QUALITY ANALYSIS OF ORGANIC RICE

ROBITA RIAMEI

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(Food Science and Nutrition)

Faculty of Agriculture
Kerala Agricultural University, Thrissur

Department of Home Science
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522
KERALA, INDIA

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DECLARATION

*I hereby declare that this thesis entitled "**Quality analysis of organic rice**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.*

Vellayani,
05-08-2013

ROBITA RIAMEI
(2011-16-107)

Dr. P.V. NANDINI
(Chairman, Advisory Committee)
Professor and Head,
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

CERTIFICATE

Certified that this thesis entitled **"Quality analysis of organic rice"** is a record of research work done independently by **Ms. Robita Riamei (2011-16-107)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,
05-08-2013

Dr. P.V. NANDINI

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Robita Riamei (2011-16-107)** a candidate for the degree of the **Master of Science in Food and Nutrition** agree that this thesis Entitled **"Quality evaluation of organic rice (Oryza Sativa L.)''** is submitted by Ms. Robita Riamei (2011-16-107) in partial fulfillment of the requirement for the degree.

Dr. P.V. Nandini
(Chairperson, Advisory Committee)
Professor and Head,
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

Dr. Mary Ukkuru
(Member, Advisory Committee)
Professor,
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

Dr. Geeethakumari V.L
(Member, Advisory Committee)
Professor and Head
Department of Agronomy
College of Agriculture,Vellayani
Thiruvananthapuram-695 522

Dr. Thomas George
(Member, Advisory Committee)
Associate Professor
Department of Soil Science and Agricultural Chemistry,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

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Dedicated to

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LIST OF ABBREVIATIONS

g	gram
mg	milligram
mm	millimeter
ml	milliliter
%	per cent
Kcal	kilo calories
min	minutes
°C	degree celsious
Fig	figure
et al	and others

Introduction

INTRODUCTION

The demand for organically produced food is increasing (Julia, 2007). Since the 1920's, when chemical fertilizers were first used commercially on a large scale, there have been claims that agricultural chemicals produce less healthful and less nutritious food crops. By the 1940's, the organic farming movement had begun in part due to this belief that food grown using more traditional, chemical free methods was more healthful. Food grown by these methods came to be known as organic. Today, the organic market is a growing sector of the agriculture industry in many parts of the world.

Adopting an organic lifestyle helps to enhance the health of ecosystems and organisms. It is generally agreed upon by its supporters that growing and eating organic food is better for the environment. Today there are more and more people switching to this healthier way of living and its benefits can be seen by both seller and consumers.

More and more people around the world are opting for organic food to maintain a healthy diet. Almost 37 million hectares are managed organically worldwide (IFOAM, 2010).

Several studies claim that organic diets can dramatically reduce pesticide exposure.

In some parts of the world, the word "to eat" literally means "to eat rice." All varieties of rice are available throughout the year, supplying as much as half of the daily calories for half of the world's population. Today, rice is the staple food of more than 3 billion people in the world and is an important non-staple food for another 2 billion. Ninety five per cent of world rice production and consumption is in Asia. More than 2 billion people in Asia alone derive 80 per cent of their calories from rice (Khatoon and Prakash, 2007).

Rice is the world's leading food crop. Global annual production of rice during 2009 was 432 million tones. India produced 99.37 million tons of rice in the same year (http://www. Business.rediff.com, 2010).

Rice is one of nature's most perfect and versatile foods, easy to digest and replete with important nutrients essential for good health, especially in its whole grain state.

Rice is one of the chief grains of India. Moreover, this country has the biggest area under rice cultivation, as it is one of the principal food crops. It is in fact the dominant crop of the country. India is one of the leading producers of this crop. Rice is the basic food crop and being a tropical plant, it flourishes comfortably in hot and humid climate. Rice is mainly grown in rain fed areas that receive heavy annual rainfall. That is why it is fundamentally a kharif crop in India.

Rice being the most important food of the world, its nutritional value and processing properties are very important for overall health of the people and commercial purposes including economy of rice grower.

Quality of rice can be influenced by many parameters like physical, cooking, nutritional and organoleptic qualities. Quality is the degree of excellence possessed by the grain (Srivastava, 1997). It depends on the geographic conditions, nutritive value, palatability, appearance and cooking qualities.

Rice has been the staple foods of Indian from ancient time and will continue to be like in the near future also. As consumers are aware of the ill effect of pesticides residue and health hazard, the demand of organic foods are increased daily among the health conscious population. Hence, there is a vital need for revolution through organic farming to ensure foods security and food safety. The quality of food grown by organic and conventional method is a subject of great controversy. The research studies in this area are mainly focused on pesticide residue in foods. Not much work is done on nutritional, cooking, holistic and sensory parameters of organically grown rice. Hence, the objective of the study was to compare the physical and cooking characteristics, nutrient content, and the qualitative difference by holistic analytical techniques, organoleptic acceptability and pesticides residue among selected rice samples cultivated under organic and conventional farming systems.

Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the study entitled “Quality aspect of organic rice ’’ is reviewed under the following headings.

2.1. Definition of organic foods and agriculture

2.2. History of organic farming

2.3. Organic production and area of cultivation in India

2.4. Advantages and disadvantages of organic food/ farming

2.5. Health benefits of organic foods

2.6. Organic certification

2.1 Definitions of organic foods and agriculture

2.1.1 Organic foods

Organic food was first introduced in 1920 by Rudolph Steiner. Robert Rodule coined the phrase in the 1940’s for a method of growing food that shows synthetic pesticides and is big on soil management/growth.

Allen et al. (2007) defined organic foods as the food that is produced using methods that do not involve modern synthetic inputs such as synthetic pesticides and chemical fertilizers. Organic foods are not processed using irradiation, industrial solvents, or chemical food additives.

Organic foods refers to food that are produced and that do not involve modern synthetic input, contains no preservatives, no added chemicals fertilizers, coloring or additives and is not genetically modified. With regards to meat, the animals are reared without any antibiotics or growth hormones (Usha, 2008).

According to USDA (2002) organic food is food produced by farmers who emphasize the use of renewable resources and the conservation of soil and water to enhance environmental quality for future generation.

2.1.2 Organic agriculture

According to Beharrell and Macfie (1991) organic farming is a method of crop and livestock production that involves non usage of pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones. Organic farming refers to a farming system that uses organic manures and limited range of organic derived chemicals.

USDA (2011) defined organic farming as a system that is designed to produce agricultural products, by the use of methods and substances that maintain the integrity of organic agricultural products until they reach the consumers.

International Federation of Organic Agricultural Movement (IFOAM, 2009) also defined organic agriculture as a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

According to Codex Alimentarius (2000), organic agriculture is a holistic production management system which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity.

2.2 History of organic farming

An organic movement began in the 1940s as a reaction to agriculture's growing reliance on synthetic fertilizers and herbicidal weed control.

Sir Albert Howard is referred to as the Father of Modern Organic Agriculture. His book, "An Agricultural Testament", is influential in promoting organic techniques and his book "The Soil Health", first book to include organic agriculture in its title (Michael, 2006).

In 1962, Rachel Carson, a prominent scientist and naturalist, published Silent Spring, chronicling the effects of DDT and other pesticides on the environment a bestseller in many countries, including the US, and widely read around the world (Paull and John, 2007).

In 1970s, "Know Your Farmer, Know Your Food" Global Movements have concerns with pollution and the health of the Earth's environment. There is an increase in focus toward organic farming.

In 1972, International Federation of Organic Agriculture Movements (IFOAM) was founded in Versailles, France and is the worldwide umbrella organization for the organic movement.

2.3 Organic production and area of cultivation in India

India has over 141 million hectares of farmland, out of which about 55 million hectare is irrigated cropland and nearly one hundred million hectares is un-irrigated. Only if India converts five per cent of its farmland (i.e. approx. 7mh) into organic, it can make significant contribution of organic farm produced.

Partap (2005) reported that organic food market in India is growing at 20-22 per cent annually. Export is valued at 1,000 crores and 3.88 million tons of certified organic product like basmati rice, pulses, honey, tea, spices, coffee, fruits etc.

2.3.1 Organic production and markets in India

Major organic produces in India include plantation crops i.e. tea, coffee, and cardamom, spices i.e., ginger, turmeric, chillies and cumin, cereals i.e., wheat, rice, jowar, and bajra, pulses i.e., pigeon pea, chickpea, green gram, red gram, and black gram, oilseeds i.e. groundnut, castor, mustard and sesame, fruits i.e. banana, sapota, custard apple and papaya, and vegetables i.e. tomato, brinjal, and other leafy vegetables, honey, cotton and sugarcane especially jaggery. But, there is no organic production of meat products like poultry, livestock and fisheries in India as yet.

Yussef and Willer (2003) reported that there are three types of organic producers in India – traditional organic growers who grow for their subsistence needs, commercial farmers who have surplus and export their produce through different channels, and private companies which either have their own farms or organize large conversion programmers with growers.

The organic products available in the domestic market are rice, wheat, tea, coffee, pulses and vegetables. On the other hand, products available for export market, besides these, include cashew nuts, cotton, oilseeds, various fruits and medicinal herbs. Whereas wholesalers and traders, super markets and own shops are the major channels in the domestic market which is mainly in metropolitan cities and accounts for only 7.5 per cent of the total organic production, the market channel for export of organic products is export companies with the exception of tea which is produced and exported by tea 15 estates. The major markets for Indian organic products are the Europe, the USA, Canada, Australia and the Middle East Asian countries.

2.4.1 Advantages of organic foods/farming

Organic farming can retain micro-nutrients via crop rotation, inter cropping techniques and extensive use of green manure. The absence of chemicals in organic farming does not kill microbes which increase nourishment of the soil (Mangan *et al*., 2011).

Mark (2011) opined that organic farming helps in building richer soil and these helps plants to grow. Rate of soil erosion is reduced drastically. Organically grown crop is more droughts tolerant. In conventional farming, chemical is soluble, plants are forced to imbibe it every time they are thirsty for water when water becomes limited, soluble nutrient salts in the cells of chemically fed plants are unable to osmotically draw sufficient water to maintain safe dilution.

Organic farming is better for the environment and reduces pollution, conserve water and increase soil fertility.

Organic farming is better for birds and small animals to reproduce and even kill those (Harner *et al.,* 2006). It is also better for the people who harvest our food.

Soil building practices such as crop rotation, intercropping, symbiotic associations, cover crops, organic fertilizers and minimum tillage are central to organic practices and these encourage soil fauna and flora, improving soil formation and structure, more stable system. In turn, nutrient and energy cycling is increased and the relative's abilities of the soil for nutrient and water are enhanced and also important role in soil erosion (IFOAM, 2009).

2.4.1.2 Impact of water

In many agriculture area, pollution of ground water causes with synthetic fertilizers and pesticides is a major problem and are prohibited in organic agriculture and they are replaced by organic fertilizers (e.g., compost, animal manure, green manure) (Robert, 2005).

2.4.1.3 Impact on air and climate change

Reynolds et al. (2005) reported that organic agriculture reduces non-renewable energy use by decreasing agrochemical needs.

The global warming potential of organic farming system is considerably smaller than that of conventional or integrated farming systems (Badgley *et al.,* 2007).

Organic agriculture contributes to migrating the greenhouse effect and global warming through its ability to sequester carbon in the soil (Alroe *et al.,* 2001).

2.4.1.4 Ill effects of pesticide

Miller (2004) reported that over 98 per cent of sprayed insecticides and 95 per cent of herbicides reach a destination other than their target species, including nontarget species, air, water, bottom sediments, and food.

Environment Protection Agency (2007) found that many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation

American rivers and streams, fouling (polluting) more than 173,000 miles of waterways by chemical, erosion and animal waste runoff from livestock production (EPA, 1998).

In 1997 over 27 per cent of wells water sampled was found to be contaminated with pesticides predominantly from routine agricultural usage. There is no economically viable method to clean up widespread contamination. Pesticide contamination poses a serious, unreasonable public threat to current and future ground water usage. Food poisoning in UK account for more than quadrupled between 1984 and 1998 from 20,000 to 94,000 report incidence. 3,000,000 people a year suffer acute pesticide poisoning and 300,000 people die as a result of pesticide poisoning in the developing countries (WHO, 2006).

Organic Trust (2004) reported that more than 400 chemical pesticides are routinely used in conventional farming. Residues of these pesticides are regularly found in a high percentage of fruits and vegetables and in 2004 the European Commission stated that a risk to human health cannot be ruled out anymore.

Pesticides Usage Survey Report (2002) found out that over 400 chemicals can be regularly used in conventional farming to kill weeds, insect pests. e.g., apples can be sprayed up to 16 times with different pesticides.

UK government research has been consistently found pesticide residues in foods including residues of more than one chemical in apple, baby foods, bread, cereal bars, fresh salmon, lemon, lettuces, peaches, potatoes and strawberries (Pesticides Residue Committee, 2008).

2.4.2 Disadvantages of organic foods/ farming:

Even though organic has many advantages, it has got some limitation. Its production and yield is very low as organic farming practices are laborious and needs greater labour input and results in higher cost of organic foods. Marketing and distribution chain are relatively inefficient because of small volumes.

An organic farm cannot produce as much food as a modern industrialized farm over a short period of time in the beginning (Chappel, 2007).

Although the benefits of eating organic food may be argued by some there is no doubt that eating organic foods reduces exposure to many chemicals. There are over 60 known carcinogens which are sprayed on food crops (Lorenz, 2009).

Ghimere (2002) reported that persistent organic pollutants (POPs) are pollutants that accumulate in the body fat of people and animals. They are pesticides and other chemicals which do not break down and degrade quality in the human body. They can be passed into humans through the consumption of meat and milk and nursing mothers can pass residues onto their babies through breast feeding. Some POP chemicals have been linked with increased birth defects, declining sperm counts and sexual abnormalities. Some research even shows that the babies exposed to low levels of these chemicals in the womb are in danger of suffering lifelong health problems.

Farmers who handle pesticides for more than 20 days in a season can develop a cancer (Dahama, 1997).

Continuous use of organic products helps in developing a natural immune system which can fight against many diseases (Sharma, 2004).

A health poll survey revealed that 50 per cent of people prefer organic over conventional food (Jennifer, 2011).

Children and foetus are most vulnerable to pesticide exposure due to their less developed immune systems (Bradman *et al*, 2006) and exposure at an early age can cause developmental delays, behavioral disorders and motor dysfunctions.

Fenske et al. (2002) found that pregnant women are more vulnerable to stress pesticides. Moreover pesticides can be passed from mother to child in the womb and through breast milk. Most of us have an accumulated buildup of pesticide exposure in our bodies due to numerous years of exposure. This chemical body burden as it is medically known could lead to health issue such as headaches, birth defects and added strain on weakened immune systems.

Aluminum has been implicated for years in the development of Alzheimer's disease (Garry, 2004).

Stolze et al. (2002) reported that in organic foods aluminum content is 40 per cent less than the conventional foods.

Lead toxicity adversely affects our children's IQ and it is 29 per cent lower in organic foods (Woese *et al*., 2006).

Crinnion (2004) had found that mercury on average contained 25 per cent lesser in organic foods than the conventional food and is associated with the cause of neurologic damage.

Organophosphates (pesticides) have been linked with range of conditions such as cancer, decreasing male fertility, foetal abnormalities, chronic fatigues syndrome in children and Parkinson's disease (Ascherio *et al*.,2008)

Hanssen, (2001) found that food colorings and additives can cause a range of health problems in adults and children like allergies, headache, asthma, growth retardation and hyperactiveness in children.

Women with breast cancer are five to nine times more likely to have pesticide residues in their blood than those who do not (Charlies *et al*., 2003).

2.4 Health benefit of organic foods

Tejjpartap and Vaidya (2009) collected all the important food crops produced in India in different state and they have made a comparison between the quality of organic products and inorganic products and found that organic produced are better in quality than inorganic.

2.5.1 Nutrients content of organic foods in comparison with non-organic foods

A study conducted by Brandt and Molgaard (2004) found that organic foods have higher vitamin C, mineral levels and phytonutrient than the conventionally grown foods.

Organic rice protein is excellent source of good quality protein and consumption of the same in proper limit ensures a trouble-healthy life (Curl *et al.*, 2005).

Mendoza (2004) reported that organic rice protein is easily digestible like mother's milk in the aspect of its nutritious quality and also having high quantity of amino acid.

Organic wheat contains higher amount of proteins, starches and gluten than conventional grown wheat (Nitika *et al*., 2008).

A review by Worthington (2001) stated that organic crops contain 27 per cent more vitamin C, 21.1 per cent more iron, 29.3 per cent more magnesium and 13.6 per cent more phosphorus than conventional crops like fruits, vegetables and grains.

A study conducted in New Jersey by Carbonaro (2008) shown that blueberry fruits grown organically yield significantly higher fructose and glucose levels, malic acid, total phenolic, total anthocyanin and antioxidant activity than fruit grown conventional methods .

The Organic Centre University of Florida Department of Horticultural and Washington State University provides evidence that organic foods contain on average 25 per cent higher concentration of 11 nutrients than conventional foods (Charles, 2004).

Organically grown apples were of higher quality with respect to parameters that relates health and taste (Weibel *et al.*, 2000).

Organic milk has 68 per cent more omega 3 fatty acids than conventional milk (Lean *et al,* 2006).

A study conducted by Faccin (2002) in UK has shown that soups sold commercially contain almost six times as much salicylic acid as non-organic soup.

Jahresis et al. (2003) found that cows grazing on fresh pasture (organic) produce milk with higher level of antioxidants and beneficial fatty acids such as conjugated linoleic acid and omega-3 fatty acids.

2.5.2 Macronutrients

Florescu et al. (1991) reported that cucumber fruits grown with urban waste compost had higher content of carbohydrate.

Bhadoria *et al*. (2002) reported that protein content of okra was high when treated with farm manure.

According to Singh (2002), organically grown french beans have higher protein content.

2.5.3 Vitamins

Regarding water soluble vitamins, higher vitamin C levels were found in organically grown vegetables like potato. (Kolbe *et al*., 1995) and tomato (Pither and Hall, 1990).

Florescu (1991) reported that organically grown amaranthus had higher ascorbic acid content. Sheeba (2004) observed that treatments with organic sources of plant nutrients gave higher amount of β-carotene in amaranth.

Vitamin C content of an organic vegetable is 27 per cent more on average than a comparable conventionally grown vegetable (Worthington, 2001).

2.5.4 Phytonutrients

Fruits and vegetables contain a large variety of micro compounds which are secondary metabolites in plants such as polyphenols, resveratrol and some non-pro-vitamin carotenoids. Phytomicronutrients are bioactive compounds that have health promoting properties. They have drastic regulatory effects at cellular level and helps in prevention of cancer and other pathogens. Fruits and vegetables contain a large variety of these micro compounds. Some of them are phytoalexins which are produced in plants as a response to external stress such as fungal disease. They act as antioxidants and help to enhance the absorption of essential nutrients. They selectively inhibit harmful intestinal bacteria and aid the growth of beneficial gastrointestinal bacteria. Phenolic compounds are the largest group of phytonutrients. They protect plants from oxidative damage and it act as antioxidants.

Zhao (2006) found that organically grown produce have higher phytomicronutrients.

Soil Association (2000) too observed increased amount of phytonutrients in organic foods.

2.5.5 Minerals

Organic rice contain more iron and less copper (Supradip *et al*., 2007). Organic potatoes has higher P, Mg, Na, k. Organic carrots has higher amount of K, Na. Organic potato leaf has higher amount of B complex vitamins and Fe (Lampkin, 2007).

Some organic vegetables like snap beans, cabbage, lettuce, tomatoes and spinach contain higher amount of minerals like calcium, magnesium, potassium, sodium, manganese, iron and copper than the conventional vegetable. (www.organic mama.com, 2011).

2.5.6 Antioxidant properties

Antioxidants are those substances that counteract the effects of oxidation inside our body. Both enzymes and nutrients may fall under the same category of antioxidants, e.g., vitamins and minerals are nutrients which have antioxidant properties, while proteins are the enzyme which help fight off the effects of oxidation (Helmut, 1997).

They protect us from the oxidative damage that occurs as a continuous process within the human body. We accumulate free radicals as a result of various external factors, pollution, sunlight, x-rays, alcohol, smoking, and even excessive exercise can result in the production of free radicals categorized as exogenous ones. These free radicals can impair the structure of the human cells and damage them beyond repair. It is important for us to take foods that are rich in antioxidants so that our body can fight off free radicals to required level.

Antioxidants neutralize the free radicals. Morgan (2009) reported that antioxidants improve immunity, low risk of many life threatening diseases, slow down or reverse the ageing process and reduce the risk of falling ill owing to physical strain.

2.5.6.1 Antioxidants in organic foods

Many studies have proved that organic foods contain higher antioxidant properties.

Higher levels of phenols and polyphenols are found in organic food stuffs like potato (Hamouz *et al.*, 1999), onion (Ren *et al.*, 2001) and tomato.

Mitchell, (2007) and Rembialkowska (2007) found that organic plant foods contain double the amount of phenolic compounds than the conventionally grown plant foods.

Organically grown tomatoes have higher salicylic acid content than conventional ones (Rossi *et al.*, 2008). It is noteworthy that salicylic acid is the active anti-inflammatory compound of aspirin. Fruits and vegetables grown organically show higher levels of anti-oxidants than conventionally grown plants.

According to Theoclark (2002) organically grown oranges had to 30 per cent more vitamin C than the conventionally grown oranges.

A study conducted in Washington State University supported by Organic Center found that organic lemonade contains ten times more eriocitrin (Thompson, 2006).

Organic lime juice had three times the level of eriocitrin compared to conventional lime juice (Mitchell, 2007).

Ren et al. (2001) found that Chinese cabbage, spinach, welsh onion, green pepper has higher level of flavonoids.

Danish (2003) had shown that organic vegetables have higher concentration of natural antioxidants called flavonoids.

Research conducted by Clark (2006) at the University of California had shown that organic tomatoes contained on an average 79 per cent and 97 per cent more quercetin and kaempferol aglycones (beneficial flavonoids) which help in preventing cancer and heart diseases.

A research team at the University of California had found that organic kiwi fruit had much higher levels of total polyphenol content than the conventional fruits, resulting in higher antioxidant activity and higher level of vitamin C (Davis, 2007).

Organic strawberries have higher antioxidant activity and concentration of ascorbic acid and phenolic compound, longer shelf life and dry matters (John *et al.*, 2011).

Organically produced food had higher level of antioxidants and lower level of mycotoxin than conventional samples (Rossi *et al.*, 2008).

At the 2005 International Congress on Organic Farming and Food quality reported that gross based organic cattle diets reduce the risk of E. coli contamination while grain-based conventional increase the risk.

A study conducted by Asami (2003) found that 30-50 per cent of phenolics were found to be more in organic marion berries and maize.

A study conducted by the university of California, revealed that antioxidant levels in organically grown corn and marrion berries had approximately 55.5 per cent and 50 per cent respectively ascorbic acid (Bagchi, 2003).

Organic food contains higher levels of vitamin C and essential minerals such as calcium, magnesium, iron and chromium (www.nutritionbusinessjournal.com, 2010).

Organic tea has higher polyphenols and shown greater antioxidant properties which help in preventing cancer (Palit *et al.,* 2008).

Organic fruits have higher level of phenolic and these reduced the incidence of coronary heart diseases and some cancer (Danny *et al.,* 2003).

Olsson et al. (2006) found that organically cultivated strawberries showed higher anti-proliferate activity against colon cancer and breast cancer than conventionally grown strawberries.

Fruits and vegetables grown organically have significantly higher level of cancer fighting antioxidants (Veberic *et al.,* 2003).

Organic fruits has higher level of phenolic compounds and these reduced the incident of coronary heart diseases and cancer (Colin, 2003).

Fafra et al. (2007) reported that the anthocyanin compounds in berries have been shown to improved neuronal and cognitive brain function and ocular health and protect genomic DNA integrity and appear to have the potential to diminish the mutagenic action of toxic compounds and inhibit the proliferation of certain cell line.

Delen et al. (2004) reported that organic wine provides greater protection against LDL oxidation than conventional wine which has a beneficial property to protect against heart diseases.

Milk taken from animals fed on forage-based diet also contain improved levels of EFAs including CLA and omega 3 and these EFA, omega 3 and CLA play an important role in metabolism and prevention of CHD and high blood pressure (Jahresis *et al.,* 2002).

Ellis et al. (2007) opined that lactating mother who consumed organic milk and meat contains more amounts of remunic acid and conjugated linoleic acid.

Organic strawberries extract has anti proliferated property and thus preventing from colon and breast cancer (Olsson *et al.,* 2006)

Schuldt and Schwarz (2010) have found that organic cookies were lower in calories thus beneficial for obese and dietetic patient.

2.6 Organic Certification

Environment Protection Agency (2007) has defined Organic Certification is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers, processors, retailers and restaurants.

Certification varies from country to country, and generally involves a set of production standards for growing, storage, processing, packaging and shipping.

2.6.1 Need / Purpose of certification

Organic certification addresses a growing worldwide demand for organic food. It is intended to assure quality and prevent fraud, and to promote commerce.

A study by Setboonsarng (2008) revealed that organic certification substantially contributes poverty and hunger and environmental sustainability by way of premium prices and better market access, among others. This study concludes that for this market-based development scheme to broaden its poverty impacts, public sector support in harmonizing standards, building up the capacity of certifiers, developing infrastructure development, and innovating alternative certification systems will be required.

In response to consumer demands, many countries have enacted new “LAWS” to regulate organic food production, handling and processing. These Laws are commonly known as “organic Standards”. A certification mark on any products is a complete guarantee for the organic quality of a product.

2.6.2 Certified Organic bodies

Strom and Stephanie (2012) reported that certification is essentially aimed at regulating and facilitating the sale of organic products to consumers. Individual certification bodies have their own service marks, which can act as branding to consumers. A certifier may promote the high consumer recognition value of its logo as a marketing advantage to producers. Some of the important certified organic bodies are:

a) Natural Organic Programmed (NOP- US, 2002)
b) USDA Organic- 100 per cent organic (may use USDA seal)
c) JAS (Japan, 2002)
d) NPOP (National Program for Organic Production-India)
e) IFOAM (International Federation of Organic Agriculture Movement)

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Quality evaluation of organic rice" encompasses an assessment of various parameters like physical characteristics, cooking characteristics, holistic analysis, nutritional composition, pesticides residue analysis and organoleptic qualities of two varieties of rice viz., Aishwarya and Uma.

3.1 Materials selected

3.1.1 Raw Materials

The organic and conventional paddy samples selected for this study were procured from CSRC karamana and Department of Agronomy, COA, Vellayani. They were Aishwarya organic, Aishwarya conventional and Uma organic and Uma conventional. Four kilogram of the procured paddy varieties were processed by two methods viz., raw milled and parboiled milled.

The processed rice samples were stored in airtight steel containers for various laboratory studies.

3.1.2 Chemicals

All the chemicals used in the present study were analytical reagent (AR) or laboratory (LR) grade. All the reagents and standard stock solution were prepared using purified deionized water.

3.1.3 Glassware

Glasswares such as burettes, pipettes, conical flasks, measuring cylinders, volumetric flasks, funnels, beakers, test tubes, boiling tubes, droppers and crucibles used for the study were obtained from the department laboratory.

3.1.4 Utensils

Stainless steel vessels, pressure cooker, sieves, ladle, spoons, trays, glass and plates etc. were obtained from the department laboratory.

3.1.5 Equipments

The lists of equipments used for the present study are given in Table 1

Table1. List of equipments used

Sl.No	Name of the equipment	Purpose
1	Electronic balance	To weigh the samples, chemicals and standards in decimals for chemical analysis
2	Hot air oven	To estimate the moisture content of the samples, drying and for sterilizing the glasswares
3	Muffle furnace	To estimate the ash/ total mineral content of the samples
4	Mixer grinder	To grind the rice samples into powder form
5	Paddy Miller	To mill the paddy samples into rice
6	Water bath	To maintain the constant temperature required by the samples during the experiments
7	Double distilled water apparatus	To provide pure distilled water for chemical analysis
8	Spectrophotometer	To measure the optical density of several components present in the samples
9	Atomic Absorption Spectrophotometer	To measure the minerals present in the samples
10	Flame Photometer	To measure Na and K present in the samples
11	Bomb Calorimeter	To measure energy or calorific value of samples
12	Micro Kjeldhal distillation	To estimate the nitrogen content of the samples
13	GLC	To measure the pesticide residue present in the samples

3.2 Methods

3.2.1 Quality parameters selected

Rice grain quality is multi-dimensional. It can be influenced by many parameters like physical, cooking, nutritional, holistic and organoleptic qualities. Quality is the degree of excellence possessed by the grain.

Different quality parameters studied were:

- ❖ Physical characteristics
- ❖ Cooking qualities
- ❖ Nutritional composition
- ❖ Sensory parameters
- ❖ Holistic analysis
- ❖ Pesticide residue analysis

Under each parameter, a number of indicators are reported to influence the quality of rice and are listed below.

3.2.2 Physical characteristics:

Physical characteristics of the rice grains were found to be a major determinant of quality and acceptability of rice. Different indicators ascertained under physical characteristics are:-

a. Colour

Colour of the rice cultures were ascertained by direct observation.

b. Size

For determining size, the rice samples were classified into three classes i.e., extra bold, bold and medium bold according to the method given by FAO (1970).

c. Shape

For determining shape, the rice samples were classified into three classes by FAO (1970) as detailed below.

Slender, long grain rice - L/B ratio >3.0

Bold, medium grain rice – L/B ratio 2.0-3.0

Round, short grain rice – L/B ratio <2.0

d. Length and Width

Grain length has been used in most rice breeding programmers as a characteristic for classifying rice varieties. Grain width is an important factor in determining the grain shape and weight. The grain length and width were determined by taking the length and width of ten grains drawn randomly using a measuring scale.

e. Length-Breadth Ratio (L/B ratio)

Length of the grain is measured in its greatest dimension, width along the ventral side. Length- breadth (L/B) ratio of rice samples were calculated as per the method outlined by Pillaiyar and Mohandoss (1981).

f. Thousand grain weight

Thousand grain weight of rice samples were determined by weighing one thousand rice grains randomly selected (Sindhu et al., 1975). An electronic balance was used for recording thousand grain weight.

g. Bulk density

Bulk is the ratio of the mass to the volume of the sample or mass per unit volume, expressed as g/ml or kg/L. Bulk density is used as an index for comparing the volume of different foods. The sample was taken in a 50ml beaker and maintained a height of 20cm and it is leveled without compressing. The weight of the sample with the beaker and water was filled to the same level. The weight of the water with beaker was recorded and calculated using the formula suggested by Fan et al. (1998).

Bulk Density = Weight of the sample/ Weight of equivalent volume of water

h. Swelling index

Swelling index of different rice sample was determined by the method of Sharma et al. (2004).

3.2.3 Nutritional composition

The major nutrients analyzed in the raw and parboiled samples are listed below:

a. Energy

Energy or calorific value was estimated using Bomb calorimeter as per the method described by Swaminathan (1984).

b. Protein

The protein content was computed by the nitrogen content of samples and it was estimated by micro Kjeldahl's wet digestion method. The nitrogen values were multiplied by the factor 6.25 to get the crude protein content (A.O.A.C, 1990).

c. Total Starch

Starch content of the samples was estimated by the Ferric cyanide method suggested by Aminoff et al. (1970).

d. Total mineral

Total mineral content was estimated as per the method described by Raghuramalu et al. (1983).

e. Sodium

Sodium concentration of samples was determined from the triple acid extract in an EEC flame photometer (Jackson, 1973).

f. Potassium

Potassium concentration of samples was determined from the triple acid extract in an EEC flame photometer (Jackson, 1973).

g. Calcium

Calcium was estimated after wet digestion of the sample with triple acid. The triple acid digest was titrated against EDTA (Jackson, 1973).

h. Phosphorus

Phosphorus was estimated after wet digestion of the sample by the Vanadopmolybdate yellow colour method as outlined by Jackson (1973).

i. Iron

The iron content was estimated by the method of Jackson (1973) in an atomic absorption spectrophotometer

3.2.4 Cooking qualities

Cooking and eating quality vary with consumer acceptance in different parts of the world and it is very important for acceptance of a variety by the consumers. It ultimately decides eating quality. Different indicators ascertained under cooking characteristics are furnished below.

a. Optimum cooking time

Optimum cooking time was estimated as per the method suggested by Bhattacharya and Sowbhagya (1971).

b. Water uptake

Water uptake is a measure of the hydration characteristics of rice. It was estimated as per the method outlined by Bhattacharya and Sowbhagya (1971).

c. Elongation ratio

Elongation ratio is an important parameter for cooked rice. It is the ratio between the length of cooked grain and that of the raw grain. It was measured as per the method suggested by Pillaiyar and Mohandoss (1981).

d. Amylose

Amylose content is a major determinant of the cooking and eating quality of rice. Total amylose content in the rice sample was determined using colorimetry method suggested by Juliano (1970).

e. Amylopectin

Amylopectin content was determined as the difference between the total starch content and amylose content and expressed as the percentage of starch.

f. Amylose-amylopectin ratio

Amylose-amylopectin ratio is the main factor for classifying rice into waxy and non-waxy. Amylose-amylopectin ratio of rice samples were estimated as per the method suggested by Mccready and Hassid (1943).

3.2.5 Organoleptic qualities

Organoleptic qualities play an important role in the quality of any food. Organoleptic quality consists of judging quality of foods by means of human sensory organs such as eye, nose and mouth. Palatability characters are the main indication of consumer preference for the different rice cultures.

Manay and Swamy (2002) opined that sensory evaluation plays a vital role in the food industry, because it represents a very unique technique that harness human behavioral instincts of perception, learning, cognition, psychophysics and psychometrics for the evaluation of food quality.

Organoleptic evaluation of rice samples were done by preparing table rice using raw and parboiled rice and assessed its qualities by a selected panel of judges.

3.2.5.1 Selection of judges

A sensory panel is a panel of members who are capable of delivering highly reliable judgments, independent of psychical factors such as bias motivation and individual motivation (Lawless, 1998).

A panel of ten judges, including the staff and students, were selected as the sensory panel for organoleptic evaluation of the rice samples. These judges were selected through triangle test, as suggested by Mahony (1985). Details are given in Appendix 1.

3.2.5.2 Preparation of score card

The score card used for the evaluation of table rice is given in Appendix 2. The major quality attributes included in the score card were appearance, colour, flavour, texture and taste.

3.2.6 Holistic analysis

The holistic analysis or visualizing techniques of organic and conventional rice samples were analyzed at MCRC laboratory, Tharamani, Chennai in order to visualize the quality of organic and conventional rice samples. Circular paper chromatography, sensitive crystallization and picture chromatography were adopted under this method.

3.2.7 Pesticide residue analysis

Samples of rice used in the study were subjected to analyze for estimation of pesticide residues at Pesticide Residue Research and Analytical Lab, COA, Vellayani . The methodology validated for cereals and pulses was adopted for extraction. A brief outline of the procedure is given below. Pesticide residue estimation was performed using Shimadzu gas chromatograph 2021 (Anastassiades *et al.*, 2003). The samples were screened for organochlorines, organophosphorus and synthetic pyrathroid residues. The operating conditions of GC are listed below.

Column= DB- 5 Capillary column.

Injection Temperature- 250°C

Column temperature Programme - 170°C-5 min (hold) - 1.5°C/min-280°C-7min (Hold)

Total min time- 70.33 min

Column flow= 0.79 mL/min

Carrier gas – Nitrogen (99.999% pure)

Detector- ECD

Detector temperature- 300°c

3.2.8 Statistical analysis

Observations were made in triplicates for each sample. Analysis of Variance was done in CRD using Statistical software developed at Common Commuting Facilities (CCF) College of Agriculture, Vellayani, KAU. As the experiment involved two varieties (Aishwarya and Uma), two kinds of rice (organic and conventional), two methods (raw and parboiled), the ANOVA was done in 2x2x2 (in all treatment) - factorial CRD with 3 replications. Marginal means and the interaction means were tested for the significance.

Results

4. RESULTS

The study entitled "Quality evaluation of organic rice" was conducted to ascertain the following parameters of the rice varieties cultivated under organic and conventional system.

4.1. Physical characteristics

4.2. Cooking qualities

4.3. Nutritional Composition

4.4. Sensory parameters

4.5. Holistic analysis and

4.6. Pesticide residue analysis

Under each parameter, a number of indicators are reported to influence the quality of rice and are listed below.

4.1. Physical characteristics

4.1.1. Size, Colour and Shape

Table 2 reveals the size, colour and shape of rice varieties.

Table 2: Size, colour and shape of rice varieties

Variety	Shape	Colour
Aishwarya	Bold, medium	Red
Uma	Bold, medium	Red

The study revealed that all the rice varieties were found to be red in colour, old and medium in shape. The size of the rice varieties depends on the values of thousand grain weight. In the present study, variety Aishwarya, both organic and conventional system, was found to be extra bold when compared to variety Uma.

4.1.2. Length

The data on the length of the rice varieties are presented in Table 3.

Table 3: Length of rice varieties (mm)

Variety	Organic			Conventional		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B Rice**	**Mean**
Aishwarya Uma	0.63 0.54	0.63 0.53	0.63 0.54	0.64 0.54	0.64 0.55	0.64 0.55
Mean	0.58	0.58	0.58*a	0.59	0.59	0.59*a
Variety	**Raw rice**	**P.B Rice**	**Mean** (variety)	CD- Variety, Treatment- 0.0075 ** Significant at 1% level * Significant at 5% level Note: ‘a’ mean value of treatment ie organic and conventional.		
Aishwarya	0.63	0.64	0.64**			
Uma	0.54	0.54	0.54**			
Mean (method)	0.59	0.59				

In the present study, the length of the rice grain was found to be higher in variety Aishwarya cultivated under conventional system for both raw and parboiled rice (0.64 mm) than Aishwarya cultivated under organic practices. Lowest length was observed in variety Uma organic parboiled rice (0.53 mm). The length of Uma variety was shorter as compared to Aishwarya. The mean value of length revealed that conventionally cultivated rice had longer length

(0.59 mm) than organically cultivated rice (0.58 mm).When statistically analysed, significant differences were observed between the two varieties (Aishwarya and Uma) (0.64 and 0.54)and also between organic and conventional system (0.58 and 0.59).

4.1.3. Breadth

Table 4 depicts the data on breadth of rice varieties.

Table 4: Breadth of rice varieties (mm)

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B rice</th><th>Mean</th><th>Raw rice</th><th>P.B rice</th><th>Mean</th></tr>
<tr><td>Aishwarya
Uma</td><td>0.24
0.24</td><td>0.23
0.22</td><td>0.24
0.23</td><td>0.23
0.23</td><td>0.23
0.23</td><td>0.23
0.23</td></tr>
<tr><td>Mean</td><td>0.24</td><td>0.23</td><td>0.23 a</td><td>0.23</td><td>0.23</td><td>0.23 a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="5">CD- method- 0.0066
* Significant at 5% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>0.24</td><td>0.23</td><td>0.23</td></tr>
<tr><td>Uma</td><td>0.24</td><td>0.22</td><td>0.23</td></tr>
<tr><td>Mean (method)</td><td>0.24*</td><td>0.23*</td><td></td></tr>
</table>

The breadth of both the varieties cultivated under organic and conventional system was ranged between 0.22 – 0.24 mm. The lowest breadth was observed in Uma organic parboiled rice (0.22 mm) and highest breadth was seen in both the varieties, i.e. Aishwarya and Uma organic raw rice (0.24 mm). In the present study, it was found that organic raw rice has higher breadth (0.24 mm) than organic parboiled rice (0.23 mm). Significant difference was also observed between raw and parboiled rice.

4.1.4. Length and breadth ratio

Table 5 depicts the Length/ Breadth ratio of rice varieties.

Table 5: Length/Breadth ratio (L/B ratio) of rice varieties

Variety	Organic			Conventional		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	2.75	2.67	2.71	2.70	2.70	2.70
Uma	2.25	2.25	2.25	2.40	2.48	2.44
Mean	2.50	2.46	2.48** a	2.55	2.59	2.57** a

Variety	**Raw rice**	**P.B Rice**	**Mean** (variety)
Aishwarya	2.72	2.68	2.70**
Uma	2.32	2.36	2.34**
Mean (method)	2.52	2.52	

CD- variety, treatment- 0.043
CD- variety x treatment-0.061

* *Significant at 1% level

Note: 'a' mean value of treatment ie organic and conventional.

Length and breadth ratio (L/B ratio) varied between the two varieties. The highest L/B ratio was recorded in Aishwarya organic raw rice (2.75 mm) and lowest in Uma organic raw and parboiled rice (2.25 mm). The L/B ratio of Aishwarya variety ranged between 2.67 – 2.75 mm and in Uma variety it ranged between 2.25 – 2.48 mm. Significant differences exist between the two varieties, Aishwarya and Uma (2.70 and 2.34), and aslo between organic rice and conventional rice (2.48 and 2.57).

4.1.5. Thousand grain weight

Table 6 depicts the thousand grain weight of rice varieties

Table 6: Thousand grain weight of rice varieties (g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B Rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya Uma	20.33 17.57	20.97 19.83	20.65 18.70	21.43 17.53	22.50 20.03	21.97 18.78
Mean	18.95	20.40	19.68**a	19.48	21.27	20.38**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD-variety, treatment, method- 0.16 CD-VT,VM,TM-0.22 * *Significant at 1% level Note: **'a'** mean value of treatment ie organic and conventional.		
Aishwarya	20.88	21.73	21.31**			
Uma	17.55	19.93	18.74**			
Mean (method)	19.22**	20.83**				

It was observed that Aishwarya variety had higher thousand grain weight compared to Uma variety. The highest grain weight was found in Aishwarya conventional parboiled rice (22.50 g) and lowest in Uma conventional raw rice (17.53 g). In the present study, it was found that conventional system of both Aishwarya and Uma have higher thousand grain weight (20.38 g) than the organic system (19.68 g). Significant differences were observed between the two varieties Aishwarya and Uma (21.31 and 18.74), and also between organic and conventional system (19.68 and 20.38). Difference was also observed in thousand grain weight between raw and parboiled rice significantly.

4.1.4. Bulk Density

The bulk density of both the rice varieties ranged between 0.93 to 1.02 g/ml. Highest bulk density was recorded in Aishwarya organic parboiled rice (1.02 g/ml) and lowest in Uma conventional raw rice (0.93 g/ml). While comparing bulk density between organic and conventional rice, it was found that the mean value for organic rice was higher (0.99 g/ml) than the conventional rice (0.96 g/ml) (Table7).

There was a significant difference exists between the two varieties Aishwarya and Uma (0.99 and 0.96), between organic and conventional system (0.99 and 0.96) and also between raw and parboiled rice (0.95 and 0.99) with respect to bulk density.

Table 7: Bulk density of rice varieties (g/ml)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	0.99	1.02	1.00	0.95	0.99	0.97
Uma	0.94	1.01	0.97	0.93	0.96	0.94
Mean	0.96	1.01	0.99**a	0.94	0.97	0.96**a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)
Aishwarya	0.97	1.01	0.99**
Uma	0.93	0.98	0.96**
Mean (method)	0.95**	0.99**	

CD-variety, treatment, method- 0.015

* *Significant at 1% level

Note: 'a' mean value of treatment ie organic and conventional.

4.1.5. Swelling Index

Table 8 depicts the swelling index of rice varieties.

In the present study, significant difference in swelling index was observed among the rice varieties between Aishwarya and Uma and between organic and conventional rice. Swelling index ranged between 0.23 – 0.37 for Aishwarya variety and for variety Uma, it ranged between 0.25 – 0.42. Highest value for swelling index was observed in Uma organic parboiled rice (0.42) and lowest in Aishwarya raw conventional rice (0.23). It was also found that the mean value of organic rice was higher (0.33) than the conventional rice (0.28). Among the two varieties, Uma variety cultivated under organic system had higher swelling index (0.35) than Aishwarya variety (0.31). Significant difference also exists between raw and parboiled rice (0.25, 0.36).

Table 8: Swelling index of rice varieties (g/ml)

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B Rice</th><th>Mean</th><th>Raw rice</th><th>P.B Rice</th><th>Mean</th></tr>
<tr><td>Aishwarya</td><td>0.25</td><td>0.37</td><td>0.31</td><td>0.23</td><td>0.32</td><td>0.28</td></tr>
<tr><td>Uma</td><td>0.28</td><td>0.42</td><td>0.35</td><td>0.25</td><td>0.33</td><td>0.29</td></tr>
<tr><td>Mean</td><td>0.27</td><td>0.39</td><td>0.33**a</td><td>0.24</td><td>0.33</td><td>0.28**a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="4">CD-variety, treatment, method-0.011
CD- VT, VM-0.016
* *Significant at 1% level
* Significant at 5% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>0.24</td><td>0.35</td><td>0.29**</td></tr>
<tr><td>Uma</td><td>0.27</td><td>0.38</td><td>0.32**</td></tr>
<tr><td>Mean (method)</td><td>0.25**</td><td>0.36**</td><td></td></tr>
</table>

4.2 Cooking characteristics

The cooking characteristics of the rice varieties were evaluated by determining the optimum cooking time, elongation ratio, water uptake ratio, cooked weight, amylose, amylopectin and amylose-amylopectin ratio.

4.2.1 Optimum Cooking time of rice varieties.

Table 9 reveals the optimum cooking time of rice varieties.

Table 9: Optimum cooking time of rice varieties (minute)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B Rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	24.60	59.53	42.07	29.50	60.17	44.84
Uma	30.50	58.83	44.67	35.39	59.34	47.37
Mean	27.05	59.85	43.37**a	32.95	59.76	46.10**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD-variety, treatment, method- 0.75 CD- VM,TM- 1.06 * *Significant at 1% level Note: 'a' mean value of treatment ie organic and conventional.		
Aishwarya	27.05	59.85	43.45**			
Uma	32.95	59.09	46.02**			
Mean (method)	30.00**	59.47**				

The optimum cooking time of parboiled rice varieties for both Aishwarya and Uma was longer than raw rice varieties. It was observed that Aishwarya conventional parboiled rice took highest time to cook (60.17 minutes) and Uma organic raw rice took lesser time (30.50 minutes) to cook. In the present study, it was found that conventional rice took higher cooking time i.e. 46.10 minutes than organic rice (43.37min). Significant differences were observed between Aishwarya and Uma varieties (43.55 and 46.02) and also between raw and parboiled rice (30.00 and 59.47).

4.2.2 Elongation ratio

Elongation ratio is the ratio between the length of cooked grain and that of raw grain. In the present study, the highest elongation ratio was possessed by Uma organic parboiled rice (2.68) and lowest by Uma conventional raw rice (1.58).

The elongation ratio for Aishwarya variety ranged between 1.71- 2.52 while for Uma variety it ranged between 1.58- 2.68. While comparing between organic and conventional system, organic rice had higher elongation ratio (2.13) than conventional rice (2.01) (Table 10).

Table 10: Elongation ratio of rice varieties (mm)

Variety	Organic			Conventional		
	Raw rice	**P.B Rice**	**Mean**	**Raw rice**	**P.B Rice**	**Mean**
Aishwarya	1.71	1.79	1.75	2.26	2.52	2.39
Uma	2.32	2.68	2.50	1.58	1.68	1.63
Mean	2.02	2.24	2.13**a	1.92	2.10	2.01**a

Variety	Raw rice	P.B rice	Mean (variety)	
Aishwarya	1.99	2.16	2.07	CD- treatment, method-0.52 CD- VT-0.073 CD-VTM-0.10 **Significant at 1% level Note: 'a' mean value of treatment ie organic and conventional.
Uma	1.95	2.18	2.07	
Mean (method)	1.97**	2.17**		

The study also revealed that significant differences were observed between the organic and conventional system and also between raw and parboiled rice. Parboiling process significantly increased the elongation ratio of the rice varieties.

4.2.3 Water uptake ratio

The data on water uptake ratio of the rice varieties is depicted in Table 11.

Table 11: Water uptake ratio of rice varieties

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B rice</th><th>Mean</th><th>Raw Rice</th><th>P.B rice</th><th>Mean</th></tr>
<tr><td>Aishwarya
Uma</td><td>2.13
2.58</td><td>3.49
2.92</td><td>2.81
2.75</td><td>3.05
1.69</td><td>3.49
2.32</td><td>3.27
2.00</td></tr>
<tr><td>Mean</td><td>2.35</td><td>3.21</td><td>2.78*a</td><td>2.37</td><td>2.91</td><td>2.64*a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="4">CD- variety, treatment, method-0.10
CD- VT, VM, TM-0.15
CD-VTM-0.21
**Significant at 1% level
*Significant at 5% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>2.59</td><td>3.49</td><td>3.04**</td></tr>
<tr><td>Uma</td><td>2.13</td><td>2.62</td><td>2.38**</td></tr>
<tr><td>Mean (method)</td><td>2.36**</td><td>3.06**</td><td></td></tr>
</table>

Water uptake is a measure of the hydration characteristics. The water uptake ratio of the varieties (Aishwarya and Uma) was significantly different. Among the rice varieties, Aishwarya variety had water uptake ratio in the range of 2.13- 3.49 and in Uma variety, it ranged between 1.69-2.92. The highest water uptake ratio was found in Aishwarya parboiled rice for both organic and conventional system (3.49) and lowest in Uma conventional raw rice (1.69). In the present study, it was found that organic rice had higher water uptake (2.78) than conventional rice (2.64). When the data was analyzed statistically significant difference exists between treatments i.e. organic and conventional system (2.78 and 2.64), between varieties (3.04, 2.38) and also between raw and parboiled rice (2.36 and 3.06).

4.2.4 Cooked weight

In the present study, a significant difference in cooked weight was observed among rice varieties. The highest cooked weight was possessed by Aishwarya conventional parboiled rice (226.20g) and lowest by Uma conventional raw rice (134.59g). Aishwarya variety had higher cooked weight than Uma variety and comparatively conventional varieties have higher cooked weight (182.69g) than organic rice (179.88g) (Table 12).

Table 12: Cooked weight of rice varieties (g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	156.41	187.84	172.12	203.87	226.20	215.03
Uma	179.18	196.12	187.65	134.59	166.11	150.35
Mean	167.79	191.98	179.88a	169.23	196.15	182.69a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)
Aishwarya	180.14	207.02	193.58**
Uma	156.89	181.11	169.00**
Mean (method)	168.51**	194.06**	

CD- treatment, method-6.05
CD- VT-8.56
**Significant at 1% level
Note: ‘a’ mean value of treatment ie organic and conventional.

There was a significant difference noticed between the varieties and also between raw and parboiled rice with respect to cooking weight. Parboiling process significantly increased the cooked weight of rice varieties.

4.2.5 Amylose

Table 13 shows the amylose content of the rice varieties.

Table 13: Amylose content of rice varieties (%)

Variety	Organic			Conventional		
	Raw rice	P.B rice	Mean	Raw rice	P.B rice	Mean
Aishwarya Uma	20.90 20.00	18.72 19.27	19.81 19.63	24.11 21.03	21.36 18.52	22.74 19.77
Mean	20.45	19.00	19.72**a	22.57	19.94	21.26**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD- variety, treatment, method- 0.38 CD- VT,VM,TM-0.55 **Significant at 1% level *Significant at 5% level Note: 'a' mean value of treatment ie organic and conventional.		
Aishwarya	22.51	20.04	21.28**			
Uma	20.51	18.89	19.70**			
Mean (method)	21.51**	19.47**				

Amylose content of rice varieties varied significantly among the varieties. Highest amylose content (24.11 %) was noticed in Aishwarya conventional raw rice while lowest (18.52 %) in Uma conventional parboiled rice. Significant decrease in amylose content was observed after parboiling. The mean value of amylose content for organic raw rice was found to be 20.45 and that of conventional it was 22.57. Conventional rice had higher amylose content (21.26 per cent) than organic rice (19.72 per cent). Significant differences where observed between organic and conventional system and also between raw and parboiled rice.

4.2.6 Amylopectin

Table 14 represents amylopectin ratio of the rice varieties.

Table 14: Amylopectin content of rice varieties (%)

Variety	Organic			Conventional		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B Rice**	**Mean**
Aishwarya Uma	56.71 60.82	54.20 54.89	55.46 57.86	50.41 54.66	42.94 45.03	46.68 49.84
Mean	58.77	54.55	56.66**a	52.54	43.99	48.26**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD- variety, treatment, method-2.22 **Significant at 1% level *Significant at 5% level Note: 'a' mean value of treatment ie organic and conventional.		
Aishwarya	53.56	48.57	51.07*			
Uma	57.74	49.96	53.85*			
Mean (method)	55.65**	49.27**				

In the present study, significant difference in amylopectin content was observed among the rice varieties.

Highest amylopectin content was noticed in Uma organic raw rice (60.82 per cent) and lowest in Aishwarya conventional parboiled rice (42.94 per cent). The ratio of amylopectin content for Aishwarya variety ranged between 42.94 to 56.71 per cent. Comparatively organic rice had higher amylopectin (56.66 per cent) than conventional rice (48.26 per cent).

A decrease in amylopectin content was observed after parboiling. There was a significant difference noticed between organic and conventional system and also between raw and parboiled rice.

4.2.7 Amylose- Amylopectin ratio

Table 15 shows the amylose-amylopectin ratio of rice varieties.

Table 15: Amylose – Amylopectin ratio

Variety	Organic			Conventional		
	Raw rice	**P. B Rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	0.36	0.34	0.35	0.47	0.50	0.49
Uma	0.32	0.35	0.34	0.38	0.40	0.39
Mean	0.34	0.34	0.34**a	0.43	0.45	0.44**a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)
Aishwarya	0.42	0.42	0.42**
Uma	0.35	0.38	0.36**
Mean (method)	0.39	0.40	

CD- variety, treatment-0.019
CD- VT-0.02
**Significant at 1% level
Note: ‘a’ mean value of treatment ie organic and conventional.

The amylose-amylopectin ratio varied significantly among the rice varieties. The highest ratio was observed in Aishwarya conventional parboiled rice (0.50) and lowest in Uma organic raw rice (0.32).

The amylose- amylopectin ratio for Aishwarya varieties (both organic and conventional rice) ranged from 0.34- 0.50 and that of Uma variety it ranged between 0.32-0.40. Among the two varieties, organic rice had lower amylose-amylopectin ratio (0.34) than conventional rice (0.44).

When the data was analyzed statistically significant difference was observed between organic and conventional rice.

4.3 Nutritional composition

The energy, protein, starch, total mineral, sodium, potassium, phosphorus, calcium, iron, copper and zinc content of the rice varieties were determined to assess the nutritional composition.

4.3.1 Calorific value

The calorific value of rice is presented in Table 16

Table 16: Calorific value of rice varieties (kcal/100g)

Variety	**Organic**		**Conventional**	
	Raw rice	**Parboiled rice**	**Raw Rice**	**Parboiled rice**
Aishwarya	375.00	378.00	396.00	402.00
Uma	411.00	414.00	399.00	426.00
Mean	393.00	396	398.00	414

The calorific value was found to be highest in Uma conventional parboiled (426kcal) and lowest in Aishwarya organic raw (375kcal). The study also revealed that conventional rice had higher energy content than organic rice.

Parboiling process was found to increase the calorific value of rice varieties. In Aishwarya and Uma organic raw rice, the calorific value was 375kcal and 411kcal respectively. After parboiling the calorific value increased to 378kcal and 414 kcal respectively. Similar trend was also noticed in conventional rice.

4.3.2 Protein

Table 17 reveals the protein content of rice varieties.

Table 17: Protein content of rice varieties (g/100g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B Rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	6.44	8.86	7.65	7.23	10.83	9.03
Uma	9.67	11.33	10.50	7.63	12.16	9.89
Mean	8.06	10.10	9.08a	7.43	11.50	9.46a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD- variety, method- 0.54 CD- VT, VM- 0.77 **Significant at 1% level Note: 'a' mean value of treatment ie organic and conventional.		
Aishwarya	6.84	9.85	8.34**			
Uma	8.65	11.74	10.20**			
Mean (method)	7.74**	10.80**				

Rice is considered to be a major source of dietary protein in Indian diets. In the present study, significant difference in protein exists between the rice varieties. Highest protein content was noted in Uma conventional parboiled rice (12.16) and lowest in Aishwarya organic raw rice (6.44). The mean values of protein content revealed that organic rice (both raw and parboiled) had higher protein content than conventional rice (both raw and parboiled). Significant different was also observed between raw and parboiled rice. It was also noticed that protein content was more in conventional rice (9.46g) than organic rice (9.08g).

4.3.3 Starch

Table 18 represents the starch content of rice varieties.

Table 18: Total starch content of rice varieties

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B Rice</th><th>Mean</th><th>Raw rice</th><th>P.B Rice</th><th>Mean</th></tr>
<tr><td>Aishwarya
Uma</td><td>77.62
80.82</td><td>72.93
74.19</td><td>75.27
77.51</td><td>74.53
75.68</td><td>64.30
63.55</td><td>69.42
69.62</td></tr>
<tr><td>Mean</td><td>79.22</td><td>73.56</td><td>76.39**a</td><td>75.11</td><td>63.93</td><td>69.52**a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="4">CD-treatment, method- 2.20
CD- TM- 3.11
**Significant at 1% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>76.07</td><td>68.62</td><td>72.34</td></tr>
<tr><td>Uma</td><td>78.25</td><td>68.87</td><td>73.56</td></tr>
<tr><td>Mean (method)</td><td>77.62**</td><td>68.74**</td><td></td></tr>
</table>

In the present study, the highest value for starch content was recorded in Uma organic raw rice (80.82 per cent) and lowest in Uma conventional parboiled rice (63.55 per cent). Among the two varieties, Uma varieties have highest starch (80.82%). The mean value for organic Aishwarya varieties was 75.27 per cent and 69.42 per cent for Aishwarya conventional rice. It was also found that organic rice had higher mean starch value (76.39 %) than conventional rice (69.52%). The mean value of starch content revealed that both organic and conventional raw rice (79.22 & 75.11) had higher starch content than organic and conventional parboiled rice (73.56 & 63.93).

Significant difference exists between the treatment i.e. between organic and conventional rice (76.39 & 69.52) and also between the method i.e. raw and parboiled rice (77.16 and 68.74).

4.3.4 Total Minerals

Table 19 shows the total mineral content of rice varieties.

Table 19: Total mineral content of the rice varieties (%)

Variety	**Organic**			**Conventional**		
	Raw Rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya Uma	0.28 0.36	0.41 0.46	0.34 0.41	0.32 0.15	0.38 0.31	0.35 0.23
Mean	0.32	0.43	0.37**a	0.24	0.35	0.29**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD- variety, treatment, method- 0.011 CD- VT, VM- 0.015 CD-VTM-0.022 **Significant at 1% level Note: 'a' mean value of treatment ie organic and conventional.		
Aishwarya	0.30	0.39	0.35**			
Uma	0.25	0.39	0.32**			
Mean (method)	0.28**	0.39**				

A significant difference was noticed between organically and conventionally cultivated systems with respect to total mineral contents. The highest value of total mineral content was recorded in Uma organic parboiled rice (0.46) and lowest in Uma conventional raw rice (0.15). The mean value of total mineral content of Aishwarya organic rice was 0.34 and that of conventional rice was 0.35. For Uma organic rice, the mean value was 0.41 and that of Uma conventional rice the mean value was 0.23. In the present study, it was found that organic rice had higher mean value (0.37) than conventional rice (0.29). It was also observed that parboiling process significantly increased the total mineral contents (0.28 and 0.39). Significant differences also exist between the two rice varieties Aishwarya and Uma (0.35 and 0.32).

4.3.5 Sodium

Table 20 depicts the sodium content of rice varieties.

Table 20: Sodium content of rice varieties (mg/100g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	2.59	3.39	2.99	1.65	2.72	2.19
Uma	4.21	4.72	4.46	2.69	3.23	2.96
Mean	3.40	4.05	3.73**a	2.17	2.98	2.57**a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	
Aishwarya	2.12	3.06	2.59**	CD- variety, treatment, method- 0.023 CD- VT, VM, TM- 0.033 CD-VTM-0.047 **Significant at 1% level Note: ‘a’ mean value of treatment ie organic and conventional.
Uma	3.45	3.98	3.71**	
Mean (method)	2.79**	3.52**		

The highest sodium content was found in Uma organic parboiled rice (4.72) and lowest in Uma conventional raw rice (1.65). The mean value for Aishwarya varieties ranged from 1.65 to 3.39 and for Uma varieties the mean value ranged between 2.69 to 4.72 for organic and conventional rice respectively. In the present study, it was found that organic rice had higher sodium content (3.73mg) than conventional rice (2.57mg).

The data revealed that the interaction between the two varieties (Aishwarya and Uma) was found to be significant. Parboiling process significantly increased the sodium content of rice varieties.

4.3.6 Potassium

Table 21 reveals the potassium content of rice varieties.

Table 21: Potassium content of rice varieties (mg/100g)

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B Rice</th><th>Mean</th><th>Raw rice</th><th>P.B rice</th><th>Mean</th></tr>
<tr><td>Aishwarya
Uma</td><td>118.33
127.63</td><td>129.83
171.90</td><td>124.08
149.77</td><td>86.00
103.33</td><td>96.77
111.10</td><td>91.38
107.22</td></tr>
<tr><td>Mean</td><td>122.98</td><td>150.87</td><td>139.93**a</td><td>94.67</td><td>103.93</td><td>99.30**a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="4">CD- variety, treatment, method- 1.54
CD- VT, VM, TM- 2.17
CD-VTM-3.08
**Significant at 1% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>102.17</td><td>113.30</td><td>107.73**</td></tr>
<tr><td>Uma</td><td>115.48</td><td>141.50</td><td>128.49**</td></tr>
<tr><td>Mean (method)</td><td>108.83**</td><td>127.40**</td><td></td></tr>
</table>

In the present study, it was found that there was a significant difference between the varieties Aishwarya and Uma. Highest potassium content was found in Uma organic parboiled rice (171.90) and lowest in Aishwarya conventional raw rice (86.00). The potassium content of Aishwarya varieties ranged between 86.00 to 129.83 mg and that of Uma varieties, it ranged between 103.33 to 171.90mg. It was also found that potassium content was highest in organic rice (139.93mg) than conventional rice (99.3mg). Parboiling process significantly increased the potassium content of rice varieties. Potassium content was found to be more in variety Uma (128.49) than variety Aishwarya (107.73).

4.3.7 Phosphorus

Table 22 depicts the phosphorous content of rice varieties.

Table 22: Phosphorus content of rice varieties (mg/100g)

Variety	**Organic**			**Conventional**		
	Raw Rice	**P.B rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	129.53	91.28	110.41	112.28	104.67	108.47
Uma	80.56	78.26	79.41	82.56	63.09	72.83
Mean	105.05	84.77	94.91**a	97.42	83.88	90.65**a
Variety	**Raw Rice**	**P.B rice**	**Mean** (variety)	CD- variety, treatment, method- 0.48		
Aishwarya	120.91	97.97	109.44**	CD- VT, VM, TM- 0.68 CD-VTM-0.96		
Uma	81.56	70.67	76.12 **	**Significant at 1% level		
Mean (method)	101.23**	84.32**		Note: 'a' mean value of treatment ie organic and conventional.		

The highest phosphorus content was found in Aishwarya organic raw (129.53) and lowest in Uma conventional parboiled (63.09). The mean value of potassium content ranged between 72.83 to 79.41mg. In the present study, it was found that organic rice had higher phosphorus content (94.91) than that of conventional rice (90.65). Significant difference was observed between the varieties (109.44 and 76.12) and also between raw and parboiled rice (101.23 and 84.32).

4.3.8 Calcium

Table 23 shows the calcium content of rice varieties.

Table 23: Calcium content of rice varieties (mg/100g)

<table>
<tr><th rowspan="2">Variety</th><th colspan="3">Organic</th><th colspan="3">Conventional</th></tr>
<tr><th>Raw rice</th><th>P.B Rice</th><th>Mean</th><th>Raw rice</th><th>P.B rice</th><th>Mean</th></tr>
<tr><td>Aishwarya
Uma</td><td>15.60
9.40</td><td>17.40
11.80</td><td>16.50
10.60</td><td>9.97
8.90</td><td>14.27
10.83</td><td>12.12
9.87</td></tr>
<tr><td>Mean</td><td>12.50</td><td>14.60</td><td>13.55**a</td><td>9.43</td><td>12.55</td><td>10.99**a</td></tr>
<tr><td>Variety</td><td>Raw rice</td><td>P.B rice</td><td>Mean (variety)</td><td colspan="3" rowspan="4">CD- variety, treatment, method- 0.63
CD- VT-0.89
CD-VTM-1.27
**Significant at 1% level
Note: ‘a’ mean value of treatment ie organic and conventional.</td></tr>
<tr><td>Aishwarya</td><td>12.78</td><td>15.83</td><td>14.31**</td></tr>
<tr><td>Uma</td><td>9.15</td><td>11.32</td><td>10.23**</td></tr>
<tr><td>Mean (method)</td><td>10.97**</td><td>13.58**</td><td></td></tr>
</table>

The highest calcium content was found in Aishwarya parboiled rice (17.40) and lowest in Uma conventional raw rice (8.90). The mean value of calcium ranged between 2.12 to16.50 mg for Aishwarya varieties and for Uma varieties it ranged between 9.87 to 10.60 mg. In the present study, it was found that organic rice had higher calcium (13.55) than that of conventional rice (10.99). The data revealed that significant differences were noticed between the varieties Aishwarya and Uma, between treatment (organic and conventional system) and also between raw and parboiled rice.

4.3.9 Iron

Table 24 reveals the iron content of rice varieties.

Table 24: Iron content of rice varieties (mg/100g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B rice**	**Mean**	**Raw Rice**	**P.B rice**	**Mean**
Aishwarya	4.14	5.40	4.77	3.25	4.76	4.00
Uma	5.55	7.51	6.53	5.22	5.28	5.25
Mean	4.85	6.45	5.65**a	4.24	5.02	4.63**a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	
Aishwarya	3.70	5.08	4.39**	CD- variety, treatment, method- 0.032 CD- VT, VM, TM- 0.046 CD-VTM-0.065
Uma	5.39	6.39	5.89 **	**Significant at 1% level
Mean (method)	4.54**	5.73**		Note: 'a' mean value of treatment ie organic and conventional.

The highest iron content was found in Uma organic parboiled rice (7.51) and lowest in Aishwarya raw conventional rice (3.25). It was also noticed that organic rice had highest iron content (5.65) than that of conventional rice (4.63). From the table it was observed that there was a significant differences exist between the varieties (Aishwarya and Uma) and also between the treatment (organic and conventional system). Parboiling process significantly increased the iron content.

4.3.10 Copper

The copper content of rice varieties is present in Table 25

Table 25: Copper content of rice varieties (mg/100g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B Rice**	**Mean**	**Raw rice**	**P.B rice**	**Mean**
Aishwarya	0.26	0.31	0.29	0.18	0.22	0.20
Uma	0.26	0.30	0.28	0.18	0.20	0.19
Mean	0.26	0.30	0.28**a	0.18	0.21	0.20**a
Variety	**Raw rice**	**P.B rice**	**Mean** (variety)	CD- treatment, method -0.013 **Significant at 1% level Note: ‘a’ mean value of treatment ie organic and conventional.		
Aishwarya	0.22	0.26	0.24			
Uma	0.22	0.25	0.24			
Mean (method)	0.22**	0.26**				

The highest copper content was found in Aishwarya organic parboiled rice (0.31) and lowest in Aishwarya conventional raw rice and Uma conventional raw rice (0.18). For Aishwarya the mean value of copper content ranged between 0.20 to 0.29 mg and that of Uma varieties it ranged between 0.19 to 0.28mg. In the present study, it was found that organic rice has higher copper content (0.28) than conventional rice (0.20).

A significant difference was observed between the treatment (organic and conventional system), (0.28 and 0.20) and also between the method (raw and parboiled) (0.22 and 0.26).

4.3.11 Zinc

Table 26 represents the zinc content of rice varieties.

Table 26: Zinc content of rice varieties (mg/100g)

Variety	**Organic**			**Conventional**		
	Raw rice	**P.B rice**	**Mean**	**Raw rice**	**P.B Rice**	**Mean**
Aishwarya	1.06	1.26	1.16	1.72	2.12	1.92
Uma	0.64	0.83	0.73	1.06	1.62	1.34
Mean	0.85	1.04	0.95**a	1.39	1.87	1.63**a

Variety	**Raw rice**	**P.B rice**	**Mean** (variety)
Aishwarya	1.39	1.69	1.54**
Uma	0.85	1.22	1.04**
Mean (method)	1.12**	1.46**	

CD- variety, treatment, method -0.14
CD- TM-0.19
**Significant at 1% level
Note: 'a' mean value of treatment ie organic and conventional.

The highest zinc content was found in Aishwarya conventional parboiled rice (2.12) and lowest in Uma organic raw rice (0.64). In the present study, it was found that conventional rice had higher zinc content (1.63) than that of organic rice (0.95).

The data revealed that significant differences were observed between the varieties (Aishwarya and Uma), between treatment (organic and conventional system) and also between method (raw and parboiled).

4.4. Sensory evaluation

Sensory evaluation is a science which uses human senses to measure the texture, appearance, aroma and flavour of food products. The qualities can be measured objectively using proper instrumentation and subjectively using a sensory panel.

Quality attributes selected in this study were appearance, colour, flavour, texture, taste and overall acceptability.

The rank mean obtained for the quality attributes of sensory parameters of rice varieties are presented in Table 27.

For the each quality attributes the rank means are given and these means are compared with CD value.

In the present study, among all the varieties Aishwarya conventional parboiled rice and Uma organic parboiled rice had highest rank mean (48.7) for the quality attribute appearance. The lowest rank mean was noticed in Uma organic raw rice (36.05). On comparing with the CD value there was no significant difference observed between Aishwarya and Uma varieties and between organic and conventional system. Among all the varieties Aishwarya conventional parboiled rice and Uma organic parboiled rice has better appearance.

Colour is one of the most important visual attribute that has been used to judge the overall quality of food.

Table 27: Organoleptic evaluation of rice varieties (mean of ranks)

Variety	Appear.	Color	Flavor	Texture	Taste	Overall accept.
Aishwarya org.raw	41.8	48.75	29.1	34.4	31.5	32.15
Aishwarya org.raw	45.25	39.15	44.5	38.2	49.75	47.2
Aishwarya con.raw	45.25	54.3	29.1	52.35	49.75	47.2
Aishwarya con.raw	48.7	34.25	47.3	34.4	26.6	44.35
Uma org.raw	36.05	36.7	41.65	35.5	32.95	32
Uma org P.B	48.7	46.3	41.65	59.25	42.85	37.15
Uma con.raw	38.35	24.65	37.45	31.7	53.2	33.15
Uma con.P.B	38.35	9.9	53.6	38.2	36.4	43.8

CD- 20.36892

In the present study, among all the varieties the highest rank mean was observed in Aishwarya conventional raw rice (54.3) and lowest in Uma conventional raw rice (24.65). On comparing with CD value there was no significant difference between Aishwarya rice varieties both organic and conventional rice and also between Uma rice varieties both under organic and conventional system. Among all the varieties Aishwarya organic raw rice has better colour followed by Uma organic parboiled rice.

Significant difference in flavour was observed among all the rice varieties when compared with CD value. However, highest score was observed in Uma conventional parboiled (53.6) and lowest in Aishwarya organic raw and Aishwarya conventional raw (29.1).

In the present study, highest rank mean for texture was found in Uma organic parboiled (59.25) and lowest in Uma conventional raw rice (31.7). There was significant difference observed between Uma organic raw rice and parboiled when compared with CD value.

Among the various quality attributes, taste is the primary one and of utmost important. There was no significant difference Aishwarya organic raw and parboiled and also between Uma varieties both organic and conventional rice but significant difference was observed among Aishwarya conventional parboiled and Uma conventional raw rice. However, highest taste score was observed in Uma conventional raw rice (53.2) and lowest for Aishwarya conventional parboiled (26.6).

The overall acceptability of different rice varieties was not significantly different when compared with CD value. However, highest score was obtained in Aishwarya organic parboiled rice and Aishwarya conventional raw rice (47.2) and lowest for Uma organic raw rice (32). Among all the varieties, overall acceptability was found to be better in Aishwarya organic parboiled rice and Aishwarya conventional raw rice.

4.5. Holistic analysis

The holistic analysis or visualizing techniques of organic and conventional rice samples were analyzed to visualize the quality.

4.5.1. Vitality of rice

The results of vitality of rice analysed through sensitive copper chloride crystallization method is depicted in Tables 28, 29 30 and 31.

Table 28: Vitality of rice variety- Aishwarya (analysed through sensitive copper chloride crystallization method)

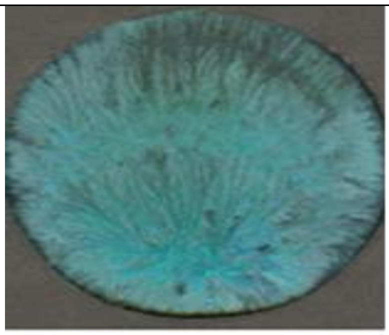
Zones/ Samples	Raw rice (organically cultivated)	Raw rice (conventionally cultivated)
Image		
Inner zone	Single origin	Multiple origin
Middle zone- Needle arrangement	Fan out and messy	Fan out and orderly
Direction	Curved	Straight
Thickness	Tight	Loose
Outer zone- structure of the needle	Thin, blunt and light permeating	Thin, blunt and light permeating

Table 29: Vitality of rice variety-Aishwarya (analysed through sensitive copper chloride crystallization method)

Zones/ Samples	Parboiled rice (organically cultivated)	Parboiled rice (conventionally cultivated)
Image		
Inner zone	Single origin	Multiple origin
Middle zone- Needle arrangement	Fan out and messy	Fan out and orderly
Direction	Curved	Curved
Thickness	Tight	Loose
Outer zone- structure of the needle	Thick, blunt and light permeating	Thin, blunt and light permeating

Table 30: Vitality of rice variety- Uma (analysed through sensitive copper chloride crystallization method)

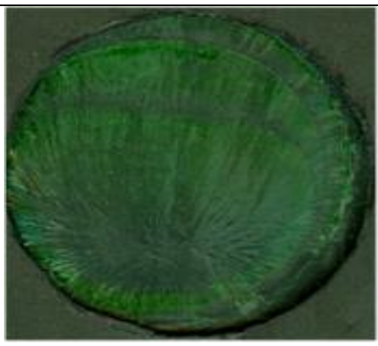
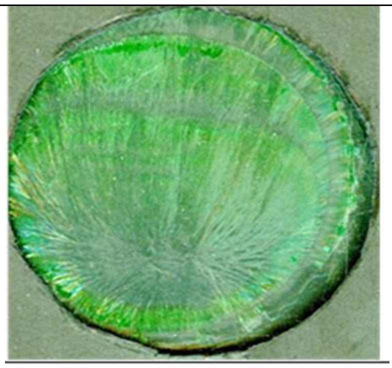
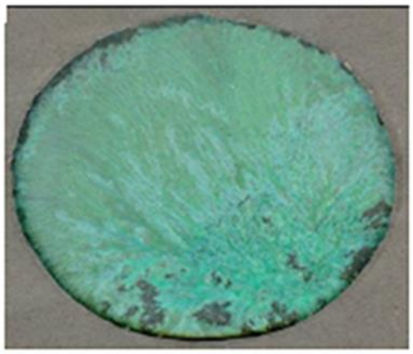
Zones/ Samples	**Raw rice (organically cultivated)**	**Raw rice (conventionally cultivated)**
Image		
Inner zone	Single origin	Multiple origin
Middle zone- Needle arrangement	Fan out and messy	Fan out and orderly
Direction	Curved	Curved
Thickness	Tight	Loose
Outer zone- structure of the needle	Thick, blunt and light permeating	Thin, blunt and light permeating

Table 31: Vitality of rice variety- Uma (analysed through sensitive copper chloride crystallization method)

Zones/ Samples	Parboiled rice (organically cultivated)	Parboiled rice (conventionally cultivated)
Image		
Inner zone	Single origin	Single origin
Middle zone- Needle arrangement	Fan out and orderly	Fan out and orderly
Direction	Curved	Curved
Thickness	Loose	Tight
Outer zone- structure of the needle	Thin, blunt and light permeating	Thin, blunt and light permeating

Among the Aishwarya rice samples, inner zones of Aishwarya conventional raw and Aishwarya conventional parboiled showed multiple origin, whereas in Aishwarya organic raw and Aishwarya organic parboiled the samples revealed single origin. In Aishwarya conventional raw and Aishwarya conventional parboiled the needle arrangement, direction, thickness and structure of the crystals in middle zones were fan out and orderly formed in both the samples.

Aishwarya organic parboiled and Aishwarya organic raw showed fan out and messy with tightly curved. In outer outer zone, structure of needle in Aishwarya conventional raw and Aishwarya conventional parboiled revealed thin, blunted with light permeating. Whereas in Aishwarya organic raw and Aishwarya organic parboiled, the samples showed thick, blunt needle with light permeating.

The crystal formations in Aishwarya organic parboiled followed by Aishwarya organic raw were reported for high vitality.

In case of varieties Uma, crystal formation of Uma conventional parboiled showed single origin, the needles are all fan out and orderly formed with tightly curved and structure of needles were thin, blunted with light permeating. Whereas Uma conventional raw sample showed double origin, the needles are all fan out and orderly formed with loosely curved and structure of needles were thin, blunted with light permeating.

Uma organic parboiled and Uma organic raw showed single origin. The needle arrangement, direction, thickness and structure of the crystals in middle zones were all fan out and orderly formed with loosely curved in the both samples.

In outer zone, structure of needle in Uma organic parboiled were thin, blunted with light permeating where as in Uma organic raw it was thick and blunted with light permeating.

The crystal formations in Uma organic parboiled followed by Uma organic raw rice were reported for high vitality.

4.5.2. Qualitative analysis of rice samples

The results of qualitative analysis of rice samples analysed through picture chromatography is given in Tables 32, 33, 34 and 35

Table 32: Qualitative analysis of rice variety- Aishwarya (analysed through picture chromatography method)

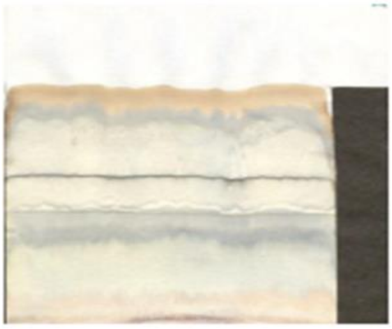
Zones/ Samples	**Raw rice (organically cultivated)**	**Raw rice (conventionally cultivated)**
Image		
Inner zone (colloidal Zone)	More colloidal with light colour zone	More colloidal with light colour zone
Middle zone- Bowl zone **Flag zone**	Medium area of bowl zone, white in colour Less flower vase structure	Medium area of bowl zone, white in colour Less flower vase structure
Outer zone (Reactive zone)	Low reactive substance	Low reactive substance

Table 33: Qualitative analysis of rice variety- Aishwarya (analysed through picture chromatography method)

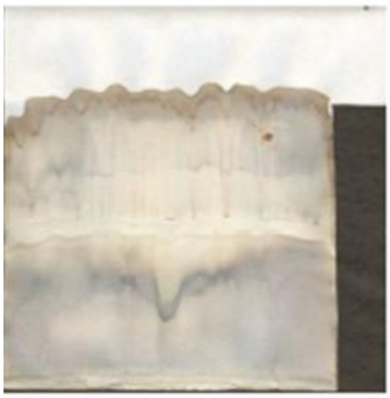
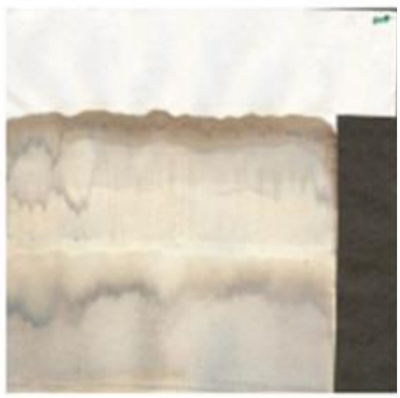
Zones/ Samples	Parboiled rice (organically cultivated)	Parboiled rice (conventionally cultivated)
Image		
Inner zone (colloidal Zone)	More colloidal with dark colour zone	More colloidal with dark colour zone
Middle zone (Flag zone)	Flower vase structure, white in colour	Flower vase structure, white in colour
Outer zone (Reactive zone)	High reactive substance	High reactive substance

Table 34: Qualitative analysis of rice variety- Uma (analysed through picture chromatography method)

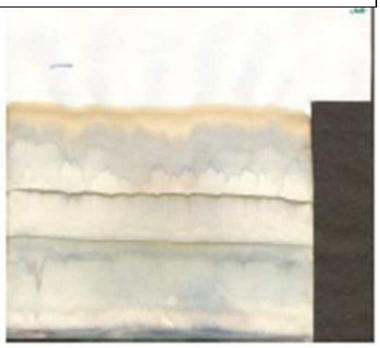
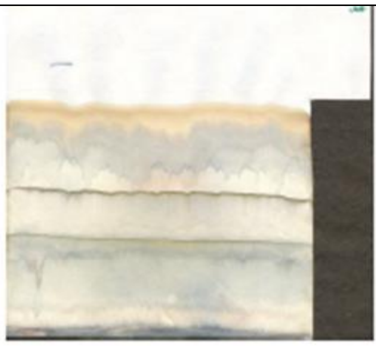
Zones/ Samples	Raw rice (organically cultivated)	Raw rice (conventionally cultivated)
Image		
Inner zone (colloidal Zone)	Less colloidal with light colour zone	More colloidal with dark colour zone
Middle zone **Flag zone**	Less flower vase structure with four different colours.	Less flower vase structure
Outer zone (Reactive zone)	High reactive substance	Low reactive substance

Table 35: Qualitative analysis of rice variety -Uma (analysed through picture chromatography method)

Zones/ Samples	**Parboiled rice (organically cultivated)**	**Parboiled rice (conventionally cultivated)**
Image		
Inner zone (colloidal Zone)	Less colloidal with light colour zone	More colloidal with dark colour zone
Middle zone **Flag zone**	Prominent flower vase structure with four different colours.	Flower vase structure
Outer zone (Reactive zone)	High reactive substance	High reactive substance

Comparison among the four different samples of Aishwarya varieties revealed that the inner zones of all the samples showed more colloidal substances (nutrients in crude form). The middle zones of Aishwarya organic parboiled and Aishwarya conventional parboiled samples showed flower vase like structures and reactive substances were observed to be high. The flower vase structure indicates carbohydrate content and reactive zone indicates photosynthetic reaction. Therefore, Aishwarya organic parboiled rice is having better life force.

Comparison between the two different conventional samples of Uma varieties revealed that the inner zones of both the samples showed more colloidal substances (nutrients in crude form). The middle and outer zones of Uma conventional parboiled sample showed prominent flower vase like structures with high reactive substances. But, in the case of Uma conventional raw sample, less flower vase structure with low reactive substances was observed in middle and outer zones respectively.

Comparison between the two different samples of organically grown Uma varieties revealed that the inner zones of both the samples showed less colloidal substances. The middle and outer zones of Uma organic parboiled sample were having prominent flower vase like structures with high reactive substances. But, in case of Uma organic raw, less flower vase structure with high reactive substances was observed in middle and outer zones respectively.

The study revealed that Uma organic parboiled and Uma conventional parboiled were having good quality traits.

4.5.3. Qualitative analysis of rice samples (analysed through circular paper chromatography)

The results qualitative analysis of rice samples analysed through circular paper chromatography is presented in Tables 36, 37, 38 and 39.

Table 36: Qualitative analysis of rice variety- Aishwarya (analysed through circular paper chromatography)

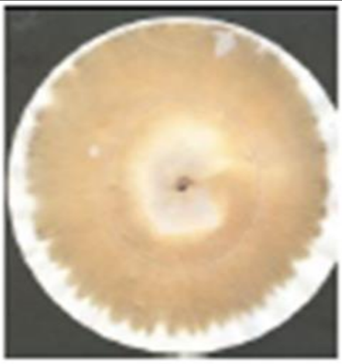
Chromatogram Zones	**Raw rice (organically cultivated)**	**Raw rice (conventional cultivated)**
Image		
Inner zone		
Width (cm)	2.75	1.70
Rf	0.39	0.24
Colour	Whitish brown	Woody brown
Pattern	Circular	Circular
Outer zone		
Width (cm)	3.0	0.75
Rf	0.42	0.10
Colour	Dull brown	Grey
Pattern and spikes	Circular with strong band spikes	Undulated with no strong band spikes

Table 37: Qualitative analysis of rice variety-Aishwarya (analysed through circular paper chromatography)

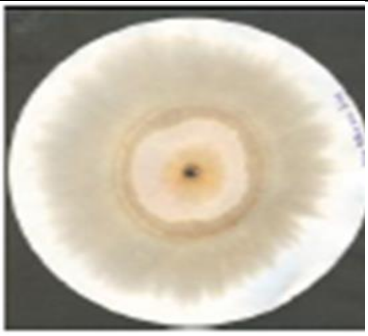
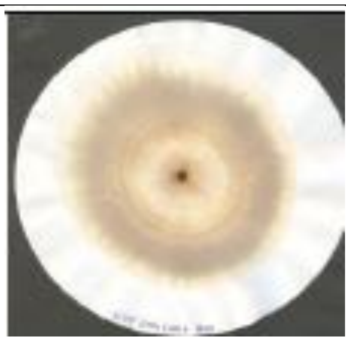
Chromatogram Zones	**Parboiled rice (organically cultivated)**	**Parboiled rice (conventionally cultivated)**
Image		
Inner zone		
Width (cm)	2.10	2.10
Rf	0.30	0.30
Colour	Pinkish white	Pinkish brown
Pattern	Circular	Circular
Outer zone		
Width (cm)	3.0	3.0
Rf	0.4	0.42
Colour	Grey	Grey
Pattern and spikes	Circular with strong band spikes	Circular with strong band spikes

Table 38: Qualitative analysis of rice variety- Uma (analysed through circular paper chromatography)

Chromatogram Zones	**Raw rice (organically cultivated)**	**Raw rice (conventionally cultivated)**
Image		
Inner zone		
Width (cm)	3.5	2.4
Rf	0.50	0.34
Colour	Whitish brown	Whitish brown
Pattern	Circular, no spikes	Circular
Outer zone		-
Width (cm)	2.0	-
Rf	0.3	-
Colour	Brown	-
Pattern and spikes	Circular with strong band spikes	-

Table 39: Qualitative analysis of rice variety- Uma (analysed through circular paper chromatography)

Chromatogram Zones	**Parboiled rice (organically cultivated)**	**Parboiled rice (conventionally cultivated)**
Image		
Inner zone		
Width (cm)	3.5	1.9
Rf	0.50	0.27
Colour	White and brown	Whitish brown
Pattern	Circular, no spikes	Circular
Outer zone		-
Width (cm)	1.5	-
Rf	0.21	-
Colour	Grayish brown	-
Pattern and spikes	Circular with strong band spikes	-

The inner zone of chromatogram for Aishwarya varieties ranged from 1.70 – 2.10 cm, which indicated no qualitative difference in the availability of minerals. The three rice samples Aishwarya organic raw rice, Aishwarya organic parboiled rice and Aishwarya conventional parboiled rice showed protruding spikes and bell shape structure from the outer zone towards inner zone indicates the presence of protein and formative forces.

For variety Uma grown organically, the chromatogram of both the samples showed a high inner zone(3.5cm) and the spikes protruding towards outer zone indicated protein present in the samples. Both the samples showed the presence of earth forces. Whereas in variety Uma grown conventionally, the inner zone of chromatogram samples ranged from 1.9 to 2.4cm which indicated availability of minerals. The middle and outer zones were not formed clearly.

4.6. Pesticides residue analysis

The sample of rice varieties under study were subjected to pesticides residue analysis. The pesticides tested were organochlorines, organophosphorus and synthetic pyrethroids. Under organochlorines, the pesticides tested were alpha HCH, beta HCH, gamma HCH/ lindane, Delta HCH, endosulfan-1, endosulfan-2, Endosulfan sulphate, P,P- DDE, DDD and P,P, DDT.

Under organophosphorus, the pesticides tested were chlorpyriphos, malathion, parathion- methyl, quinalphos, profenophos and ethion and under synthetic pyrethroids the pesticides tested were fenvalerate, λ- cyhalothrin, β- cyfluthrin and fenpropathrin .

The results revealed that the pesticide residues were below the detection limit of 0.1 and 0.5ppm in all the rice samples tested (both organic and conventional) (Table 40).

Table 40: Pesticide residues in rice samples

Sl.No.	**Pesticides tested**	**Result**	**LOQ (mgkg-1)**
Organochlorines			
1	Alpha HCH	BLQ	0.01
2	Beta HCH	BLQ	0.01
3	Gamma HCH/Lindane	BLQ	0.01
4	Delta HCH	BLQ	0.01
5	Endosulfan-I	BLQ	0.01
6	Endosulfan-II	BLQ	0.01
7	Endosulfan sulphate	BLQ	0.01
8	P,P'- DDE	BLQ	0.01
9	P,P'-DDD	BLQ	0.01
10	P,P'-DDT	BLQ	0.01
Organophosphorus			
11	Phorate	BLQ	0.05
12	Chlorpyriphos	BLQ	0.05
13	Malathion	BLQ	0.05
14	Parathion- methyl	BLQ	0.05
15	Quinalphos	BLQ	0.05
16	Profenophos	BLQ	0.05
17	Ethion	BLQ	0.05
Synthetic pyrethroids			
18	Fenvalerate	BLQ	0.1
19	λ-Cyhalothrin	BLQ	0.1
20	Cypermethrin	BLQ	0.1
21	β-Cyfluthrin	BLQ	0.1
22	Fenpropathrin	BLQ	0.1

BLQ- Below Limit of Quantitation and LOQ- Limit of Quantification.

Discussion

5. DISCUSSION

This chapter encompasses a critical appraisal of the salient findings of the study "Quality evaluation of organic rice" and the discussion is presented under:

5.1. Physical characteristics
5.2. Cooking characteristics
5.3. Nutritional composition
5.4. Sensory parameters
5.5. Holistic analysis
5.6. Pesticide residue analysis

5.1. Physical Characteristics

The physical dimensions of rice kernels are of vital interest to those engaged in the rice industry (Anon, 2007). These dimensions are important in marketing and grading in developing new rice varieties, in cleaning and grading equipment, in drying operations and in processing. This includes the seed or grain size, shape and weight. These can be determined by careful measurement of the seed and grain of the rice kernels (Rickman *et al.,* 2006; Slaton *et al.,* 2002).

Appearance is also another critical quality attribute for rice. Rice buyers, millers and consumers judge the quality by rice-shape relationship (Armstrong *et al.,* 2005). Rice varieties can be grouped on the basis of its size to long, medium or short (Bhattarcharya *et al.,* 2006). In the present study, all the two varieties are bold and medium in shape. Rice of different sizes adversely affects the milling quality and yield.

Preference for grain size and shape vary from one group of consumers to the other. In general, long grains are preferred in Indian subcontinent (Dela and Khush, 2000).

When colour was observed, both the two rice varieties were found to be red in colour. In the present study, parboiling process was found to retain more color than the raw process. Lieve et al. (2000) had also found that both brown and milled samples of parboiled rice were darker and more red and yellow after parboiling.

Physical dimensions like length, breadth and length/breadth ratio vary according to the variety and are considered as most important criteria of rice quality in developing new varieties.

Grain length in rice plays an important role in determining rice appearance, milling, cooking and eating quality (Luo *et al.*, 2004). In the present study, the length was found to be highest in Aishwarya conventional for both raw and parboiled rice (0.64 mm). While comparing mean length between conventional and organic system conventional rice were found to have higher length (0.59 mm) than organic rice (0.58 mm).

Breadth is an important factor in determining grain shape and width (Badavi and Hisseway, 2001). In the present study, the breadth of both the varieties i.e. Aishwarya and Uma (organic and conventional rice) were ranged between 0.22 mm to 0.24 mm. However, organic raw rice has higher breadth (0.24 mm) than the parboiled (0.23 mm).

Food Corporation of India (1978) has also given a scheme in which all rice varieties are classified into three groups based on L/B ratio. The varieties having L/B ratio below 2.5 are classified as common, those having L/B ratio of 2.5to 3.0 are fine and those having L/B ratio of 3.0 and above are super fine. In the present study, it was observed that conventional rice was found to have higher L/B ratio than organic rice. So, organic rice is fine and conventional varieties are common.

Thousand grain weight is an important factor affecting grain yield as well as grain quality in rice and affecting appearance and cooking qualities of rice.

In the present study, a value for thousand grain weight was recorded highest for Aishwarya varieties than Uma varieties. However, organic rice had higher thousand grain weight (20.40 g) than the conventional rice (20.38 g).

The thousand grain weight was found to increase after parboiling. The increase in thousand grain weight after parboiling might be due to the excess moisture content absorbed during the process. Yadav (2007) reported that the thousand grain weight of the rice varieties varied considerably with the moisture content in the grain.

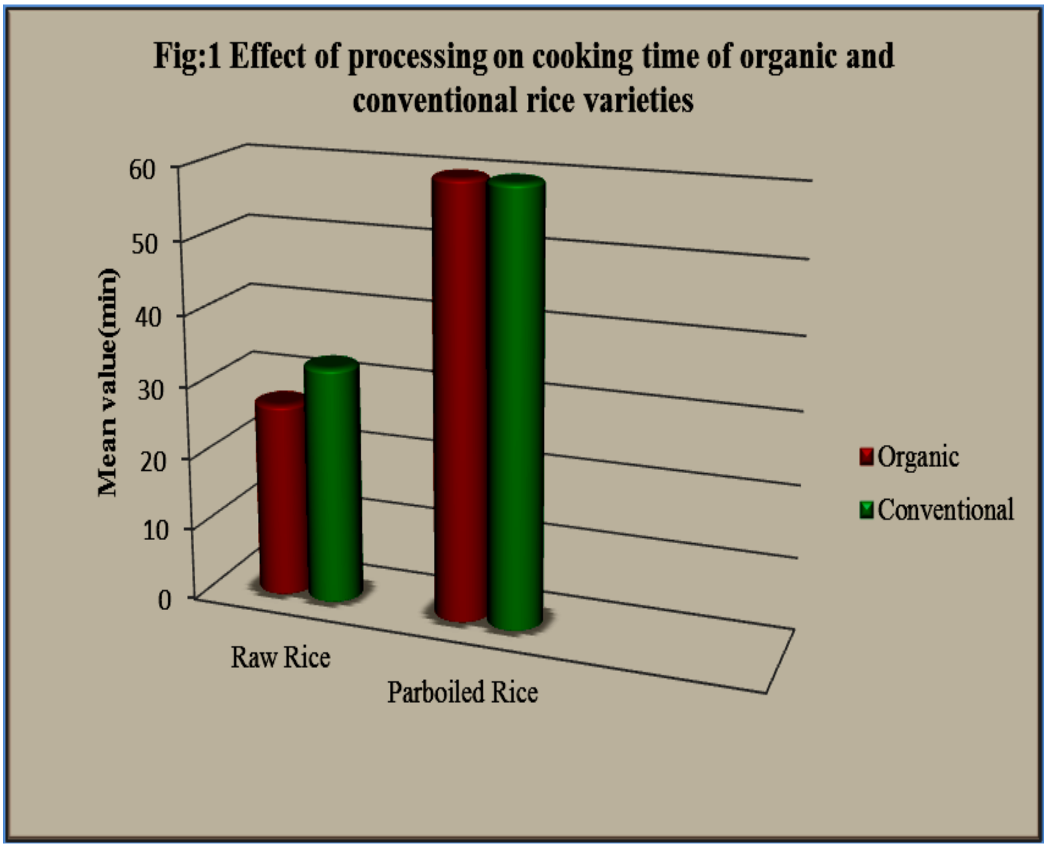
Bulk density of any material indicates the weight volume ratio and is an important parameter from storage point of view. Bulk density can be useful in sizing grain hoppers and storage facilities. The bulk density of both the varieties ranged between 0.93 to 1.02 g/ml. Bulk density slightly increased after parboiling. While comparing between organic and conventional rice, bulk density was more in organic rice than conventional rice. The range of values reported by Khatoon and Prakash (2007) were lower i.e. 0.781 – 0.860 g/ml.

In the present study, it was found that the swelling index of organic varieties were higher than the conventional varieties.

5.2 Cooking characteristics

Cooking and processing qualities largely determined the economic value of rice. They are assessed by determining optimum cooking time, elongation ratio, water uptake, cooked weight, amylose, amylopectin, amylose-amylopectin ratio.

Cooking time is one of the major determinants of the quality of rice grain. Consumer prefers rice grain with less cooking time. In the present study, optimum cooking time varied significantly among the rice varieties. Aishwarya conventional parboiled rice took higher time to cook (60.17 min) and Aishwarya organic raw rice took lesser time to cook (24.60 min). Parboiling process significantly increased the cooking time of rice varieties (Fig 1).



` The increase in the optimum cooking time after parboiling may be due to the variations in the rate of hydration and consequent gelatinization. Gunasekara and Dharmasena (2011) have reported similar observations. Limpawattana et al. (2008) reported that cooking time varied between 38-45 minutes depending on the rice type.

Elongation ratio is the ratio between the length of cooked grain and that of the raw grain. Higher values for elongation ratio of cooked rice are positive and desirable characters.

In the present study, it was noticed that parboiling significantly increased the elongation ratio. The highest elongation ratio was found in Uma organic parboiled rice and lowest was observed in Uma conventional raw and Uma conventional parboiled. The increase in elongation ratio might be due to increase in grain length brought about by parboiling of paddy. The result is in line with the findings of Dipti et al. (2002).

Water uptake is another important index of cooking quality of rice. Higher water uptake is an indicator of better cooking quality of rice. Begum and Bhattacharya (2000) reported that when more fat was available in raw rice, water uptake decreases.

In the present study, compared to raw rice, parboiled rice had significantly higher value for water uptake ratio for both organic and conventional. Highest water uptake ratio was recorded in Aishwarya conventional parboiled rice and Aishwarya organic parboiled rice and lowest in Uma conventional raw rice. Similar results were also reported by Otebaya et al. (2001).

High water uptake ratio affects the palatability of the cooked rice (Juliano, 2003). Frei and Becker (2008) had reported that rice with high amylose content absorb more water upon cooking.

In the present study, a significant difference in cooked weight was observed among the rice varieties. Parboiling process significantly increased the cooked weight of the rice varieties.

Amylose content determines the texture of cooked rice. Rice varieties with amylose content of more than 25 per cent absorb more water and have fluffy texture after cooking. According to Shi et al. (2005) amylose content is important because firmness and stickiness are two properties of cooked rice that influence consumer preference.

Rice varieties are grouped on the basis of their amylose content into waxy (0-2 per cent), very low (3-9 per cent) low (10-19 per cent) intermediate (20-25 per cent) and high (>25 per cent). Consumer prefers rice grain with intermediate amylose content (Frei *et al.,* 2003).

It was found that Aishwarya organic raw rice and Aishwarya conventional raw rice and parboiled belong to intermediate amylose group. But Aishwarya organic parboiled rice had low amylose i.e. 18.72. Uma organic raw rice and Uma conventional raw rice belong to intermediate amylose group. But in Uma organic parboiled and Uma conventional parboiled rice the amylose content is low i.e. 19.27 and 18.52 per cent.

Shahidullah et al. (2009) reported that the amylose content in all grades of rice ranged between 20.7-21.4 per cent. Cooked rice becomes moist and sticky due to low amylose content.

It was also found that organic rice has lower amylose content than conventional rice. Amylopectin is the major starch constituent and is the only starch fraction of waxy rice. In the present study, the amylopectin content varied significantly among the rice varieties. Significant decrease in amylopectin content was observed after parboiling. It was found that Uma organic raw had highest amylopectin whereas lowest was noticed in Aishwarya conventional parboiled.

In the present study, it was found that amylose-amylopectin ratio varied significantly among the rice varieties and treatment. Highest amylose-amylopectin ratio was recorded in Aishwarya conventional parboiled rice and lowest in Uma organic raw rice. The results obtained are in accordance with the observations made by Usha et al. (2012).

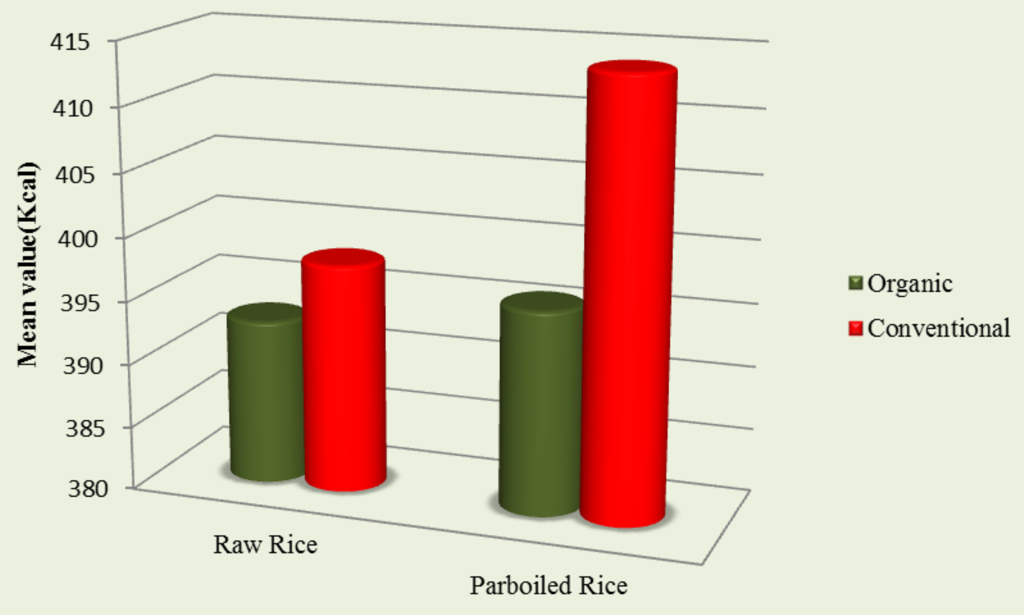
5.3 Nutritional composition.

Rice is a rich source of energy and moderate source of protein. It contributes over 20 per cent of the total calorie intake of the human population (Bhattacharjee *et al.*, 2002). Rice also provides a trace amount of minerals, vitamins and fibre.

According to Srilakshmi (2004) cereals are the main source of energy contributing 70-80 per cent of the requirement.

An increase in calorific value was noticed as a result of parboiling. During parboiling, the brown outer layers adhere to the grain and most of the nutrients are driven into the interior of the grain. Similar findings were also reported by Heinemann et al. (2005). In the present study highest calorific value was observed in Uma conventional parboiled and lowest in Aishwarya organic raw (Fig 2).

Fig2: Effect of processing on calorific value of organic and conventional rice varieties



Supradip et al. (2007) also found out that conventional rice has higher calorific value than organic rice.

Protein is the second most abundant constituent in rice. The protein content of rice though relatively low, its nutrient value is much higher compared to other cereals. Rice protein is easily digested and contains all the essential amino acid (except for lysine) which are higher in number than in other cereals crops (Zelensky, 2001). In the present study, it was found that the highest protein content was found in Uma conventional parboiled rice and lowest in Aishwarya organic raw rice.

Among the organic and conventional system, it was found that conventional rice have higher protein content than that of organic rice. Similar studies were also reported by Elaine (2006). Supradip et al. (2007) also found that the protein content was least in organic rice but of better quality than conventional ones.

It was noticed that parboiling increased the protein content of rice. Study conducted by Sadhna et al. (2004) also reported that parboiled rice was found to have higher protein and ash contents.

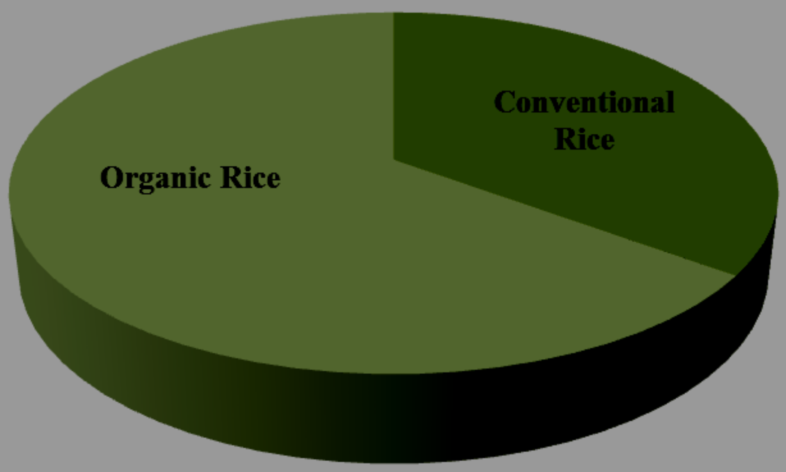
Starch is a polysaccharide found in nature by the condensation of a large number of glucose molecules. Starch forms 90 per cent of rice by weight. According to Srilakshmi (2004) the major carbohydrate of rice is starch which is 72-75 per cent. In the present study, it was found that Uma organic raw rice had highest starch content and lowest was noticed in Uma conventional parboiled rice. Among the treatment i.e. between organic and conventional system it was found that the mean value of organic rice was higher starch value (76.39) than that of conventional rice (69.52). But according to Daniel (2006) it was found that starch and mineral contents do not differ among organic and conventional rice.

The physical properties of the grain are more closely related to the starch content or to protein content than to amylose content. It was noticed that starch content of rice varieties decreased as a result of parboiling. This may be due to the fact that during parboiling, starch granules gelatinized and squeezed together, making the endosperm hard and compact (Gill *et al.*, 2003).

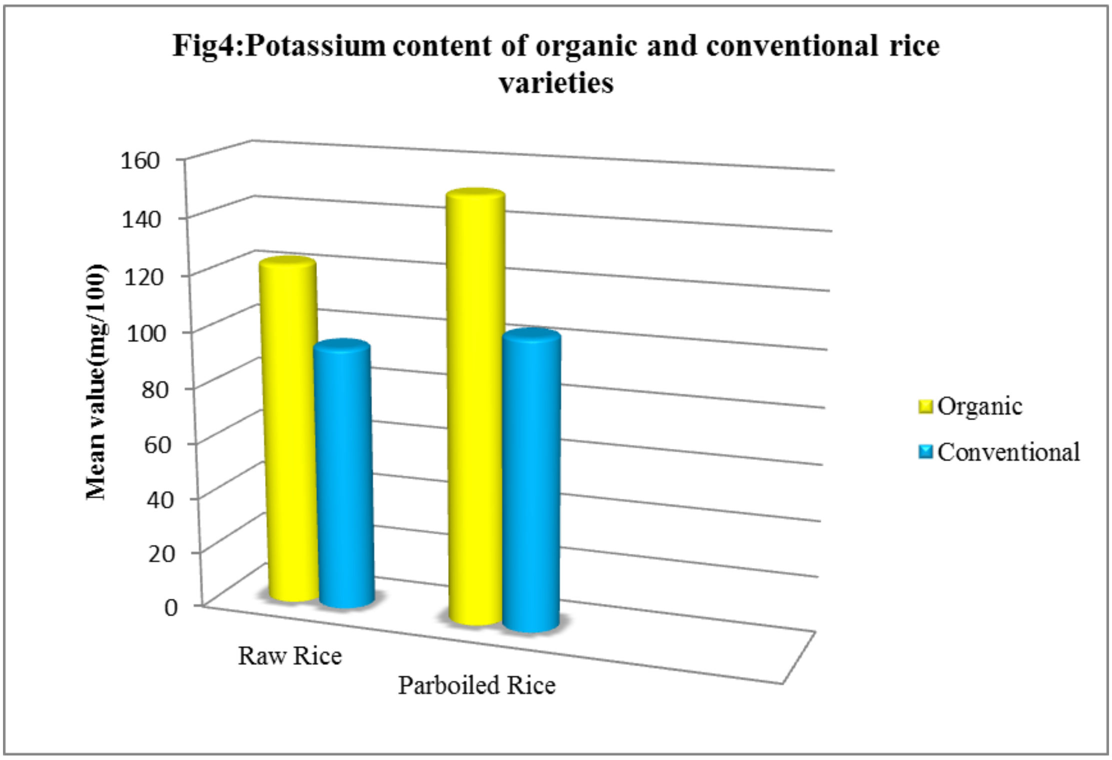
In the present study, it was found that parboiling process significantly increased the total mineral content of rice varieties. The study is in tune with the findings of Gujral and Singh (2001) who had reported lower mineral contents in raw rice than parboiled rice. The per cent reduction in mineral content was greater with increasing degree of milling. It was also found that organic rice had higher mineral content than conventional rice. The study is in accordance with the findings of Darbaba (2012).

In the present study, it was found that organic rice has higher sodium content than conventional rice. A study conducted by Anne (2008) also reported that organic rice has higher sodium content (Fig 3).

Fig3: Sodium content of organic and conventional rice varieties

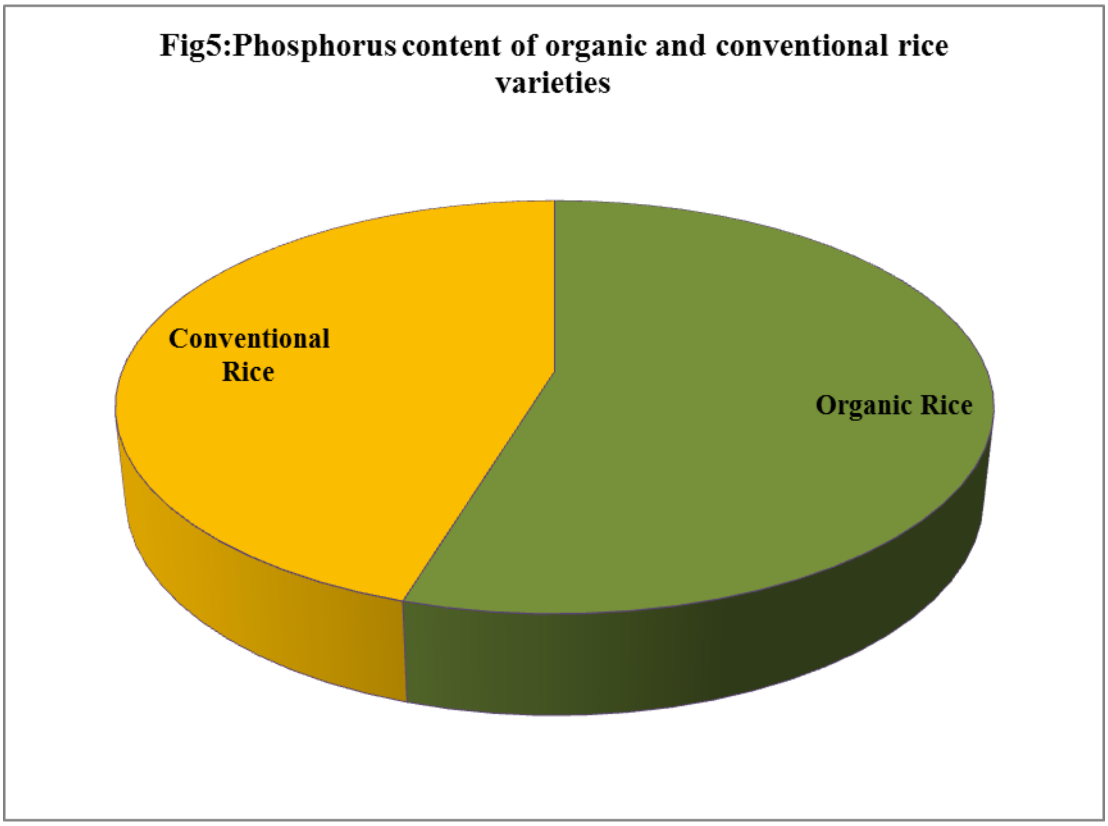


The mean value of organic rice had revealed higher potassium content than that of conventional rice (Fig 4).



Similar studies were reported by Ronald (2011). Lotus Foods Association (2012) also found that rice grown organically also has higher potassium content than conventional rice.

In the present study, highest phosphorus content was found in Aishwarya organic raw and lowest in Uma organic parboiled. Organic rice had higher phosphorus content than conventional (Fig 5).



Lotus Foods Association (2012) also reported similar findings. Surekha et al. (2009) opined that organic rice especially brown rice has higher phosphorus content.

Rice is a poor source of calcium. In general, rice has 10 mg calcium per 100 mg and it is mostly present in bran. A significant difference was observed among the varieties i.e. Aishwarya and Uma and also between organic and conventional system. In the present study, it was found that highest calcium content was recorded in Aishwarya organic parboiled rice and lowest in Uma conventional raw rice. It was noticed that parboiling significantly increased the calcium content of the rice varieties. This may be due to nutrient elements like calcium present in outer layers migrated deep into the grain during parboiling resulting in a greater retention milled parboiled grain. The result was in confirmation with the report of Heinemann et al. (2005).

A study conducted by Oghbaei and Prakash (2010) reported that the calcium content of rice samples were in the range of 13.07 to 19.36 mg/100 mg.

In the present study it was found that organic rice had higher calcium content i.e. (13.55mg/100g) than conventional rice (10.99mg/100g). Neeson (2011) also found that organic rice had higher calcium content than conventional rice and it ranged from 11.12 mg/100g to 14.2 mg/100g.

Rice is a very poor source of iron. The present study revealed that iron content of parboiled rice sample was more when compared to raw rice samples. Highest value of iron content was noticed in Uma organic raw rice. Heinemann et al. (2005) also reported that iron content was found to be retained more in parboiled rice samples when compared to raw rice samples.

It was also found that organic rice had higher iron content than conventional rice. Similar finding were also reported by Supradip et al. (2007) and Sadhana et al. (2004).

The copper content was highest in Aishwarya organic parboiled rice and lowest in Aishwarya conventional and Uma conventional raw rice. Among the two treatments between organic and conventional system, the mean value of organic rice varieties showed higher copper content than that of conventional. However, Supradip et al. (2007) reported that inorganic treatment had higher copper content than organic treatment.

Among the two treatments, organic rice shown lower zinc content (0.73) than that of conventional rice. The result is in line with the findings of Supradip et al. (2007).

5.4. Sensory parameters

A sensory specification defines the sensory parameters of an ingredient or finished product, such as flavour, aroma, texture or absence of off flavour.

The above attributes make food desirable to consumers. Sensory methods are used to determine whether foods differ in such qualities as taste, odour, juiciness, tenderness or texture and the extent and direction of the differences. They are also used to determine consumer preference among food.

Sensory evaluation is defined as “A scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Stone and Sidel, 2004).

Sensory evaluation by laboratory panels and consumer panels give indication to the eating quality of rice and it varies according to personal preference. Sensory parameters selected in this study were appearance, colour, flavour, texture, taste and overall acceptability.

Appearance is the criterion for the desirability of any food product. The appearance of the food product is contributed by surface characteristic viz., size, shape, colour, transparency, opaqueness, turbidity and dullness (Srilakshmi, 2004).

General appearance is an important quality trait, because mostly rice is consumed in whole grain form. Numerous factors constitute general appearance including size and shape, uniformity, translucency, chalkiness, colour, damaged and imperfect grains. In the present study, the highest rank mean was observed in Aishwarya conventional raw rice and Uma organic parboiled rice. There was no significant difference among all the varieties both cultivated under organic and conventional system and also between raw rice and parboiled rice. Among all varieties, Aishwarya conventional parboiled rice and Uma organic raw rice have better appearance. However, Mcclung (2009) reported that organic rice did appear to be whiter and softer when cooked than conventional rice.

Colour, is one of the important visual attributes that has been used to judge the overall quality of food for a very long time. If colour is unattractive, a potential consumer may not be impressed by any other attributes.

Colour is used as one criteria of quality of all rice varieties. The assessment is performed on whole milled rice. In the present study, highest rank mean was observed in Aishwarya conventional raw rice. On comparing with CD value, there was no significant difference found between the varieties of rice with respect to quality attribute colour. Supradip et al. (2007) also reported similar findings.

Flavour is one of the important criteria of sensory attributes that affects acceptability of foods (Prinyawatkul et al., 2003). In the present study, there was no significant difference in flavour among all the varieties when compared with CD value. However highest rank means was observed in Uma conventional parboiled. Mcclung (2009) also reported that no difference in the taste or aroma of organic versus conventionally grown rice. Similar findings were observed by Supradip et al. (2007).

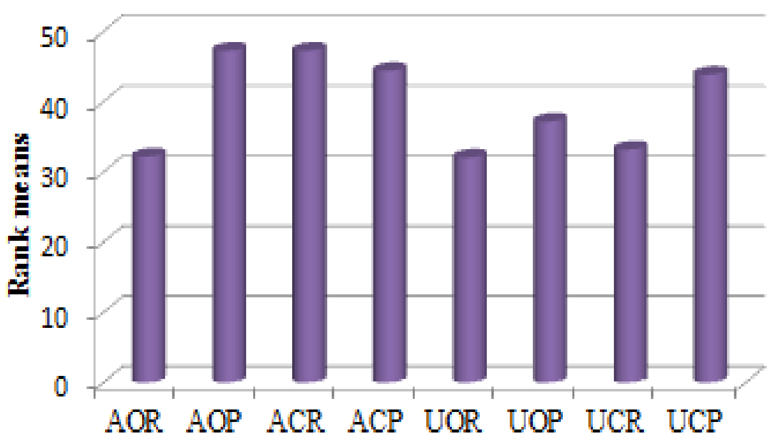
The measurement of cooked rice texture by sensory and instrumental methods is important because of the increasing popularity of rice and rice products by globally diverse cultures (Lyon et al., 2000). The authors also opined that factors influencing cooked rice texture are cultivars, physicochemical properties, post-harvest handling practices (milling degree, grain conditions and final moisture) and cooking method.

In the present study, highest rank mean for texture was found in Uma organic parboiled rice and lowest in Uma conventional raw rice. Traore (2005) also reported that organic rice has softer texture than conventional rice.

Among the various quality attributes taste is of primary consumer interest for its marketability. Zheng and Zhao (2000) reported that drying temperature of paddy is the main factor affecting rice taste. In the present study, it was observed that Uma conventional raw rice had obtained highest score for taste. Supradip et al. (2007) also reported that there was no taste difference between organic and conventional.

According to Savithri et al. (2005) the overall acceptability depends on the concentration of amount of particular components, the nutritional and other hidden attributes of the food and its palatability or sensory quality. In the present study, the overall acceptability of different rice varieties was not significantly different when compared with CD value. However, highest score was obtained in Aishwarya organic parboiled rice and Aishwarya conventional raw rice. Among all the varieties Aishwarya organic parboiled rice and Aishwarya conventional raw rice have better preference than other varieties and were the most accepted in all aspects of sensory parameters (Fig 6).

Fig 6: Overall acceptability of organic and conventional rice



AOP-Aishwarya organic raw
AOP-Aishwarya organic parboiled
ACR-Aishwarya conventional raw
ACP-Aishwarya conventional parboiled
UOR-Uma organic raw
UOP- Uma organic parboiled
UCR-Uma conventional raw
UCP-Uma conventional parboiled

Sayadi and Samir (2005) and Sudha (2013) were also reported that consumer prefers organic rice better than conventional rice.

5.5. Holistic analysis

Plant product and food quality aims to enhance the health benefits of foods to the public. Analysis of the nutritional properties such as shelf life, chemical (minerals) and biochemical (vitamin, protein, carbohydrate and lipid) of both raw and processed products ensure the quality and vitality of the product. The qualities determine the nutritional properties and nature of the product. Vitality represents the presence and growth of natural and healthy forces at work. Therefore; simpler and reliable assessment technique is needed for testing the vitality and quality.

5.5.1 Vitality of rice analyzed through analyzed sensitive copper chloride crystallization method

It has been developed in the last century by Ehrenfried Pfeiffer following Rudolf Steiner's. The crystallization is evaluated based on the formation of needle, size and thickness. For good quality and vitality of a rice, the central zone should be of single origin, the middle zone needle should be fan out very finely, needle arrangement should be orderly, direction should be straight and thickness should be tight and for outer zone structure of needle should be thin, pointed out and refracting (Arunkumar and Perumal, 2006).

In the present study, it was noticed that both Aishwarya and Uma organic (both raw and parboiled) were from single origin, the needle arrangement was fan out and orderly. However it was also noticed that Uma conventional parboiled rice was also from single origin, needle arrangement was fan out and orderly. So, it can be concluded that organic rice has more vitality than conventional system. However, parboiled rice also showed vitality.

5.5.2 Qualitative analysis of rice samples analyzed through picture chromatography method

In Aishwarya variety, the inner zones of all the samples showed more colloidal substances (nutrient in crude form). However, in Uma organic rice, the inner zone was less colloidal. The middle zones of Aishwarya and Uma organic parboiled and Aishwarya and Uma conventional parboiled rice samples were having flower vase like structures. The reactive substances were observed to be high. The flower vase structure indicates carbohydrate content and reactive zone indicates photosynthesis reaction, showing more life force. Therefore, while comparing between all the rice varieties parboiled rice has better quality than raw rice and are more vital.

5.5.3 Vitality of rice samples analyzed through circular paper chromatography method

It was developed by Ehrenfried Pfeiffer in 1953. The presence of the spike indicates the superior nutritional quality (Chandra *et al.,* 2005). In the present study, it was revealed that strong band spike was seen in organic rice for both Aishwarya and Uma varieties. However, Aishwarya conventional parboiled rice also showed strong band spike. It was concluded that organic rice has better quality than conventional rice.

From all the above analysis it was found that organic rice has more vitality and of good quality. However, parboiled rice also showed good quality traits.

5.6. Pesticide residue analysis

"Pesticides" means any substance intended for preventing, destroying, attracting, repelling or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities or animal feeds or which may be administered to animals for the control of ecto parasites. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport.

The results of analysis of samples for pesticides residue were compared with chromatogram of standard mixture (46 pesticides). A comparison of sample chromatogram with standard chromatogram indicated that no residues of any of the pesticides are present in the sample at level above the LOQ (Limit of Quantification) of respective pesticides. Hence, samples of both organic and conventional rice varieties were free of any pesticides. The LOQ value fixed for organochlorines was 0.1 ppm while that of organophosphorous and synthetic pyrethroids was 0.5 ppm. All the samples can be assumed to be free of residue of any of the commonly used pesticides in rice. The observations of the present study are in agreement with the finding of Lee et al. (2009), where no pesticide residue was found in polished rice. Similar finding was also reported by Punzi et al. (2005) on rice.

The absence of residue in polished rice could be either due to long gap between pesticides application and harvesting. Pesticides are generally applied before ear head emerged in paddy. Even if pesticides applied after harvesting, dehusking, milling process and polishing would have removed considerable residue. Similar report was also found by Charles (2010).

Christie (2010) is of the opinion that pesticides residue levels were affected by the amount of chemical applied, the formulation of the pH of the water diluent and of the target tissue, soil or water, the nature of the surface to which it is applied, exposure to weathering from wind, rain etc., chemical breakdown from high temperature and humidity, photo chemical reaction from sunlight and biological reaction.

Summary

6. SUMMARY

A study entitled "Quality evaluation of organic rice" was conducted to ascertain the major quality parameters such as physical characteristic, cooking characteristic, nutritional composition, sensory parameters, holistic and pesticides residue analysis. The organic and conventional paddy samples selected for this study were procured from CSRC karamana and Department of Agronomy, COA, Vellayani. They were Aishwarya and Uma cultivated under organic and conventional farming systems. The paddy samples were processed by two methods viz, raw milling and parboiled milling and stored in airtight containers for laboratory studies. The results of the study obtained are summarized below.

The parameters selected under physical characteristics were size, colour and shape, length, width, L/B ratio, thousand grain weight, bulk density and swelling index.

The result reveled that all the rice varieties were found to be red in colour, bold and medium in shape. However, variety Aishwarya, both cultivated under organic and conventional system was found to be extra bold when compared to variety Uma.

The length of the rice grain was found to be higher in Aishwarya conventional rice for both raw and parboiled and lowest length was observed in Uma organic parboiled rice. The length of Uma variety was shorter as compared to Aishwarya.

The lowest breadth was observed in Uma organic parboiled rice and highest breadth seen in both the varieties, i.e. Aishwarya and Uma organic raw rice. In the present study, it was found that organic raw rice had higher breadth than organic parboiled rice.

Length and breadth ratio (L/B ratio) varied between the two varieties. The highest L/B ratio was recorded in Aishwarya organic raw rice and lowest in

organic Uma raw and parboiled rice. Significant differences exist between the two varieties, (Aishwarya and Uma), between organic and conventional and also between raw and parboiled rice.

Thousand grainweight was found highest for Aishwarya varieties compared to Uma varieties. The highest grain weight was found in Aishwarya conventional parboiled rice and lowest in Uma conventional raw rice. In the present study, it was found that conventionally cultivated rice varieties (both Aishwarya and Uma) have higher thousand grain weight than the organically cultivated rice.

Highest bulk density was recorded in Aishwarya organic parboiled rice and lowest in Uma conventional raw rice. The bulk density of organic rice was higher than the conventional rice.

Highest value for swelling index was observed in Uma organic parboiled rice and lowest in Aishwarya conventional raw rice. It was also found that the mean value of organic rice was higher than the conventional rice. Among the two varieties, Uma organic rice had higher swelling index than variety Aishwarya.

The cooking characteristics studied were optimum cooking time, elongation ratio, water uptake, cooked weight, amylose, amylopectin, amylose-amylopectin ratio.

The optimum cooking time of parboiled rice samples for both Aishwarya and Uma were longer than raw rice samples. Aishwarya conventional parboiled rice took higher cooking time and Uma organic raw rice took lesser time to cook.

The highest elongation ratio was possessed by Uma organic parboiled rice and lowest by Uma conventional raw rice. Between organic and conventional system, organically cultivated rice had higher elongation ratio than conventionally cultivated rice.

The highest water uptake ratio was found in Aishwarya parboiled rice for both organic and conventional system and lowest in Uma conventional raw rice.

In the present study, it was found that organic rice had higher water uptake than conventional rice. The water uptake ratio of the varieties, Aishwarya and Uma were significantly different.

The highest cooked weight was observed in Aishwarya conventional parboiled and lowest in Uma conventional raw rice. Aishwarya varieties have higher cooked weight than Uma varieties and comparatively conventional rice have higher cooked weight than organic rice. Parboiling process significantly increased the cooked weight of the rice varieties.

Amylose content of rice varied significantly among the varieties. Highest amylose content was noticed in Aishwarya conventional raw rice while lowest in Uma conventional parboiled rice. Conventionally cultivated rice had higher amylose content than organically cultivated rice.

Highest amylopectin content was noticed in Uma organic raw rice and lowest in Aishwarya conventional parboiled rice. Comparatively, organic rice had higher amylopectin than conventional rice. Significant decrease in amylopectin content was observed after parboiling. There was a significant difference observed between organic and conventional system of cultivation and also between raw and parboiled rice.

The highest amylose- amylopectin ratio was observed in Aishwarya conventional parboiled rice and lowest in Uma organic raw rice. Among the two systems of cultivation, organic rice had lower amylose-amylopectin ratio than conventional system of rice.

Nutritional composition of the rice varieties were assessed by estimating calorific value, protein, starch, total minerals, sodium, potassium, phosphorus, calcium, iron, copper and zinc content.

The calorific value was found to be highest in Uma conventional parboiled rice and lowest in Aishwarya organic raw rice. It was also found that conventional rice had higher energy content than organic rice. Parboiling process was found to increase the calorific value of rice varieties.

Highest protein content was noted in Uma conventional parboiled rice and lowest in Aishwarya organic raw rice. The mean values of protein content revealed that conventional rice had higher protein content than organic rice.

The highest value for starch content was recorded in Uma organic raw rice and lowest in Uma conventional parboiled rice. Among the two varieties, Uma varieties have highest starch. It was also found that organic rice had higher (mean starch) value than conventional rice.

The minerals contents estimated revealed that sodium, potassium, phosphorus, calcium, iron and copper were found to be higher in organically cultivated varieties than conventionally cultivated ones. Whereas, zinc content was found to be more in conventionally cultivated parboiled rice. Parboiling process significantly increased the mineral content of rice samples.

Sensory evaluation of the cooked rice (both raw and parboiled) samples were carried out with the help of selected panel members. The quality attributes selected were appearance, colour, flavour, texture, taste and overall acceptability.

Among all the varieties, Aishwarya conventional parboiled rice and Uma organic raw rice had better appearance.

The highest rank mean for colour was observed in Aishwarya conventional raw rice and lowest in Uma conventional raw rice. Among all the varieties, Aishwarya conventional raw rice has better colour followed by Aishwarya organic raw rice.

Highest rank mean for texture was found in Uma organic parboiled rice and lowest in Uma conventional raw rice. Highest taste score was observed in Uma conventional raw rice and lowest in Aishwarya conventional parboiled rice.

Statistical analysis revealed that the overall acceptability of different rice varieties was not significantly different. However, highest score was obtained for Aishwarya organic parboiled rice and Aishwarya conventional raw rice and lowest for Uma organic raw rice. Among all the varieties, overall acceptability was found to be better in Aishwarya organic parboiled rice and Aishwarya conventional raw rice.

The holistic analysis or visualizing techniques such as sensitive copper chloride crystallization method, picture chromatography and circular paper chromatography were carried out to visualize the quality.

Rice analysed through sensitive copper chloride crystallization method revealed that organically cultivated rice (both raw and parboiled) had more vitality.

Qualitative analysis of rice samples analysed through picture chromatography method revealed that all the parboiled rice samples have better quality than raw rice.

Vitality of rice samples analysed through circular paper chromatography method revealed that strong band spike was seen in organic rice for both Aishwarya and Uma varieties. However, Aishwarya conventional parboiled rice also showed strong band spike. It was concluded that organic rice has better quality than conventional.

The rice varieties were tested for pesticide residue analysis. The pesticides tested were organochlorines, organophosphorus and synthetic pyrathroids. The results revealed that the pesticides were below the minimum limit of quantification.

It can be concluded that organically cultivated rice has more mineral contents and higher vitality. However, parboiled rice cultivated under conventional system also showed good quality traits in terms of energy, protein and overall acceptability.

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Appendices

Appendix I

Specimen evaluation card for triangle test

Name: Date:

Product: Time:

Two of the three samples are identical

Determine the odd sample:

Pair number	Code number of samples	Code number of odd samples
1		
2		
3		
4		

Signature.

Appendix II

Score card for sensory evaluation

Quality attributes	Criteria	Maximum score	Sample 1	Sample 2	Sample 3
	Excellent				
	Very good				
	Good				
	Fair				
	Poor				

QUALITY ANYLYSIS OF ORGANIC RICE

ROBITA RIAMEI

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Department of Home Science
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

ABSTRACT

"Quality evaluation of organic rice" was a study undertaken to determine the quality aspects of rice varieties cultivated under organic and conventional practices of crop production. The study was taken up as factorial CRD experiment with three factors. The factors studied were varieties, system of cultivation and method of processing. The varieties selected were Uma and Aishwarya. The systems of cultivation practiced were organic and conventional and the methods of processing employed were raw milling and parboiled milling. The processed rice samples were stored in air tight containers for laboratory studies..

The quality parameters tested were physical characteristics, cooking characteristics, nutritional composition, visualizing techniques, organoleptic qualities and pesticide residue analysis.

Physical characteristics revealed that both varieties were red in colour, bold and medium in shape. The grain length of Uma was shorter when compared to Aishwarya. Rice varieties under conventional system recorded higher breadth and thousand grain weight when compared to varieties cultivated under organic system. Rice varieties cultivated organically recorded higher bulk density and swelling index than the conventional system.

Conventional produce required more cooking time than organic produce. Organic produce recorded higher elongation ratio, water uptake and amylopectin content, whereas, cooked weight, amylose content and amylose- amylopectin ratio were recorded highest in conventional produce.

Consumers prefer varieties of higher nutritional quality. Comparing between organically and conventionally cultivated varieties, organic produce have higher starch, sodium, potassium, phosphorus, calcium and iron. However, protein, calorie and zinc content were found higher in convention produce.

Organoleptic qualities studied were appearance, colour, flavour, texture, taste and overall acceptability. The data revealed that the overall acceptability of the two rice samples was not significantly different. However, among all the rice samples, overall acceptability was found to be better in Aishwarya (both organically and conventionally cultivated).

The holistic analysis or visualizing techniques of rice samples were carried out to visualize the quality and it was found that organic product had more vitality and better quality. Parboiled rice also showed good quality traits.

The rice samples were tested for pesticide residue analysis. The pesticides tested were organochlorines, organophosphorus and synthetic pyrethroids. The results revealed that the pesticide residues were below the minimum limit of quantification in all the samples tested.

It can be concluded that organic system of cultivation are of better than conventional system in terms of mineral contents. The study also revealed that parboiled rice cultivated under conventional system also showed good quality traits with respect to overall acceptability, nutrient composition and cooking qualities.