour of newly released varieties were comparable with that of control varieties.

4. 1. 5. Storage qualities of rice and roasted rice flour

4. 1. 5. 1. Microbial enumeration of rice and roasted rice flour

Rice and roasted flour prepared from rice varieties were evaluated for bacteria, fungi and yeast initially and at monthly intervals until the end of 6th month

Table 7: Retrogradation property of unroasted and roasted flour of rice varieties

(Synerisis %)

Rice varieties	Days							
	3rd day		6th day		9th day		12th day	
	UR	R	UR	R	UR	R	UR	R
Ezhome - 1	15	25	25	30	26	36	34	42
Ezhome - 2	13	26	28	25	24	36	35	33
Prathyasha (MO-21)	6	10	18	16	25	33	29	24
Vyttila - 8	5	9	31	28	32	37	36	34
Vishak (PTB-60)	4	8	11	29	27	35	34	37
Jyothi	3	10	16	25	23	28	26	28
Uma	2	11	12	17	22	24	25	27

UR-unroasted rice flour
R-roasted rice f lour

of storage. The results of microbial enumeration of raw rice and of roasted rice flour are given in Table 8 to Table 13.

4. 1. 5. 2. Microbial enumeration of rice

Initially the bacterial count in rice varieties was found to be in a range of 1.3 x 10^5 cfu g^{-1} (5.11 x 10^5 cfu g^{-1}) to 1.6 x 10^5 cfu g^{-1} (5.20 x 10^5 cfu g^{-1}). During the period of storage it was found that there was gradual increase in the bacterial count in all seven varieties. Among newly released rice varieties, *Vyttila*-8 obtained the highest microbial count of 4.3 x 10^5 cfu g^{-1} (5.63 x 10^5 cfu g^{-1}) at the end of storage period. Control varieties *Jyothi* and *Uma* obtained a bacterial count of 3.3 x 10^5 cfu g^{-1} (5.51 x 10^5 cfu g^{-1}) and 3.6 x 10^5 cfu g^{-1} (5.55 x 10^5 cfu g^{-1}) at the end of 6^{th} month of study.

Fungal growth was not detected till the fourth month of study in any of the rice varieties. During 5^{th} month, fungal growth was detected in all the varieties except in *Vaishak* (PTB-60) and *Uma.* Among newly released rice varieties, *Ezhome*-1, *Ezhome*-2 and *Vyttila*-8 obtained the highest fungal count of 0.6 x 10^3 cfu g^{-1} (2.77 x 10^3 cfu g^{-1}) at the end of 6^{th} month. Fungal growth of 0.6 x 10^3 cfu g^{-1} (2.77 x 10^3 cfu g^{-1}) and 0.3 x 10^3 cfu g^{-1} (2.47 x 10^3 cfu g^{-1}) was noticed in control varieties *Jyothi* and *Uma* at the end of storage period.

Yeast count was not detected until 5^{th} month of the study, in any of the rice varieties. Yeast count was observed in a range of 0.3 x 10^3 cfu g^{-1} (2.47 x 10^3 cfu g^{-1}) to 1.6 x 10^3 cfu g^{-1}(2.77 x 10^3 cfu g^{-1}) in different rice varieties at the end of storage study.

Table 8: Effect of storage on the bacterial count of different rice varieties ($x\ 10^5$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	1.3 (5.11)	1.3 (5.11)	2.6 (5.41)	3.3 (5.51)	3.3 (5.51)	3.6 (5.55)
Ezhome - 2	1.6 (5.20)	1.6 (5.20)	1.6 (5.20)	1.6 (5.20)	2.3 (5.36)	2.6 (5.41)
Prathyasha (MO-21)	1.6 (5.20)	1.6 (5.20)	1.6 (5.20)	1.6 (5.20)	2.3 (5.36)	2.3 (5.36)
Vyttila - 8	1.6 (5.20)	2.3 (5.36)	2.6 (5.41)	2.6 (5.41)	3.3 (5.51)	4.3 (5.63)
Vaishak (PTB-60)	1.3 (5.11)	1.3 (5.11)	1.6 (5.20)	1.6 (5.20)	2.3 (5.36)	2.3 (5.36)
Jyothi	1.6 (5.20)	1.6 (5.20)	1.6 (5.20)	2.6 (5.41)	2.6 (5.41)	3.3 (5.51)
Uma	1.6 (5.20)	1.6 (5.20)	2.3 (5.36)	2.3 (5.36)	3.3 (5.51)	3.6 (5.55)

Values in parenthesis are log cfu/ g

Table 9: Effect of storage on the fungal count of different rice varieties ($x\ 10^3$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Ezhome - 2	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Prathyasha (MO-21)	ND	ND	ND	ND	0.3 (2.47)	0.3 (2.47)
Vyttila - 8	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Vaishak (PTB-60)	ND	ND	ND	ND	ND	0.3 (2.47)
Jyothi	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Uma	ND	ND	ND	ND	ND	0.3 (2.47)

ND: not detected

Values in parenthesis are log cfu/ g

Table 10: Effect of storage on the yeast count of different rice varieties ($x\ 10^3$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	ND	ND	ND	ND	ND	0.6 (2.77)
Ezhome - 2	ND	ND	ND	ND	ND	0.3 (2.47)
Prathyasha (MO-21)	ND	ND	ND	ND	ND	0.3 (2.47)
Vyttila - 8	ND	ND	ND	ND	ND	1.6 (3.20)
Vaishak (PTB-60)	ND	ND	ND	ND	ND	0.6 (2.77)
Jyothi	ND	ND	ND	ND	ND	0.3 (2.47)
Uma	ND	ND	ND	ND	ND	0.6 (2.77)

ND: not detected

Values in parenthesis are log cfu/ g

Table 11: Effect of storage on the bacterial count of flour of different rice varieties ($x\ 10^5$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	1.6 (5.20)	1.6 (5.20)	2.6 (5.41)	3.3 (5.51)	3.3 (5.51)	3.3 (5.51)
Ezhome - 2	1.6 (5.20)	1.6 (5.20)	2.6 (5.41)	2.6 (5.41)	3.3 (5.51)	3.3 (5.51)
Prathyasha (MO-21)	1.3 (5.11)	1.3 (5.11)	1.6 (5.20)	2.3 (5.36)	2.3 (5.36)	2.3 (5.36)
Vyttila - 8	2.3 (5.36)	2.3 (5.36)	2.6 (5.41)	3.3 (5.51)	3.6 (5.55)	3.6 (5.55)
Vaishak (PTB-60)	2.3 (5.36)	2.3 (5.36)	2.3 (5.36)	2.6 (5.41)	2.6 (5.41)	2.6 (5.41)
Jyothi	2.6 (5.41)	2.6 (5.41)	3.3 (5.51)	3.3 (5.51)	3.6 (5.55)	3.6 (5.55)
Uma	2.3 (5.36)	2.3 (5.36)	2.6 (5.41)	3.3 (5.51)	3.3 (5.51)	3.6 (5.55)

Values in parenthesis are log cfu/ g

4. 1. 5. 3. Microbial enumeration of roasted rice flour

The bacterial count in roasted flour of rice varieties was found to be in a range of 1.3 x 10^5 cfu g^{-1} (5.11 x 10^5 cfu g^{-1}) to 2.6 x 10^5 cfu g^{-1} (5.41 x 10^5 cfu g^{-1}) during 1st month of study. During the period of storage, a gradual increase was observed in the bacterial count in roasted rice flour in all seven varieties. *Vyttila*-8 (3.6 x 10^5 cfu g^{-1}) (5.55 x 10^5 cfu g^{-1}) variety had the highest microbial count compared to other newly released varieties. A bacterial count of 3.3 x 10^5 cfu g^{-1} (5.51 x 10^5 cfu g^{-1}) was noticed in roasted rice flour of *Ezhome*-1 and *Ezhome*-2. *Prathyasha* (MO-21), and *Vaishak* (PTB-60) obtained a bacterial count of 2.3 x 10^5 cfu g^{-1} (5.36 x 10^5 cfu g^{-1}) and 2.6 x 10^5 cfu g^{-1} (5.41 x 10^5 cfu g^{-1}). Roasted rice flour prepared with *Jyothi* and *Uma* obtained bacterial count of 3.6 x 10^5 cfu g^{-1} (5.55 x 10^5 cfu g^{-1}) at the end of 6th month of study.

Fungal growth was not detected till 4th month of study, in any of the rice varieties. Among different rice varieties under the study, fungal growth was detected during 5th month of storage in all rice varieties except in *Prathyasha* (MO-21) and *Vyttila*-8. Fungal count in a range of 0.3 x 10^3 cfu g^{-1} (2.47 x 10^3 cfu g^{-1}) to 0.6 x 10^3 cfu g^{-1} (2.77 x 10^3 cfu g^{-1}) was noticed in all the seven rice varieties at the end of 6th month of study. Control varieties *Jyothi* and *Uma* obtained fungal count of 0.6 x 10^3 cfu g^{-1} (2.77 x 10^3 cfu g^{-1}) for each at the end of storage study.

Yeast count was not detected in roasted rice flour till the 5th month of study in any of the rice varieties. Newly released rice varieties showed a yeast count of 0.6 x 10^3 cfu g^{-1} (2.77 x 10^3 cfu g^{-1}) except in *Ezhome*-1 variety at the end of 6th month of storage. Yeast count was not detected in *Vaishak* (PTB-60) rice variety at the end of the storage period. Control varieties *Jyothi* and *Uma* obtained a yeast count of 0.3

Table 12: Effect of storage on the fungal count of flour of different rice varieties ($\times 10^3$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Ezhome - 2	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Prathyasha (MO-21)	ND	ND	ND	ND	ND	0.3 (2.47)
Vyttila - 8	ND	ND	ND	ND	ND	0.3 (2.47)
Vaishak (PTB-60)	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)
Jyothi	ND	ND	ND	ND	ND	0.6 (2.77)
Uma	ND	ND	ND	ND	0.3 (2.47)	0.6 (2.77)

ND: not detected
Values in parenthesis are log cfu/ g

Table 13: Effect of storage on the yeast count of flour of different rice varieties ($\times 10^3$ cfu g^{-1})

Rice varieties	Storage period in months					
	1st month	2nd month	3rd month	4th month	5th month	6th month
Ezhome - 1	ND	ND	ND	ND	ND	0.3 (2.47)
Ezhome - 2	ND	ND	ND	ND	ND	0.6 (2.77)
Prathyasha (MO-21)	ND	ND	ND	ND	ND	0.6 (2.77)
Vyttila - 8	ND	ND	ND	ND	ND	0.6 (2.77)
Vaishak (PTB-60)	ND	ND	ND	ND	ND	ND
Jyothi	ND	ND	ND	ND	ND	0.3 (2.47)
Uma	ND	ND	ND	ND	ND	0.6 (2.77)

ND: not detected
Values in parenthesis are log cfu/ g

$x10^3$ cfu g^{-1} (2.47 x 10^3 cfu g^{-1}) and 0.6 $x10^3$ cfu g^{-1}(2.77 x 10^3 cfu g^{-1}) at the end of the study.

4. 1. 5. 4. Insect infestation in rice and roasted rice flour

The rice and roasted flour of seven rice varieties were visually examined for the presence of insects for a period of six months. No storage pest was observed in newly released rice varieties as well as in control varieties. There was no insect infestation in the roasted rice flour of all the varieties throughout the storage period.

4. 2. Acceptability of rice based traditional food products

Six traditional food products were prepared from rice varieties and acceptability of these products was evaluated. Rice flakes were prepared with paddy and *iddli* was prepared using raw rice. Unroasted flour of rice varieties were used to prepare traditional food products like *appam* and *unniappam*. Products namely *puttu* and *ada* were prepared with roasted flour of rice varieties. The mean organoleptic scores and mean rank scores obtained for the various organoleptic attributes of the product are presented in this section. The scores of total index were worked out for the rice varieties and based on this, suitability of the varieties for different preparations were determined.

4. 2. 1. Organoleptic evaluation of rice and rice based products

4. 2. 1. 1. Rice flakes

Mean scores for different quality attributes of rice flakes are given in Table 14 and the total index obtained for selected rice varieties are given along with the mean scores. In rice flakes prepared using paddy of newly released rice varieties, the mean score for appearance varied from 7.10 (*Ezhome*-1) to 8.40 (*Vyttila*-8) with a mean rank score in the range of 2.50 and 5.80. Rice flakes prepared with *Prathyasha* (MO-21), *Ezhome*-2 and *Vaishak* (PTB-60) obtained a mean score of 7.50, 7.60 and 7.80 with a mean rank score of 3.65, 3.85 and 4.45 respectively. Control varieties *Jyothi* and *Uma* obtained a mean score of 7.90 and 7.30 with a mean rank score of 4.80 and 2.95 respectively for appearance. The highest mean rank score for appearance of rice flakes was observed for *Vyttila*-8 (5.80) and the lowest for *Ezhome*-1 (2.50).

For colour, the highest mean score of 7.90 for rice flakes was observed in *Prathyasha* (MO-21) and *Vaishak* (PTB-60) with a mean rank score of 4.80 and 4.55 respectively. Rice flakes prepared with varieties like *Vyttila*-8 and *Ezhome*-2 obtained a mean rank score of 4.15 and 4.45 respectively. Mean scores of 7.70 and 7.30 was observed in rice flakes prepared with control varieties *Jyothi* and *Uma* with a mean rank score of 4.20 and 2.90.

For flavour of rice flakes, the highest mean rank score of 4.70 was obtained for both *Prathyasha* (MO-21) and *Vyttila-8.* The lowest mean score of 7.00 with a mean rank score of 2.60 was noticed in rice flakes prepared with *Ezhome*-1. The mean score of 7.8 was recorded for rice flakes prepared with control variety *Jyothi* and it was found to be same as that of *Prathyasha* (MO-21) and *Vyttila*-8.

In rice flakes prepared with different rice varieties, the mean rank score for texture varied from 2.15 (*Ezhome*-1) to 4.80 (*Prathyasha* (MO-21)) with a mean score of 6.90 and 8.00. Texture of rice flakes prepared with *Vaishak* (PTB-60), *Ezhome*-2 and *Vyttila*-8 obtained a mean score of 7.50, 7.60 and 7.90 respectively. Rice flakes prepared with control variety *Jyothi* obtained a mean score of 8.00 for texture with a mean rank score of 4.70. Rice flakes prepared with control variety

Jyothi and newly released rice variety *Prathyasha* (MO-21) obtained a mean score of 8.00 for texture.

The mean scores for taste varied from 7.10 to 8.20 with a mean rank score of 2.50 (*Ezhome*-1) and 5.25 (*Vyttila*-8). Rice flakes prepared with *Vyttila*-8 obtained the highest mean rank score among the different varieties. The mean score for taste recorded in rice flakes prepared with control varieties *Jyothi* and *Uma* were 8.00 and 7.70 respectively.

The mean rank score for overall acceptability of rice flakes prepared with newly released rice varieties varied from 6.90 (*Ezhome*-1) to 8.30 (*Vyttila*-8). The highest overall acceptability was noticed in rice flakes prepared with *Vyttila*-8 and the lowest in *Ezhome*-1. The mean rank score for overall acceptability noticed in rice flakes prepared with *Vaishak* (PTB-60) was 3.10. Rice flakes prepared with *Ezhome*-2 and *Prathyasha* (MO-21) obtained the mean rank score of 4.30 for overall acceptability. In *Jyothi* and *Uma*, the mean score of 7.80 was observed for overall acceptability. Rice flakes prepared with different rice varieties are shown in Plate 5a and 5b.

Significant agreement among judges was noticed in the evaluating quality attributes like appearance, colour, flavour, texture, taste and overall acceptability.

For rice flakes, the highest total index of 14.73 was noticed in newly released rice variety *Vyttila*-8 followed by control variety *Jyothi* (14.04). These varieties were found to be the most suitable for the preparation of rice flakes.

Table 14: Mean scores for different organoleptic qualities of rice flakes

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	7.10 (2.50)	7.20 (2.95)	7.00 (2.60)	6.90 (2.15)	7.10 (2.50)	6.90 (1.90)	7.41
Ezhome – 2	7.60 (3.85)	7.8 (4.45)	7.60 (4.00)	7.60 (3.75)	7.80 (4.15)	7.80 (4.30)	12.04
Prathyasha (MO-21)	7.50 (3.65)	7.90 (4.80)	7.80 (4.70)	8.00 (4.80)	7.70 (3.75)	7.80 (4.30)	12.94
Vyttila-8	8.40 (5.80)	7.70 (4.15)	7.80 (4.70)	7.90 (4.60)	8.20 (5.25)	8.30 (5.70)	**14.73**
Vaishak (PTB-60)	7.80 (4.45)	7.90 (4.55)	7.70 (4.20)	7.50 (3.50)	7.70 (3.85)	7.40 (3.10)	11.87
Jyothi	7.90 (4.80)	7.70 (4.20)	7.80 (4.65)	8.00 (4.75)	8.00 (4.75)	7.80 (4.35)	14.04
Uma	7.30 (2.95)	7.30 (2.90)	7.30 (3.15)	7.90 (4.45)	7.70 (3.75)	7.80 (4.35)	10.95
Kendall's W	***0.402	*0.192	**0.221	***0.323	**0.250	***0.460	

Figures in parenthesis are mean scores

*Significant at 10% level, ** Significant at 5% level and ***Significant at 1% level

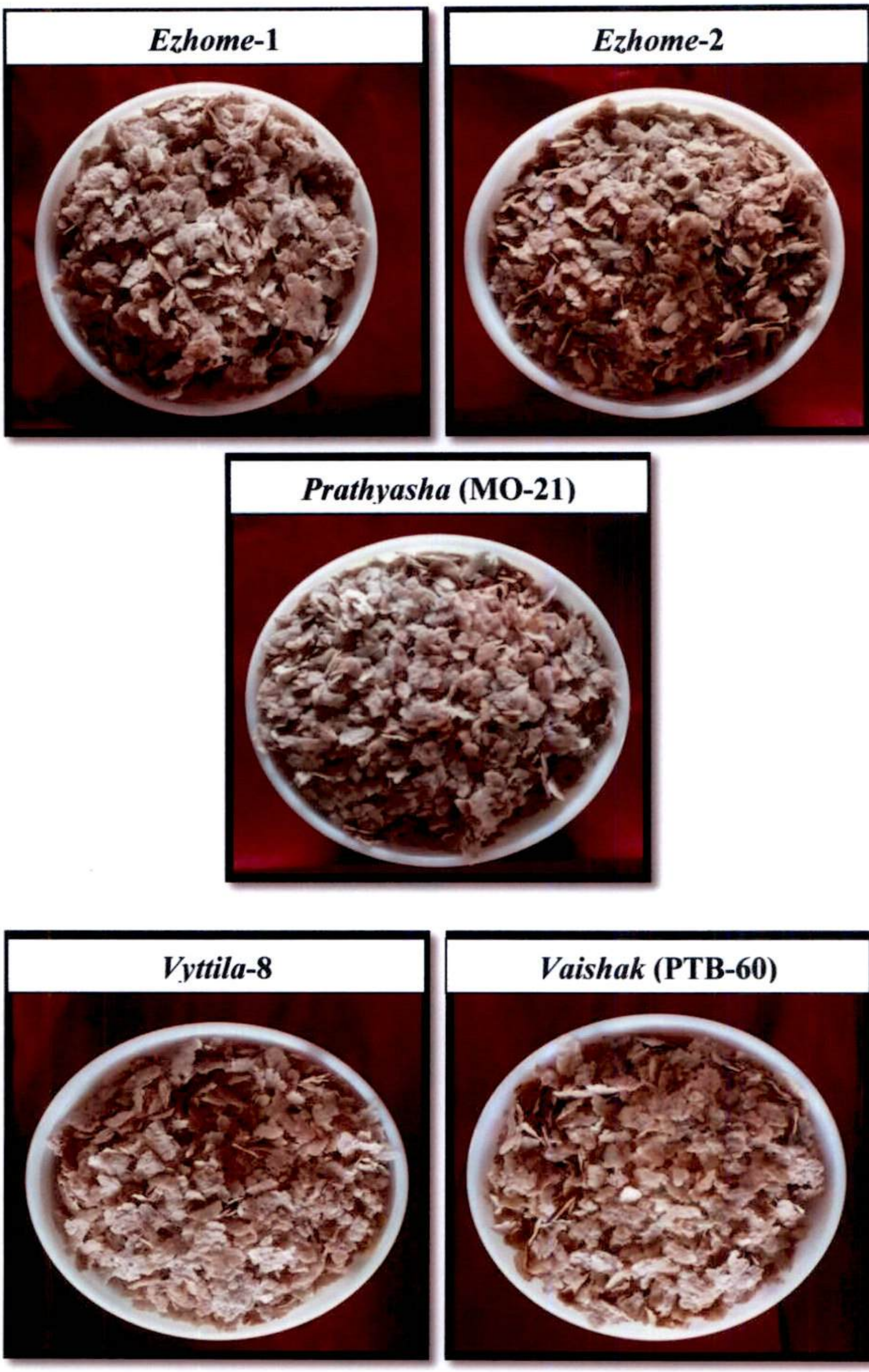


Plate 5a: Rice flakes prepared with rice varieties

Plate 5b: Rice flakes prepared with rice varieties

4. 2. 1. 2. *Iddli*

Traditional fermented breakfast preparation *iddli* was prepared with raw rice of rice varieties and are presented in Plate 6a and 6b. Mean scores for different quality attributes of *iddli* are given in Table 15. Traditional product *iddli* was prepared with raw rice of newly released rice varieties as well as control rice varieties *Jyothi* and *Uma*. Mean score for appearance of *iddli* varied from 7.50 (*Vaishak* (PTB-60)) to 8.10 (*Ezhome*-1) with a mean rank score in the range of 2.95 and 4.80. A mean score of 7.70 was recorded by *Prathyasha* (MO-21) and *Vyttila*-8 with a mean rank score of 3.65 for appearance of *iddli.* Control varieties *Jyothi* and *Uma* obtained a mean score of 7.90 and 8.00 for appearance of *iddli* with a mean rank scores of 4.30 and 4.65 respectively. *Iddli* prepared with newly released rice varieties were compared and found that *Ezhome*-1 obtained the highest mean score of 8.10 for appearance.

The mean scores for colour of *iddli* prepared with newly released rice varieties varied from 7.40 (*Vaishak* (PTB-60)) to 8.20 (*Ezhome*-2) with a mean rank score in the range of 3.15 to 4.95. Varieties like *Vyttila*-8, *Ezhome*-1 and *Prathyasha* (MO-21) obtained a mean rank score of 3.25, 3.55 and 4.15 respectively for colour of *iddli.* Control varieties *Jyothi* and *Uma* recorded a mean score of 7.70 and 8.00 for colour of *iddli* with a mean rank score of 3.95 and 5.00 respectively.

In *iddli* prepared with newly released rice varieties, mean score for flavour varied from 7.20 to 7.80 with a mean rank score of 2.80 in *Vaishak* (PTB-60) and 4.40 in *Prathyasha* (MO-21). *Iddli* prepared with control variety *Uma* had the highest mean score of 8.00 with a mean rank score of 4.95. *Iddli* prepared with newly released rice varieties obtained lower mean score for flavour when compared with that of the control rice variety *Uma.*

The mean rank scores for texture varied from 3.10 to 4.35 in *Vaishak* (PTB-60) and *Prathyasha* (MO-21) with a mean score of 7.40 and 8.00. *Iddli* prepared with the control variety *Jyothi* obtained the mean score of 8.00 and the highest mean score of 8.30 for *Uma*.

For taste, *iddli* prepared with *Ezhome*-2 and *Vyttila*-8 obtained a higher mean score of 8.00 followed by 7.90 for *Prathyasha* (MO-21). Control rice varieties *Jyothi* and *Uma* obtained the highest mean score of 8.20 and 8.10 with a mean rank scores of 5.00 and 4.60 for taste of *iddli*.

The mean rank scores for overall acceptability of *iddli* prepared with newly released rice varieties varied from 7.60 (*Vaishak* (PTB-60)) to 8.10 (*Prathyasha* (MO-21)). Mean scores of 8.00 was obtained for both *Vyttila-8* and *Ezhome-2* and 7.8 for *Ezhome-1*. *Iddli* prepared with newly released rice varieties were compared and it was found that *Prathyasha* (MO-21) obtained the highest mean score for overall acceptability of 8.10. But when compared with the *iddli* prepared with control rice varieties, the highest mean rank score of 8.20 for overall acceptability was shown by *Jyothi* variety.

Significant agreement among the judges was noticed in the quality attributes like appearance, colour, texture and taste for *iddli* prepared with different rice varieties. For flavour and overall acceptability of *iddli*, there was no significant agreement was observed among the judges.

Among different rice varieties, the highest total index of 14.78 was obtained by *iddli* prepared with control variety *Uma*. Newly released rice varieties obtained lower total index compared to control varieties. *Prathyasha* (MO-21) obtained the

Table 15: Mean scores for different organoleptic qualities of *iddli*

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	8.10 (4.80)	7.50 (3.55)	7.60 (3.70)	7.80 (3.70)	7.30 (2.30)	7.80 (3.6)	9.98
Ezhome – 2	7.80 (4.00)	8.20 (4.95)	7.70 (4.30)	7.60 (3.40)	8.00 (4.25)	8.00 (4.05)	12.23
Prathyasha (MO-21)	7.70 (3.65)	7.80 (4.15)	7.80 (4.40)	8.00 (4.35)	7.90 (4.00)	8.10 (4.40)	12.46
Vyttila-8	7.70 (3.65)	7.50 (3.25)	7.50 (3.50)	7.80 (3.55)	8.00 (4.20)	8.00 (3.95)	11.21
Vaishak (PTB-60)	7.50 (2.95)	7.40 (3.15)	7.20 (2.80)	7.40 (3.10)	7.70 (3.65)	7.60 (2.95)	9.64
Jyothi	7.90 (4.30)	7.70 (3.95)	7.80 (4.35)	8.00 (4.50)	8.20 (5.00)	8.20 (4.65)	13.68
Uma	8.00 (4.65)	8.00 (5.00)	8.00 (4.95)	8.30 (5.40)	8.10 (4.60)	8.10 (4.40)	**14.78**
Kendall's W	***0.196**	***0.169**	**0.152^{NS}**	***0.177**	***0.241**	**0.102^{NS}**	

Figures in parenthesis are mean scores
*Significant at 10% level
NS: Not significant

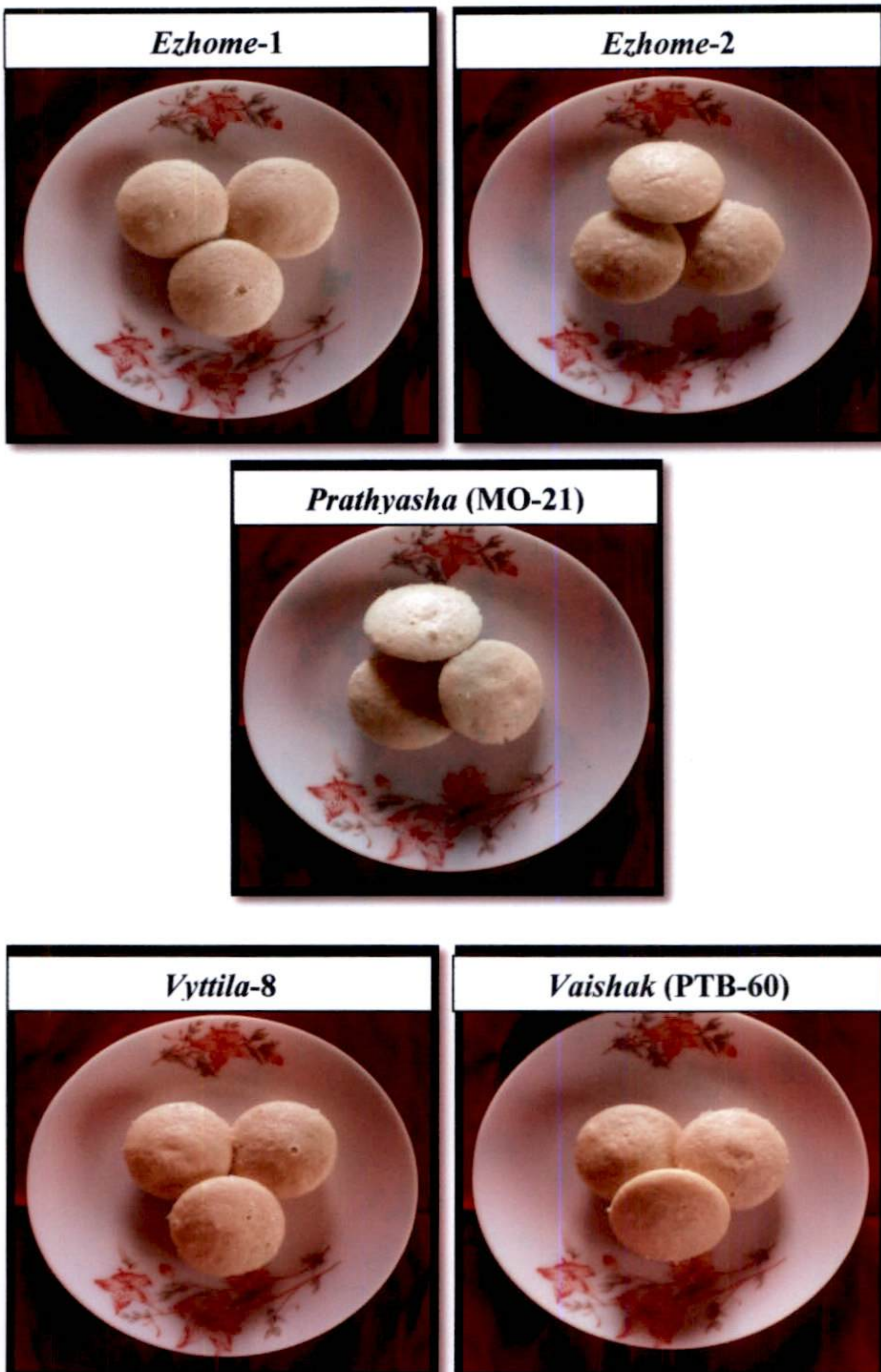


Plate 6a: *Iddli* prepared with different rice varieties

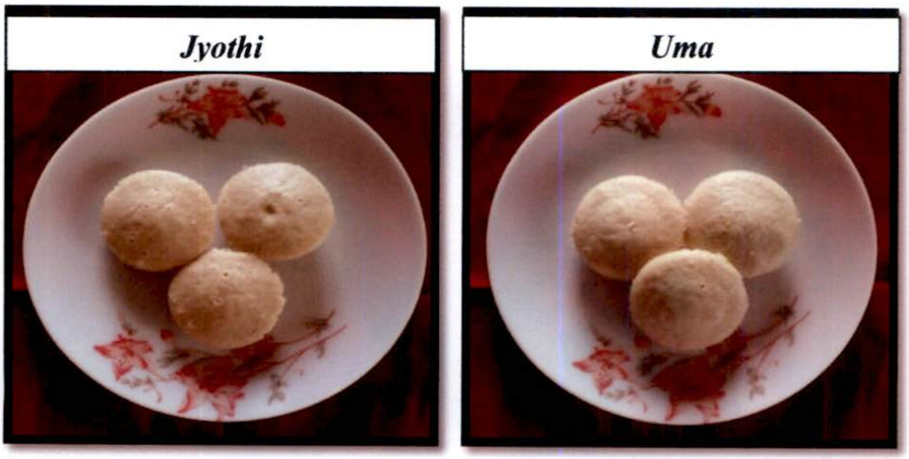


Plate 6b: ***Iddli*** **prepared with different rice varieties**

highest total index of 12.46 for *iddli* among newly released rice varieties. *Uma* was found to be the most suitable variety for the preparation of *iddli*.

4. 2. 2. Organoleptic evaluation of rice flour based products

4. 2. 2. 1. *Appam*

Traditional fermented product *appam* was prepared with unroasted flour of rice varieties (Plate 7a and 7b) and the organoleptic qualities were assessed. Mean scores for different quality attributes of *appam* are given in Table 16 and the total index obtained for selected rice varieties are given along with the mean scores. *Appam* prepared with unroasted rice flour obtained the mean scores for appearance in a range of 7.00 (*Vaishak* (PTB-60)) to 7.70 (*Vyttila*-8) with a mean rank score ranging from 3.15 to 4.85. *Ezhome*-2, *Prathyasha* (MO-21) and *Ezhome*-1 had a mean rank score of 3.80, 4.15 and 4.50 respectively. *Vyttila*-8 was found to have a high mean score of 7.70 for appearance of *appam* when compared to the mean score obtained for that of the control varieties *Jyothi* (7.2) and *Uma* (7.6).

In *appam* prepared with newly released rice varieties, the mean scores for colour varied from 6.8 to 7.50 with a mean rank score in the range of 3.05 to 4.80. Maximum mean score for colour was noticed in *appam* prepared with *Ezhome*-2 and minimum in *Vaishak* (PTB-60). *Appam* prepared with varieties like *Ezhome*-1, *Prathyasha* (MO-21) and *Vyttila*-8 had a mean rank score of 3.90, 4.15 and 4.20 respectively. Control varieties obtained a mean score of 7.3 and 7.2 for *appam* with mean rank score of 4.04 (*Jyothi*) and 3.85 (*Uma*).

The mean scores for flavour of *appam* prepared with different rice varieties were evaluated and found that it varied from 7.10 to 7.40 with a mean rank score of 3.65 in *Ezhome*-1 and 4.65 in *Ezhome*-2. The mean score of 7.3 was recorded in *appam* prepared with *Vyttila*-8 and *Prathyasha* (MO-21). Control varieties *Jyothi* and *Uma* obtained the same mean rank score of 7.10 for *appam* with varying mean rank scores of 3.65 and 3.70 respectively.

In *appam* prepared with newly released rice varieties, the mean rank scores for texture varied from 3.30 (*Vaishak* (PTB-6)) to 4.40 (*Prathyasha* (MO-21)). *Appam* prepared with *Ezhome*-2 and *Vyttila*-8 and the control variety *Jyothi* obtained the mean score of 7.20 for texture. The control variety *Uma* obtained the highest mean score of 7.40 with a mean rank score of 4.60 for texture.

For taste of *appam* prepared with newly released rice varieties, the highest mean score of 7.30 with a mean rank score of 4.65 was noticed in *Prathyasha* (MO-21). *Appam* prepared with *Vaishak* (PTB-60) and *Ezhome -2* obtained a mean score of 7.10 and a mean rank score of 4.00 and 4.05 respectively. *Appam* prepared with control varieties *Jyothi* and *Uma* obtained a mean score of 6.9 and 7.3 with a mean rank score of 3.70 and 4.65 respectively for taste.

The overall acceptability for *appam* prepared with different rice varieties obtained a mean score in the range of 6.90 (*Jyothi*) to 7.30 (*Uma* and *Ezhome*-2). *Appam* prepared with *Pratyasha, Vyttila*-8 and *Vaishak* (PTB-60) obtained the same mean score of 7.20 for overall acceptability. The highest mean score of 7.3 for overall acceptability was noticed in *appam* prepared with *Uma* and *Ezhome*-2 with the highest mean rank score of 4.50 in *Uma*.

No significant agreement among judges was noticed in the quality attributes like colour, flavour, texture, taste and overall acceptability of *appam*.

Table 16: Mean scores for different organoleptic qualities of *appam*

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	7.60 (4.50)	7.20 (3.90)	7.10 (3.65)	7.10 (3.70)	6.90 (3.45)	7.00 (3.45)	11.12
Ezhome – 2	7.40 (3.80)	7.50 (4.80)	7.40 (4.65)	7.20 (3.95)	7.10 (4.05)	7.30 (4.30)	12.58
Prathyasha (MO-21)	7.50 (4.15)	7.30 (4.15)	7.30 (4.25)	7.30 (4.40)	7.30 (4.65)	7.20 (4.15)	**13.21**
Vyttila-8	7.70 (4.85)	7.30 (4.20)	7.30 (4.25)	7.20 (4.00)	6.90 (3.50)	7.20 (4.20)	11.96
Vaishak (PTB-60)	7.00 (3.15)	6.80 (3.05)	7.10 (3.85)	6.90 (3.30)	7.10 (4.00)	7.20 (4.20)	10.81
Jyothi	7.20 (3.10)	7.30 (4.05)	7.10 (3.65)	7.20 (4.05)	6.90 (3.70)	6.90 (3.20)	11.27
Uma	7.60 (4.45)	7.20 (3.85)	7.10 (3.70)	7.40 (4.60)	7.30 (4.65)	7.30 (4:50)	13.04
Kendall's W	***0.188**	**0.083**^{NS}	**0.054**^{NS}	**0.067**^{NS}	**0.093**^{NS}	**0.078**^{NS}	

Figures in parenthesis are mean scores

*Significant at 10% level

NS: Not significant

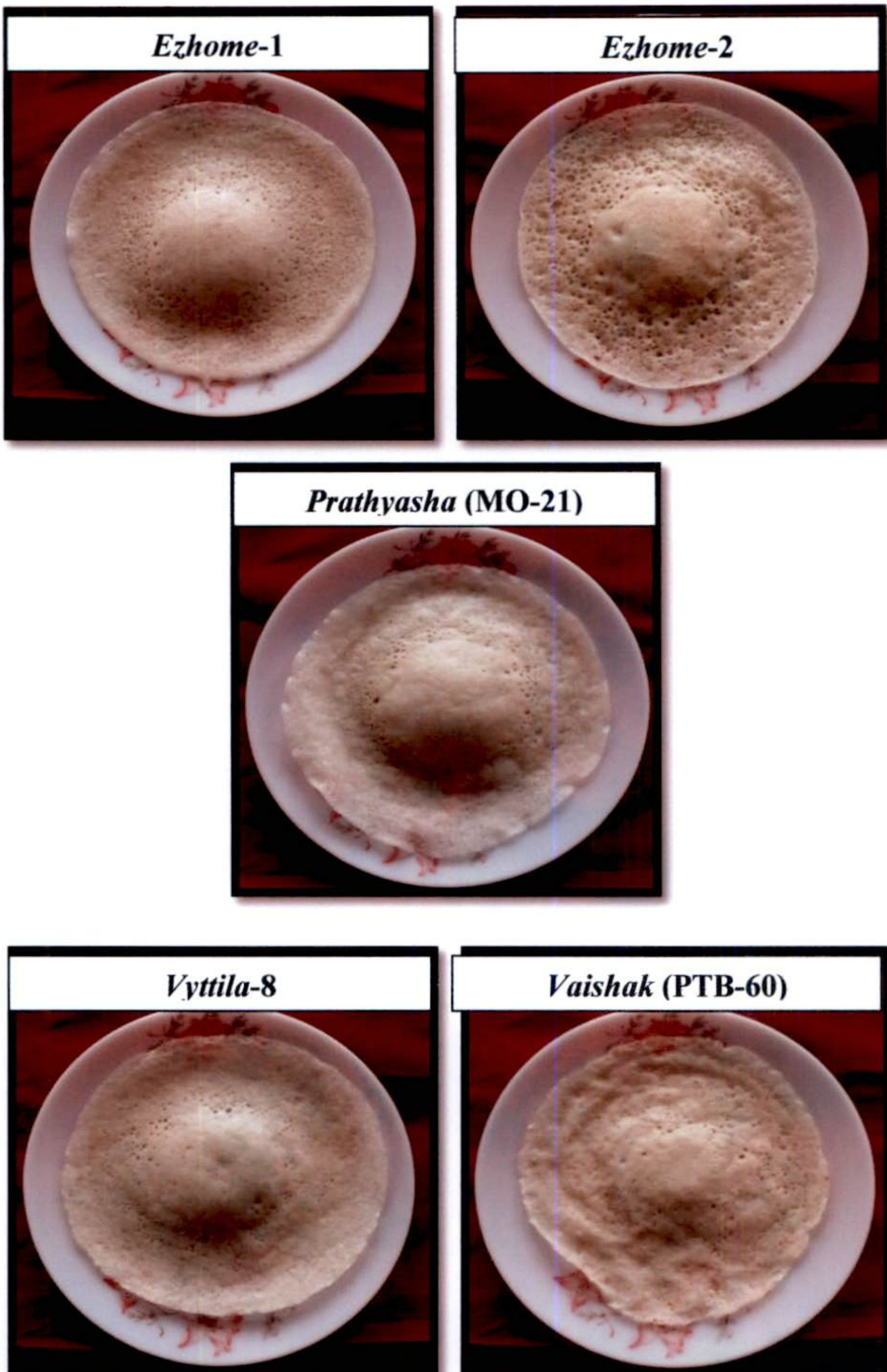


Plate 7a: *Appam* prepared with unroasted flour of rice varieties

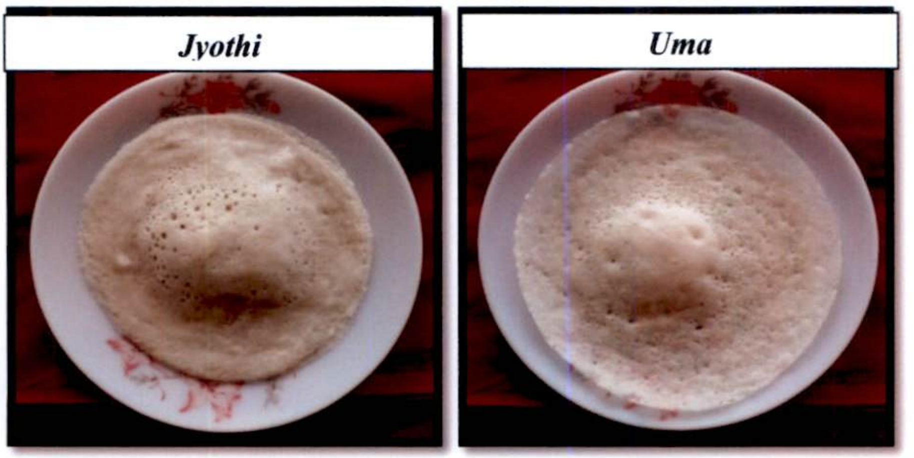


Plate 7b: *Appam* prepared with unroasted flour of rice varieties

The highest total index of 13.21 for *appam* was obtained by *Prathyasha* (MO-21) variety followed by the control variety *Uma* (13.04). *Prathyasha* (MO-21) was found to be the most suitable variety for the preparation of *appam*.

4. 2. 2. 2. *Unniappam*

Traditional fermented product *unniappam* was prepared with unroasted flour of rice varieties. As revealed in the Table 17, the mean scores for appearance of *unniappam* varied from 7.10 in *Vaishak* (PTB-60) to 8.00 in *Vyttila*-8. *Unniappam* prepared with *Ezhome*-2, *Prathyasha* (MO-21) and *Ezhome*-1 obtained a mean score of 7.90, 7.70 and 7.60 with a mean rank score of 4.50, 3.80 and 3.50 respectively. *Unniappam* prepared with the control varieties obtained a mean score of 7.80 and 8.00 respectively with a mean rank score of 4.30 (*Jyothi*) and 4.55 (*Uma*).

The mean scores for colour of *unniappam* varied from 7.40 (*Ezhome*-1) to 7.90 (*Ezhome*-2) with the mean rank score in the range of 2.95 to 4.25. *Vyttila*-8 and *Prathyasha* (MO-21) obtained the same mean scores of 7.80 with a mean rank score of 4.05. The mean scores obtained for *unniappam* prepared with control variety *Jyothi* and *Uma* were 8.00 and 7.90 with a mean rank score of 5.00 and 4.45 respectively. For *Unniappam* prepared from different rice varieties, the highest mean score for colour was obtained for control variety *Jyothi*.

The highest mean score for flavour was noticed in *unniyappam* prepared with *Vyttila*-8 (8.00) followed by that of *Ezhome*-2 (7.80), *Prathyasha* (MO-21) (7.80) and *Vaishak* (PTB-60) (7.70). The lowest mean score of 7.40 was noticed in *unniappam* prepared with *Ezhome*-1 with a mean rank score of 2.95. Control varieties *Jyothi* and *Uma* obtained the same mean score of 7.90 for *unniappam* prepared with the mean score rank of 4.45 and 4.30 respectively.

For texture of *unniappam* prepared with different rice varieties, the mean score varied from 7.30 (*Ezhome*-1) to 8.20 (*Vyttila*-8) with the mean rank score of 3.20 and 5.30. The mean rank scores of 4.45 to 3.30 was observed in control rice varieties with mean score of 7.60 in *Jyothi* and 7.40 in *Uma*. *Unniappam* prepared using *Vyttila*-8 rice variety ranked the highest for texture.

The mean scores for taste varied from 7.4 to 8.1 with the mean rank score of 2.80 in *unniappam* prepared with *Ezhome*-1 and 4.50 in that of *Vaishak* (PTB-60). *Ezhome*-2, *Vyttila*-8 and *Prathyasha* (MO-21) obtained a mean rank score of 4.05, 4.25 and 4.30 for taste. *Unniappam* prepared with control varieties *Jyothi* and *Uma* recorded a mean score of 7.80 with a mean rank score of 4.25 and 3.85 respectively.

For *unniappam*, the mean scores for overall acceptability were in the range of 7.50 in *Ezhome*-1 to 8.10 in *Vyttila*-8. *Vaishak* (PTB-60), *Ezhome*-2 and *Prathyasha* (MO-21) obtained a mean score of 7.80, 7.90 and 8.00 with a mean rank score of 3.75, 4.05 and 4.35 respectively for overall acceptability. Control varieties *Jyothi* and *Uma* obtained a mean rank score of 4.20 and 4.25 respectively for overall acceptability with a mean score of 7.9 and 8.00. *Unniappam* prepared with different rice varieties are presented in Plate 8a and 8b.

No significant agreement among judges was noticed in any of the quality attributes of the product *unniappam*.

For *unniappam* prepared with different rice varieties, the highest total index of 13.89 was obtained by newly released variety *Vyttila*-8 followed by control variety *Jyothi* (13.27). *Vyttila*-8 was found to be the most suitable variety for the preparation of *unniappam*.

Table 17: Mean scores for different organoleptic qualities of *unniappam*

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	7.60 (3.50)	7.40 (2.95)	7.40 (2.95)	7.30 (3.20)	7.40 (2.80)	7.50 (2.9)	9.06
Ezhome – 2	7.90 (4.50)	7.90 (4.25)	7.80 (4.00)	7.60 (3.80)	8.00 (4.05)	7.90 (4.05)	12.11
Prathyasha (MO-21)	7.70 (3.80)	7.80 (4.05)	7.80 (4.00)	7.80 (4.15)	8.00 (4.30)	8.00 (4.35)	12.37
Vyttila-8	8.00 (4.65)	7.80 (4.05)	8.00 (4.65)	8.20 (5.30)	8.00 (4.25)	8.10 (4.50)	**13.89**
Vaishak (PTB-60)	7.10 (2.70)	7.50 (3.25)	7.70 (3.65)	7.60 (3.80)	8.10 (4.50)	7.80 (3.75)	11.51
Jyothi	7.80 (4.30)	8.00 (5.00)	7.90 (4.45)	7.60 (4.45)	7.80 (4.25)	7.90 (4.20)	13.27
Uma	8.00 (4.55)	7.90 (4.45)	7.90 (4.30)	7.40 (3.30)	7.80 (3.85)	8.00 (4.25)	11.77
Kendall's W	**0.138** NS	**0.137** NS	**0.089** NS	**0.140** NS	**0.090** NS	**0.078** NS	

Figures in parenthesis are mean scores
NS: Not significant

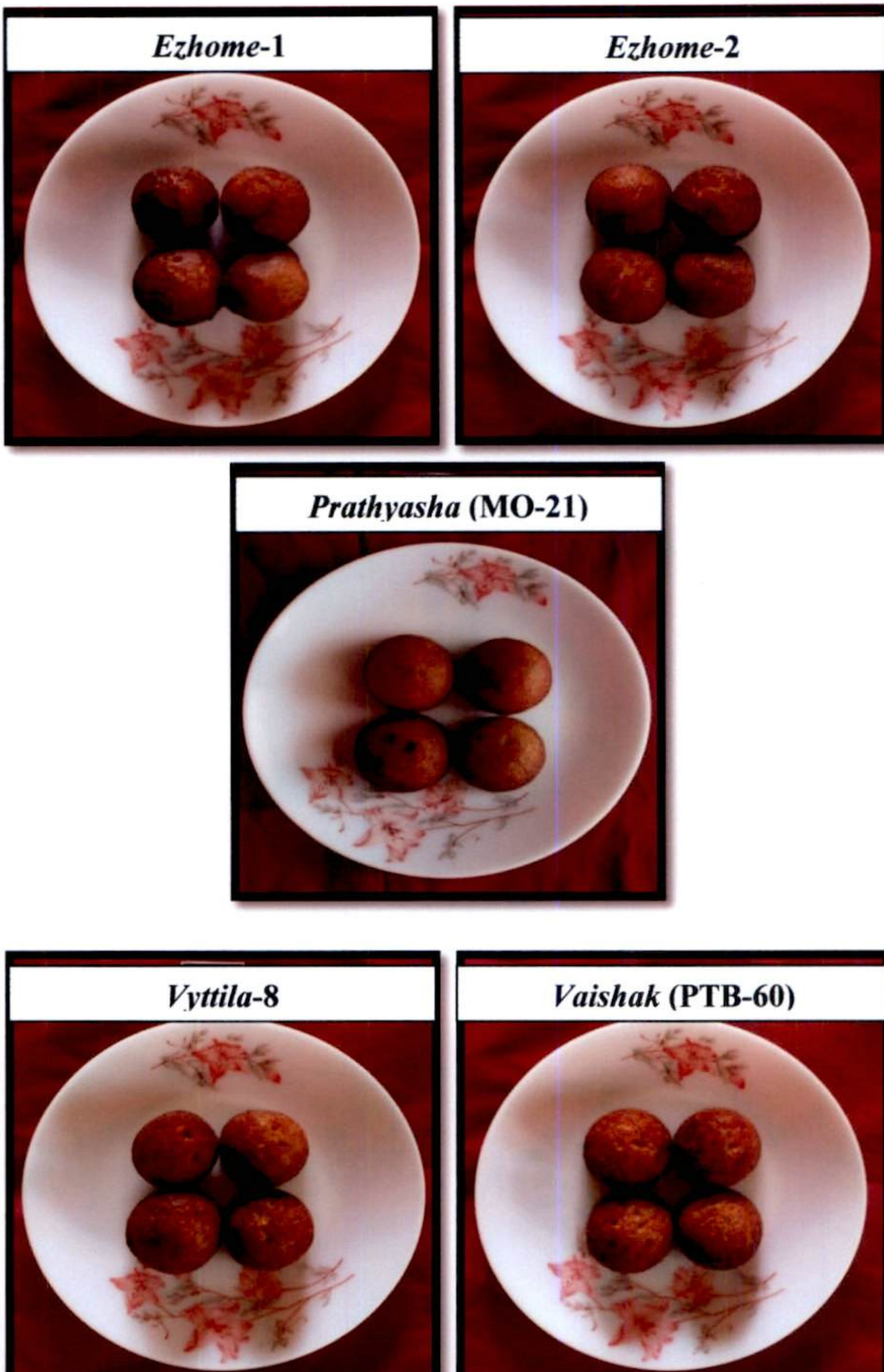


Plate 8a: *Unniappam* prepared with unroasted flour of rice varieties

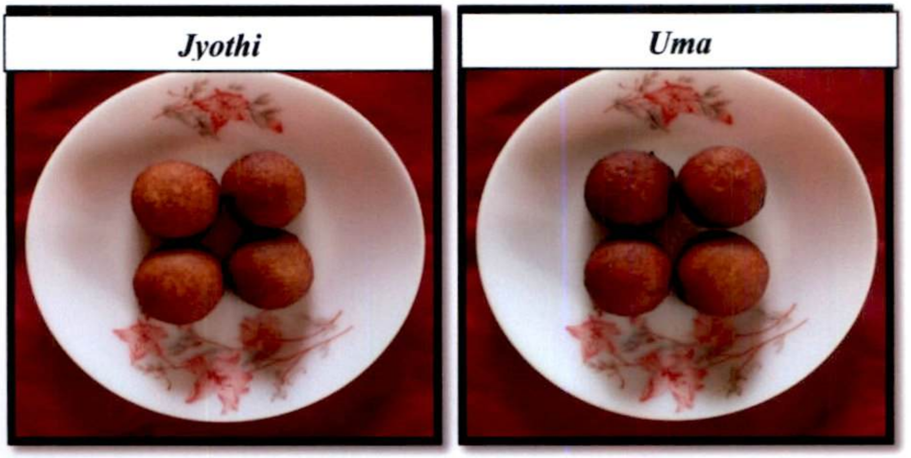


Plate 8b: *Unniappam* prepared with unroasted flour of rice varieties

4. 2. 2. 3. *Puttu*

Puttu was prepared with roasted flour of rice varieties. As revealed in the Table 18, in *puttu*, the highest mean score of 8.30 for appearance was noticed in both *puttu* prepared with *Ezhome*-1 and *Vaishak* (PTB-60) with mean rank scores of 4.55 and 4.50. *Vyttila*-8, *Ezhome*-2 and *Prathyasha* (MO-21) obtained a mean score of 7.90, 8.10 and 8.20 for appearance of *puttu* with a mean rank score of 3.30, 4.00 and 4.35 respectively. The mean scores of 7.80 and 8.10 with a mean rank score of 3.25 and 4.05 was recorded for appearance of *puttu* prepared with control varieties *Jyothi* and *Uma*.

The mean scores for colour of *puttu* varied from 7.80 in *Ezhome*-2 to 8.10 in *Vaishak* (PTB-60). *Puttu* prepared with *Ezhome*-1 and *Prathyasha* (MO-21) obtained a mean score of 7.90 and a mean rank score of 4.25. *Vyttila*-8 recorded a mean score of 8.00 with a mean rank score of 4.55 for *puttu*. The mean score of 7.40 and 7.70 with a mean rank score of 2.80 (*Jyothi*) and 3.60 (*Uma*) respectively was noticed in *puttu* prepared with control varieties. For *puttu* prepared with different rice varieties under the study, the highest mean score for colour was observed in *Vaishak* (PTB-60) and the lowest in the control variety *Jyothi*.

The mean score for flavour of *puttu* varied from 7.90 to 8.10. Mean rank scores of 7.90 was noticed in *puttu* prepared with *Prathyasha* (MO-21), *Vyttila*-8 and *Ezhome*-1. The highest mean rank score of 8.10 for flavour was recorded for *puttu* prepared with *Ezhome*-2 and *Vaishak* (PTB-60) with a mean rank score of 4.80 and 4.95 respectively. *Jyothi* and *Uma* obtained the same mean score of 7.50 with a mean rank score of 2.80 and 2.95 respectively for *puttu* prepared using these varieties.

The mean rank score for texture in *puttu* varied from 3.50 to 5.20 in *Vyttila*-8 and *Vaishak* (PTB-60) with a mean score of 7.80 and 8.40. Selected varieties *Ezhome*-1, *Ezhome*-2 and *Prathyasha* (MO-21) obtained the mean score of 7.90, 8.00 and 8.20 respectively for texture of *puttu*. Control varieties *Jyothi* and *Uma* obtained the mean score of 7.50 with the mean rank score of 3.45 and 2.80 respectively for *puttu* prepared with these varieties.

The highest mean score for taste of *puttu* was noticed in *Vaishak* (PTB-60) (8.60) with a mean rank score of 5.75 followed by 8.20 (4.55) in *puttu* prepared with *Ezhome*-1. *Puttu* prepared with both *Ezhome*-2 and *Prathyasha* (MO-21) obtained the same mean score of 8.00 with a mean rank score of 4.05 and 3.15. *Puttu* prepared with control varieties *Jyothi* (7.6) and *Uma* (7.5) obtained the mean rank scores of 3.50 and 2.85 respectively. The lowest mean rank score for *puttu* was observed in control variety *Uma* (2.85).

For overall acceptability of *puttu* prepared with newly released rice varieties, mean score varied from 7.90 (*Prathyasha* (MO-21)) to 8.50 (*Vaishak* (PTB-60)) with a mean rank score ranging from 3.65 to 5.45. *Puttu* prepared with *Ezhome*-2 and *Vyttila*-8 obtained a mean score of 8.00 with a mean rank score of 3.95 and 3.90 respectively. The lowest mean score of 7.7 was noticed in overall acceptability of *puttu* prepared with *Jyothi*. *Puttu* prepared with different rice varieties are presented in Plate 9a and 9b.

Significant agreement among judges was noticed in evaluating the quality attributes like flavour, texture, taste and overall acceptability of the product *puttu*. For *puttu*, the highest total index of 15.64 was noticed in newly released variety *Vaishak* (PTB-60) among different rice varieties. This was found to be the most suitable rice variety for the preparation of *puttu*.

Table 18: Mean scores for different organoleptic qualities of *puttu*

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	8.30 (4.55)	7.90 (4.25)	7.90 (4.20)	8.20 (4.95)	8.20 (4.55)	8.20 (4.45)	13.67
Ezhome – 2	8.10 (4.00)	7.80 (3.85)	8.10 (4.80)	8.00 (4.10)	8.00 (4.05)	8.00 (3.95)	12.56
Prathyasha (MO-21)	8.20 (4.35)	7.90 (4.25)	7.90 (4.10)	7.90 (4.00)	8.00 (4.15)	7.90 (3.65)	12.39
Vyttila-8	7.90 (3.30)	8.00 (4.55)	7.90 (4.20)	7.80 (3.50)	7.70 (3.15)	8.00 (3.90)	10.82
Vaishak (PTB-60)	8.30 (4.50)	8.10 (4.70)	8.10 (4.95)	8.40 (5.20)	8.60 (5.75)	8.50 (5.45)	**15.64**
Jyothi	7.80 (3.25)	7.40 (2.80)	7.50 (2.80)	7.50 (3.45)	7.60 (3.50)	7.70 (3.20)	9.81
Uma	8.10 (4.05)	7.70 (3.60)	7.50 (2.95)	7.50 (2.80)	7.50 (2.85)	7.80 (3.40)	9.15
Kendall's W	**0.101 NS**	**0.150 NS**	****0.226**	****0.248**	*****0.303**	***0.194**	

Figures in parenthesis are mean scores
*Significant at 10% level, ** Significant at 5% level and ***Significant at 1% level
NS: Not significant

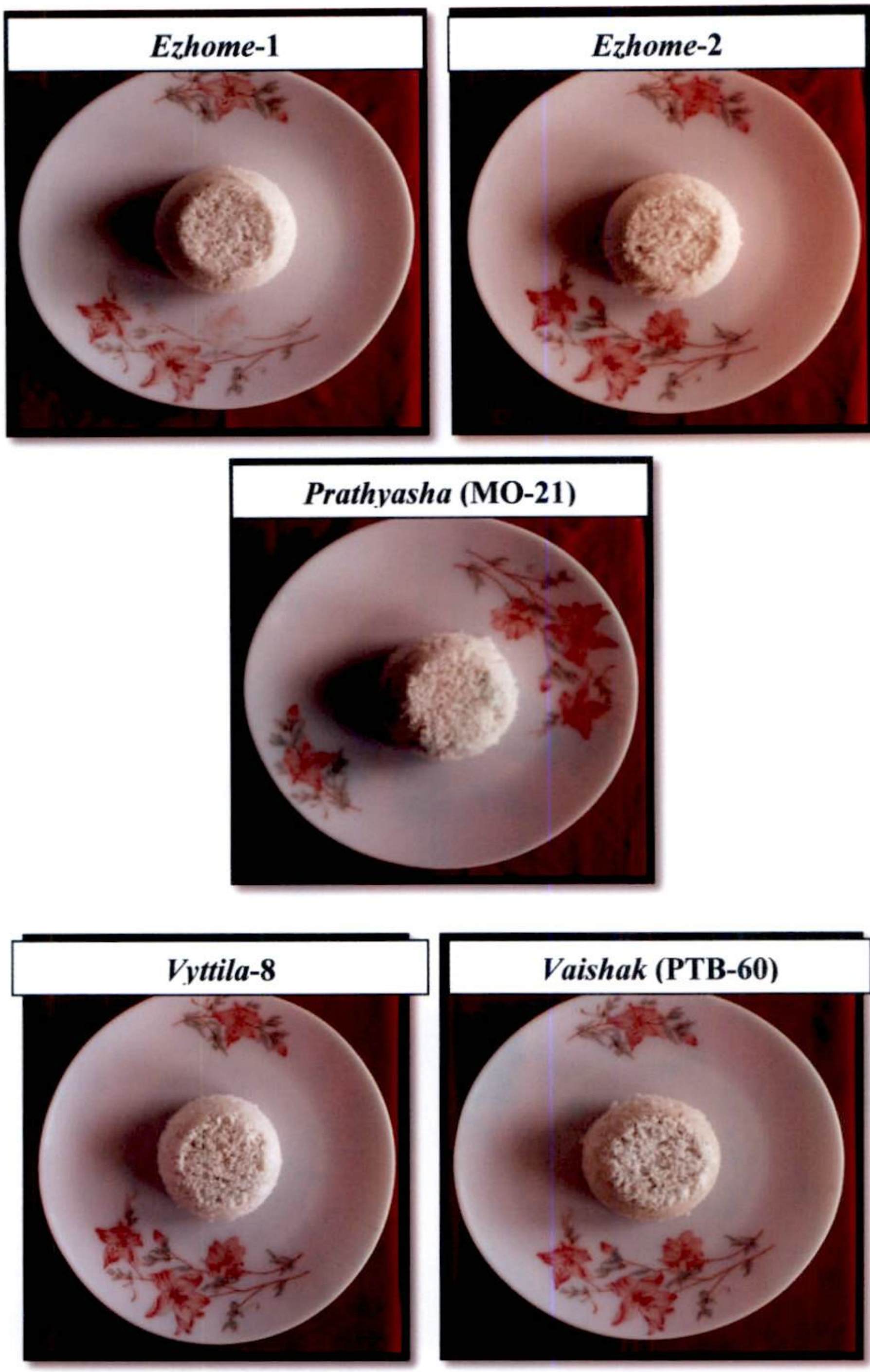


Plate 9a: *Puttu* prepared with roasted flour of rice varieties

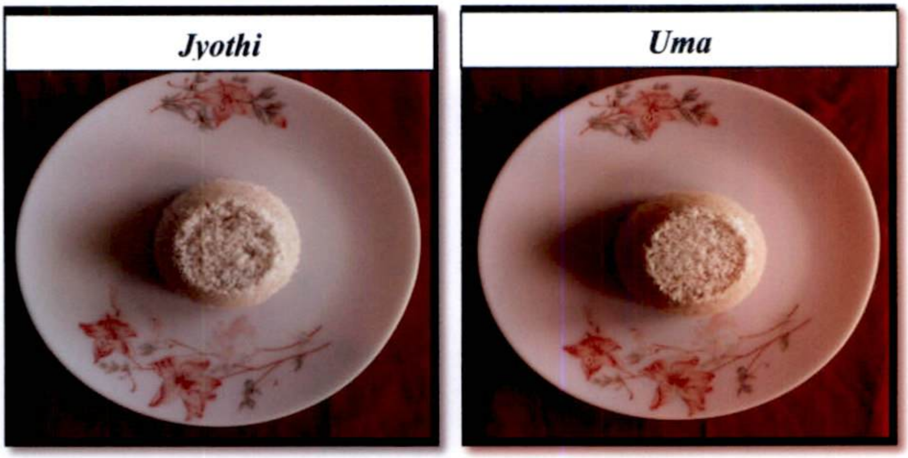


Plate 9b: *Puttu* prepared with roasted flour of rice varieties

4. 2. 2. 4. *Ada*

Ada was prepared with roasted flour of rice varieties. The mean scores for organoleptic qualities of *ada* prepared with different rice varieties are presented in Table 19 and also in Plate 10a and 10b. The mean score for appearance of *ada* varied from 7.00 (*Ezhome*-2) to 8.30 (*Prathyasha* (MO-21)). The mean scores of 7.80, 7.50 and 7.40 were observed in *ada* prepared with *Vyttila*-8, *Vaishak* (PTB-60) and *Ezhome*-1 respectively. Control varieties *Jyothi* and *Uma* recorded a mean score of 8.30 and 7.90 with a mean rank score of 3.20 and 3.40 for appearance of *ada*. Among different rice varieties under the study, *ada* prepared with both *Prathyasha* (MO-21) and control variety *Jyothi* obtained the highest mean score for appearance.

The highest mean score for colour was noticed in *ada* prepared with *Prathyasha* (MO-21) (8.40) followed by *Vyttila*-8 (7.80), *Vaishak* (PTB-60) (7.60) and *Ezhome*-1 (7.20). *Ada* prepared with *Ezhome*-2 was found to be having the lowest mean score of 7.00 with a mean rank score of 2.25 for colour. The mean rank score obtained for *ada* prepared with control varieties *Jyothi* and *Uma* were 4.60 and 4.10 respectively.

The highest mean score of 8.00 for flavour was recorded in *ada* prepared with *Prathyasha* (MO-21) as well as in the control variety *Jyothi*. *Vaishak* (PTB-60), *Vyttila*-8 and *Ezhome*-2 obtained mean scores of 7.60, 7.50 and 7.20 with a mean rank score of 4.05, 3.65 and 3.40 respectively. Among all, the lowest mean rank score was noticed in *ada* prepared with *Ezhome*-2 (2.05). Control varieties *Jyothi* and *Uma* obtained the mean score of 7.9 and 8 with the same mean rank score of 4.85 for flavour of *ada*.

Table 19: Mean scores for different organoleptic qualities of *ada*

Rice varieties	Mean rank score						
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total index
Ezhome -1	7.40 (4.45)	7.20 (2.90)	7.20 (3.40)	7.20 (3.05)	7.40 (3.25)	7.30 (2.70)	9.93
Ezhome – 2	7.00 (3.95)	7.00 (2.25)	6.90 (2.05)	7.10 (2.90)	6.90 (1.80)	7.00 (2.00)	7.21
Prathyasha (MO-21)	8.30 (3.65)	8.40 (5.95)	8.00 (5.15)	8.20 (5.70)	8.30 (5.70)	8.20 (5.45)	**16.23**
Vyttila-8	7.80 (3.90)	7.80 (4.30)	7.50 (3.65)	7.40 (3.55)	7.80 (4.20)	7.80 (4.20)	11.69
Vaishak (PTB-60)	7.50 (5.45)	7.60 (3.90)	7.60 (4.05)	7.30 (3.30)	7.60 (3.65)	7.60 (3.50)	11.52
Jyothi	8.30 (3.20)	8.00 (4.60)	8.00 (4.85)	8.00 (5.30)	8.20 (5.00)	8.40 (5.75)	14.49
Uma	7.90 (3.40)	7.70 (4.10)	7.90 (4.85)	7.60 (4.20)	8.00 (4.50)	8.00 (4.40)	13.02
Kendall's W	***0.194**	*****0.389**	*****0.348**	*****0.324**	*****0.442**	*****0.507**	

Figures in parenthesis are mean scores
*Significant at 10% level and ***Significant at 1% level

***Ezhome*-1**

***Ezhome*-2**

***Prathyasha* (MO-21)**

***Vyttila*-8**

***Vaishak* (PTB-60)**

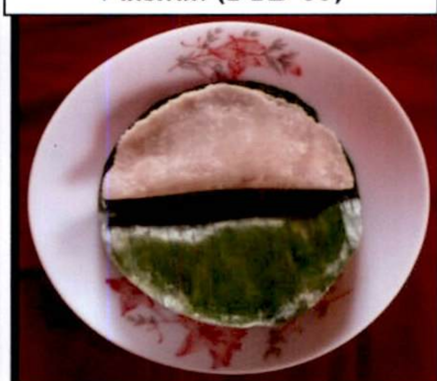


Plate 10a: *Ada* prepared with roasted flour of rice varieties

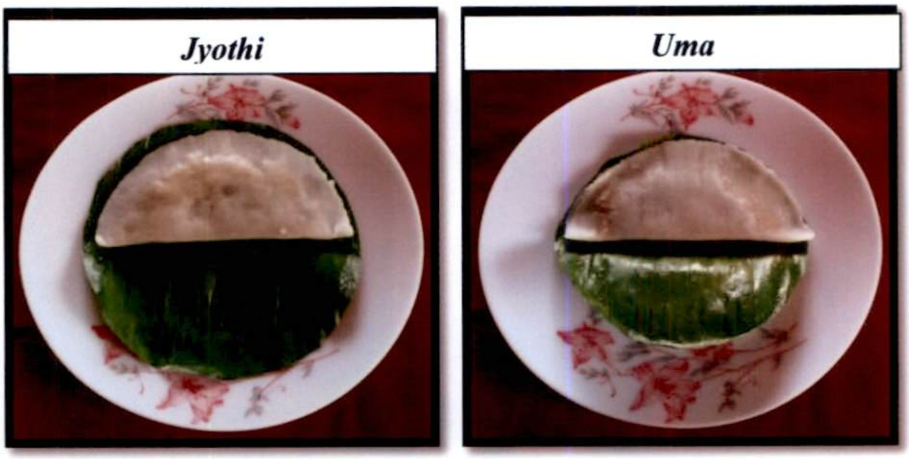


Plate 10b: ***Ada*** **prepared with roasted flour of rice varieties**

The mean score for texture varied from 7.10 to 8.20 with a mean rank score of 2.90 in *ada* prepared with *Ezhome*-2 and 5.70 in *Prathyasha* (MO-21). Mean scores of 7.40, 7.30 and 7.20 with a mean rank scores of 3.55, 3.30 and 3.05 were noticed in *ada* prepared with *Vyttila*-8, *Vaishak* (PTB-60) and *Ezhome*-1 respectively. *Ada* prepared with control varieties obtained a mean rank score ranging from 5.30 to 4.20 with a mean score of 8.00 for *Jyothi* and 7.60 for *Uma* variety. *Ada* prepared using *Prathyasha* (MO-21) rice variety ranked high among all the seven rice varieties.

The mean rank score of 8.30 for taste of *ada* prepared with *Prathyasha* (MO-21) was recorded as the highest. The mean scores for taste of *ada* prepared using different rice varieties varied from 6.90 to 8.30 with the mean rank scores of 1.80 and 5.70. *Ada* prepared with *Vyttila*-8, *Vaishak* (PTB-60), *Ezhome*-1 and *Ezhome*-2 were found to have a mean score of 7.80, 7.60, 7.40 and 6.90 with a mean rank score of 4.20, 7.60, 3.25 and 1.80 respectively. Control varieties *Jyothi* and *Uma* obtained a mean score of 8.20 and 8.00 respectively for taste of *ada.*

For overall acceptability of the product *ada* prepared with newly released rice varieties, *Prathyasha* (MO-21) obtained the highest score of 8.20 followed by *Vyttila*-8, *Vaishak* (PTB-60), *Ezhome*-1 and *Ezhome*-2 with a mean score of 7.80, 7.60, 7.30 and 7.00. Control varieties *Jyothi* and *Uma* recorded the mean rank scores of 5.75 and 4.40 respectively with mean scores of 8.40 and 8.00.

Significant agreement among judges was noticed in the quality attributes like appearance, colour, flavour, texture, taste and overall acceptability of the product *ada.*

Among different rice varieties, the highest total index of 16.23 for *ada* was noticed in newly released variety *Prathyasha* (MO-21) which was found to be the most suitable rice variety for the preparation of *ada*.

Discussion

5. DISCUSSION

The results of the study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' are discussed under the following headings.

5. 1. Quality evaluation of rice and flour of rice varieties

5. 1. 1. Physical qualities of rice

5. 1. 2. Cooking qualities of rice

5. 1. 3. Chemical and nutritional qualities of rice

5. 1. 4. Physical qualities of roasted and unroasted rice flour

5. 1. 5. Storage qualities of rice and roasted rice flour

5. 2. Acceptability of traditional food products

5. 2. 1. Organoleptic evaluation of rice and rice based products

5. 2. 2. Organoleptic evaluation of rice flour based products

5. 1. Quality evaluation of rice and flour of different rice varieties

5. 1. 1. Physical qualities of rice

Quality traits highly influence consumption and trade of rice and rice products and are vital for the performance evaluation of different rice cultivars.

Physical properties of rice like milling per cent, head rice recovery, thousand grain weight, volume weight, grain shape and size of different rice varieties were evaluated. Milling yield is one of the most important criteria of rice quality and it is a very important factor in rice processing, storage and also in marketing. Degree of milling affects milling recovery and influence consumer acceptance.

In the present study, considerable variation in milling per cent was noticed among different rice varieties. The milling per cent of newly released rice varieties varied from 64.07 per cent in *Prathyasha* (MO-21) to 77.83 per cent in *Ezhome*-2. The milling per cent of *Ezhome* varieties observed in the present study is in line with the observations reported by Government of India (2013). The report indicated that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* had a milling per cent of 76.9 per cent, 75.3 per cent, 74.8 per cent and 75.1 per cent respectively.

A lower milling per cent of 69 per cent, 68 per cent and 63.7 per cent in *Ezhome*-1, *Ezhome*-2 and *Ezhome*-3 rice varieties respectively (Vanaja *et al.*, 2003). Devika *et al.* (2004) reported that the red rice variety *Ramanika* (MO-15) recorded a milling recovery of 76.5 per cent while it was 76 per cent in both *Uma* (MO-16) and *Revathy* (MO-17) rice varieties.

In this study, the milling recovery observed for *Vyttila*-8 was 74.10 per cent. Different studies indicated the milling per cent in the range of 70 in various *Vyttila* varieties. Shylaraj and Sasidharan (2005) observed a milling recovery of 78.30 per cent in *Vyttila*-5 variety. Vanaja and Babu (2006) reported that *Vyttila*-3 and *Vyttila*-4 rice varieties recorded a milling recovery of 70.7 per cent and 71.1 per cent respectively. The author also reported a lower milling recovery of 52.2 per cent in *Vyttila*-2 variety.

Control variety *Jyothi* obtained a milling recovery of 73.8 per cent. Vanaja and Babu (2006) reported a higher milling recovery of 64.2 per cent in *Jyothi* and 63.1 per cent in *Matta Triveni* rice varieties. Shilpa and Sellappan (2010) and Lakshmi (2011) also observed higher milling recovery of 78.3 per cent and 72.10 per cent respectively in *Jyothi* variety. A milling yield of 66.60 per cent was noticed in *Jyothi* variety (Sathyan, 2012).

A study by Binodh *et al.* (2006) indicated that the milling per cent of rice varieties ranged from 49.20 to 89.50 per cent among fifty five promising rice cultural varieties and hybrids from Tamil Nadu. Milling per cent can be influenced by cultivar differences, climatic conditions during grain maturation and harvest moisture content etc. (Thompson *et al.*, 2006, Siebenmorgen *et al.*, 2007 and Salassi *et al.*, 2013). The variations in milling percentage among different rice varieties are illustrated in Figure 1.

Head rice recovery depends on the grain type, chalkiness, cultivation practices and drying condition. A quality rice variety should have a head rice recovery of at least 70 per cent of the whole grain in milled rice (Dipti *et al.*, 2003).

In the present study, the head rice recovery among newly released rice varieties varied from 49.48 (*Ezhome*-2) to 57.45 (*Vyttila*-8). *Ezhome*-1, *Vaishak* (PTB-60) and *Prathyasha* (MO-21) obtained a head rice recovery of 55.49 per cent, 54.09 per cent and 52.80 per cent respectively. Grain quality characteristics of fifty five cultural varieties and hybrids from Tamil Nadu were analyzed and found that head rice recovery of the rice varieties ranged from 27.50 per cent to 67.40 per cent (Binodh *et al.*, 2006). The head rice recovery of selected rice varieties are presented in Figure 2.

Another study conducted by Vanaja *et al.* (2003) reported a head rice recovery of 62.6 per cent in *Ezhome*-3. Shylaraj and Sasidharan (2005) reported head rice recovery of 60.50 per cent in *Vyttila*-5. A report by Government of India (2013) indicated higher head rice recovery of 62 and 63 per cent respectively in *Ezhome*-1 and *Ezhome*-2.

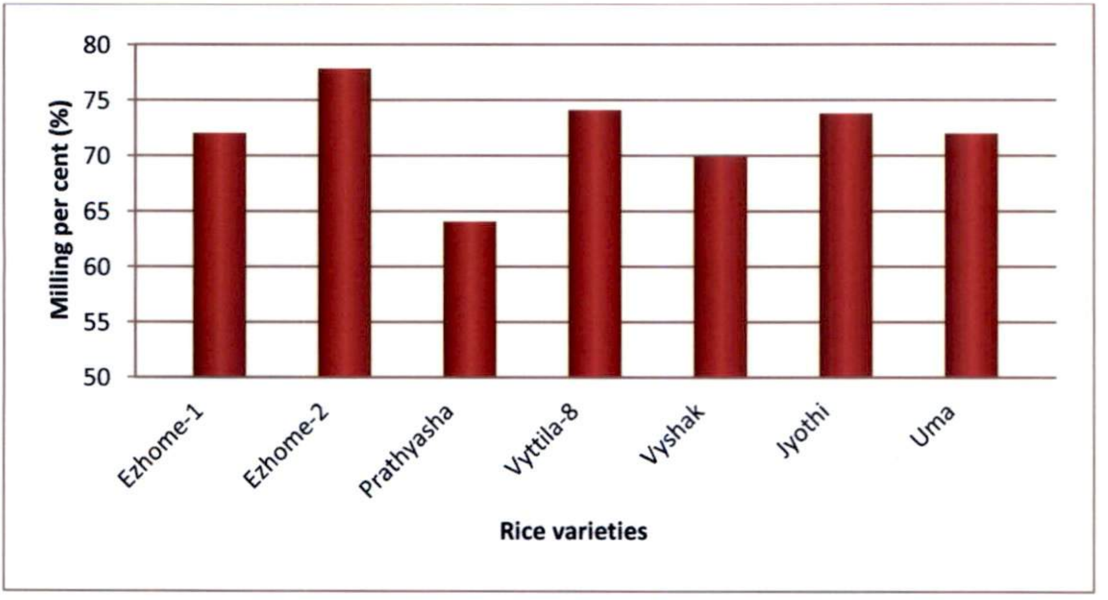


Fig. 1: Milling per cent of rice varieties

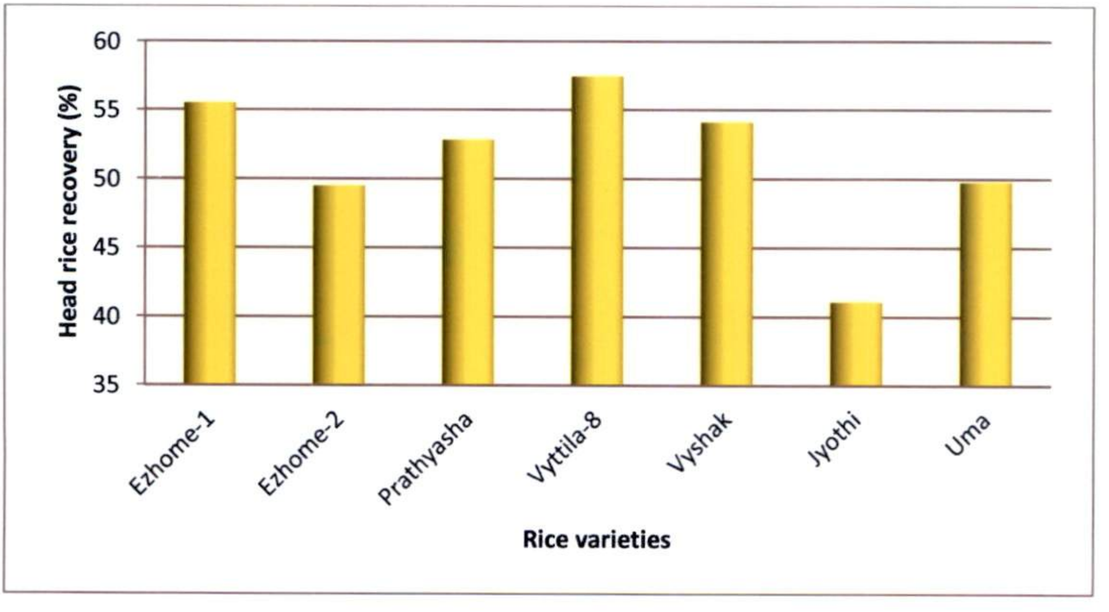


Fig. 2: Head rice recovery of rice varieties

Devika *et al.* (2004) observed head rice recovery of 54 per cent and 55 per cent in red rice varieties of KAU namely *Uma* and *Revathy*. The control varieties *Jyothi* and *Uma* obtained a head rice recovery of 41.08 per cent and 49.75 per cent respectively. A study conducted by Shilpa and Sellappan (2010) also indicated a higher head rice recovery of 68 per cent in *Jyothi* variety. Head rice recovery of 62.16 per cent and 33.66 per cent was observed in raw and parboiled rice variety *Jyothi* (Lakshmi, 2011 and Sathyan, 2012).

Head rice recovery is an inherited trait, although environmental factors such as temperature and humidity, grain size, grain shape, hardness, moisture content, harvest and storage conditions, processing and type of mills employed have direct bearing on head rice recovery (Dipti *et al.*, 2003 and Rani *et al.*, 2006). Verma *et al.* (2012) reported less breakage and higher head rice recovery in a range of 47-55 per cent in bold and short grains. In the present study, head rice recovery in the range of 49.48 (*Ezhome*-2) to 57.45 (*Vyttila*-8) was observed in newly released rice varieties and these belong to the category of bold medium rice. During milling, higher breakage is caused due to low surface hardness which in turn leads to low quality and low recovery of milled rice (Puri *et al.*, 2014).

According to Dhankar (2014) under controlled conditions head rice recovery can be as high as 84 per cent of the total milled rice or 58 per cent of the paddy weight. Commercial rice mills turn out 55 per cent head rice on average, whereas head rice recovery of village type rice mills is in the order of 30 per cent. The observed decrease in head rice per cent may be due to the difference in milling conditions.

Over exposure of mature paddy to fluctuating temperature and moisture conditions leads to more breakage during milling. Moisture content and temperature of drying are critical in determining the cracks in the grain structure. Dried paddy that is too dry becomes brittle and has greater breakage. Dilday (1987) found that the breakage during milling process decrease with increasing moisture content in the range of 12 to 16 per cent. Peuty *et al.* (1994) also reported that paddy drying condition affect the rice breakage. In this study moisture content of different selected rice varieties are in the range of 8.5 to 11.6 per cent. The low moisture content can be the reason for the observed low milling per cent and head rice recovery.

Grain weight highly influences grain yield and effects cooking and sensory qualities of rice. According to Kwarteng *et al.* (2003) thousand grain weight of 20 to 30 g is acceptable in rice. In the present study, thousand grain weight was found to be the highest in *Vaishak* (PTB-60) (20.68 g) followed by *Ezhome*-1 (20.38 g), *Vyttila*-8 (19.08 g), *Ezhome*-2 (18.6 g) and *Prathyasha* (MO-21) (17.41 g). This is in line with the observations of Ozguven and Kubilay (2004) and Varnamkhasti *et al.* (2008). The authors observed a thousand kernel weight in the range of 18.81 to 22.92 g in brown rice. They also reported that, the thousand kernel weight decreased with the level of processing from rough to brown rice. Another study by Meena *et al.* (2010) indicated that the thousand grain weight ranged between 11.36 and 20.18 g in brown rice. The thousand grain weight of different rice varieties are shown in Figure 3.

Brown rice varieties like IR-8, *Govinda* and *Sharbati* had thousand kernel weight of 24.02, 18.25 and 14.31 g respectively (Gujral and Kumar, 2003). Rice cultivars like PR-106, IR-8 and *Basmati*-370 showed thousand kernel weights of 16.55, 23.42 and 18.71 g respectively (Singh *et al.*, 2003). Grain quality characteristics of ten *Beruin* rice varieties were studied in *Bangladesh,* and observed thousand grain weight in the range of 14.3 g to 25.5 g (Dipti *et al.*, 2003). Singh *et al.* (2005) observed a thousand grain weight of 19.9 g in *IR-8* followed by 19.5 in *IET-16313*, 19.4 g in *IET-16310*, 19.4 g in *PR-113* and 13.3 g in *PR-108*. According to

Ravi *et al.* (2012) the thousand grain weight of paddy and brown rice were found to be 16.9 g and 13.5 g in Salem samba rice varieties.

Saeed *et al.* (2011) indicated that thousand kernel weight of brown rice variety of *Basmathi* in the range of 15.52 g to 18.007 g. The author also found thousand grain weight in the range of 19.42g to 18.67 g in coarse varieties.

Yadav *et al.* (2007) reported thousand grain weight of Indian rice cultivars in the range of 14.82 g to 21.02 g. The author also reported that *Sharbati* cultivar had the lowest thousand-kernel weight of 14.82 g whereas *Jaya* showed the highest value of 21.02g. In rice varieties of *Tirunelveli, Madurai* and *Virudhunagar*, thousand grain weight was noticed as 14.5g (*CO 31*) and 18.5g (*Ambai 16*), 14.0g (*Sonam*) and 18.2g (*CR 1009*), 15.7g (*TR 1*) and 17.9g (*CR 1*), respectively (Kanchana *et al.*, 2012).

Saini *et al.* (2013) reported a thousand grain weight of 22.52g, 22.77 g, 23.19 g, 22.60 g, 22.78 g, 22.76 g, 22.61 g, 22.55 g, 23.09 g, 21.37 g and 22.76 g in the rice varieties namely *Jayathi, Onam, Tulasi, Parambuvattan, Thekkancheera, Mancumpu 519, Annapoorna, Thottacheera, Karuthadukkan, Chomala* and Mo-7 respectively.

Vanaja *et al.* (2003) reported a thousand grain weight of 35.70 g in *Vyttila*-8 rice variety. In the present study, thousand grain weight of 19.98 g and 16.38 g was observed in control rice varieties *Jyothi* and *Uma*. A higher thousand grain weight of 26.56 and 25.67 was reported by Lakshmi (2011) and Sathyan (2012) in *Jyothi* variety. Government of India (2013) reported that *Kaipad* rice varieties had a thousand grain weight of 28.3, 25.6, 31.3 and 32.6 g for *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* respectively.

Most of the newly released rice varieties which are low in amylose content obtained higher, thousand grain weight than that of control varieties. In line with this, Thomas *et al.* (2013) found that glutinous rice had the highest thousand kernel weight (19.43 g) followed by Bario rice (19.23 g) and brown rice (18.66 g), respectively. The lightest thousand kernel weight was recorded for the white rice variety (16.97 g).

Grain weight can vary among the different cultivars as it is a genetically controlled parameter. It can also be affected by environment, climatic conditions, fertilizer application *etc.* In support to this Sarwar *et al.* (1998) indicated that thousand grain weight vary significantly with cultivar differences.

Volume weight of selected rice varieties varied from 12.81 mm^3 in *Ezhome*-2 to 14.6 mm^3 in *Vaishak* (PTB-60). Control rice varieties *Jyothi* and *Uma* obtained a volume weight of 12.33 mm^3 and 12.85 mm^3 respectively. Varnamkhasti *et al.* (2008) reported that the grain volume of *Sorkheh* and *Sazandegi* cultivars as 20.27 mm^3 and 21.06 mm. Sathyan (2012) observed a higher grain volume of 25.8 mm^3 in *Jyothi.* According to Mir and Bosco (2013) the mean kernel volume in brown rice varied from 14.54 (K-332) to 18.51 mm^3 (SKAU-345). The volume weight of different rice varieties of the present study are shown in Figure 4.

Grain length is an important agronomic trait determining the sensory and milling qualities of rice. Among newly released rice varieties, length of rice grain was found to be the lowest in *Prathyasha* (MO-21) (4.33 mm) and the highest in *Ezhome*-1 (4.95 mm). Control variety *Jyothi* has shown the highest grain length of 5.4 mm among all selected rice varieties. In support to this, Meena *et al.* (2010) indicated that the grain length varied from 4.30 to 7.80 mm among different rice varieties.

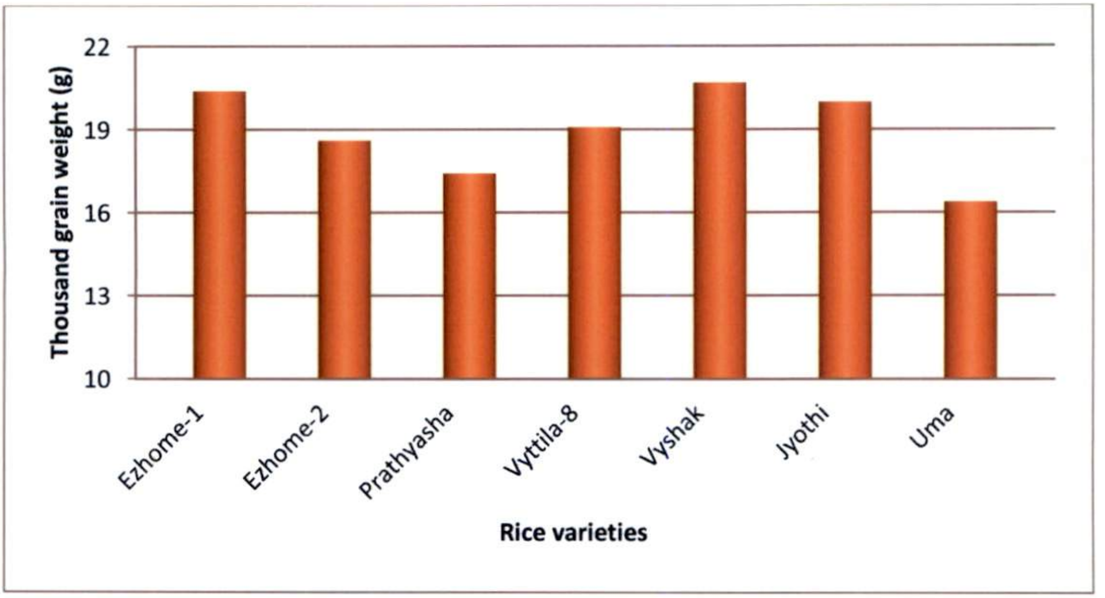


Fig. 3: Thousand grain weight of rice varieties

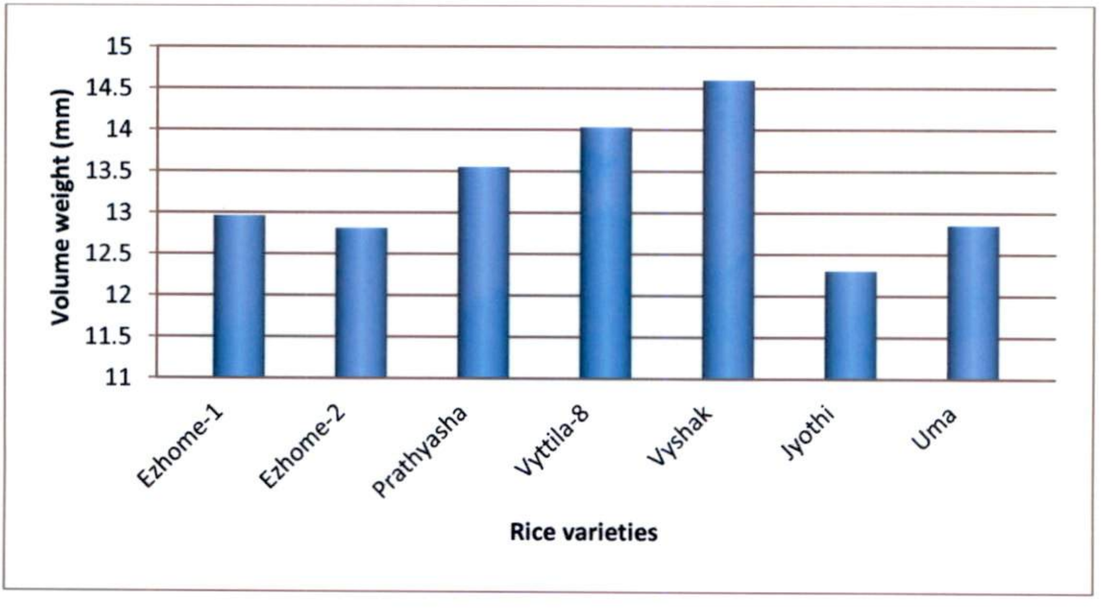


Fig. 4: Volume weight of rice varieties

Yadav *et al.* (2007) reported grain length in the range of 5.85 mm to 8.25 mm in Indian rice cultivars. Government of India (2013) reported a higher grain length of 8.3 mm, 8.1 mm and 8.7 mm and 8.9 mm in *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* respectively. In the present study, the grain length of *Vyttila*-8 was observed as 4.46 mm.

Shylaraj and Sasidharan (2005) reported a grain length of 5.90 mm in *Vyttila*-5 variety. Higher grain length of 9.09 mm, 8.84 mm and 9.16 mm was recorded in rice varieties *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 (Vanaja and Babu, 2006).

According to Vanaja and Babu (2006) *Jyothi and Matta Triveni* rice varieties recorded a grain length of 9.73 mm and 8.55 mm respectively. Lakshmi (2011) and Sathyan (2012) observed a grain length of 6.70 mm and 6.65 mm in parboiled and raw rice variety of *Jyothi*. Saini *et al.* (2013) reported a grain length of 6.85 mm, 7.13 mm, 8.77 mm, 6.61 mm, 6.56 mm, 8.09 mm, 6.33 mm, 7.04 mm, 7.84 mm, 5.28 mm and 7.33 in the rice varieties *Jayathi, Onam, Tulasi, Parambuvattan, Thekkancheera, Mancumpu 519, Annapoorna, Thottacheera, Karuthadukkan, Chomala* and Mo-7 respectively. The grain length of selected rice varieties in the present study is comparatively lower. Grain characteristics such as size and shape have a direct influence on the consumer preference and marketability of modern rice cultivars. In a study conducted by Rebeira *et al.* (2014), the *Pokkali* rice variety obtained a grain length of 5.60 mm.

The grain width of different rice varieties under the study was in the range of 1.21 to 1.86 mm. The highest grain width was observed in *Vaishak* (PTB-60) and the lowest in both *Ezhome*-2 and *Prathyasha* (MO-21). Saini *et al.* (2013) reported a grain width of 1.75 mm, 1.98 mm, 1.97 mm, 1.30 mm, 1.56 mm, 0.79 mm, 1.43 mm, 1.43 mm, 1.41 mm, 0.37 mm and 2.47 mm in the rice varieties *Jayathi, Onam, Tulasi,* *Parambuvattan, Thekkancheera, Mancumpu 519, Annapoorna, Thottacheera, Karuthadukkan, Chomala* and Mo-7 respectively.

Dipti *et al.* (2003) reported that the breadth of some rice varieties ranged from 1.7 mm to 3.7 mm. Yadav *et al.* (2007) reported grain breadth in the range of 1.65 mm to 2.93 mm in Indian rice cultivars. Meena *et al.* (2010) observed grain breadth from 1.84 mm to 2.27 mm among different rice varieties. A grain width of 1.84 mm and 1.21 mm was noticed in rice varieties *Ezhome*-1 and *Ezhome*-2. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* are having higher grain width of 3.0 mm, 3.0 mm, 3.3 mm and 3.2 mm respectively.

Shylaraj and Sasidharan (2005) reported a breadth of 2.50 mm in *Vyttila*-5 variety. Vanaja and Babu (2006) reported that *Vyttila*-2, *Vyttila*-3 *and Vyttila*-4 rice varieties recorded a higher grain width of 3.63 mm, 3.65 mm and 3.48 mm respectively. In the study *Vyttila*-8 obtained a lower grain width of 1.82 mm.

Vanaja and Babu (2006) mentioned that *Jyothi* and *Mattatriveni* rice was recorded higher grain width of 3.13 mm and 3.36 mm respectively. In the present study, the control varieties *Jyothi* and *Uma* obtained a grain width of 1.82 mm and 1.79 mm. In *Jyothi* rice varieties higher grain width of 2.50 mm and 2.20 mm was reported by Lakshmi (2011) and Sathyan (2012) respectively. A study conducted by Rebeira *et al.* (2014) found that the *Pokkali* rice variety obtained a grain breadth of 2.22 mm.

Grain shape was determined by considering the L/B ratio of milled rice. L/B ratio from 2.5 to 3.0 has been considered widely acceptable (IRRI, 2002). In the present study, the highest L/B ratio was found in *Ezhome*-2 (3.59) followed by

Prathyasha (MO-21) (3.57), *Vyttila*-8 (2.45), *Vaishak* (PTB-60) (2.4) and *Ezhome*-1 (2.3). A slightly higher L/B ratio of 2.3 and 3.59 was observed in newly released rice varieties *Ezhome*-1 and *Ezhome*-2. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* are having L/B ratio of 2.76, 2.70, 2.63 and 2.78 respectively and these are classified as medium grain rice varieties.

Yadav *et al.* (2007) reported a L/B ratio of 1.99 to 4.39 in Indian rice cultivars. According to Deepa *et al.* (2008) *Jyothi* and *Njavara* and are classified as bold and long varieties which obtained a L/B ratio of 2.65 and 2.72 respectively.

In the present study, *Vyttila*-8 obtained L/B ratio of 2.45. In support to this, Vanaja *et al.* (2003) observed L/B ratio of 2.66 in *Vyttila*-8 rice variety and Shylaraj and Sasidharan (2005) observed L/B ratio of 2.36 in *Vyttila*-5 variety. Vanaja and Babu (2006) indicated that *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 rice had a L/B ratio of 2.53, 2.48 and 2.63 respectively.

Meena *et al.* (2010) found that L/B ratio of rice varieties varied from 2.02 to 4.22 among different rice varieties. A study conducted by Rebeira *et al.* (2014) *Pokkali* rice variety obtained L/B ratio of 2.52 and it was classified as bold medium grain.

The control variety *Jyothi* and *Uma* obtained a L/B ratio of 3 and 2.22 respectively. Vanaja and Babu (2006) reported that, *Jyothi* and *Matta Triveni* rice varieties recorded L/B ratio of 3.11 and 2.82 respectively. Lakshmi (2011) observed L/B ratio of 2.66 in *Jyothi* and classified it as long medium grain. In a study conducted by Sathyan (2012), it was found that *Jyothi* rice have L/B ratio of 3.02 and

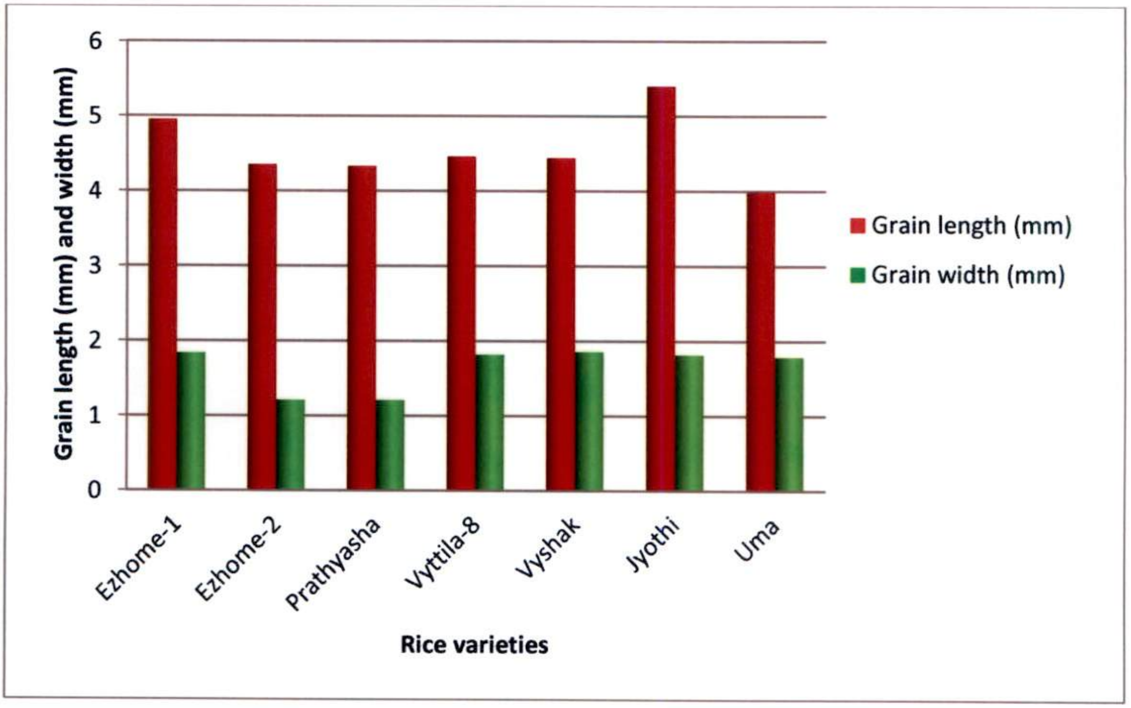


Fig. 5: Grain length and width of rice varieties

is classified as long slender. Suganthi and Naccbair (2015) observed L/B ratio of 2.93 in *Uma* rice variety.

Binodh *et al.* (2006) mentioned that length and breadth of the varieties ranges from 4 mm to 7 mm and 1.7 mm to 4 mm respectively. The varieties having L/B ratio below 2.5 are common, those having L/B ratio of 2.5 to 3.0 as fine and those having L/B ratio of 3.0 and above are super fine (Rani *et al.*, 2006).

The increase in length to breadth ratio is due to the decrease in length of rice kernel as compared to breadth upon polishing (Gujral and Kumar, 2003). The grain length and width of different rice varieties are presented in Figure 5. In the present study, variations in grain length, grain width and L/B ratio were observed among the different rice varieties. Grain dimensions are highly variable even within a variety and depend upon post harvest operations like threshing, milling etc. For most of the physical quality parameters, raw rice of newly released varieties were found to be superior.

5. 1. 2. Cooking qualities of rice

Cooking quality of rice is directly related to the physical and chemical characteristics of the starch in the endosperm and amylose and amylopectin ratio (Tan *et al.*, 1999).

Sensory qualities of cooked rice indicated a highest mean score of 8.0 in control variety *Jyothi* followed by 7.7 in *Uma* for appearance. Most of the varieties obtained a higher mean score for appearance. Nandini *et al.* (2004) reported that, raw rice varieties like *Vyttila*-1, *Vyttila*-3, *Jaya, Jyothi* and *Matta Triveni,* showed the highest mean score for appearance. Cooked rice prepared using parboiled rice obtained a mean score of 7.74 for appearance (Kunhimon, 2010).

The mean scores for overall acceptability of the cooked rice varied from 7.1 to 7.8 for *Prathyasha* (MO-21) and *Jyothi* respectively. Cooked rice prepared from *Jyothi* rice variety had the highest mean score for overall acceptability when compared to newly released varieties. Among newly released rice varieties under the present study, *Ezhome*-2 had maximum mean score of 7.40 for overall acceptability.

Nandini (1995) reported that among 60 rice varieties of Kerala, thirty five varieties were homogeneous with respect to quality attributes such as appearance, colour, flavour, texture and taste for the preparation of cooked rice. The author also reported that *Jyothi, Vyttila*-1 and *Vyttila*-3 were found to be highly suitable for the preparation of cooked rice using raw rice. According to Singh *et al.* (2000) traditional rice varieties grown in India are of intermediate amylose content and are generally preferred. High or medium amylose rice showed a high degree of volume expansion. High amylose rice, cooks dry and are less tender and becomes hard upon cooling whereas low amylose grains cooks moist and sticky (Singh *et al.*, 2001). Divakar and Francis (2010) evaluated the suitability of seven KAU rice varieties and the variety *Karuna* was found to be the most favourable for table rice. According to Sathyan (2012) lower amylose content and starch content in rice affect the textural properties of the products.

In the present study, the highest mean score for most of the quality attributes was shown by control variety *Jyothi*. The highest amylose content was observed in control varieties *Jyothi* and *Uma*. For newly released varieties like *Prathyasha* (MO-21) and *Vyttila*-8 gel consistency was found to be soft and the texture of cooked rice of these varieties obtained a lower mean score of 6.8. Low amylose content, low volume expansion and low textural qualities observed in *Prathyasha* (MO-21) and *Vaishak* (PTB-60) rice varieties clearly indicate that these are not suitable for table rice. Higher mean scores for texture was observed in different varieties except in *Prathysha* (MO-21) and *Vaishak* (PTB-60). Total index score for different rice varieties was found to be highest in *Ezhome*-2 followed by *Vyttila*-8 and *Ezhome*-1. Hence based on mean scores and total index score, all other varieties except *Prathyasha* (MO-21) and *Vaishak* (PTB-60) can be recommended for table rice. Mean scores obtained for organoleptic evaluation of cooked rice prepared using different rice varieties are shown in Figure 6.

The physicochemical properties, such as moisture content, hardness and adhesion of cooked rice, affect the eating quality of rice. Hardness and adhesion of cooked rice is highly determined by the moisture content (Roy *et al.*, 2008). Varietal and cultivar differences can be considered as the major factor behind differences in cooking behaviour of rice (Ashogbon and Akintayo, 2012).

Gelatinization temperature determines the amount of time it takes for a particular variety of rice to cook. In the present study, all newly released rice varieties were found to be of high gelatinisation index. It was found that the control rice varieties *Jyothi* and *Uma* were partially disintegrated in alkali and were found to be of intermediate gelatinisation index. Lakshmi (2011) and Sathyan (2012) reported an intermediate gelatinisation temperature index for *Jyothi* rice variety.

Higher gelatinisation temperature or lower alkali spreading score was indicative of a more crystalline structure and more resistance to water penetration and swelling in rice kernels (Yadav and Jindal, 2007).

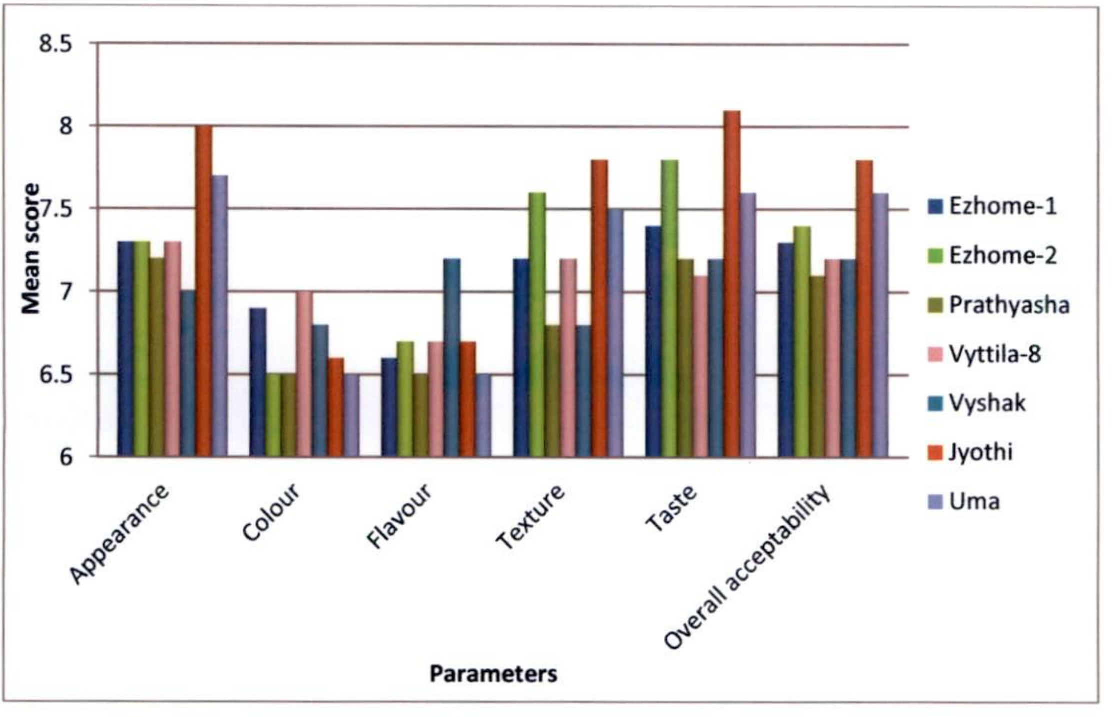


Fig. 6: Mean scores for different organoleptic qualities of cooked rice

Newly released rice varieties of this study remained unaffected in alkali solution and were of lower amylose content. Jennings *et al.* (1979) and Rani *et al.* (2006) found that rice varieties with high gelatinisation temperature generally have low amylose content.

Cruz and Khush (2000) reported that all varieties that have intermediate gelatinisation temperature are either intermediate or high in amylose content. The low gelatinising class has no strict association with low, intermediate and high amylose contents. Low gelatinisation temperature is readily recombined with the three amylose levels.

Cooking is intended to improve the moisture content and reduce the hardness of rice. The cooking time noticed in newly released rice varieties was in the range of 18.51 minutes (*Prathyasha* (MO-21)) to 24.75 minutes (*Ezhome*-2). *Vaishak* (PTB-60), *Vyttila*-8 and *Ezhome*-1 obtained a cooking time of 23.83 minutes, 22.39 minutes and 24.45 minutes respectively. Kandathil (1997) observed a cooking time of 26.00 minutes to 43.33 minutes for raw rice. Yadav *et al.* (2007) reported a cooking time in the range of 16.50 minutes to 18.30 minutes in Indian rice cultivars.

The cooking time obtained for control variety *Jyohti* and *Uma* were 22.2 minutes and 22.42 minutes. This is in line with the observations of Juliano *et al.* (1987) in which, cooking time of more than 20 minutes has been reported in rice with intermediate gelatinisation temperature index. According to Nandini (1995) an optimum cooking time of 37.00 minutes was recorded in *Jyothi* which was higher than the observations of the study. Deepa *et al.* (2008) also observed cooking time of 30 minutes for *Jyothi* variety. Sathyan (2012) reported that *Jyothi* rice variety has a cooking time of 29.33 minutes. The cooking time obtained for different rice varieties are presented in Figure 7.

Cooking time of the rice depends on coarseness of the grain and its gelatinisation temperature. The variations in cooking time were observed between short and long grain rice cultivars (Dipti *et al.*, 2002). Gelatinisation temperature and cooking time of milled rice are positively correlated (IRRI, 2004). Rice with high gelatinisation temperature takes longer time to cook than low-gelatinisation temperature types. High gelatinization temperature index was noticed in newly released rice varieties. The cooking time of almost all newly released varieties were slightly higher than that of control varieties.

Rice grain qualities are highly influenced by variety, native area of cultivation, environmental factors and physical properties like kernel size, shape, milling recovery, degree of milling and amylose content (Singh *et al.*, 2000).

Cooking time and bulk density are highly related and the rice with higher bulk density showed a slower water uptake resulting in longer cooking time (Lisle *et al.*, 2000). Higher bulk density of 0.73 was observed in unroasted rice flour of newly released rice variety *Ezhome*-2 for which obtained a higher cooking time. Control variety *Jyothi* showed a lower bulk density of 0.63 and lower cooking time.

Water uptake is a measure of the hydration characteristics of rice, which may be influenced by factors such as gelatinisation temperature and porosity of kernels (Bandyopadhyay and Roy, 1992). Vanaja *et al.* (2003) observed a water uptake of 2.61 ml/ g for *Ezhome*-3 rice variety. Among newly released rice varieties *Ezhome*-1 and *Ezhome*-2 obtained a water uptake of 3.47 ml/ g and 5.74 ml/ g. Yadav and Jindal (2007) reported water uptake of Indian rice cultivars in the range of 2.89 ml/ g to 4.63 ml/g. The water uptake ratio noticed for different rice varieties are shown in Figure 8.

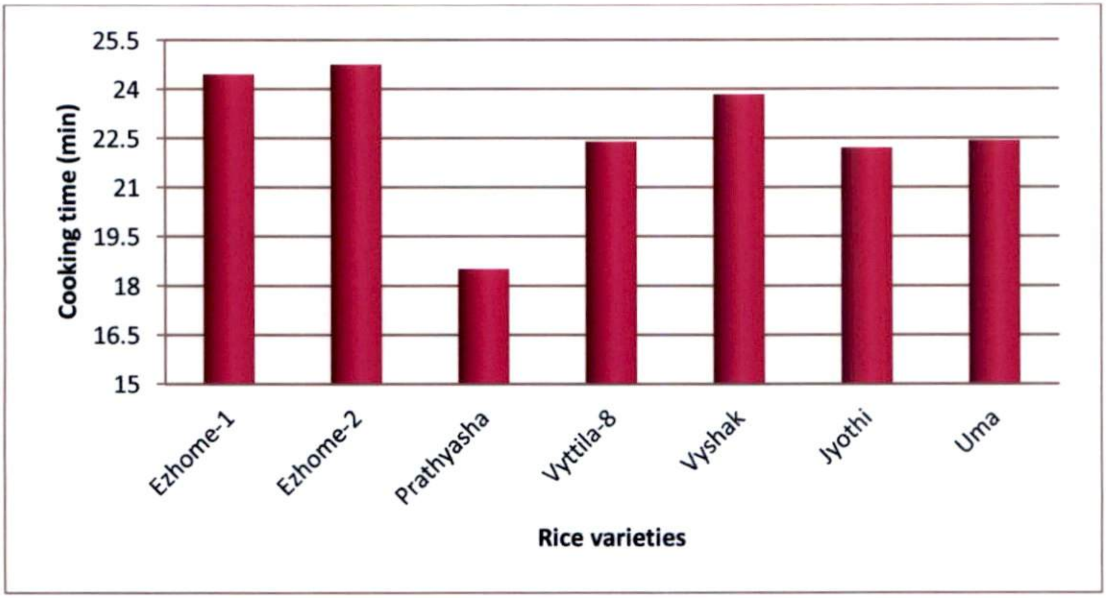


Fig. 7: Cooking time of rice varieties

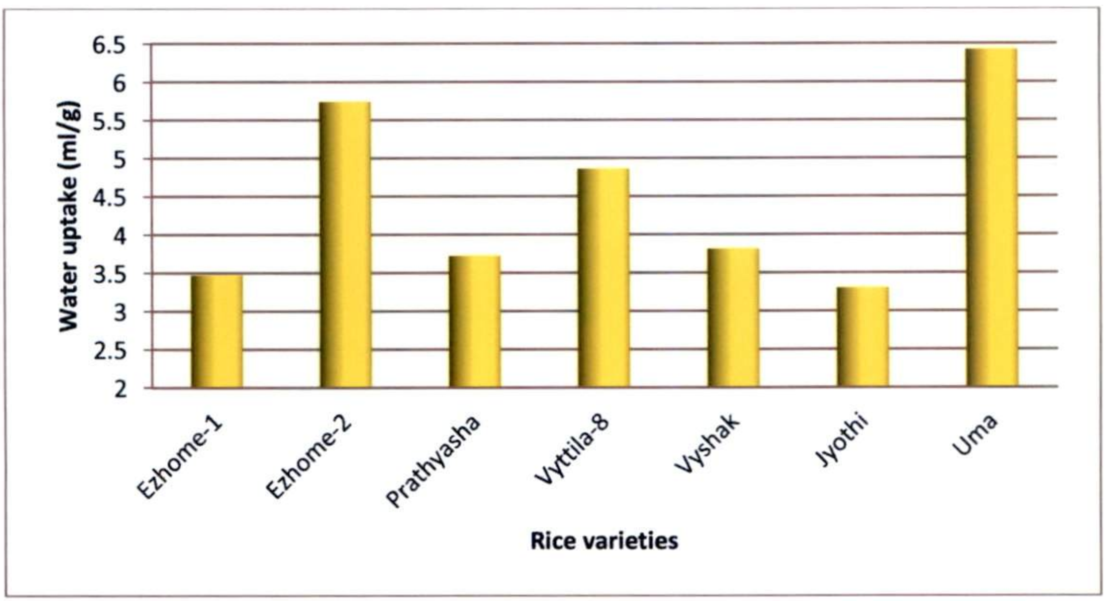


Fig. 8: Water uptake of rice varieties

Among different varieties under the study, control variety *Jyothi* obtained the lowest water uptake of 3.3 ml/ g and *Uma* obtained the highest value of 6.42 ml/ g. Nandini (1995) reported that among 60 rice varieties of Kerala CSRC collection, *Matta thriveni* and *Aranmula local* were found to be having water uptake of 5.25 ml/ g. In contrast to this Vanaja and Babu (2006) observed a lower water uptake ratio of 0.57 and 0.55 in *Jyothi* and *Mattatriveni*. Lower water uptake ratio was mentioned in different rice varieties. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* obtained water uptake of 1.60 ml/ g, 1.90 ml/ g, 1.69 ml/ g and 1.65 ml/ g respectively.

Nandini (1995) reported a water uptake ratio of 2.70 ml/ g in both *Vyttila*-1 and *Vyttila*-3 varieties. Vanaja and Babu (2006) reported a water uptake ratio of 0.47, 0.59 and 0.57 in rice varieties *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 respectively.

Water uptake of 1.52 ml/ g was reported in OM-4 and 1.40 in M-108-262-1 variety among eight KAU varieties (Sugeetha, 2010). In a varietal evaluation study using six different rice unit varieties, Thomas *et al.* (2013) observed the water uptake of 3.95 ml/ g for brown rice and 2.33 ml/ g for glutinous rice.

Water uptake ratio of grains is determined by several factors like moisture content, amylose content, size and shape of grains after milling. According to Barber (1972), IRRI (1974), Villareal *et al.* (1976) and Ali *et al.* (1976), total water uptake on cooking is generally more in old rice than fresh samples.

There is no much variation in amylose content of control varieties *Jyothi* and *Uma*. But considerable variation was observed in water uptake among these varieties. The size and shape of kernels after milling highly influence the water uptake. Rani *et al.* (2006) reported that water uptake and cooking time are strongly influenced by size and shape of rice grain. Water uptake is positively correlated with bulk density also. In line with this, among newly released varieties, higher water uptake was observed in *Ezhome*-2 for which highest bulk density was obtained in the present study.

Volume expansion, is very important in determining the quality of cooked rice grains. Higher volume expansion ratio after cooking is a desirable trait preferred by consumers. The highest volume expansion ratio of 6.07 was noticed in *Uma* and the lowest of 4.49 in *Prathyasha* (MO-21) among selected rice varieties. In the present study volume expansion ratio of 4.50 was noticed in *Vyttila*-8 variety. According to Nandini (1995) *Vyttila*-1 and *Vyttila*-3 recorded a volume expansion ratio of 3.70 and 3.50 respectively. Shylaraj and Sasidharan (2005) reported a volume expansion ratio of 4 in *Vyttila*-5 variety. A lower volume expansion ratio of 2.33, 2.55 and 2.52 was observed in rice varieties such as *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 respectively by Vanaja and Babu (2006).

In this study, *Ezhome*-1 and *Ezhome*-2 obtained a volume expansion ratio of 5.18 and 5.60. Vanaja *et al.* (2003) reported a volume expansion of 2.0 for *Ezhome*-3 rice variety. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* are have a lower volume expansion ratio of 3.2, 3.3, 3.5 and 2.8 respectively. The volume expansion ratio obtained for different rice varieties are presented in Figure 9.

Highest volume expansion ratio of 6.07 was noticed in *Uma* variety in the present study. Nandini (1995) reported a volume expansion ratio of 6.25 in Aranmula local and CSRC collection. Lower volume expansion ratio of 2.38 and 2.17 was noticed in rice varieties such as *Jyothi* and *Mattatriveni* (Vanaja and Babu, 2006). Sathyan (2012) reported a volume expansion ratio of 5.45 and 4.10 respectively in *Jyothi* rice variety.

Dipti *et al.* (2003) reported that volume expansion ratio is associated with high amylose content. According to Mohapatra and Bal (2006) amylose content had a positive impact on volume expansion ratio. In the present study, the highest volume expansion ratio was noticed in *Uma* which had the highest amylose content.

Newly released rice varieties *Ezhome*-1 and *Ezhome*-2 are having an amylose content of 15.31 and 15.61 per cent respectively. Neelofer (1992) and Nandini (1995) reported wide variation in the amylose content (18.11 to 22.07 per cent) of different varieties of rice. Yadav *et al.* (2007) reported an amylose content in the range of 2.25 to 22.21 per cent in Indian rice cultivars. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* obtained an amylose content of 26.40, 29.00, 24.99 and 23.64 per cent respectively, which was found be higher compared to amylose content observed in the present study.

Among different rice varieties *Vyttila*-8 rice recorded the highest amylose content of 11.86. Vanaja *et al.* (2003) reported an amylose content of 23.17 in *Vyttila*-8 rice variety which is higher than the observed value of the present study. In a study conducted by Vanaja and Babu (2006) the rice varieties such *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 obtained an amylose content of 31.07 per cent, 30.28 per cent and 30.70 per cent.

In the present study the amylose content of control rice varieties *Jyothi* and *Uma* were 22.17 per cent and 23.32 per cent respectively. Vanaja and Babu (2006) found that the rice varieties such as *Jyothi* and *Mattatriveni* obtained an amylose content of 25.67 per cent and 30.44 per cent. According to Rebeira *et al.* (2014) *Pokkali* rice variety obtained an amylose content of 23.34.

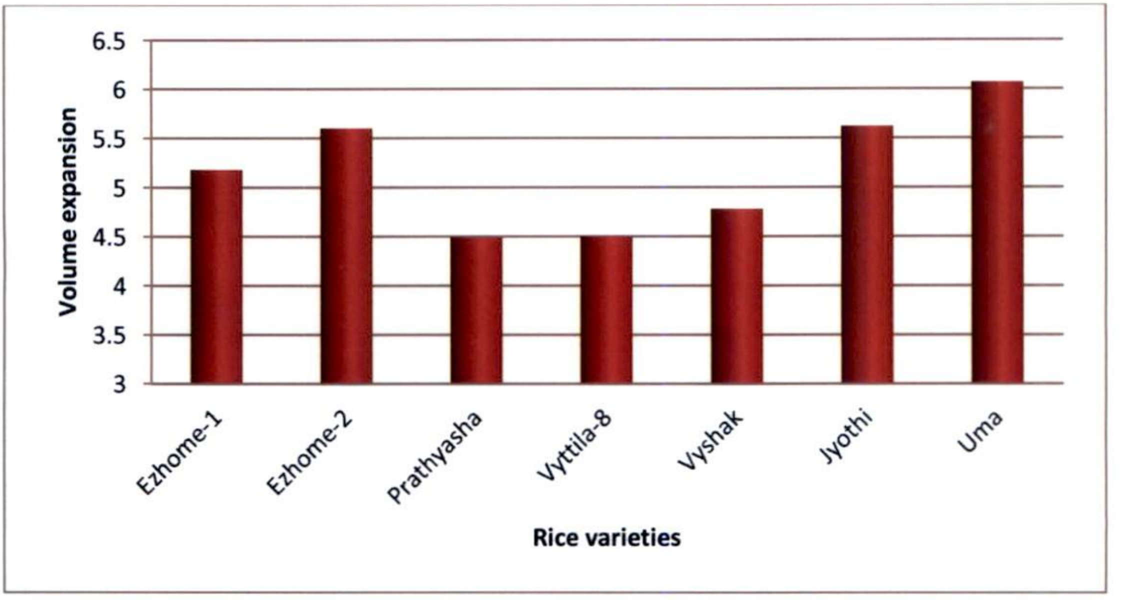


Fig. 9: Volume expansion of rice varieties

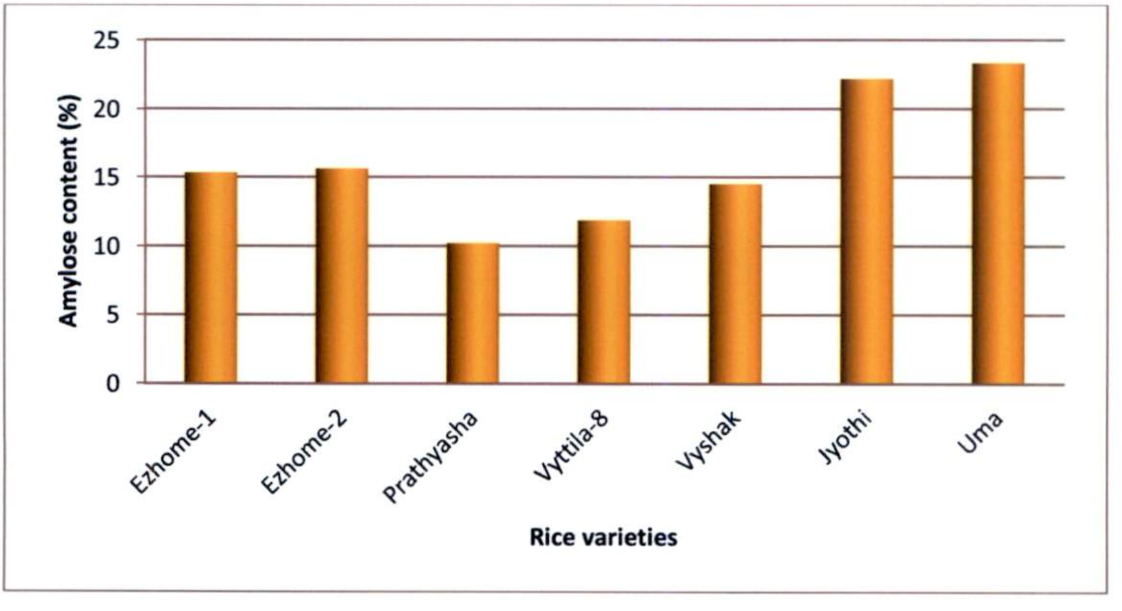


Fig. 10: Amlylose content of rice varieties

Sathyan (2012) reported an amylose content of 24.50 per cent in *Jyothi* rice variety. The amylose content observed in different rice varieties are shown in Figure 10.

Variations in amylose content can be observed in different rice cultivars. Amylose content can vary as much as 6 per cent depending upon the environmental conditions. High temperature during ripening may result in relatively lower amylose content (Dipti *et al.*, 2003).

Gel consistency measures the tendency of the cooked rice to harden on cooling. Gel consistency is related to the eating quality of rice, higher the gel the harder the rice (Kanlayakrit and Maweang, 2013).

Maximum gel length of 145 mm was noticed in *Prathyasha* (MO-21) and minimum of 29.89 mm in *Ezhome*-2 variety and has shown soft and hard gel consistency respectively. *Vaishak* (PTB-60) and *Ezhome*-1 obtained a medium gel consistency. In this study, control varieties *Jyothi* and *Uma* recorded gel consistency of 37.2 and 27.5 respectively. Lakshmi (2011) and Sathyan (2012) observed a gel length of 37.66 mm and 48.10 mm in parboiled and raw rice respectively of *Jyothi* variety. Rebeira *et al.* (2014) found that the *Pokkali* rice variety obtained a gel consistency of 7.30 which classify it as soft grain.

IRRI (2002) classified the gel consistency in grains as hard (40mm or less), medium (41-60mm) and soft (>61mm). Cohesiveness, tenderness, colour and gloss differ greatly based on the gel consistency, when the amylose content is high. According to Rani *et al.* (2006) varietal differences in gel consistency exist among varieties of similar amylose content. The gel consistency recorded by different rice varieties of the present study shown in Figure 11.

On assessing the cooking qualities of different rice varieties, it was found that low amylose rice varieties like *Prathyasha* (MO-21) and *Vyttila*-8 showed a poor texture on cooking. The value of hardness was observed to be higher in those varieties, which have high content of amylose. The cooked rice grains having low amylose content generally give a sticky and glossy appearance after cooking (Noda *et al.*, 2003). In the present study also, the control varieties which have higher amylose content than the newly released rice varieties showed a better texture. Amylose content showed a stronger correlation with the texture of cooked rice. Higher the amount of amylose harden the texture of cooked rice (Cameron and Wang, 2005).

The elongation of rice grains after cooking was found to be an important quality parameter and it is reported that if cooked rice grain elongates more lengthwise, it gives a finer appearance (Dipti *et al.*, 2002). Elongation ratio is the ratio between the length of cooked to that of raw rice grain. According to Singh *et al.* (2005) both L/B ratio and amylose content are important in determining the elongation of cooked grains. Minimum grain elongation ratio of 0.72 was noticed in *Ezhome*-1. Government of India (2013) reported that *Kaipad* rice varieties *Ezhome*-1, *Ezhome*-2, *Kuthiru* and *Orkayama* are having a higher grain elongation ratio of 1.45, 1.50, 1.52 and 1.40 respectively.

Vanaja *et al.* (2003) reported a grain elongation ratio of 1.45 for *Ezhome*-3 rice variety. Binodh *et al.* (2006) also mentioned that elongation ratio of raw rice varieties range from 1.18 to 1.88. According to Yadav *et al.* (2007) elongation ratio in the range of 1.52 to 1.89 was observed in Indian rice cultivars. Kanlayakrit and Maweang (2013) indicated that higher elongation ratio means better cooking quality. The grain elongation ratio of different rice varieties are presented in Figure 12.

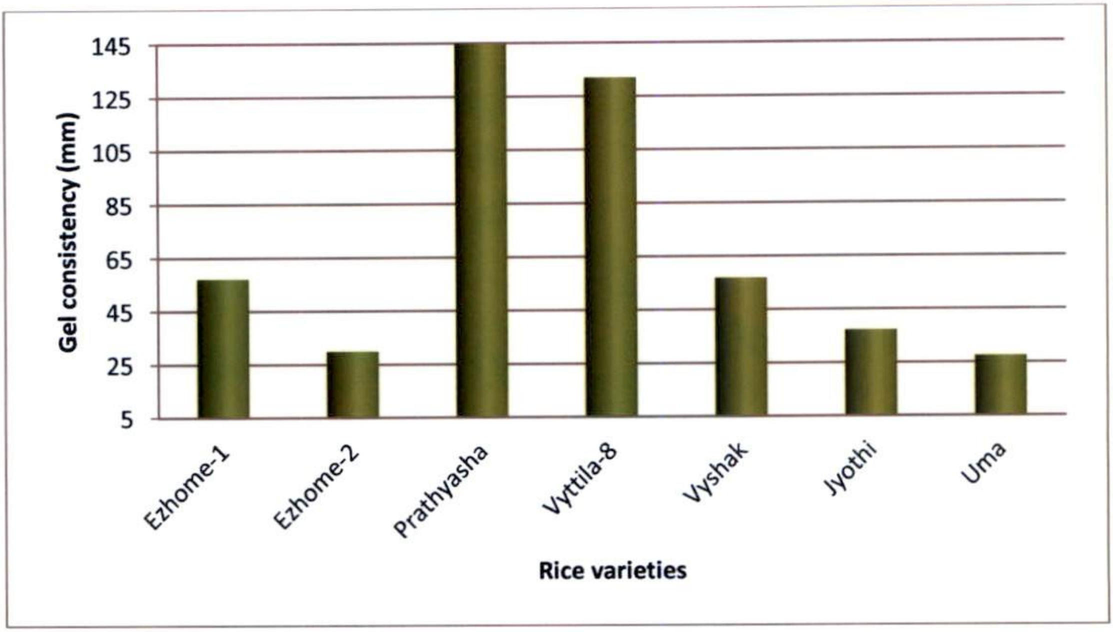


Fig. 11: Gel consistency of rice varieties

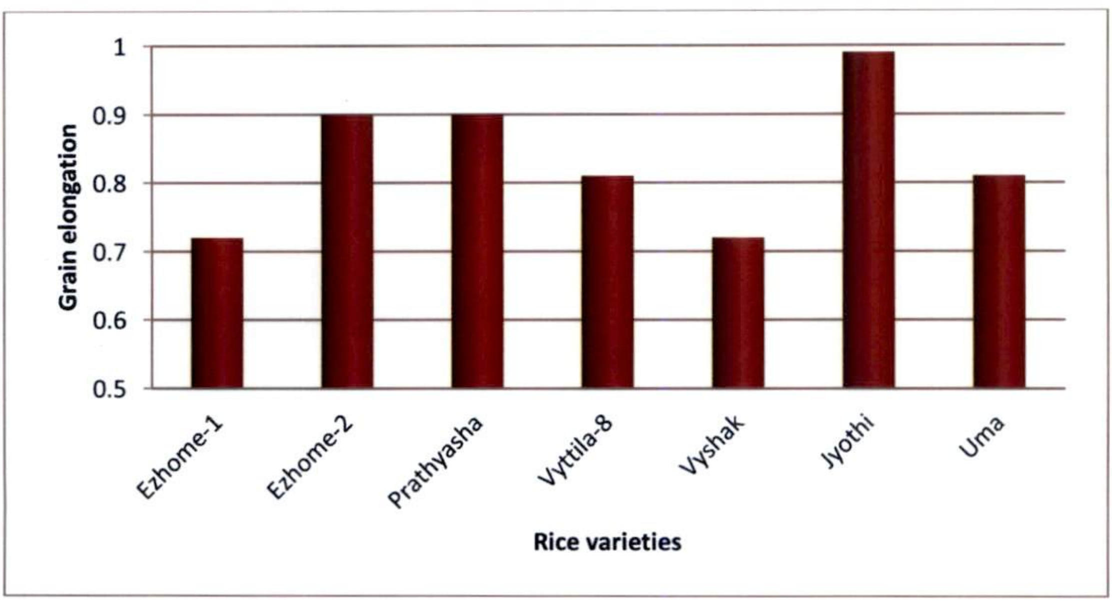


Fig. 12: Grain elongation ratio of rice varieties

Nandini (1995) reported elongation ratio of 1.37 and 1.46 in *Vyttila*-1 and *Vyttila*-3 variety. Newly released rice variety *Vyttila*-8 obtained grain elongation ratio of 0.81. Shylaraj and Sasidharan (2005) reported an elongation ratio of 1.41 in *Vyttila*-5 variety which is higher than the observed values in the present study. Vanaja and Babu (2006) reported that the rice varieties *Vyttila*-2, *Vyttila*-3 and *Vyttila*-4 obtained a kernel elongation ratio of 1.20, 1.36 and 1.45 respectively.

In the present study, control varieties *Jyothi* and *Uma* obtained an elongation ratio of 0.99 and 0.81. Vanaja and Babu (2006) found that the rice varieties such as *Jyothi* and *Mattatriveni* obtained kernel elongation ratio of 1.20 and 1.32. According to Sugeetha (2010) elongation ratio of 1.68 was obtained in MO6-10-KR variety and of 1.51 in MO-4 variety. Lakshmi (2011) and Sathyan (2012) reported that parboiled and raw rice of *Jyothi* variety have a grain elongation ratio of 1.43 per cent and 1.80 per cent respectively.

The less elongation of non-basmati rice is due to the high gelatinisation temperature, which elongates less during cooking than low and intermediate gelatinising rice (Singh *et al*., 2000). According to Kamath *et al*. (2002) the elongation ratio was more than 1.9 in all the basmati varieties and less in non-basmati varieties. All the newly released rice varieties of the present study were of high gelatinisation temperature index. This may be the reason for the lower elongation ratio.

Rice once cooked is perishable. During spoilage enzyme activities takes place in cooked rice and make changes in physical conditions of rice (Waduwawara *et al.,* 2009). Among newly released rice varieties maximum keeping quality up to 12.60 hours was noticed in *Vaishak* (PTB-60) and minimum of 11.24 hours in *Prathyasha* (MO-21). Control rice varieties *Jyothi* and *Uma* obtained a keeping quality up to

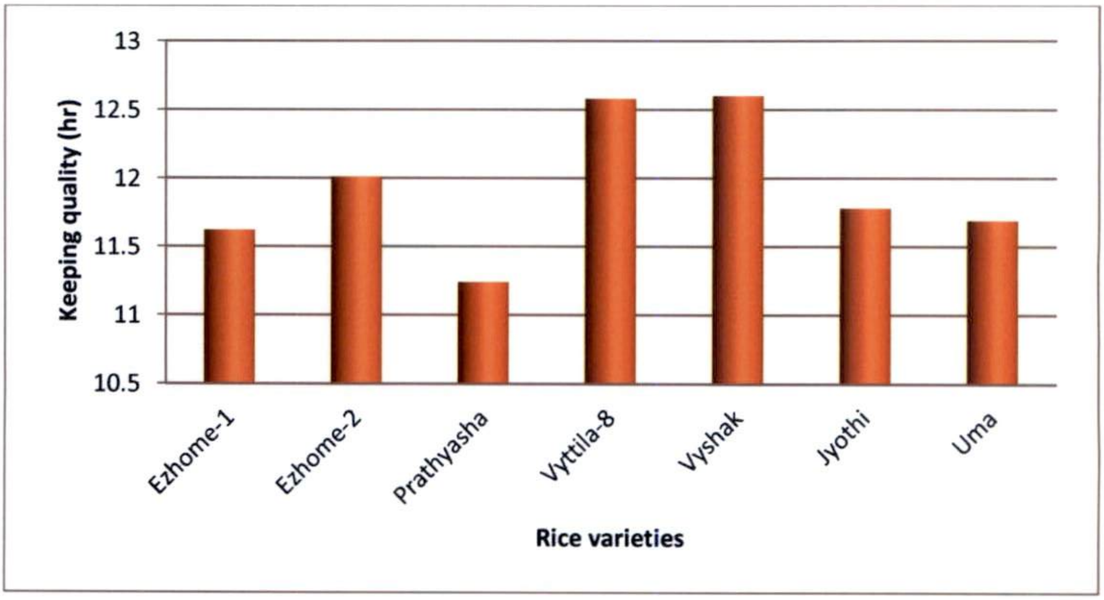


Fig. 13: Keeping quality of rice varieties

11.78 hours and 11.69 hours, which is found to be lower than the keeping quality of most of the newly released rice varieties. Duration of keeping quality of selected rice varieties are shown in Figure 13.

Cooking quality of rice depend upon variety of rice, crop production environment, harvesting, processing and milling conditions. Changes of chemical and physical properties affects the cooking quality of the rice especially texture, flavour and quality of product after processing (Fari *et al.*, 2011). Cooking qualities of newly released rice varieties were found to be comparable with that of the control varieties.

5. 1. 3. Chemical and nutritional qualities of rice

Moisture content gives an index of quality and consistency of the milled grains. In the present study, the moisture content among newly released rice varieties varied from 8.5 to 11.6 per cent. The moisture content of selected rice varieties are presented in Figure 14. *Vyttila*-8 obtained a moisture content of 10.4 per cent in the present study. In line with this, Nandini (1995) recorded a moisture content of 10.33 and 9.33 per cent in *Vyttila*-1 and *Vyttila*-3 varieties respectively. A moisture content of 10 and 10.3 was noticed in control varieties *Jyothi* and *Uma*. Sugeetha (2010) reported that MO-87-5 and MO-95-1 are having moisture content of 13.40 per cent among the six varieties from KAU. Moisture content of 11.7 per cent was noticed in *Uma* rice variety (Shobana *et al.*, 2011). Lakshmi (2011) and Sathyan (2012) reported a moisture content of 12.10 per cent and 12.67 per cent in parboiled and raw *Jyothi* rice variety respectively.

Deepa *et al.* (2008) reported a moisture content of 13 per cent for *Jyothi* rice variety.

According to Ayernor and Ocloo (2007) the moisture content of rice varied from 9.06 to 13.50 per cent and the duration of drying and the temperature used were the factors that influence the moisture content. Yadav *et al.* (2007) reported moisture content in the range of 11.64 to 12.72 per cent in Indian rice cultivars. Zubairu *et al.* (2014) conducted a study on a variety grown in *Malaysia* and found that the variety MR 219 showed a moisture content of 14.26 per cent.

In a study conducted by Manful *et al.* (1996), among ten cultivars of locally grown rice moisture content was in the range of 12 to 13.1 per cent The moisture content observed in different rice varieties under the present study is lower. Lower moisture content of less than 12 per cent was observed in stored grain (IRRI, 2012). Suganthi and Naccbair (2015) observed a moisture content of 13.3 per cent in *Uma* rice variety.

Carbohydrates are the most prevalent source of food energy in the world. They play a major role in human diet, comprising about 40 to 75 per cent of energy intake. Determination and quantification of carbohydrate fractions in foods is currently of great interest in nutrition research and essential for computing the correct energy intake (Devindra and Longvah, 2011).

In the present study, the carbohydrate content of rice variety ranged from 71.01 to 81.43 g/ 100g. Rice contains about 90 per cent carbohydrate (Martin and Fitzgerald, 2002). This is in line with the study of Rosniyana *et al.* (2006). The author reported that carbohydrate is the major constituent of rice and was present in the range of 78.25 g/ 100g to 81.31 g/ 100g in different varieties. In contrast to this Fernando (2013) reported a higher carbohydrate content of 88 g/ 100g in brown rice. In the present study *Ezhome*- 1 and *Ezhome*-2 obtained a carbohydrate content of 78 g/ 100g and 81 g/ 100g respectively. In line with this Government of India (2013)

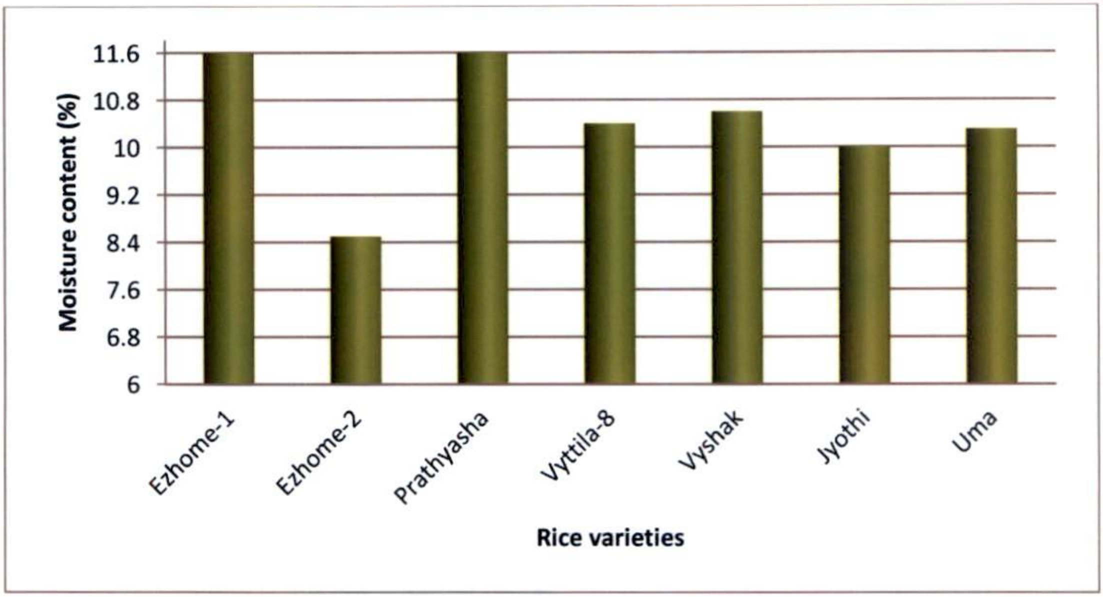


Fig. 14: Moisture content of rice varieties

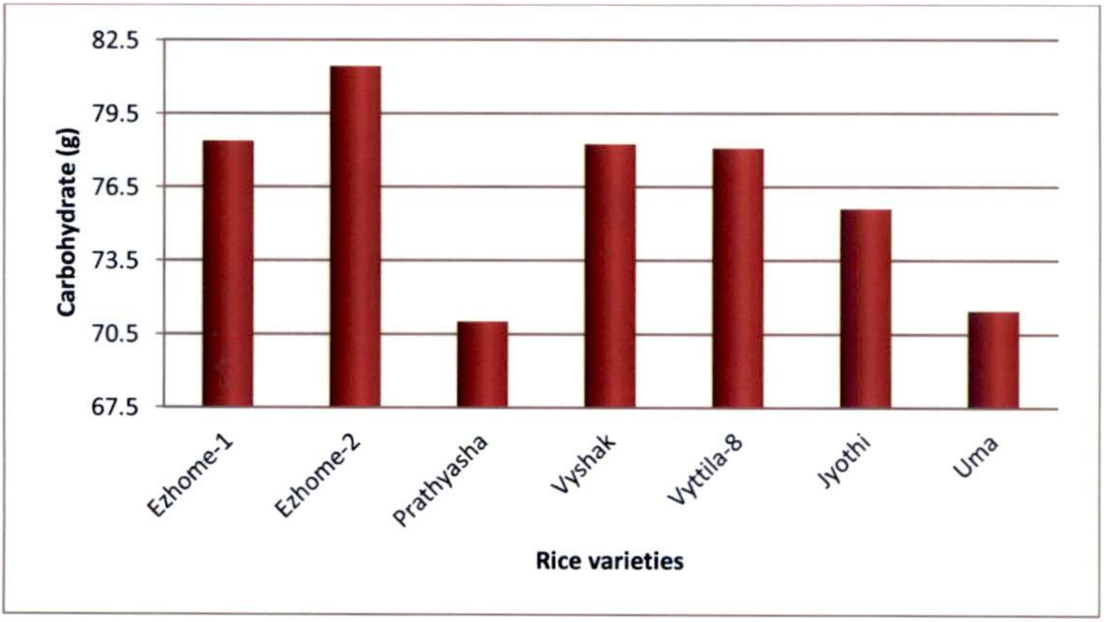


Fig. 15: Total carbohydrate content of rice varieties

reported carbohydrate content of 83.2 g/ 100g and 83.0 g/ 100g in *Ezhome*-1 and *Ezhome*-2. Carbohydrate content obtained for selected rice varieties are shown in Figure 15.

Yadav *et al.* (2007) reported a starch content in the range of 68.73 g/ 100g to 70.24 g/ 100g in Indian rice cultivars. Starch content of different rice varieties were found to be in the range of 51.5 g/ 100g (*Prathyasha* (MO-21)) to 68.6 g/ 100g (*Ezhome*-2). Sugeetha (2010) evaluated the starch content of eight varieties of KAU and found the highest starch content of 76.25 g/ 100g present in MO8-20-KR variety. In the present study, control variety *Jyothi* obtained a starch content of 63.1 g/ 100g. A higher starch content of 75.13 and 79.61 g/ 100g was observed in *Jyothi* variety (Lakshmi, 2011 and Sathyan, 2012). Starch content obtained for selected rice varieties are shown in Figure 16.

In the present study, energy content of different rice varieties varied from 318.70 Kcal/ 100g *(Prathyasha* (MO-21)) to 363.55 Kcal/ 100g (*Ezhome*-2). Control varieties *Jyothi* and *Uma* obtained a energy content of 335.81 Kcal/ 100g and 319.71 Kcal/ 100g respectively. The highest energy value of 358 Kcal/ 100g was noticed in traditional variety *Thekkancheera* (Nandini, 1995). In a study conducted by Manful *et al.* (1996) among ten cultivars of locally grown rice and reported energy content in a range of 341 Kcal/ 100g to 353 Kcal/ 100g. Sugeetha (2010) reported that among eight rice varieties of KAU, the highest energy value of 386.17 Kcal/ 100g was obtained for MO8-20-KR variety. The energy content of different rice varieties are shown in Figure 17.

Rice protein is valuable because it ranks rich in essential amino acid lysine and high in nutritional quality among the cereal proteins (Bean and Nishita, 2000). Protein is the most abundant component in rice grain next to starch (Xie *et al.*, 2008).

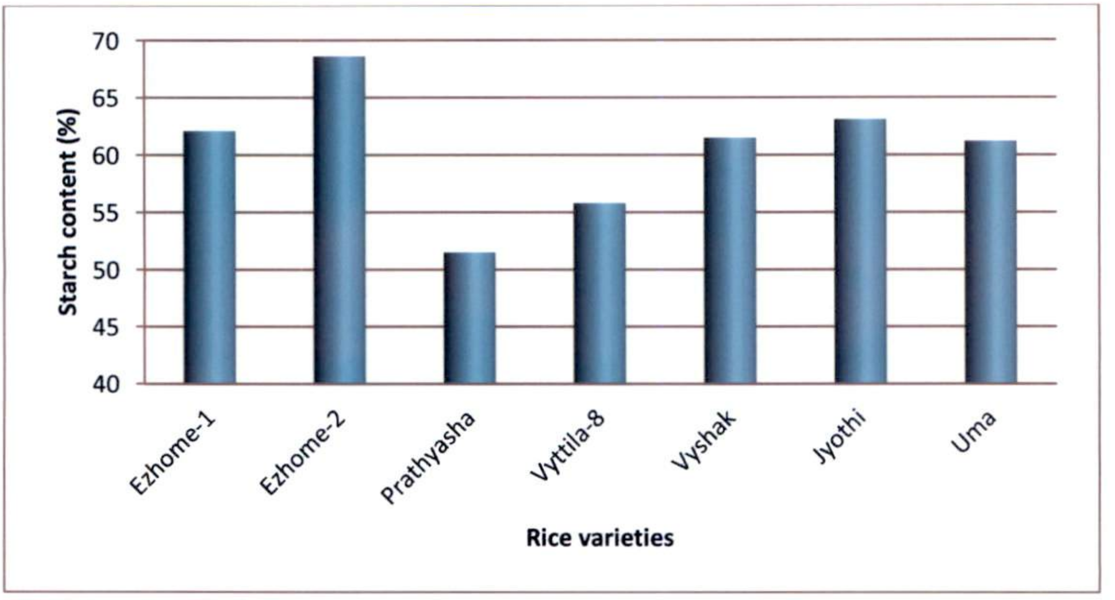


Fig. 16: Starch content of rice varieties

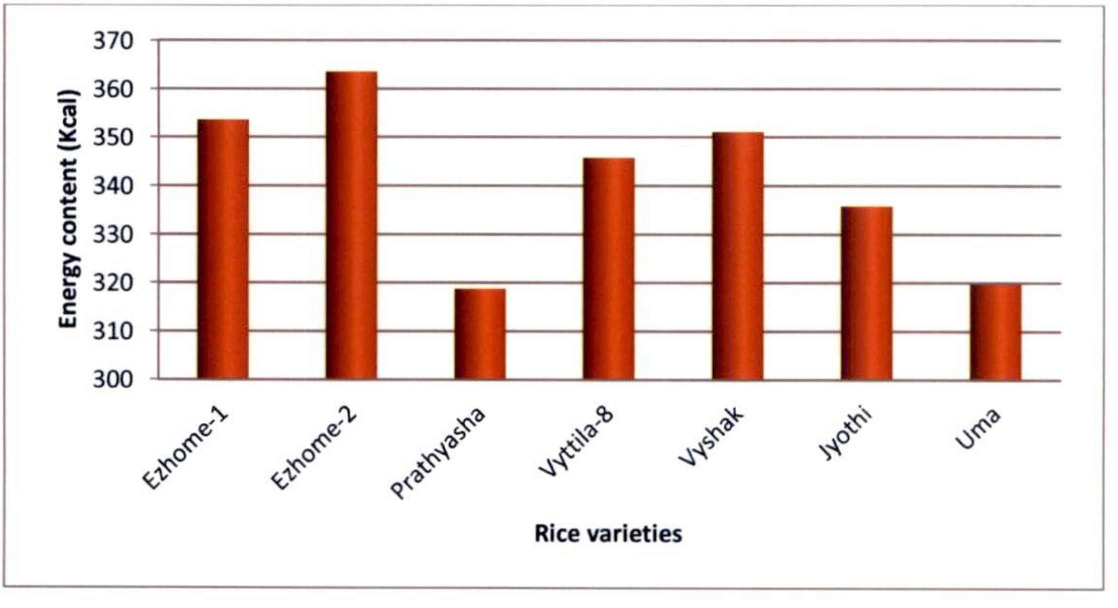


Fig. 17: Energy content of rice varieties

In the present study, protein content of different rice varieties are ranged from 7.0 g/ 100g to 8.95 g/ 100g. In the present study, *Vyttila*-8 obtained a protein content of 7 g/ 100g. A higher protein content of 8.76 g/ 100g was reported by Nandini (1995) in *Vyttila*-3 rice variety. Protein content of 7.5 g/ 100g and 7.7 g/ 100g was noticed in control rice varieties *Jyothi* and *Uma*. Among different rice varieties, the highest protein content of 8.95 g/ 100g was observed in *Ezhome*-2 variety. Deepa *et al.* (2008) reported a protein content of 7.97 g/ 100g in *Jyothi*. Sugeetha (2010) reported that OM-2 obtained the highest protein content of 8.17g/ 100 among different Kerala rice varieties. Protien content of 7.6 g/ 100g in *Uma* variety was reported by Shobana *et al.* (2011). In a study conducted by Lakshmi (2011) and Sathyan (2012) a protein content of 7.55 g/ 100g and 8.11 g/ 100g in parboiled and raw rice of *Jyothi* variety was observed. Gopalan *et al.* (2012) reported a protein content of 6.8 g/ 100g in milled raw rice. The protein content of different rice varieties are presented in Figure 18.

Nandini (1995) observed the highest protein content of 10.75 g/ 100g in hybrid derivative *Ramya* among 60 different rice varieties of Kerala. Yousaf (2000) reported that the protein content of milled rice is low compared to other cereals, and it ranged from 7.0 to 10.8 g/100g. According to Manay and Shadaksharaswamy (2008) milled rice contained 6.9 g/ 100g protein. A study conducted by Thomas *et al.* (2013) 'Black rice' variety had the highest protein content (8.16 g/ 100g).

In a study conducted by Manful *et al.* (1996) among ten cultivars of locally grown rice protein content was in the range of 7.5 to 9.8 g/100g. Yadav *et al.* (2007) reported a protein content in the range of 5.46 to 7.02 g/100g in Indian rice cultivars.

Rice fat consists of unsaturated fatty acids (Chen and Chang, 1998). In the present study, fat content observed in newly released rice varieties were in the range of 0.3 to 0.71 g/ 100g. The observed fat content of milled rice is considerably low. Hoseny (1998) mentioned that the lipid content decreases when the rice is milled because lipids are more concentrated in the peripheral part of the grain. Milled rice has an average of 0.3 to 0.5 g/ 100g lipids. Fat content of different rice varieties are presented in Figure 19.

Sugimoto *et al.* (1998) evaluated the lipid content of six varieties of brown rice and milled rice and it ranged from 2.1 to 3.2 g/ 100g and 0.61 to 0.95 g/ 100g, respectively.

In a study conducted by Manful *et al.* (1996) among ten cultivars of locally grown rice fat content was in the range of 0.5 to 0.7 g/ 100g. Yadav *et al.* (2007) reported a fat content in the range of 0.54 to 0.82 in Indian rice cultivars.

In the present study, control varieties *Jyothi* and *Uma* obtained a fat content of 0.42 and 0.35 g/ 100g. According to Lakshmi (2011) and Sathyan (2012) higher fat content of 1.30 g/ 100g and 1.92 g/ 100g was found in *Jyothi* variety. In a study conducted by Thomas *et al.* (2013) among six different rice varieties from Malaysia, highest fat content of 1.74 g/ 100g was observed in brown rice variety.

Rice is a good source of insoluble fibre. In the present study, the highest fibre content of 0.7 g/ 100g was noticed in *Ezhome*-1 and the lowest of 0.08 g/ 100g in *Vaishak* (PTB-60) variety. Fibre content of different rice varieties of the present study are shown in Figure 20. Nandini (1995) reported that among seventeen selected rice varieties of Kerala, the crude fibre content was found to be higher in traditional varieties when compared to hybrid derivatives. Manay and Shadaksharaswamy

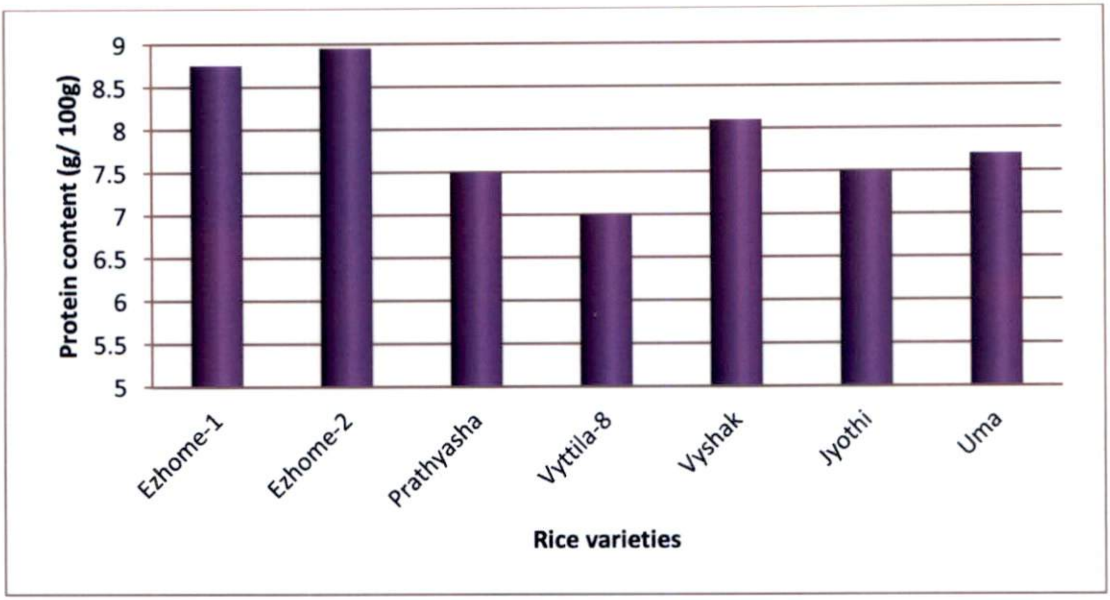


Fig. 18: Protein content of rice varieties

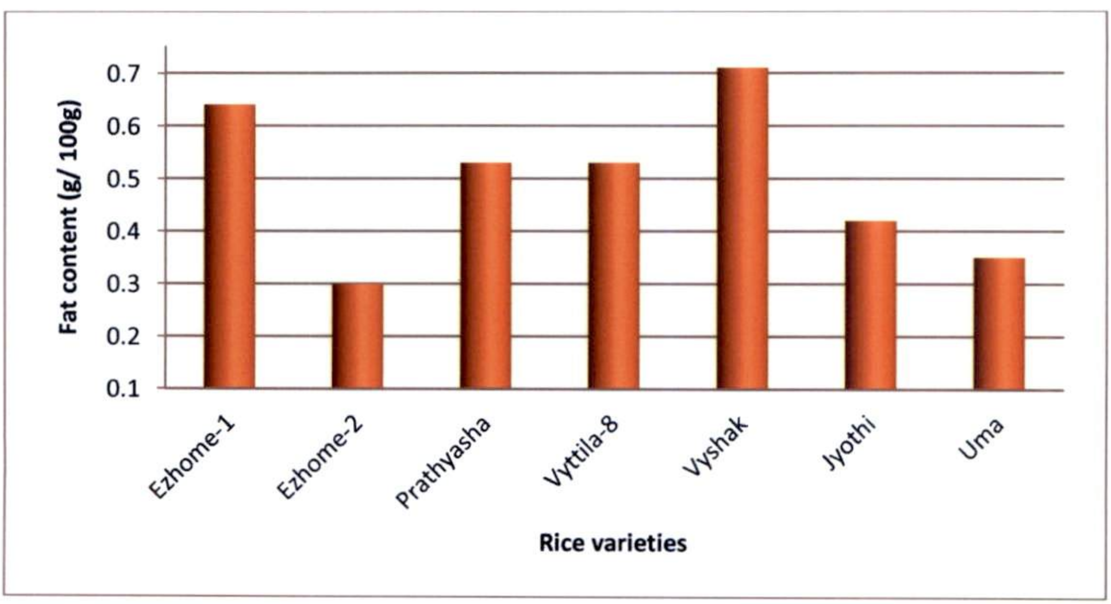


Fig. 19: Fat content of rice varieties

(2008) reported that rice is a moderate source of fibre and the fibre content varied from 0.2 to 1.0 g/ 100g. The variety *Kutticheradi* have high amount of crude fibre content of 0.51 g/ 100g. Among eight rice varieties from KAU, Sugeetha (2010) found the highest fibre content of 0.29 g/ 100g in MO-95-1 variety. In control rice varieties *Jyothi* and *Uma,* fibre content of 0.18 and 0.2 g/100g was observed. In a study conducted by Lakshmi (2011) and Sathyan (2012), parboiled and raw rice of *Jyothi* rice variety obtained a fibre content of 0.83 g/ 100g and 1.07 g/ 100g. According to Gopalan *et al.* (2012) milled rice had 0.2 g/ 100 g fibre.

In the present study, newly released rice variety, *Vyttila*-8 obtained a fibre content of 0.26 g/ 100g, in line with this Nandini (1995) reported a fibre content of 0.27 g/ 100g for *Vyttila*-3 variety.

Brown rice is a rich source of B vitamins. The outer layer of grain was removed on milling, which is high in fibre, vitamins and minerals as well as proteins. The removal of outer layer results in losses of nutrients especially B vitamins (Babu *et al.,* 2009).

In the present study, thiamine content in the range of 0.02 to 0.07 mg/ 100g was observed in newly released rice varieties. Menon (2004) reported that the high thiamine content in *Njavara* rice variety. Deepa *et al*. (2008) reported a higher thiamine content of 0.35 in *Jyothi* rice variety. Sugeetha (2010) reported that when compared to eight KAU rice varieties MO-95-1 has obtained the highest thiamine content of 0.29 mg/ 100g and MO-2 variety obtained the lowest of 0.05 mg/ 100g. Thiamine content observed in the present study in control variety *Jyothi* was 0.05 mg. This is in line with the study of Sathyan (2012). The author observed a thiamine content of 0.05 mg/ 100g in *Jyothi*. The thiamine content observed in different rice varieties are presented in Figure 21.

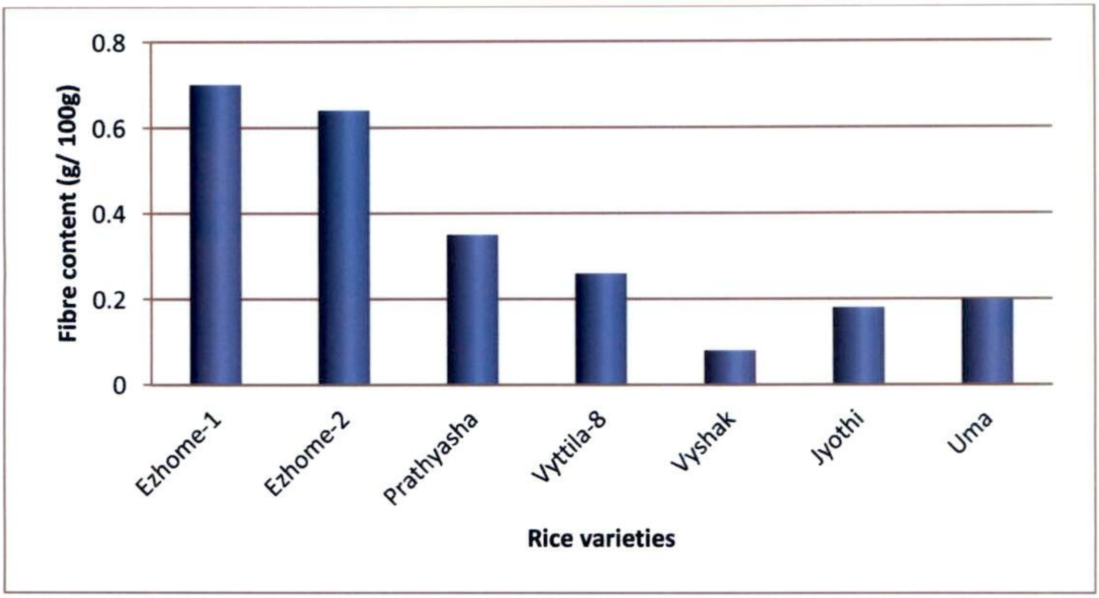


Fig. 20: Fibre content of rice varieties

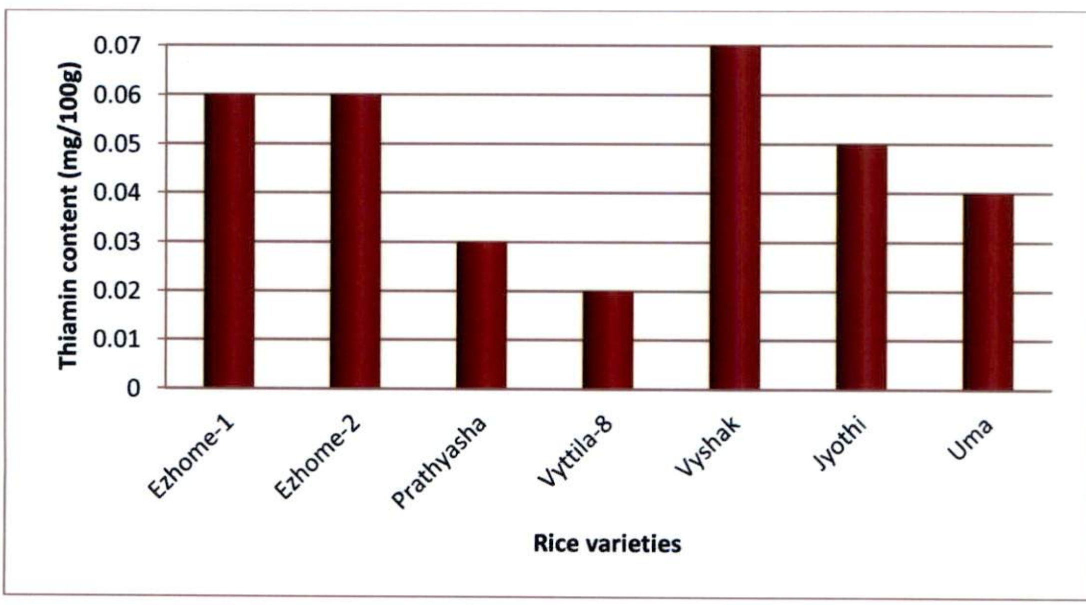


Fig. 21: Thiamine content of rice varieties

Brown rice provides valuable quantities of minerals (Sujatha *et al.,* 2004). Among newly released rice varieties, the calcium content observed in the present study is in the range of 4.92 to 6 mg/ 100g. Sugeetha (2010) observed the highest calcium content of 12mg/100g in MO8-20-KR among other seven KAU varieties in the study.

Nandini (1995) reported that hybrid rice varieties recorded higher value for minerals and the calcium content in it varied from 9.85 to 11.25 mg/ 100g. High calcium content of 11.25 mg/ 100g was observed in *Vyttila*-3 variety. In the present study, *Vyttila*-8 obtained a lower calcium content of 5.7 mg/ 100g. Deepa *et al.* (2008) reported a calcium content of 9.70 mg/ 100g in *Jyothi* rice variety. According to Lakshmi (2011) and Sathyan (2012), parboiled and raw rice of *Jyothi* variety had a calcium content of 6.50 mg/ 100g and 5.94 mg/ 100g respectively. In the present study, control variety *Jyothi* obtained a calcium content of 6.6 mg/ 100g. The calcium content of different rice varieties are presented in Figure 22.

The zinc content observed in the present study is in the range of 1.01 to 1.31 mg/ 100g among newly released rice varieties. Control varieties *Jyothi* and *Uma* obtained a zinc content of 1.11 to 1.07 mg/ 100g. In polished rice, low zinc content was observed and the highest in unpolished (Sotelo *et al.* 1990). The highest zinc content of 2.97 per cent respectively were found in *Irri*-6 (Ahuja *et al*., 2007). *Nerica* rice varieties of Africa have high micronutrients like iron and zinc ranging between 21.1 mg/ kg^{-1} to 25.3 mg/ kg^{-1} for iron and 53.2 mg/kg^{-1} to 48.7 mg/ kg^{-1} for zinc in upland rice (Somado *et al*., 2008). Zinc content noticed in different rice varieties are presented in Figure 23.

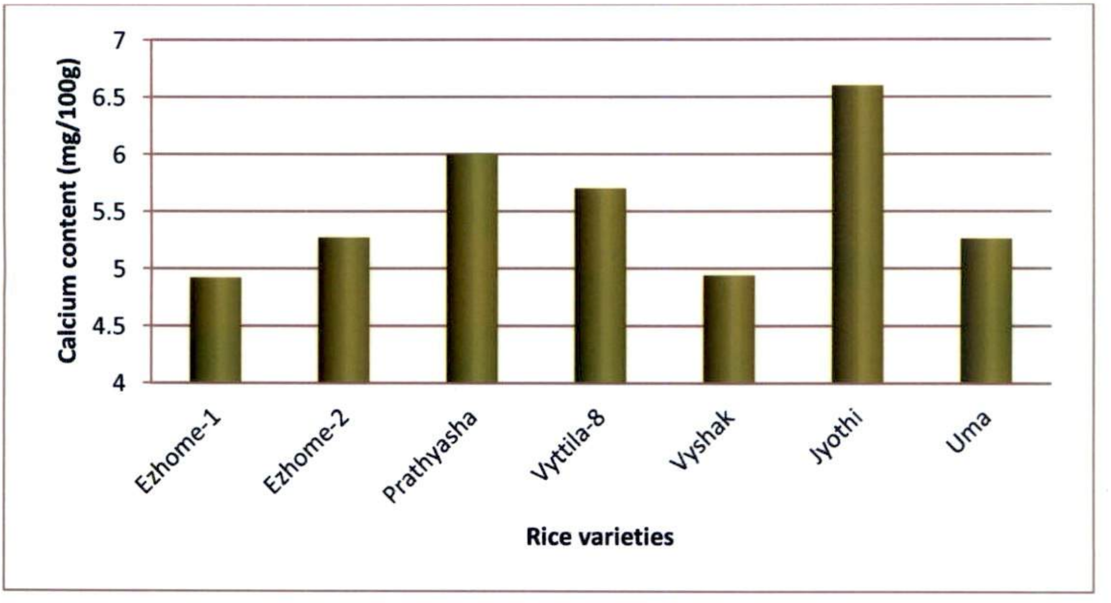


Fig. 22: Calcium content of rice varieties

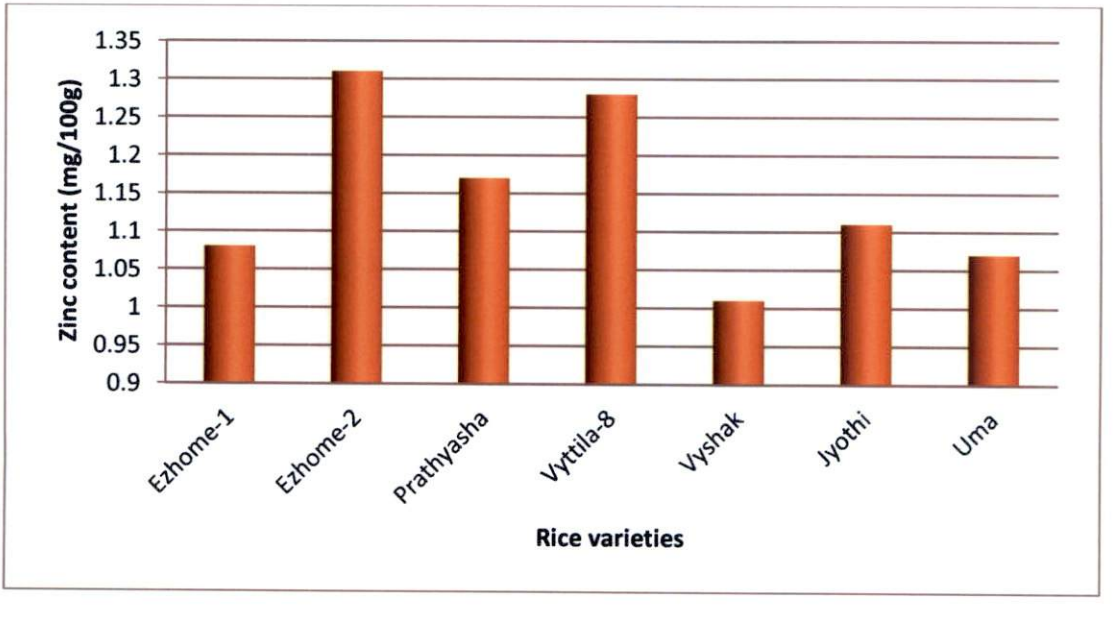


Fig. 23: Zinc content of rice varieties

Rice is the cereal which is low in iron content (Gregorio *et al.*, 2000). The iron content observed in the present study is in the range of 0.41 to 0.61 mg/ 100g among newly released rice varieties. In contrast to this, a higher iron content of 1.94 per cent was observed in *Irri*-6 by Ahuja *et al.* (2007).

Nandini (1995) reported that iron content of hybrid varieties varied from 2.52 to 3.43 mg/ 100g. High iron content of 3.42 mg/ 100g was noticed in *Hraswa* variety. Rood (2000) reported high iron content in the Chinese red rice varieties *Bloody sticky* and *Dragon eyeball*. Iron content in rice was found to be 2.2 per cent in milled rice (Anon, 2001). Deepa *et al.* (2008) reported an iron content of 3.95 in *Jyothi* rice variety. A lower iron content of 0.57 mg/ 100g was observed in *Jyothi* variety in the present study. Iron content of 1.97 mg/ 100g and 1.94 mg/ 100g was observed in *Jyothi* rice variety (Lakshmi, 2011 and Sathyan, 2012). The iron content observed in different rice varieties of the present study are shown in Figure 24.

Among newly released rice varieties, phosphorus content was observed in the range of 90.29 to 135.41 mg/ 100g. According to Nandini (1995) hybrid rice varieties recorded a higher value for minerals and the phosphorous content of these varieties varied from 116 to 155.50 mg/ 100g. Deepa *et al.* (2008) reported a higher phosphorus content of 324 mg/ 100g in *Jyothi* rice variety. In the present study, control varieties *Jyothi* and *Uma* obtained a phosphorus content of 133.2 mg/ 100g and 101.35 mg/ 100g respectively. High phosphorus content of 155.50 mg/ 100g was found in *Jayanthi* variety. In a study conducted by Lakshmi (2011) and Sathyan (2012) phosphorus content of 161.83 mg/ 100g and 158.60 mg/ 100g was noticed in parboiled and raw rice of *Jyothi* variety. Phosphorous content of different rice varieties are presented in Figure 25.

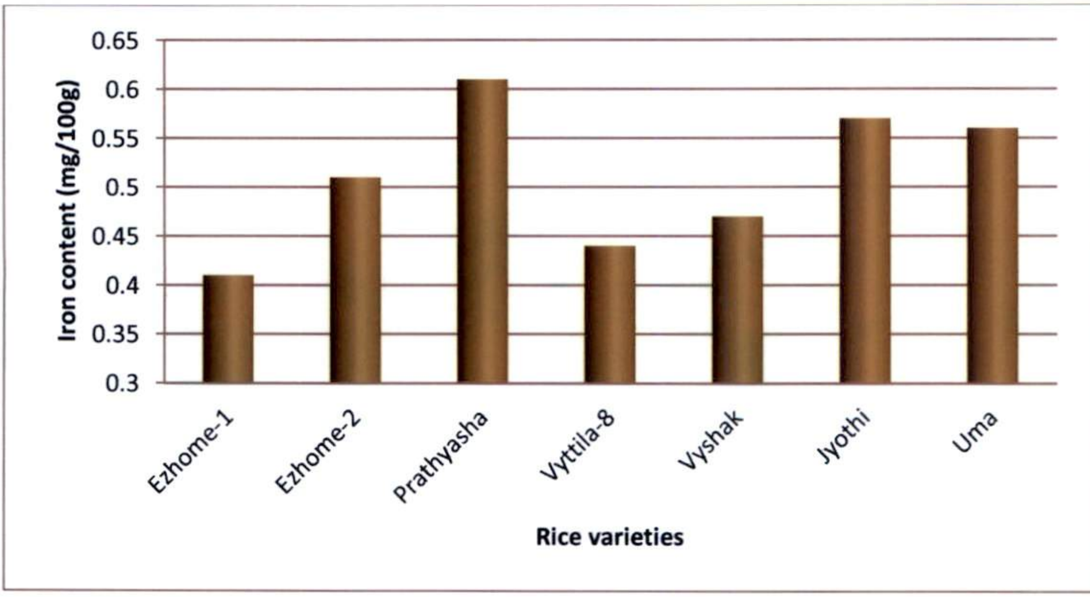


Fig. 24: Iron content of rice varieties

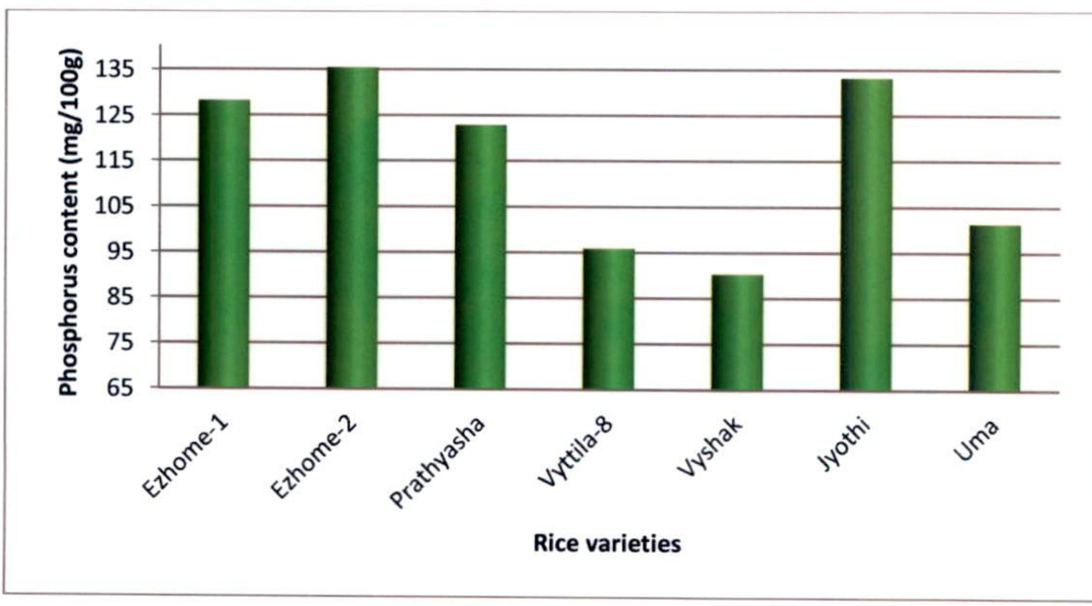


Fig. 25: Phosphorous content of rice varieties

The values observed for different minerals were slightly lower. The differences may be due to the difference in degree of milling, cultivation practices like fertilizer application and amount of soil nutrients present in different areas. Suzuki *et al*. (2004) reported that mineral content in rice was highly influenced not only by the difference among cultivar, but also difference in cultivating area. Newly released rice varieties were found to be superior in nutritional qualities when compared with the control varieties. Rivero *et al*. (2006) reported that greater amount of rice bran are removed from grain during milling ahd polishing.

5. 1. 4. Physical qualities of roasted and unroasted rice flour

Bulk density is an important physical property of rough and milled rice. The bulk density of rice is dependent on grain type, moisture content, kernel density and additional physical properties such as kernel shape and dimensional characteristics (Fan *et al*., 1998). The bulk density obtained for unroasted and roasted flour of different rice varieties are presented in Figure 26.

Bhattacharya *et al.* (1972) observed that bulk density is related to the L/B ratio of the grain, the more round the kernel greater the bulk density. Among different rice varieties *Ezhome*-2 obtained the highest L/B ratio which obtained the highest bulk density in unroasted rice flour. Varieties like *Uma* and *Ezhome*-1 obtained a lower L/B ratio and they were found to be having lower bulk density. In the present study, lower bulk density of 0.54 g/ ml and 0.63 g/ ml was recorded in roasted and unroasted rice flour of *Jyothi* variety.

Among different rice varieties bulk density of roasted and unroasted rice flour were obtained in a range of 0.53 g/ml to 0.62 g/ml and 0.63 g/ml to 0.73 g/ml respectively. Singh *et al*. (2003) reported a bulk density in the range of 0.77 to 0.85

g/ml in rice flour. Yadav *et al.* (2007) reported a bulk density in the range of 0.83 to 0.92 g/ ml in Indian rice cultivars. According to Lakshmi (2011) and Sathyan (2012) and bulk density of 0.84 g/ml was noticed in rice flour of *Jyothi* variety. This is slightly higher than the observation of the present study. This may be due to the difference in milling and particle size of the flour. In support to this, Subba and Katawal (2013) found that the bulk density increased with increase in the particle size. The author noticed a low bulk density in flour of finer particle size.

Bulk density is significantly correlated with water uptake in raw rice. Highest water uptake among newly released rice varieties was observed in *Ezhome*-2 which has the highest bulk density. Prathyasha (MO-21) obtained the lowest bulk density and the lowest water uptake. Bulk density has a positive correlation with cooking time. Among newly released rice varieties, the highest bulk density was observed in *Ezhome*-2 for which the highest cooking time was noticed.

In the present study, roasted and unroasted rice flour obtained a water absorption index in the range of 22.17 to 25.11 and 22.67 to 25.46 respectively. Control varieties *Jyothi* and *Uma* recorded a water absorption index of 24.65 and 25.11 respectively for roasted rice flour and 25.46 and 25.45 respectively for unroasted rice flour. The difference in the water absorption index is because of the difference in amylose content of the rice varieties. Water absorption index of 22.07 and 17.60 was obtained for rice flour of raw and parboiled *Jyothi* rice variety respectively (Lakshmi, 2011 and Sathyan, 2012). Water absorption index ranged between 21.5 and 2.41 per cent in brown raw rice varieties of Kashmir (Mir and Bosco, 2013). Water absorption index of unroasted and roasted flour of different rice varieties are shown in Figure 27.

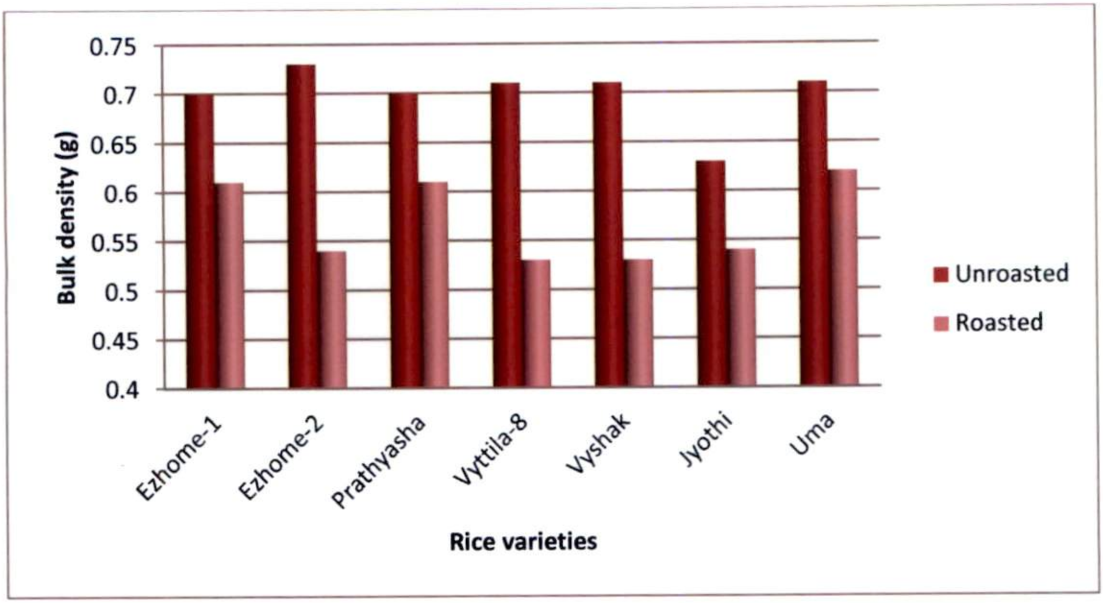


Fig. 26: Bulk density of unroasted and roasted flour of rice varieties

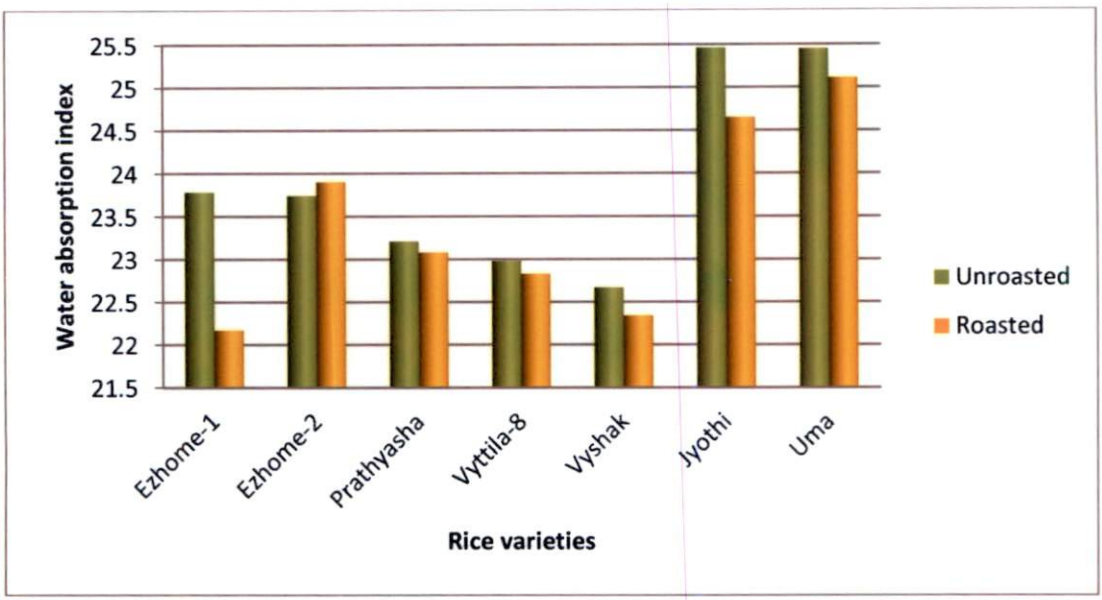


Fig. 27: Water absorption index of unroasted and roasted flour of rice varieties

Water absorption by flour is mainly due to the swelling and solubility of starch granules which in turn depends on amylose content (Kaur *et al.,* 2002). Increase in amylose content improves the capacity of the starch granule to absorb water and expand in volume without collapsing because of the greater capacity of amylose to hydrogen bond or retrograde. The particle size of the rice flour also affects the water absorption capacity (Williams *et al*., 2005). The newly released rice varieties are of low amylose content and it varied from 10 to 15.61 per cent in *Prathyasha* (MO-21) and *Ezhome*-2 respectively and are having low water absorption index when compared to the high amylose varieties *Jyothi* and *Uma*.

Manisha (2000) pointed out that the decrease in water absorption index is related to the degradation of starch, which causes a reduction in the water holding capacity of the molecules as a result of decrease in the molecular size. At a low temperature, more undamaged polymer chains and a greater availability of hydrophilic groups can bind more water resulting in higher values of water absorption index.

Water absorption index is positively correlated with high protein. In line with this, rice varieties *Ezhome*-1 and *Ezhome*-2 that recorded high protein content showed higher water absorption index.

The water solubility index depends on quantity of soluble matter which increases due to the degradation of starch (Manisha, 2000). Higher water binding capacity, swelling ratio, peak viscosity and reduced optimum cooking time have been observed with higher degree of milling (Mohapatra and Bal, 2006). In the present study unroasted and roasted rice flour obtained water solubility index in a range of 0.34 to 0.78 and 0.28 to 0.81respectively. Control variety *Jyothi* obtained water solubility index of 0.42 and 0.49 in roasted and unroasted rice flour. A lower water

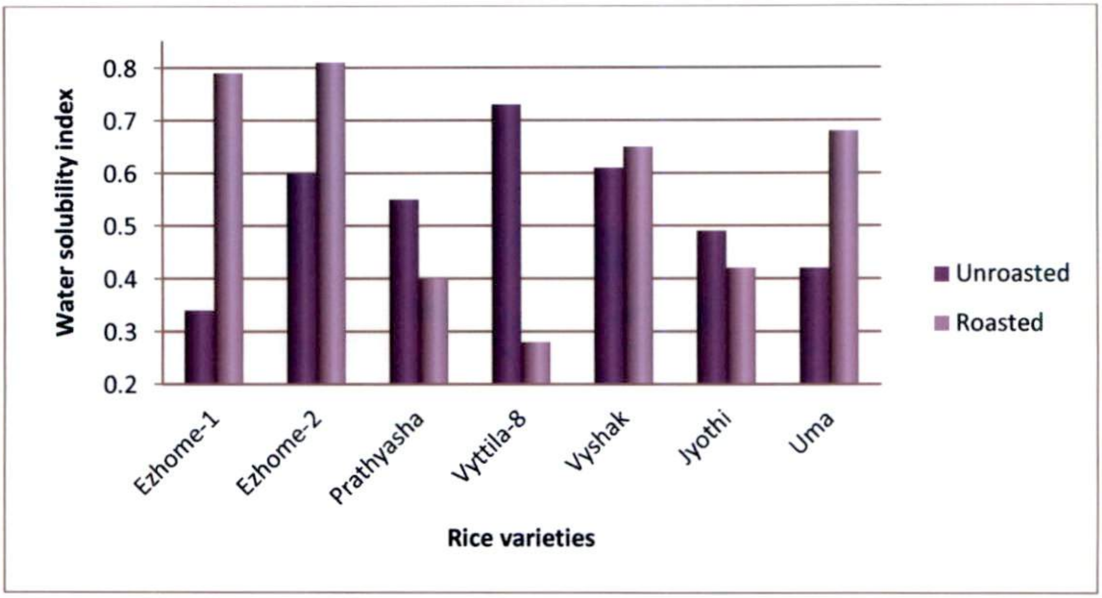


Fig. 28: Water solubility index of unroasted and roasted flour of rice varieties

solubility index of 0.12 and 0.20 was noticed in parboiled and raw rice flour of *Jyothi* variety (Lakshmi, 2011 and Sathyan, 2012). Ashogbon and Akintayo (2012) reported that cultivars differences have an effect on starch properties. Water solubility index observed for unroasted and roasted flour of different rice varieties are presented in Figure 28.

Retrogradation in rice is a trait that describes the hardening of gel after storage or cooling and it has significant role in determining processing qualities and consumer preferences.

The synerisis per cent was measured in cooked paste of both unroasted and roasted flour of different rice varieties at timely intervals. In unroasted rice flour at the end of 12th day of study, the lower synerisis was observed in control varieties, *Uma* and *Jyothi*. In roasted rice flour also control rice varieties *Jyothi* and *Uma*, which had a high amylose content obtained lower synerisis per cent at the end of 12th day of observation. The synerisis per cent obtained for unroasted and roasted flour of different rice varieties are presented in Figure 29 and 30 respectively.

Keetels *et al.* (1996) reported that amylose and amylopectin retrogradation contribute to the hardness in rice. Both these varieties were having higher amylose content and more crystal nuclei than other varieties. This may be the reason for higher retrogradation observed in *Jyothi* and *Uma.* Retrogradation of rice flour samples increased with increasing amylose content and percentage crystallinity. Amylose content was correlated with the retrogradation behaviour of rice flour (Varavinit *et al.*, 2003).

According to Thumrongchote *et al*. (2012) amylose could associate more easily resulting in more crystal nuclei and hence faster the retrogradation. The author

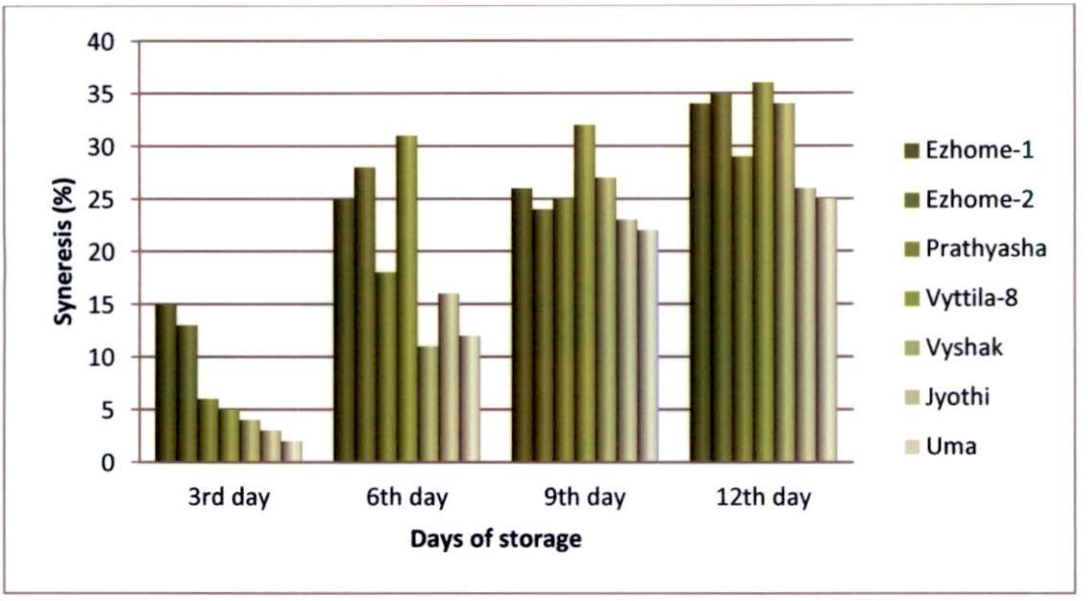


Fig. 29: Retrogradation property of unroasted flour of rice varieties

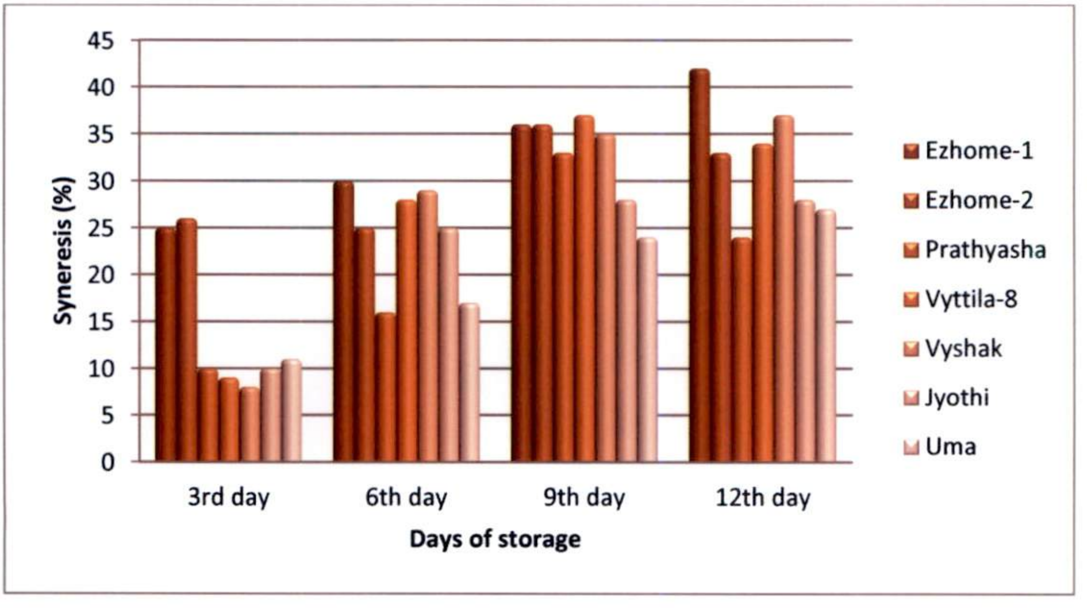


Fig. 30: Retrogradation property of roasted flour of rice varieties

also reported that varieties having amylose content of 18 to 22 per cent had percentage retrogradation of 32 to 40 in a period of 7 days for six rice varieties of Thailand. The degree of retrogradation was determined by the availability of long chain amylose.

Fan *et al.* (1998) reported that high amylose rice flour give high rate of retrogradation and the rate of retrogradation was significantly influenced by cultivars. The authors also indicated that long grain rice retrograded faster than medium grain rice. This is in line with the observations of present study, *Jyothi*, *Prathyasha* (MO-21) and *Ezhome*-2 which were identified as slender long rice varieties, showed lower syneresis percentage at the end of 12th day.

Villareal *et al.* (1976) indicated that the rate of retrogradation, is due to differences in molecular properties of the amylopectin from each cultivar. Perdon *et al.* (1999) reported that an increase in storage duration increases the degree of starch retrogradation, hence the observed difference in retrogradation properties may be due to difference in cultivars or grain procurement operations.

Physical properties of raw rice and rice flour of newly released varieties were comparable with that of control varieties.

5. 1. 5. Microbial enumeration of rice and roasted rice flour

Microbial enumeration of rice and roasted rice flour was carried out for a period of six months. Presence of bacteria was detected in rice and roasted flour of all selected rice varieties during the period of storage. Fungal growth was not observed in raw rice and roasted flour of any of the selected rice varieties until fourth month of study. Fungal growth was detected in roasted flour of *Ezhome*-1, *Ezhome*-2, *Vaishak*

(PTB-60) and *Uma* rice varieties from fifth month onwards. Yeast count was not detected in rice and roasted flour of any of the selected rice varieties till fifth month of study. At the end of the storage period, yeast count was noticed in all raw rice varieties. Although the bacterial, fungal and yeast count was noticed in rice and rice flour during storage, it was found to be minimum and did not affect the quality of rice and rice flour.

According to Brown (1996) the microbial load of food stuffs depends mainly on the processing techniques used and their keeping quality depends on type of packaging and temperature of storage. The microbial growth of product dependents upon chemical and physical factors like moisture, temperature and water activity, which make it favourable for their growth (Tahir *et al.*, 2012).

5. 1. 6. Insect infestation in rice and roasted rice flour

Insect infestation was not detected in raw rice and roasted flour of different rice varieties at the end of storage study. Lakshmi (2011) and Sathyan (2012) reported that no storage pestes were noticed in *Jyothi* rice variety up to three months of storage.

5. 2. Acceptability of traditional food products

5. 2. 1. Organoleptic evaluation of rice and rice based food products

Rice flakes are one of most preferred and nutritious breakfast cereal used all over in India. Rice flakes were prepared with paddy of different rice varieties. The mean rank score for overall acceptability of rice flakes prepared with newly released rice varieties varied from 6.9 (*Ezhome*-1) to 8.3 (*Vyttila*-8). The highest overall acceptability was noticed in rice flakes prepared with *Vyttila*-8 and the lowest in

Ezhome-1. The mean score of 7.8 with mean rank score of 4.35 was observed for overall acceptability of *Jyothi* and *Uma* varieties. The mean scores observed for different organoleptic qualities of rice flakes are presented in Figure 31.

Gupta *et al.* (2012) reported mean score of 7.55 for colour, 7.66 for texture, 7.65 for flavour, 7.55 for taste and 7.60 for overall acceptability of rice flakes. Sharon and Kareem (2013) reported a higher mean score for overall acceptability of rice flakes prepared with *Njavara* rice variety. To select the most suitable variety, total index scores were worked out. Based on total index scores, *Vyttila*-8 was found to be the most suitable variety for the preparation of rice flakes.

Iddli is a popular fermented breakfast item widely consumed especially in south India. For *iddli* prepared with different newly released rice varieties, *Jyothi* obtained the highest mean rank score of 8.2 followed by 8.1 for *Prathyasha* (MO-21). Nazni and Shalini (2010) found that *iddli* prepared using rice flour obtained the higher mean score for all quality attributes. Lakshmi (2011) reported that *iddli* prepared from parboiled rice flour of *Jyothi* variety obtained the highest mean score for different quality attributes. Among different rice varieties, the highest total index score was noticed in control variety *Uma*. *Prathyasha* (MO-21) obtained the highest total index for *iddli* among newly released rice varieties. Based on total index score, *Uma* was found to be the most suitable variety for the preparation of *iddli*. The mean scores obtained for different organoleptic qualities of *iddli* are presented in Figure 32.

Among newly released rice varieties, *Prathyasa* variety which have lower amylose content, higher water solubility index and the highest gel consistency obtained higher mean score for texture. This is in line with the study of Kunhimon (2010), who reported that gel consistency contributes a better texture for the prepared product.

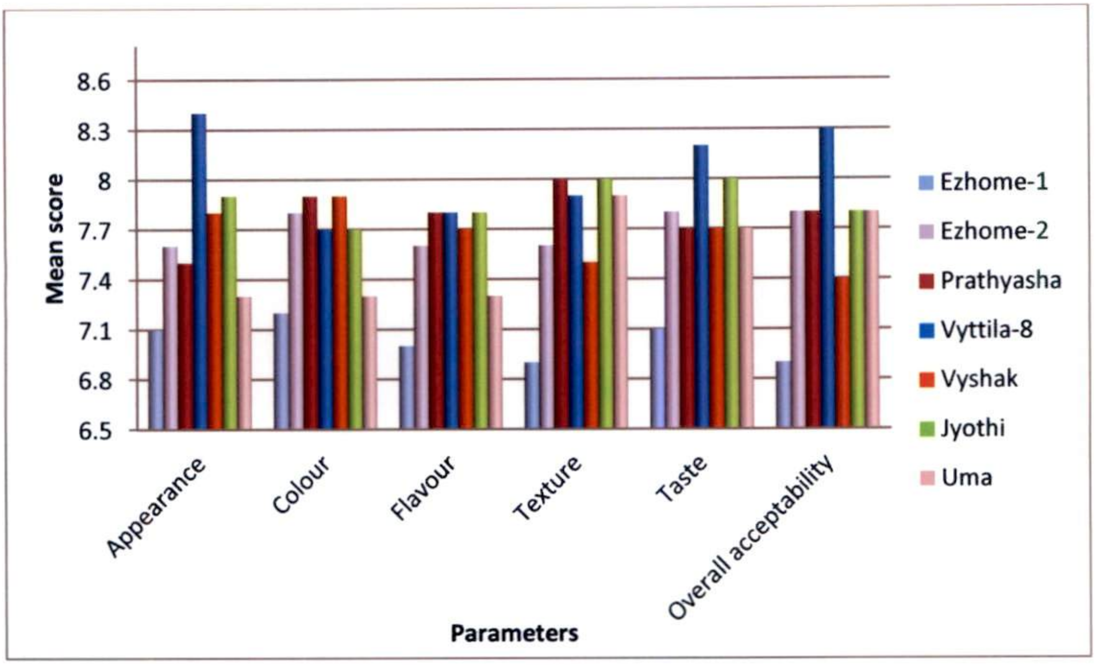


Fig. 31: Mean scores for different organoleptic qualities of rice flakes

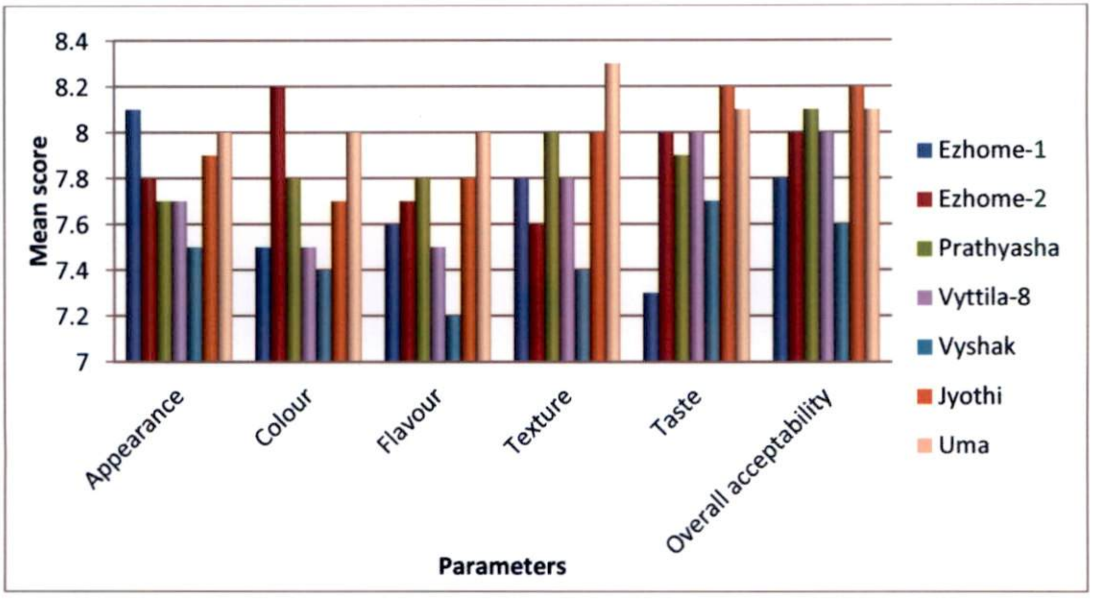


Fig. 32: Mean scores for different organoleptic qualities of *iddli*

Varieties having high amylose content resulted in hard and shorter length of gel than varieties with low amylose content due to retrogradation behaviour of amylose during the cooling of gel (Rani *et al*., 2006).

Water solubility index of *Prathyasha* (MO-21) is comparatively high and when more water penetration is permitted fermenting quality also will be high. In line with this, Prathyasha (MO-21) was found to the most suitable variety for *iddli*.

5. 2. 2. Organoleptic evaluation of rice flour based food products

Rice flour has excellent processing qualities and is highly suited for various steamed and fried products. Organoleptic evaluation of *appam* and *unniappam* prepared using unroasted rice flour and *puttu* and *ada* prepared with roasted rice flour was conducted.

Among newly released rice varieties, *appam* prepared with unroasted flour of *Ezhome*-2 obtained maximum mean score for overall acceptability. Unroasted rice flour of almost all varieties obtained a mean score above 7 for *appam*. Control variety *Jyothi* obtained lower overall acceptability when compared to the newly released varieties. In the study conducted by Kunhimon (2010), *appam* prepared using rice flour obtained a mean score of 7.28. Based on total index scores, *Prathyasha* (MO-21) was found to be the most suitable variety for the preparation of *appam* among different rice varieties.

Low amylose rice varieties are preferred for fermented foods sweets, puddings, desserts and cakes because of their expanded volume which inturn favours the texture (Antonio and Juliano, 1974). Nandini (1995) reported that varieties such

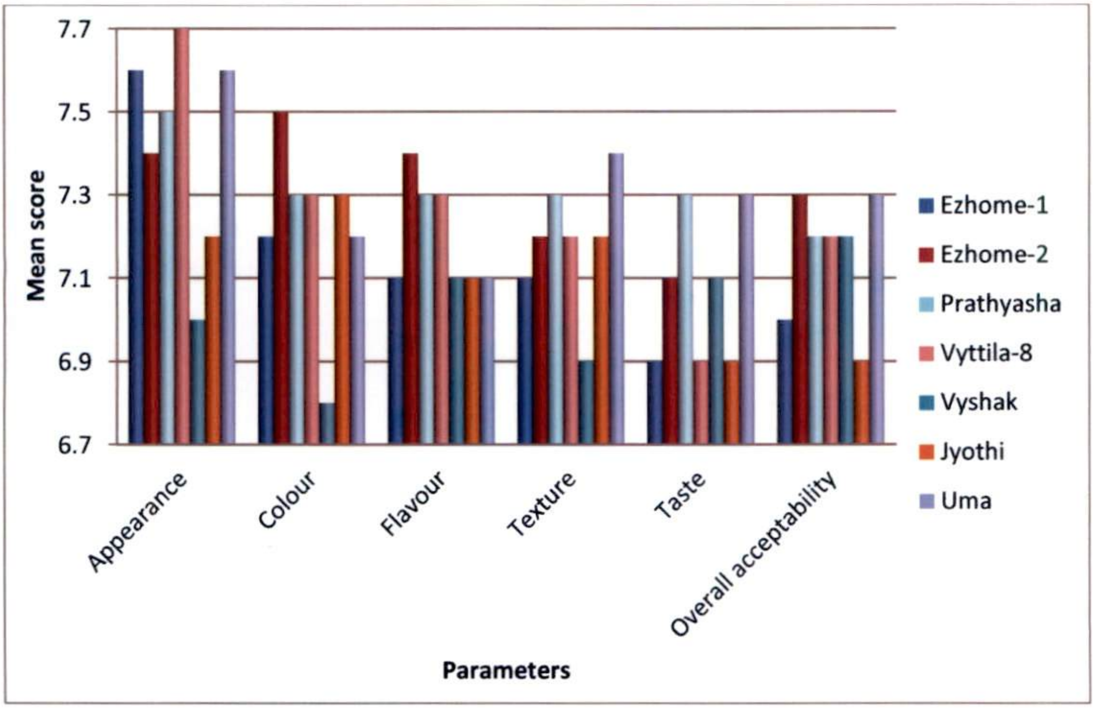


Fig. 33: Mean scores for different organoleptic qualities of *appam*

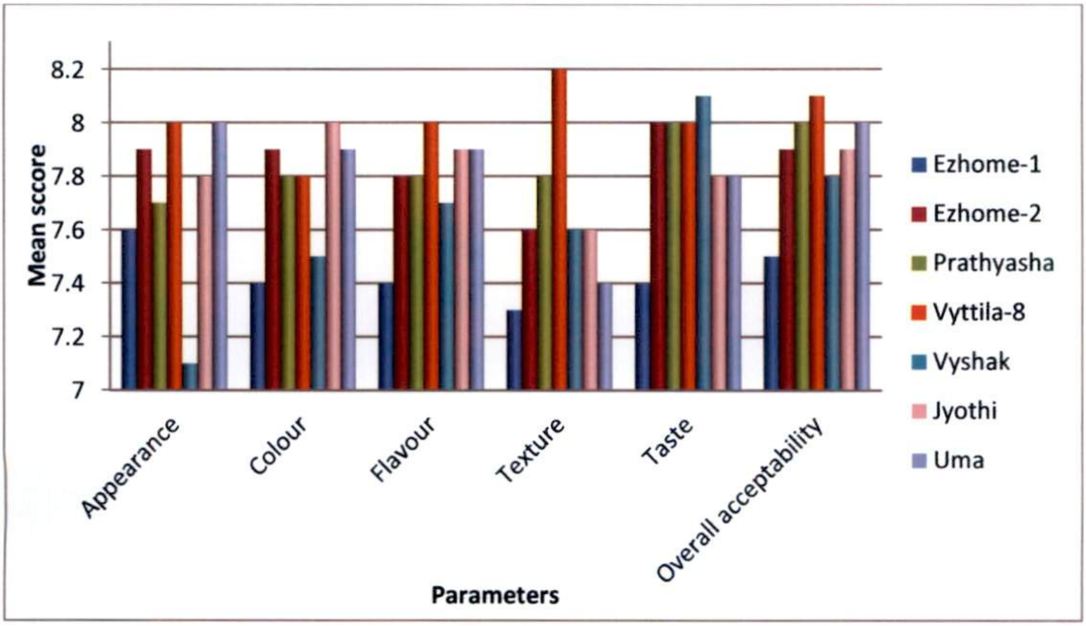


Fig. 34: Mean scores for different organoleptic qualities of *unniappam*

as *Vyttila*-1, *Kavunginpoothala* and *Vellari* were found to be highly suitable for *appam*. In line with this, *Prathyasha* (MO-21) variety which obtained the lowest amylose content was found to be the most suitable variety for the preparation of *appam*.

A Kerala traditional delicacy *unniappam* was prepared with unroasted flour of different rice varieties. For taste, higher mean scores were noticed in *unniappam* prepared with all most all rice varieties. Based on total index scores, the highest total index was obtained for newly released variety *Vyttila*-8 followed by control variety *Jyothi*. These varieties were found to be suitable for the preparation of *unniappam*. Kunhimon (2010) reported that *unniappam* prepared using rice flour obtained the highest score of 8.26 for overall acceptability. Sathyan (2012) reported that *unniyappam* prepared with *Jyothi* variety scored the highest mean score for different quality attributes. The mean scores of organoleptic qualities of *appam* and *unniappam* prepared with different varieties are presented in Figure 33 and 34.

Roasted rice flour of different rice varieties was used to prepare two traditional food products namely *puttu* and *ada*. The highest mean score of 8.5 for overall acceptability and the highest total index score was noticed in *Vaishak* (PTB-60) among different rice varieties. This was found to be the most suitable rice variety for the preparation of *puttu*. The mean scores obtained for *puttu* prepared with different varieties are presented in Figure 35.

Kunhimon (2010) reported that rice flour based *puttu* obtained a mean score of 7.76. Lijitha (2012) mentioned that *puttu* prepared with rice flour obtained a higher mean score of 8.53 for over all acceptability. Mean scores in the range of 7.9 to 8.5 was observed in different newly released rice varieties. Sathyan (2012) mentioned that *puttu* prepared using roasted rice flour of *Jyothi* obtained the highest mean score of 7.43 for overall acceptability.

Nandini (1995) reported that the varieties such as *Vyttila*-1and *Vyttila*-3 were suitable for powdering and are suited for steamed preparation like *puttu*. Arumugasamy *et al.* (2001) observed that glutinous rice is used in making *puttu* in South India. A study conducted by Lakshmi (2011) reported that *puttu* prepared using parboiled roasted rice flour of *Jyothi* variety obtained the highest mean score for different quality attributes. In the present study, newly released varieties were of low amylose content and low water absorption index. These varieties obtained higher scores for texture were found to be suitable for steamed product *puttu*.

For *ada*, roasted rice flour of newly released rice varieties obtained lower mean scores for overall acceptability when compared with that of control varieties. Among different rice varieties, newly released *Prathyasha* (MO-21) variety obtained the highest score of 8.2 and the highest total index for *ada*. So that *Prathyasha* (MO-21) was found to be the most suitable rice variety for the preparation of *ada*. Low amylose content in Prathyasha (MO-21) might have contributed to product cohesiveness. Kunhimon (2010) and Lijitha (2012) reported that *ada* prepared using rice flour obtained a mean score of 7.94 and 8.53 for overall acceptability.

Divakar and Francis (2010) found that *Swetha* and *Ashwathi* were most acceptable for rice flour based traditional preparations. Lakshmi (2011) and Sathyan (2012) reported a mean score of 8.36 and 7.27 for the overall acceptability for a similar product *kozukatta*. The mean scores obtained for *ada* prepared with different varieties are presented in Figure 36.

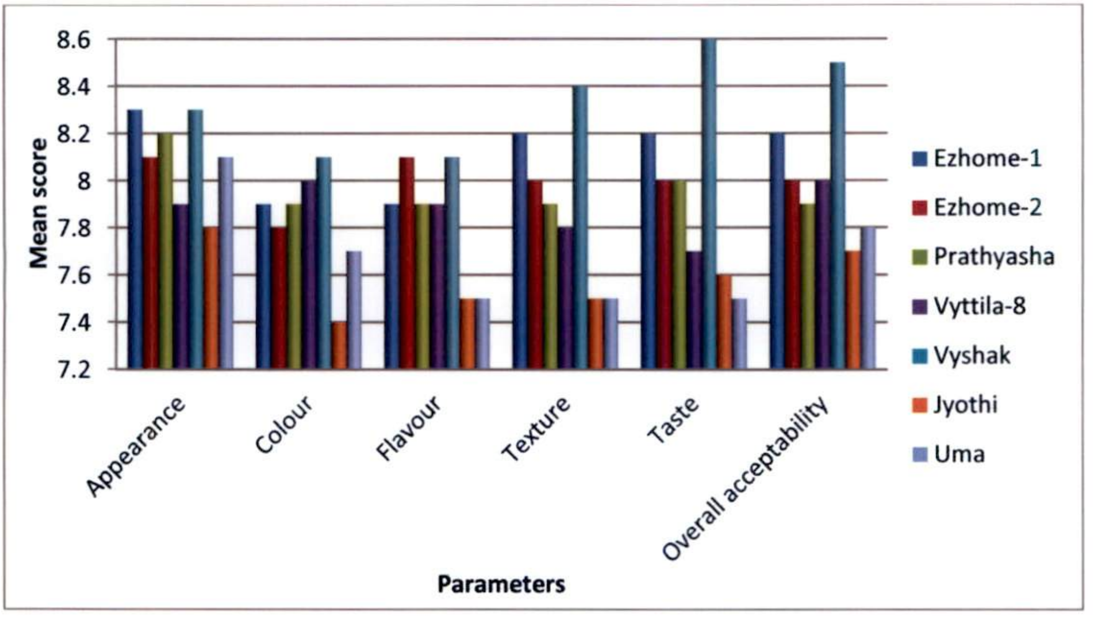


Fig. 35: Mean scores for different organoleptic qualities of *puttu*

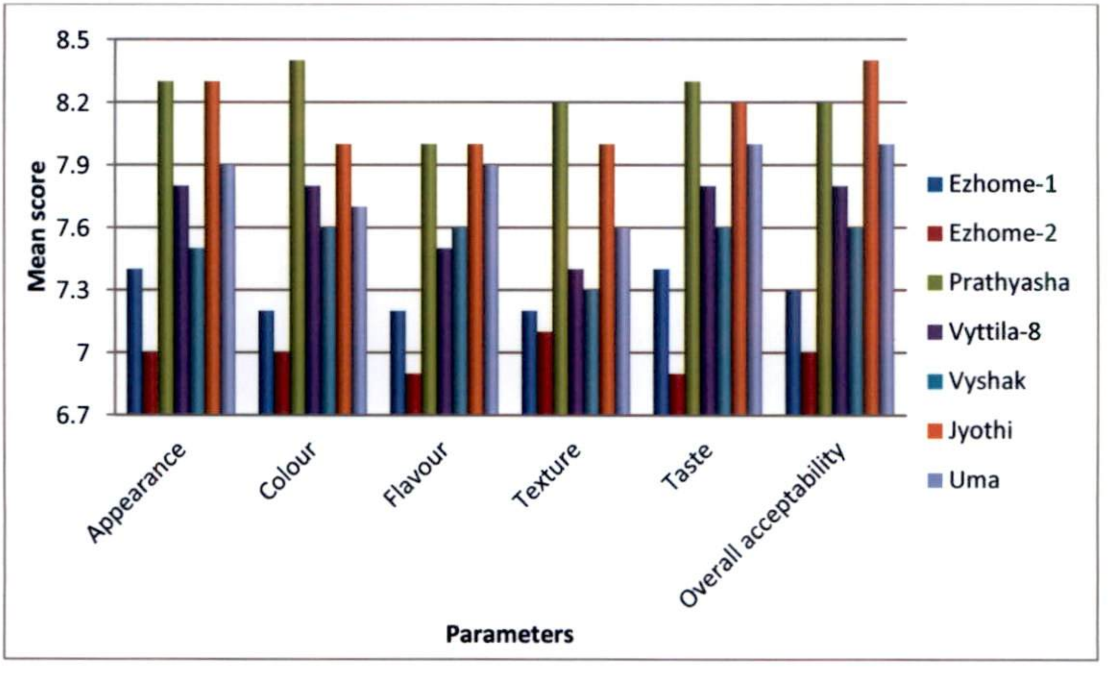


Fig. 36: Mean scores for different organoleptic qualities of *ada*

To summarise, wide variation in physicochemical properties and cooking qualities was observed among cultivars. For most of the physical quality parameters, raw rice of newly released varieties were found to be superior to the control variety *Jyothi* and *Uma*. Higher milling per cent, head rice recovery, thousand grain weight, volume weight, grain width and L/B ratio was observed in newly released varieties. Cooking qualities of newly released rice varieties were found to be comparable with that of control varieties. Newly released rice varieties were found to be superior in nutritional qualities also. In the present study, newly released rice varieties were found to be highly suitable for the preparation of different traditional food products. List of suitable varieties for each product are presented in Table 23.

Table 20. List of suitable varieties for cooked rice and for different traditional preparations.

Product	Recommended varieties
Cooked rice	*Ezhome*-2, *Vyttilla*-8 and *Ezhome*-1
Rice flakes	*Vyttila*-8, *Prathyasha* (MO-21), *Ezhome*-2 and *Vaishak* (PTB-60)
Iddli	*Prathyasha* (MO-21), *Ezhome*-2 and *Vyttila* -8
Appam	*Prathyasha* (MO-21), *Ezhome*-2, *Vyttila* -8, *Ezhome*-1 and *Vaishak* (PTB-60)
Unniappm	*Vyttila*-8,*Prathyasha* (MO-21), *Ezhome*-2 and *Vaishak* (PTB-60)
Puttu	*Vaishak* (PTB-60), *Ezhome*-1, *Ezhome*-2, *Prathyasha* (MO-21) and *Vyttila*-8
Ada	*Prathyasha* (MO-21), *Vyttila*-8 and *Vaishak* (PTB-60)

Rice varieties such as *Ezhome*-2, *Vyttilla*-8 and *Ezhome*-1 which obtained higher scores for organoleptic qualities, have high carbohydrate content and higher keeping quality also. Hence these varieties can be recommended for table rice. Newly released varieties which were of low amylose content and low water absorption index were found to be suitable for steamed product *puttu*. *Prathyasha* (MO-21) was found to be the most suitable rice variety for the preparation of *iddli, appam* and *ada*. Low amylose content and higher gel consistency in *Prathyasha* (MO-21) might have contributed the fermenting quality and product cohesiveness. All newly released varieties were of low amylose content and found to be suitable for different traditional food preparations.

Summary

6. SUMMARY

The present study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' was conducted to evaluate the physical, biochemical, nutritional, cooking and organoleptic qualities of newly released KAU rice varieties. The study also aims to assess the suitability of these rice varieties for the preparation of selected traditional food products.

Newly released KAU red rice varieties namely *Ezhome*-1 and *Ezhome*-2 were collected from College of Agriculture, Padannakkad. *Prathyasha* (MO-21) from Rice Research Station, Mancompu. *Vyttila*-8 from Rice Research Station, Vyttila. *Vaishak* (PTB- 60) from Regional Agricultural Research Station, Pattambi. Commonly used red rice varieties *Jyothi* and *Uma* were collected from Agricultural Research Station, Mannuthy served as control. A part of collected paddy was kept as such for evaluating physical qualities and for preparing rice flakes. The rice varieties were milled and various physical quality attributes were assessed. The organoleptic qualities of cooked rice and suitability for product development was also carried out. Unroasted rice flour was used for quality evaluation and for preparation of traditional products like *appam, unniyappam.* Food products like *puttu* and *ada* were prepared using roasted rice flour. The physical qualities of both unroasted and roasted rice flour were also assessed.

Physical qualities of rice like milling per cent, head rice recovery, thousand grain weight, volume weight, grain shape and size were determined. Milling per cent among rice varieties varied from 64.07 to 77.83 per cent. The results revealed that among newly released rice varieties the milling per cent of the rice varieties were found to be highest in *Ezhome*-2 (77.83 %) and lowest in *Prathyasha* (MO-21) (64.07 %) variety. Among newly released rice varieties, *Vyttila-8* obtained the highest head rice recovery of 57.45 per cent and the lowest in *Ezhome*-2 (49.48 %). Control varieties *Jyothi* and *Uma* obtained head rice recovery of 41.08 and 49.75 per cent respectively.

The highest thousand grain weight of 20.68 g was observed in *Vaishak* (PTB-60) among newly released rice varieties. The highest volume weight of 14.6 mm^3 and lowest of 12.81 mm^3 was recorded for newly released rice varieties *Vaishak* (PTB-60) and *Ezhome*-2 respectively. Among newly released rice varieties, grain length and grain width varied in the range of 4.33 to 4.95 mm and 1.21 to 1.86 mm respectively. Highest L/B ratio was noticed in *Ezhome*-2 variety. Based on the L/B ratio, the grain shape of *Ezhome*-1, *Vyttila*-8, *Vaishak* (PTB-60) and *Uma* were classified as bold medium. *Ezhome*-2, *Prathyasha* (MO-21) and *Jyothi* varieties were categorised as slender long grains. For most of the physical quality parameters, raw rice of newly released varieties were found to be superior.

Cooked rice prepared using different rice varieties were evaluated for sensory qualities. Among different rice varieties, highest mean score for overall acceptability was observed in control variety *Jyothi* (7.8) followed by *Uma* (7.6) and *Ezhome*-2 (7.4). Newly released rice varieties obtained lower total index for organoleptic qualities than control varieties and among those, cooked rice of *Ezhome*-2 obtained highest total index (13.34). The newly released rice varieties remained unaffected in alkali and were found to have high gelatinization temperature index. Among different rice varieties, lowest cooking time of 18.51(*Prathyasha* (MO-21)) to highest of 24.75 (*Ezhome*-2) minutes was noticed for obtaining optimum cooked rice. Highest water uptake of 5.74 ml/ g was observed in *Ezhome*-2 variety and lowest of 3.47 in *Ezhome*-1 among newly released rice varieties. The highest volume expansion ratio of 5.60 was noticed in *Ezhome*-2 and the lowest of 4.50 in *Vyttila*-8 among newly released rice varieties. The volume expansion noticed in control varieties was higher than that of newly released rice varieties and obtained volume expansion ratio of 5.62 (*Jyothi*) and 6.07 (*Uma*) respectively.

Among different rice varieties, amylose content varied from 10.20 per cent in *Prathyasha* (MO-21) to 23.32 per cent in control variety *Uma*. Compared to control varieties newly released rice varieties obtained lower amylose content. The highest gel consistency was noticed in *Prathyasha* (MO-21) (145) followed by *Vyttila*-8 (132). These varieties were classified as those having soft gel. Both *Ezhome*-1 and *Vaishak* (PTB-60) were of medium gel consistency where as *Ezhome*-2 and control variety *Uma* were of hard gel consistency. Among newly released rice varieties, higher grain elongation ratio of 0.90 was noticed in both *Ezhome*-2 and *Prathyasha* (MO-21). Maximum keeping quality up to 12.60 hours was noticed in *Vaishak* (PTB-60) among newly released rice varieties and *Prathyasha* (MO-21) obtained minimum keeping quality. Cooking qualities of newly released rice varieties were found to be comparable with that of control varieties.

The moisture content of rice varieties ranged from 8.5 in *Ezhome*-2 to 11.6 per cent in both *Ezhome*-1 and *Prathyasha* (MO-21). The highest carbohydrate content of 81.43 g was observed in *Ezhome*-2 and lowest of 71.01 g in *Prathyasha* (MO-21). Among newly released rice varieties, the highest starch content of 68.6 g/ 100g was noticed in *Ezhome*-2 and the lowest of 51.5 g/ 100g in *Prathyasha* (MO-21). Among different rice varieties minimum energy content of 318.70 Kcal and maximum of 363.55 Kcal was observed in *Prathyasha* (MO-21) and *Ezhome*-2 varieties respectively. Highest protein content of 8.95 g/ 100g among newly released rice varieties was noticed in *Ezhome*-2 and the lowest of 7.0 g/ 100g in *Vyttila*-8. Fat content in different rice varieties ranged from 0.30 per cent in *Ezhome*-2 to 0.71 per cent in *Vaishak* (PTB-60). The highest fibre content of 0.7 g/ 100g was observed in *Ezhome*-1 and lowest of 0.08 g/ 100g was recorded in *Vaishak* (PTB-60) variety.

Among newly released rice varieties maximum thiamine content of 0.07 mg/ 100g was noticed in *Vaishak* (PTB-60) and minimum of 0.02 mg/ 100g was noticed in *Vyttila*-8.

The highest calcium content of 6 mg/ 100g was noticed in *Prathyasha* (MO-21) and the lowest of 4.92 mg/ 100g in *Ezhome*-1 variety. Comparatively higher calcium content was observed in both control varieties *Jyothi* (6.6 mg/ 100g) and *Uma* (5.26 mg/ 100g). Among newly released rice varieties the highest zinc content of 1.31 mg/ 100g was noticed in *Ezhome*-2 and the lowest of 1.01 mg/ 100g in *Vaishak* (PTB-60). The highest iron content of 0.61 mg/ 100g was noticed in *Prathyasha* (MO-21) variety and lowest of 0.41 mg/ 100g in *Ezhome*-1. Iron content of control rice varieties were 0.56 mg/ 100g for *Jyothi* and *Uma* respectively. Among newly released rice varieties the highest phosphorus content of 135.41 mg/ 100g was noticed in *Ezhome*-2 and lowest of 90.29 mg/ 100g in *Vaishak* (PTB-60). A phosphorus content of 133.2 mg/ 100g and 101.35mg/ 100g was noticed in control varieties *Jyothi* and *Uma* respectively. Newly released rice varieties were found to be superior in nutritional qualities when compared with control varieties.

In the case of unroasted rice flour, highest bulk density of 0.73 g per ml was noticed in *Ezhome*-2 and the lowest of 0.70 g per ml in *Ezhome*-1 and *Prathyasha* (MO-21). In roasted rice flour of various newly released rice varieties, highest bulk density of 0.61 g per ml was observed in both *Prathyasha* (MO-21) and *Ezhome*-1. Among unroasted flour of newly released varieties, highest water absorption index was observed in *Ezhome*-1 (23.78) and lowest of 22.67 in *Vaishak* (PTB-60). Water absorption index of roasted rice flour of newly released rice varieties was found to be highest in *Ezhome*- 2 (23.90) and the lowest in *Ezhome*-1 (22.17). Compared to the control varieties *Jyothi* and *Uma*, newly released rice varieties obtained a lower water absorption index in both roasted and unroasted flour. Highest water solubility index of 0.78 was observed in unroasted rice flour of *Vyttila-8* and the lowest of 0.34 in *Ezhome*-1 rice variety. Unroasted rice flour of all newly released rice varieties, except that of *Ezhome*-1 showed higher water solubility with respect to control varieties *Jyothi* and *Uma*. In roasted rice flour of newly released rice varieties, the highest water solubility index of 0.81 was noticed in *Ezhome*-2 and the lowest in *Vyttila*-8 (0.28). Among the unroasted flour prepared with rice varieties, *Ezhome*-1 obtained the highest synerisis percentage during 3rd day of observation. At the end of 12th day of study, the highest synerisis percentage was noticed in unroasted rice flour of *Vyttila*-8. Among roasted flour of rice varieties *Ezhome*-2 obtained highest synerisis percentage at 3rd day of study. At the end of 12th day of study, the highest synerisis percentage was noticed in *Ezhome*-1. Physical properties of rice flour of newly released rice varieties were comparable with that of control varieties.

Bacterial growth was detected initially and the count increased during the period of study in both raw rice and roasted rice flour of different varieties. Among newly released rice varieties highest bacterial count was observed in rice and roasted flour of *Vyttila*-8 variety. Fungal growth was not detected till the fourth month of study in any of the raw rice and roasted flour of different rice varieties. Yeast count was not observed in any of the raw rice and roasted rice flour of different varieties till 5th month of study. Insect infestation was not observed in rice and roasted flour of any variety initially and at the end of six months of storage.

Acceptability of traditional food products prepared with rice varieties namely rice flakes, *iddli*, *appam*, *unniappam*, *puttu* and *ada* was evaluated. For organoleptic qualities of rice flakes, the highest total index of 14.73 was noticed in *Vyttila*-8 followed by control variety *Jyothi* (14.04). These varieties were found to be suitable for the preparation of rice flakes. For *iddli* the highest total index of 14.78 was obtained for control variety *Uma,* hence *Uma* was found to be the most suitable variety for the preparation of *iddli*. The highest total index of 13.21 was obtained for *appam* prepared with *Prathyasha* (MO-21) variety. Among different rice varieties, *Prathyasha* (MO-21) was found to be the most suitable variety for the preparation of *appam*. For *unniappam* prepared with *Vyttila*-8, the highest total index of 13.89 was obtained and was found to be the most suitable variety for the preparation of *unniappam*. *Vaishak* (PTB-60) obtained the highest total index of 15.64 and was found to be the most suitable rice variety for the preparation of *puttu*. Among different rice varieties, highest total index of 16.23 for *ada* was noticed in newly released variety *Prathyasha* (MO-21). *Prathyasha* (MO-21) was found to be the most suitable rice variety for the preparation of *ada*. In the present study, it was observed that newly released red rice varieties were suitable for the preparation for different traditional products.

Varietal differences highly influence grain quality characteristics of rice. In the present study, substantial variation in different physical and cooking qualities was observed among varieties. For most of the physical and nutritional quality attributes, raw rice of newly released varieties were found to be superior. Cooking qualities of newly released rice varieties and physical properties of rice flour were found to be comparable with that of control varieties. The study clearly specified the suitability of each variety for selected food preparations. The data on various nutritional and physiochemical properties is useful in commercialisation of varieties suited to the interest of consumers and also for optimising rice breeding programs.

Novel range of products can be developed based on the known quality attributes of newly released rice varieties. The knowledge on rice grain qualities of different varieties and their suitability for products can be transferred to farming community to promote end use specific cultivation.

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Appendices

APPENDIX I

Score card for the organoleptic evaluation of rice and rice flour based products

Rice variety: **Name:**

Food product: **Date:**

Sl No.	Parameters	Replication (R)		
		R1	R2	R3
1	Appearance			
2	Colour			
3	Flavour			
4	Texture			
5	Taste			
6	Overall acceptability			

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature:

APPENDIX II

RECIPES FOR THE PREPARATION OF RICE AND RICE FLOUR BASED PRODUCTS

1. COOKED RICE

Ingredients:

Rice – 100g

Water – As required

Procedure:

Add washed rice to sufficient amount of boiling water. Cook it well. After cooking, strain the excess water to get the cooked rice.

2. RICE FLAKES

Ingredients:

Paddy – 500 g

Water – As required

Procedure:

Soak the paddy in excess water for 24 hr for softening. Remove water, wet paddy is heated using a pan until it get tender. The tender grains are rolled, then flattened using a flaking machine.

3. *IDDLI*

Ingredients:

Rice – 2 cup

Black gram dhal (white) – 1 cup

Salt – 1 ½ tbsp

Oil – (for greasing the pans)

Procedure

Wash and soak the rice and dhal separately for four to six hours. After draining grind rice and dhal separately into a smooth and frothy paste. Mix the ground rice and dhal together into a batter. Mix salt and set aside in a warm place for 8-9 hours or overnight for fermentation. Grease the *iddli* holder well and fill each of them with 3/4 of batter. Steam cook *iddlis* on medium flame for about 10 minutes or until done.

4. *PUTTU*

Ingredients:

Roasted rice flour – 2 cups

Grated coconut – 1 cup

Water – to sprinkle

Salt – as required

Procedure

Mix salt with water and sprinkle this to the roasted rice flour just to make the flour wet. Put a handful of grated coconut in the *puttu* maker and then put flour till one fourth followed by another handful of grated coconut. This is done till the top. Close the lid and steam it for five minutes.

5. *ADA*

Ingredients:

Roasted flour – 2 cup

Jaggery – 100g

Cardamom – 2 nos

Water – as required

Procedure

Prepare jaggery syrup with thick consistency. Add grated coconut and cardamom into it and mix well. Heat water in a vessel and bring to boil. To this add roasted flour and stir well so as to make a thick paste. Spread a thin layer of this flour paste on a banana leaf. Spread the jaggery mix above it and fold the leaf. Steam it well to get *ada.*

6. *APPAM*

Ingredients:

Flour – 1 cup

Cooked rice – 2tbsp

Grated coconut – 3 tbsp

Yeast – a pinch

Salt & sugar – to taste

Procedure

To the flour, cooked rice and coconut were added and ground together to get a batter of medium consistency. Add yeast and sugar to it and allow fermenting overnight. The batter is poured in a heated kadai to prepare *appam.*

7. *UNNIAPPAM*

Ingredients:

Flour – 2cup

Jaggery – 200 g

Coconut pieces (small) – 50 g

Cardamom – 4 nos

Plantain – 2 nos

Oil – to fry

Procedure

To the flour add jaggery syrup, cardamom and çoconut (pieces). Mash plantain with the batter and mix well. The batter is kept aside for 5 hours. Heat oil in *unniyappam* pan and pour the batter into it and fry well to make *unniappam*

QUALITY EVALUATION OF NEWLY RELEASED KAU RICE (*Oryza sativa* L.) VARIETIES AND THEIR SUITABILITY FOR TRADITIONAL FOOD PRODUCTS

By

CHANDHNI A. A.

(2012-16-112)

ABSTRACT OF THE THESIS

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VELLANIKKARA, THRISSUR - 680 656

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2015

ABSTRACT

The present study entitled 'Quality evaluation of newly released KAU rice (*Oryza sativa* L.) varieties and their suitability for traditional food products' was conducted to evaluate the physical, biochemical, nutritional, cooking and organoleptic qualities of newly released KAU rice varieties. The study also aimed to assess the suitability of these rice varieties for the preparation of selected traditional food products.

Milling per cent among rice varieties varied from 64.07 per cent in *Prathyasha* (MO-21) to 77.83 per cent in *Ezhome*-2. *Vyttila*-8 obtained the highest head rice recovery of 57.45 per cent while it was lowest in control variety *Jyothi* (41.08 per cent). The highest thousand grain weight (20.68 g) and volume weight (14.6 mm^3) was observed in *Vaishak* (PTB-60). Based on the L/B ratio, the grain shape of *Ezhome*-1, *Vyttila*-8, *Vaishak* (PTB-60) and *Uma* were classified as bold medium. *Ezhome*-2, *Prathyasha* (MO-21) and *Jyothi* varieties were categorised as slender long grains. For most of the physical quality parameters, raw rice of newly released varieties were found to be superior over the control varieties *Jyothi* and *Uma*.

Newly released rice varieties obtained lower total index for organoleptic qualities than control varieties. *Ezhome*-2 obtained highest total index for table rice among newly released varieties. Among rice varieties, lowest cooking time of 18.51(*Prathyasha* (MO-21)) to highest of 24.75 (*Ezhome*-2) minutes was noticed for obtaining optimum cooked rice. Highest water uptake of 5.74 ml/ g was observed in *Ezhome*-2 and lowest of 3.3 ml/ g in *Jyothi*. Control varieties *Jyothi* and *Uma* obtained volume expansion ratio of 5.62 and 6.07 respectively, which was higher than that of the newly released rice varieties. Among rice varieties, amylose content varied from 10.20 per cent in *Prathyasha* (MO-21) to 23.32 per cent in control variety *Uma*.

Gel consistency of different rice varieties was determined and it varied from 27.50 to 145 mm. Cooking qualities of the newly released rice varieties were found to be comparable with that of the control varieties. Among newly released rice varieties, higher grain elongation ratio of 0.90 was noticed in both *Ezhome*-2 and *Prathyasha* (MO-21). Maximum keeping quality up to 12.60 hours was noticed in *Vaishak* (PTB-60) and minimum of 11.24 hours in *Prathyasha* (MO-21).

The moisture content of different rice varieties ranged from 8.5 per cent in *Ezhome*-2 to 11.6 per cent in *Ezhome* -1 and *Prathyasa* (MO-21). The highest total carbohydrate, starch, energy, protein, zinc and phosphorous content was noticed in newly released rice variety *Ezhome*-2. Fat content in different rice varieties ranged from 0.30 per cent in *Ezhome*-2 to 0.71 per cent in *Vaishak* (PTB-60). The highest fibre content of 0.7 g/ 100g was noticed in *Ezhome*-1. Maximum thiamine content of 0.07 mg/ 100g was noticed in *Vaishak* (PTB-60). The highest calcium and iron content was noticed in *Jyothi* and *Prathyasha* (MO-21) respectively. Newly released rice varieties were found to be superior to control varieties in nutritional qualities.

In the case of unroasted rice flour, highest bulk density of 0.73 g per ml was noticed in *Ezhome*-2 and the lowest of 0.63 g per ml in *Jyothi*. In roasted rice flour, the highest bulk density of 0.62 g per ml was observed in control variety *Uma*. The highest water absorption index of 25.46 was observed in unroasted rice flour of variety *Jyothi* (control) and 25.11in roasted rice flour of *Uma* (control). Highest water solubility index of 0.78 was observed in unroasted rice flour of *Vyttila*-8 and the lowest of 0.34 in *Ezhome*-1. In roasted rice flour the highest water solubility index of 0.81 was noticed in *Ezhome*-2 and the lowest in *Vyttila*-8 (0.28). At the end of the 12^{th} day of study the highest synerisis per cent in unroasted rice flour was noticed in *Vyttila*-8 and that of roasted rice flour in *Ezhome*-1. Physical properties of rice flour of newly released rice varieties were comparable with that of the control varieties.

Evaluation of microbial qualities indicated that at the end of 6th month of storage bacterial count and fungal growth was observed in raw and roasted flour of different rice variety. Yeast was not observed in any of the raw rice and roasted rice flour of different varieties till 5th month of study. *Vyttila*-8 was found to be the most suitable rice variety for the preparation of rice flakes and *unniyappam*. The most suitable variety for the preparation of cooked rice and *iddli* was control varieties *Jyothi and Uma* respectively. *Prathyasha* (MO-21) was found to be the most suitable variety for the preparation of *appam* and *ada* and is also suited for *idli*. *Vaishak* (PTB-60) was the most suitable rice variety for *puttu*. In the present study, It was observed that newly released red rice varieties were suitable for the preparation of different traditional food products.