EVALUATION OF CYCAS SEED FLOUR FOR PRODUCT DEVELOPMENT

By

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(2009 16-102)

THESIS

Submitted in partial fulfilment of the

requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE AND NUTRITION)

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VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2012

DECLARATION

I, hereby declare that this thesis entitled **"Evaluation of cycas seed flour for product development"** is a bonafide record of research work done by me during the course of research and this 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.

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Certified that this thesis, entitled **"Evaluation of cycas seed flour for product development"** is a bonafide record of research work done independently by **Miss. Lijitha, S.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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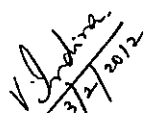

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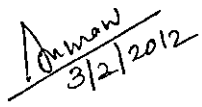

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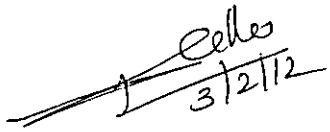

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ACKNOWLEDGEMENT

At this moment of fulfilment, I would like to bow my head before God Almighty whose grace had endowed me the inner strength and confidence and blessed me with a helping hand at each step of my life.

I wish to place on record my profound sense of gratitude to my guide Dr.V. Indira, Professor & Head, Department of Home Science for her exceptional guidance and ever willing help rendered at all stages of this endeavour. Always looking for perfection, she corrected me several times but with understanding and forbearance. I feel greatly honoured by getting a chance to work under her guidance. It was a great experience to work under her personified with personal attributes. My sincere and heartfelt gratitude ever remains with her.

I consider it as my privilege to express my deep felt gratitude to Dr.Suman. K. T, Assistant Professor, Department of Home Science, College of Horticulture, Vellanikkara and member of my Advisory Committee for her valuable help, suggestions, guidance and constant encouragement throughout the period of the work. I thank her for all the help and co-operation she has extended to me.

I am extremely delighted to place on record my profound sense of gratitude to Dr.Seeja Thomachan, Assistant Professor (Home Science), Krishi Vigyan Kendra, Thrissur for her suggestions and guidance during the conduct of this research work. I thank her for all the help and co-operation she has extended to me.

My heartfelt thanks to Dr. P.B. Pushpalatha ,Professor (Processing Technology) & Registrar, (KAU), for her valuable suggestions.

I would like to specially thank Shri. S. Krishnan, Associate Professor and Head, Department of Agricultural Statistics, College of Horticulture, Vellanikkara for his timely help, valuable suggestions and critical scrutiny of statistical analysis.

My heartfelt gratitude to my friends Shabina, Aparna ,Anitha and Renisha for their constant encouragement and support.

*I wish to express my sincere gratitude to my seniors **Bindhya, Mittu, Kavitha, Saritha, Shabna, Lakshmy, Neethu, Anusha, Lilia and Blossom** for their constant support, ever-willing help all through the course of my study which gave me enough mental strength to get through all tedious circumstances.*

*My heart never forgets my junior friends **Swati , Simi , Suvarna** and **Aswathy** for their whole hearted support and help.*

*My sincere thanks to **Mrs. Umaiva** (Permanent labourour, Department of Home Science) for her timely help, love and support.*

*Words can never truly portrait the love, affection, care, constant encouragement, patience, unflinching support and valuable advice of **Niya chechi, Kaveramma chechi** and **Jyothi chechi** .*

*I am happy to place on record my sincere thanks to my room mates, **Meera, Resmi and Aswathi.** My heartful thanks to my friend **Manju** for the heartfelt help and back-up which gave me enough mental strength to get through all mind-numbing circumstances.*

*Special thanks go to **Mr. Aravind** of student's computer club, College of Horticulture, for rendering necessary help whenever needed.*

*The award of **KAU junior research fellowship** is greatly acknowledged.*

*I am forever indebted to **my beloved parents** for their support, encouragement, deep concern and prayers, which helped me to overcome many hurdles experienced during the course of time.*

*With gratitude and affection, I recall the boundless affection, constant encouragement, warm blessings, moral support, unfailing inspiration and motivations from **my family members**, without which this endeavour would never have become a reality.*

*Above all, I bow my head before the Great Truth, the **Almighty**, for enlightening and making me confident and optimistic throughout my life.*

Lijitha, S.

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ABREVIATIONS

A.O.A.C.	- Association of Official Analytical Chemists
g	- Gram
mg	- Milligram
m	- Metre
ml	- Milli litre
cm	- Centimetre
° C	- Degree centigrade
%	- Per cent
nm	- Nanometre
KJ	- Kilo Joules
Kcal	-Kilo calories
no	-Number
nos	-Numbers
OD	-Optical density
tbsp	-Table spoon
$CuSO_4$	- Copper sulphate
HCl	- Hydrochloric acid
H_2SO_4	- Sulphuric acid
N	- Normal
NaOH	- Sodium hydroxide
OD	-Optical density
K_2SO_4	-Potassium sulphate
µl	-Micro litre
µg	-Micro gram
cfu	-Colony forming unit

Introduction

INTRODUCTION

Cycads are believed to be the oldest of the extant seed bearing plants and they are often termed as "living fossils" as their morphology has changed little from that of their ancestors (Schneider *et al.*, 2002). *Cycas* is the only genus represented in India within cycads. Six species namely *Cycas rumphii*, *Cycas sphaerica*, *Cycas circinalis*, *Cycas beddomei*, *Cycas pectinata* and *Cycas annaikalensis* occur in India of which the last four are endemic.

Cycas circinalis, otherwise known as queen sago palm, is a cycas endemic to South India and is an important multi-use Non Timber Forest Produce for indigenous communities throughout India's Western Ghats. Erstwhile Malabar Coast of Kerala happens to be the locality of *C. circinalis*, the first known cycad described by Linnaeus in 1753. It is a small, evergreen, palm-like tree growing to 25 ft. in height and found in the deciduous forest upto 1200 m altitude (Saneesh, 2009). All parts of the plant are used as food, either in the cooked form or uncooked form. The mature seeds of cycas palm are large, orange red in colour and have medicinal, economic and nutritional importance in areas where they are indigenous. They are also used in cosmetics as well as in cultural and religious ceremonies.

Cycas seeds known as '*eenth seeds*' in Malayalam is a common food among the tribal communities of Kerala. They grind and soak the seeds in water to remove the toxic constituents, making the food generally safe to eat. Properly dried cycas seed flour is stored for several years without deterioration and the flour of cycas seeds is called '*eenthakka podi*'. Cycas seeds are used as staple food or as basic component of substantial meals in combination with other cereal sources and '*enthakka podi*' is used to prepare products of improved nutritional quality. Even today, it is a major energy food for many poor populations and is also a valuable famine food in some areas of Kerala.

The nutritional aspect of the cycas palm is mainly centered on its stem and seeds. Cycas starch is a constituent of poor man's food and is used in times of food scarcity. The seeds contain protein, energy, carbohydrates, fat and fibre with small quantities of macro and micro minerals.

Tribal people through their traditional knowledge are thoroughly acquainted with the methods of excluding the harmful substances from cycas seeds and preparing acceptable recipes for their meagre meals. Cycas seeds are used in different traditional preparations in different parts of the world. Food items like eenthu kanji, pidy, puttu, idly, puzhukku and eenthu payasam are made out of cycas seeds. The food items are particularly prepared in heavy rainy season in Kerala. Syrup, beer, bread, pancakes, sweets, wine and several indigenous dishes can also be prepared using cycas seeds. Processed cycas seed flour is also used as a thickening agent in soups, puddings and porridges.

Though, cycas seed is used for home consumption, authentic information is not available on the use of cycas seed flour for product development and on the quality characterestics of the products. Hence, the present study, entitled **"Evaluation of cycas seed flour for product development"** was undertaken with the following objectives.

1. To evaluate the biochemical constituents and shelf life of processed cycas seed flour

2. To develop cycas seed flour supplemented products and to evaluate the nutritional and organoleptic qualities of the developed products

Review of literature

2. REVIEW OF LITERATURE

Cycads are cosmopolitan in distribution and are the most primitive seed plants found today. So they are known as living fossils. *Cycas circinalis* L. is a multi-use cycad endemic to Western Ghats of India. It is used as food as it is having significant nutritive value, containing medicinal, ceremonial and economic importance.

The interest of using cycas seeds in combination with other cereal sources to prepare products of improved nutritive quality is gaining importance.

The literature pertaining to the study has been reviewed under the following sub headings.

2.1. Importance of cycas seeds
2.2. Composition of cycas seeds
2.3. Processing of cycas seeds
2.4. Product development using cycas seeds

2.1. Importance of cycas seeds

The use of cycas seeds for medicinal purpose and as food for human consumption in different countries were indicated by Whiting (1963) and Hall (1987). The consumption of foods and medicine prepared from cycads has been recorded for many years (Harrison, 1966 and Spencer, 1990). According to Schneider *et al.* (2002) cycad plants are still traditionally favoured as food, delicacy and medicine. Lal (2003) also indicated the suitability of cycas seed for food and medicinal purposes.

Whiting (1963) indicated that the seeds and trunk of cycas palm serve as a source of food starch in many tropical and sub-tropical areas and is a reliable food reserve during periods of food shortage. The cycas seeds and nuts were used as food during droughts and

following devasting typhoons (Campbell *et al.*, 1966). Yang *et al.* (1966) suggested that the native population in Guam used the flour prepared from the seeds of *Cycas circinalis* for food.

Beaton (1977) reported the role of cycas seeds in the indigenous Australian diet. The importance of cycas as an Aboriginal plant food due to its relatively high yield and potential reliability was indicated by Beaton (1982).

Spencer *et al.* (1987) reported the use of cycad products as a source of edible starch. The cycas seeds represented a major source of food for the indigenous residents of Guam (Spencer, 1990). The author also indicated cycas as a famine food and considered it as a traditional delicacy. Bonta and Osborne (2003) indicated that the starch from cycas cones and cycas stem were widely consumed and indicated their role in supplementary traditional diet in times of scarcity, particularly when maize stores became depleted.

Pregnant women demanded sago palm seed flour preparations as part of their pregnancy cravings if they were in the habit of consuming it during their childhood days (Lal, 2003). Chang *et al.* (2004) indicated the use of cycas seeds as a major food source in some Western Pacific areas.

According to Cox (2004) cycas seeds played a role in the Australian diet and used by indigenous people as a reliable source of starch and as a famine food. Varghese and Ticktin (2006) indicated that *Cycas circinalis* fruits and young leaves are harvested by indigenous communities in the Nilgiri Biosphere Reserve, South India for food.

Krishnamurthy (2008) suggested the use of cycas seeds for food purposes. Saneesh (2009) indicated the use of steamed fruit of *Cycas circinalis* as a traditional food by many indigenous communities in the NBR, particularly those who have close access to wild populations.

Harrison (1966) reported the medicinal importance of cycas products and indicated its use in the form of beverages and tea, as purgatives and as pain depressants. Hall (1987) indicated the suitability of cycas in the treatment of hypertension, musculo skeletal disorders, gastro intestinal disturbances, cough and amenorrhoea in the traditional Chinese medicine. Spencer (1990) revealed the use of an oral aqueous steep prepared from 3-10g of cycas seed for the treatment of ailments such as diarrhoea, dysmenorrhoea, tuberculosis, neuralgia and to "strengthen the body". The author also indicated the use of cycas seeds as an ideal medicine for topical treatments of various skin lesions including open sores.

Lal (2003) indicated the medicinal uses of cycas seed especially in the treatment of piles and decoction prepared by boiling young cycas seeds as purgative. Chang *et al.* (2004) reported that cycas seeds were used to treat many disorders in traditional Chinese medicine and indicated that the male cones of cycas are harvested for medicinal use in ayurveda system of medicine.

Indigenous people harvest the leaves, seeds and bark for medicinal purpose and used cycads in proprietary drugs available in the market (Prathapan, 2006). Varghese and Ticktin (2006) indicated that the fruits of *Cycas circinalis* are heavily harvested and sold locally as medicine and also suggested the local residents of Kerala cook the flour and eat it for its medicinal qualities. Bissa *et al.* (2008) indicated the use of cycad plants for therapeutic purposes. Cycas seeds have medicinal properties like anti-tumerogenic, antimicrobial, purgative, hypoglycemic, abortificient, analgesic, anti-septic, anti-pyretic and anti-inflammatory (Latheef *et al.*, 2008). The authors also indicated its use in herbal therapy to cure a wide range of health problems.

Whiting (1963) indicated the use of cycads for ceremonial purposes. Bonta and Osborne (2003) reported the use of cycad leaves for catholic ceremonies such as the Day of the Cross and the Day of the Dead. Lal (2003) also emphasized the role of cycas in various religious and cultural activities of local population.

Varghese and Ticktin (2006) indicated the use of mature leaves of *C. circinalis* for making shelters for special rituals. Saneesh (2009) reported the use of mature leaves to decorate temples during festivals.

2.2. Composition of cycas seeds

The cycas seeds are made up of three components, the outer layer (sarcotesta) is fleshy, the adjacent layer within it (sclerotesta) is strong and within these lie the female gametophyte and the embryo, which together make up the starchy kernel (Harvey, 1945 and Spencer, 1990). The authors also indicated that the sarcotesta and the kernel are edible. According to Read and Solt (1986) the bulk of the cycas seed is embedded in a starchy endosperm containg the embryo. Norstog and Nicholls (1997) also indicated the cycas seed coat, which develops from the integument consist of three layers, the fine inner endotesta, the middle rigid sclerotesta and the outer, typically fleshy sarcotesta. Scleotesta and sarcotesta tissue of cycas seeds contain greater concentrations of sterols and steryl glycosides (Marler *et al.*, 2005 and Shaw *et al.*, 2006).

Australian cycas species have seeds with 2.5 to 4 cm in length (Harris, 1975). Spencer (1990) indicated that the cycas seeds are brightly coloured (red, brown, green) and has the appearance of an edible fruit. According to Hill (2000) cycas seeds have yellow, orange or brown fleshy outer sarcotesta, and with or without spongy tissue beneath the inner woody sclerotesta. Mature cycas seed is differentiated into an outer orange red coloured fleshy layer, stony middle layer and fleshy inner layer (Lal, 2003). Varghese and Ticktin (2006) indicated that cycas seeds are yellow or red globose up to 4 cm in length.

Cycads are rich in starch and were found to be suitable for the conversion of glucose (Spencer, 1990). Beck (1992) reported that fresh cycas seeds contain about 50 per cent water whereas aged seeds contain only 1-2 per cent water. The author also revealed that cycas seeds contain 5g protein and 583 to 1306 kilo joules of energy per 100g.

The nutritional constituents of cycas seeds were evaluated by Miller *et al.* (1993) and indicated that the seeds contain 5 - 8 per cent protein, 338 KJ of energy, 0.4 per cent fat and 28.1 per cent fibre with small quantities of macro and micro elements. The mineral constituents included 21 mg of calcium, 1 mg of copper, 4.6 mg of iron, 26 mg of magnesium, 66 mg of potassium, 5 mg of sodium and 1.2 mg of zinc per 100 g.

The nutritional aspect of the cycas palm is mainly centered on its stem and seeds (Lal, 2003). The author indicated cycas as one of the cheapest and most readily available source of food starch and as a major energy food for many populations. According to Tharakan (2007) starch derived from the powdered nuts of cycas palm was traditionally used as an important source of carbohydrates. Cycas starch in combination with protein sources like fish and nuts and vitamins from wild fruits, nourished the communities in under developed regions for many centuries (Lal, 2003).

Das *et al.* (2006) indicated the presence of bioflavanoids in cycas. Bissa *et al.* (2008) revealed the presence of glycosides, flavanoids and triterpenoids in *Cycas circinalis*.

There are some toxic principles in cycas palm which include a glycoside, cycasin and an amino acid β methyl amino L- alanine (BMAA) (Lal, 2003). The author also revealed the presence of other toxic glycosides macrozamin and neocycasin in cycas palm.

The cycas seeds are known to have cyanogenic potential due to the presence of toxic cyanogenic glycosides and indicated cycasin and neocycasin as the toxic factors in cycas seeds (Birdsley, 1972 and Chang *et al.*, 2004). The endosperm and the embryo of cycas seeds contain more toxins (Charlton *et al.*, 1992, Norstog and Nicholls, 1997).

Schneider *et al.* (2002) indicated that cycads produce a variety of secondary substances; most important of such allelochemicals are dimeric flavones, the nitrogen containing methyl azoxyglycosides, cycasin, macrozamin and several neocycasin.

According to Marler and Shaw (2009) azoxyglycosides, cycasin and macrozamin were more abundant in seed tissue than in leaf tissue.

The existence of a series of glycosides namely neocycasin A and B were observed in the cycas seeds by Nagahama *et al.* (1959) and Nishida *et al.* (1959). Azoxyglycoside was detected in the outer shells of *Cycas circinalis* nuts by Nagahama *et al.* (1964). The authors also detected macrozamin as the main glycoside and cycasin is rather a minor one in the green outer shells of the seeds. The presence of azoxyglycoside (AZG) content in seeds of various cycas were evaluated by DeLuca *et al.* (1980); Moretti *et al.* (1981); Yagi and Tadera, (1987) and Vovides *et al.* (1993) and revealed 0.01 per cent to 5 per cent AZG in cycads on fresh weight basis.

Vega and Bell (1967) identified a neurotoxic compound, a non protein amino acid BMAA, in cycads. Yagi and Tadera (1987) noticed azoxyglycosides, glycoside of MAM in cycadales plants and indicated cycasin and macrozamin as the major azoxyglycosides and neocycasin as the minor ones. Duncan *et al.* (1989) analysed the BMAA content of *Cycas circinalis* seeds and *Cycas revolta* seeds and indicated that *Cycas circinalis* seeds had higher BMAA content (1 mg/ g) when compared to *Cycas revolta* seeds (0.32 mg/ g).

Cycasin is a secondary metabolite present in cycad belonging to the azoxyglycoside group (Matsumoto and Strong, 1963; Whiting, 1963; Kobayashi and Matsumoto, 1965; Morgan and Hoffmann, 1983; Norstog and Nicholls, 1997; Jones, 2000). Nagahama (1964) reported that cycasin content of *Cycas circinalis* nuts was three to five times higher than that of *Cycas revolta* nuts. Campbell *et al.* (1966) indicated that the toxicity of the cycas nuts due to cycasin is related to their stage of maturity. The green nuts are more toxic than the ripe or brown coloured ones. Highest cycasin content was noticed in the cycas seed with both the gametophyte and embryo intact and indicated that freshly harvested seeds had 0.64 g cycasin per 100g of fresh gametophyte (Beck, 1992).

Cycasin was found in the seeds of *Cycas circinalis* L. a cycad indigenous to Guam (Nishida *et al.*, 1955 and Riggs, 1956). Matsumoto (1962) estimated 2 - 3 per cent cycasin in the nuts of *Cycas circinalis,* and Mickelsen (1962) detected 4 per cent cycasin level, while Kurland (1962) mentioned 3 - 6 per cent in Guam *Cycas circinalis.* Campbell *et al.* (1966) revealed 2 - 3 per cent cycasin in cycas seed flour. However Moretti *et al.* (1981) found 0.72 per cent cycasin in cycas seeds.

Methyl azoxy methanol (MAM) is produced from cycasin by the microbial β-glucosidase found in the gastro intestinal tract of animals (Laqueur, 1964). The active component namely aglycone MAM leads to acute toxicity and carcinogenicity (Kobayashi and Matsumoto, 1965; Laqueur, 1965; Laqueur and Matsumoto, 1966; Hirono *et al.*, 1970; Hooper, 1978).

Cycasin is a carcinogen and have recognized its profound effects on the central nervous system during embryonic and foetal development (Laqueur and Spatz, 1968). Incomplete detoxification of cycas seeds and the manifestations of toxicity range from a mild to severe gastroenteritis with evidence of liver injury and jaundice exhibited in some cases (Mugera, 1969 and Hooper, 1983).

Wink and Schimmer (1999) revealed that cycasin is cleaved in mammals to MAM, which causes acute intoxication as well as mutation and tumour initiation. Lal (2003) indicated that the active component of the glycoside in MAM, is known to be hepatotoxic and carcinogenic. The author indicated cycasin and its aglycone MAM impair human β cell function which may lead to death of pancreatic islets, leading to very high prevalence of glucose intolerance and diabetes mellitus. The general symptoms of the cycas toxicity include diarrhoea, headache, dizziness, vomiting and mortality. The teratogenic, mutagenic and carcinogenic properties of cycasin were indicated by Chang *et al.* (2004).

2.3. Processing of cycas seeds

Whiting (1963) indicated that by an elaborate process of soaking and sun drying, a high quality starch is obtained from the seeds and pith and indicated the washed and dried pieces of cycas seeds are usually ground and stored for later use in homes. Campbell *et al.* (1966) also indicated soaking and sun drying of cycas seeds as the effective processing methods for the preparation of flour. Fine quality starch can be extracted from the fibrous pulp by the process of cutting, soaking and drying (Harrison, 1966).

Cycas seeds are detoxified by a variety of processes which are all based on the fact that the toxin is water soluble (Tustin, 1974). Food processing of cyanogenic plants reduces their toxicity by the removal cyanogenic glycosides, inactivation of β glucosidase or a combination of both (Poulton, 1983).

Beck (1992) explained three methods for cycas processing which included brief leaching for 24 hours, prolonged leaching for more than 24 hours in still or running water, as well as ageing. Boiling the fruit four times and draining the water each time was also explained as one of the processing techniques for cycas fruit (Varghese and Ticktin, 2006). The authors also indicated smoking the seeds in a bamboo mat, dehusking and drying as the processing methods employed for cycas seeds. Leaching several times in cold water before preparing flour was the method suggested by Saneesh (2009).

The repeated washing and soaking for eight days through three changes of water was reported to be an effective method to remove the cycasin from the cycad nut (Keresztesy, 1962; Dastur, 1964; Palekar and Dastur, 1965). Campbell *et al.* (1966) indicated a decrease in the toxic constituents of cycas seeds by soaking and incubation in water, heating and storage. Ageing of dried cycas powder was also found to be an effective method to decrease toxicity (Campbell *et al.*, 1966). The authors also indicated that the toxic factor is labile to both moist and dry heat at 90°C and reported that dry heat is slightly more effective in destroying the toxin than the moist heat.

Dastur and Palekar (1966) revealed that prolonged boiling destroys cycasin by breaking the cell wall and exposing the enzyme which is then destroyed by heat. Yang *et al.* (1966) revealed prolonged soaking in water and subsequent drying in the sun to remove the toxic components from the cycad kernel. Spencer (1990) reported water leaching and roasting as the two methods used by Aboriginals to detoxify the cycas seeds.

Repeated leaching in water of gametophyte or pith fermentation was suggested as the detoxifying methods for cycas seeds (Hill and Osborne, 2001). Repeated washing of dried cycas seeds in cold water for at least seven times was suggested by Lal (2003) for the complete removal of toxins.

Though, the glycosides are heat stable, the endogenous β glucosidase is inactivated by boiling, roasting or frying the cyanogenic plants which removes cycasin (Chang *et al.*, 2004). The authors also explained that exposing the endogenous β glucosidase by grinding the seeds hydrolyse MAM, which can be eliminated by solution in water. Braceloux (2008) indicated that processing removes the cycasin in cycas by inactivating the enzyme β glucosidase or removal of the cyanogenic glycosides by exposure to β glucosidase.

Saneesh (2009) indicated that in Kerala, for processing, the cycas seeds are first halved and placed on raised platforms made of bamboo for smoking and stored for more than three years. The author also suggested two leaching methods applied to cycas seeds before preparing the flour. One is to keep the seeds in a bamboo basket or a jute sack in running water. The other method was to boil seeds in water more than three times. After leaching, the seeds were left to dry and then powdered.

2.4. Product development using cycas seeds

The use of starchy kernels of cycas in different traditional preparations in different parts of the world was indicated by Thieret (1958). The use of cycas fruits after boiling, steaming and fermentation for human consumption was indicated by Thieret (1962) and

Whiting (1962). The high quality starch obtained from the seeds after soaking and sun drying was considered as an important food during World war II (Whiting, 1963). The author also revealed the use of cycas seed flour as a thickening agent in soups, puddings and porridges.

Cycas flour was used as an ingredient in the cooked dishes of the Guamanian people (Campbell *et al.*, 1966). Meehan and Jones (1977) suggested the use of raw soaked kernels and roasted kernels as human food. The authors also indicated that the soaked seeds after grinding with water could also be used to prepare large loaves and consumed after baking. Levitt (1981) indicated the use of ground cycas nuts to prepare bread. White (1983) indicated the use of cycas seeds in the preparation of bread and 'ngathu'.

Tadera *et al.* (1987) reported that cycas seeds were utilized as starchy food in famine years and as raw materials of bean paste, "Miso". All cycas preparations were made up of naturally or artificially aged cycas seeds (Beck *et al.*, 1988). Spencer (1990) reported the use of cycas in the preparation of food, syrup and beer. Beck (1992) explained the preparation of cycas bread called "rarrak rarrak".

In New Guinea, processed cycas starch from a species of cycas was used to make a kind of cake or bread (Whitelock, 2002). The suitability of cycas seed flour in the preparation of bread, steam cakes, sweets, wine and several indigenous dishes was indicated by Lal (2003).

Saneesh and Varghese (2007) reported that forest gathers relish *eentha* seeds and they make pancakes with the processed flour. Saneesh (2009) indicated the use of cycas seed flour in the preparation of steamed cake, pidy, idly, baby food and puzhukku. Steam cake, locally known as puttu was prepared using powdered *Cycas circinalis* L. seed flour (Binu, 2010). The author also indicated that the tribals relish cycas seeds after frying.

White (1983) indicated that the aged cycas seeds have been more commonly eaten than preparations of fresh seeds. The author also explained two methods of preparing fresh cycas seeds. The most common method involved the extraction of the kernels from the sarcotesta and roughly crushing them. The crushed material is leached in running water in Pandanus fibre bag for about a week, then ground into a paste, wrapped in paper bark and roasted in ashes for thirty minutes to one hour to prepare "ngathu". The other method of preparing fresh cycas seeds was the use of hammer stone for the preparation of cycas bread.

Beck (1992) suggested that the aged cycas seeds can be eaten as raw after careful selection, leaching in still water for five months or baking into loaves and cooking either in a dish of leaves or directly on the coals. The final product after baking was a black coloured bread with good shelf life. The author also indicated that after prolonged leaching, the cracked seeds were taken and the kernels flattened into paste on grindstone. The final cake was cooked in ashes for five to eight minutes, and then lightly beaten with a stone just prior to consumption. The author also explained that the entire kernels can be rolled in hot sand mixed with charcoal and then placed in a bag with more charcoal. This bag was dried in the sun for several days and then leached in running water. After four days, the kernels were removed from the water and pounded into a long cake and roasted. This procedure resulted in a bread of different taste and texture to that of other methods. Saneesh (2009) indicated that cycas seed flour prepared after processing can be used for the preparation of pidy and porridges.

Materials and Methods

3. MATERIALS AND METHODS

The materials used and the methods followed for the study entitled "Evaluation of cycas seed flour for product development" are given under the following headings.

3.1. Collection of ingredients

3.2. Preparation of cycas seed flour

3.3. Analysis of chemical constituents of cycas seed flour

3.4. Microbial enumeration and assessment of insect infestation of cycas seed flour

3.5. Organoleptic evaluation of the products prepared using cycas seed flour

3.6. Computation of nutritive value of the products

3.7. Statistical analysis

3.1. Collection of ingredients

Cycas seeds and other ingredients required for the study were procured from the market. Cycas seeds selected for the study are shown in Plate 1.

3.2. Preparation of cycas seed flour

The cycas seed flour was prepared as suggested by Lal (2003). The procured cycas seeds were washed thoroughly in water and were sun dried for two days. The dried seeds were soaked in cold water for six hours, stirred well and drained off the foamy water. This washing process was repeated for seven times. After this, the seeds were sun dried for half an hour and powdered in a mixer. The prepared flour was again dried in a cabinet drier at 60 ± 5°C till the flour attained a moisture content of 10-12 per cent. Then, the dried flour was filled in glass bottles and stored for a period of three months under ambient conditions.

3.3. Analysis of chemical constituents of cycas seed flour

The following chemical constituents in the cycas seed flour were analysed initially and at the end of three months of storage. All analysis were carried out in triplicate samples.

Plate 1. Cycas seeds selected for the study

3.3.1. Moisture

Moisture content of the cycas seed flour was estimated using the method suggested by A.O.A.C (1980). To determine the moisture content, five grams of cycas seed flour was taken in a petridish and dried in a hot air oven at 60 to 70°C, cooled in a desiccator and weighed. The process of heating and cooling were repeated until constant weight was achieved. The moisture content was calculated from the loss in weight during drying and expressed in g $100g^{-1}$ of sample.

3.3.2. Protein

Protein content of cycas seed flour was estimated using the method of A.O.A.C (1980). Sample (0.2 g) was digested with 10 ml conc. H_2SO_4 after adding 0.4 g of $CuSO_4$ and 3.5 g K_2SO_4 in a digestion flask until the colour of the sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. This distillate was collected in 20 per cent boric acid containing mixed indicators and then titrated with 0.2N HCl. The nitrogen content obtained was multiplied with a factor of 6.25 to get the protein content and expressed in g $100g^{-1}$ of the sample.

3.3.3. Starch

The starch content was estimated colourimetrically using anthrone reagent (Sadasivam and Manickam, 1992). The sample (0.1 g) was extracted repeatedly with 80 per cent ethanol to remove sugars completely. The residue was dried over a water-bath and 5 ml of water and 6.5 ml of 52 per cent perchloric acid were added and extracted at 0°C for 20 minutes. The supernatant was pooled and made upto 100 ml. Pipetted 0.1 ml of the supernatant and made up to 1 ml with water and 4 ml of anthrone reagent was added, heated for 8 minutes, cooled and read the OD at 630 nm in spectrophotometer.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was computed and multiplied by a factor of 0.9 to arrive the starch content and expressed in g $100g^{-1}$ of the sample.

3.3.4. Total carbohydrate

The total carbohydrate content was analysed colourimetrically using anthrone reagent (Sadasivam and Manickam, 1992). The sample (0.1 g) was hydrolysed with 5 ml of 2.5 N HCl and then cooled to room temperature. The residue was then neutralised with solid sodium carbonate until the effervescence ceases. Made up the volume to 100 ml and centrifuged. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for 8 minutes, cooled rapidly and the intensity of green to dark green colour was read at 630 nm.

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

3.3.5. Crude fibre

The fibre content was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978). Two grams of sample was boiled with 200 ml of 1.25 per cent H_2SO_4 for 30 minutes. It was filtered through a muslin cloth and washed with boiling water. The residue was again boiled with 200 ml of 1.25 per cent NaOH for 30 minutes. Repeated the filtration through a muslin cloth and the residue was washed with 1.25 per cent H_2SO_4, water and alcohol. The residue was transferred to a pre-weighed ashing dish, dried, cooled and weighed. The residue was then ignited in a muffle furnace at 600°C for 30 minutes, cooled in a desiccator and reweighed. The crude fibre content of the sample was calculated from the loss in weight on ignition and expressed in g $100g^{-1}$ of the sample.

3.3.6. Fat

The fat content of cycas seed flour was estimated using the method of A.O.A.C (1955). Two grams of cycas seed flour was taken in a thimble and plugged with cotton. The material was extracted with petroleum ether for 6 hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled, and ether was removed by heating and then the weight was taken. The fat content was expressed in g $100g^{-1}$ of the sample.

3.3.7. Calcium

The calcium content of the sample was estimated by atomic absorption spectro photometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982). The diacid was prepared by mixing 70 per cent nitric acid and 70 per cent perchloric acid in the ratio of 9:4. One gram of sample was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer and calcium content was expressed in mg $100g^{-1}$ of the sample.

3.3.8. Iron

The iron content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982). The prepared diacid extract was directly read in atomic absorption spectrophotometer. The iron content was expressed in mg $100g^{-1}$ of the sample.

3.3.9. Phosphorous

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

A standard graph was prepared using the serial dilution of standard phosphorous solution. The phosphorous content of the sample was estimated from the standard graph and expressed in mg $100g^{-1}$ of the sample.

3.3.10. Sodium

The sodium content was estimated using flame photometer as suggested by Jackson (1973). The diacid solution prepared was directly fed in the flame photometer and sodium content was expressed in mg$100g^{-1}$ of the sample.

3.3.11. Potassium

The potassium content was estimated by using flame photometer as suggested by Jackson (1973). The diacid solution was read directly in flame photometer and potassium content was expressed in mg $100g^{-1}$ of the sample.

3.3.12. Crude alkaloid

The crude alkaloid content of the sample was analysed using a simple spectrophotometric method based on the reaction with bromocresol green as suggested by Shamsa *et al.* (2008). Ten grams of sample was extracted with methanol for 24 hours in a shaker. The extract was filtered and methanol was evaporated in a water-bath at a temperature of 45°C to dryness. A part of this residue was dissolved in 2 N HCl and then filtered. One ml of this solution was transferred to a separatory funnel and washed with 10 ml chloroform (3 times). The pH of this solution was adjusted to neutral with 0.1 N NaOH. Then, 5 ml of bromocresol green solution and 5 ml of phosphate buffer were added to this solution. The mixture was shaken and the complex formed was extracted with 1, 2, 3 and 4 ml chloroform by vigorous shaking. The extracts were collected in a 10 ml volumetric flask and diluted to volume with chloroform. The absorbance of the complex in chloroform was measured at 470 nm.

A standard curve was drawn using atropine standard solution. The absorbance of the complex in chloroform was measured at 470 nm against blank prepared but without atropine. The crude alkaloid content was expressed in mg $100g^{-1}$ of the sample.

3.3.13. Hydrocyanic acid

The hydrocyanic acid content of the cycas seeds was estimated by the method suggested by Sadasivam and Manickam (1992). One gram of sample was homogenised in 25 ml water with 3-4 drops of chloroform and the homogenate was placed in 500 ml conical flask. A filter paper cut into strips of 10-12 cm long and 0.5 cm wide was saturated with alkaline picrate solution. The saturated filter paper was placed in the conical flask in hanging position with the help of the cork stopper and incubated at 20°C for 24 hours. Then, the filter paper was placed in a test tube containing 10 ml distilled water to elute the colour and absorbance was measured at 625 nm. Potassium cyanide was used as the standard.

3.3.14. Cycasin

The cycasin content of the cycas seeds was estimated by the method suggested by Yagi *et al.* (1983). One gram of cycas seed flour was taken and extracted with 70 per cent ethanol. The extract was diluted four times with water and 10 µl of an aqueous solution of sulfosalicylic acid (250 mg/ml) was further added. After standing for 10 min at 0° C, the sample was passed through a membrane filter. A portion (10 to 30 µl) of the filtrate was applied to column for chromatography. The absorbance of the effluent was recorded at 215 nm. Methyl β-D glucopyranoside was used as the standard.

3.4. Microbial enumeration and assessment of insect infestation of cycas seed flour

The total microbes of cycas seed flour was enumerated initially and after a period of three months. The method used for evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). One gram sample was added to 9 ml sterile water and agitated for 20 minutes. One ml of this solution was transferred to a test tube

containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} dilution was also prepared.

Enumeration of total microbial count was carried out using different nutrient media purchased from Himedia, Mumbai. For bacteria, nutrient agar media (NA), for fungus, potato dextrose agar media (PDA) and for yeast, sabouraud's dextrose agar media (SDA) were used. The dilution used for bacteria was 10^{-5} and for fungi and yeast 10^{-3} dilution were used.

Presence of storage insects was assessed by examining cycas seed flour under the microscope. Flour was sieved first with 60 BL sieve and followed by 100 BL sieve and observed under microscope.

3.5. Organoleptic evaluation of the products prepared using cycas seed flour

3.5.1. Preparation of standard products

To find out the feasibility of incorporating cycas seed flour in common products, such as puttu, ada, pathiri, biscuit and chapathi were prepared using standard procedures. In these products the main ingredient commonly used was taken as the control and the products were prepared by incorporating cycas seed flour along with main ingredient in different proportions. All the items were also prepared exclusively with cycas seed flour. Rice flour was used as the main ingredient in puttu, ada and pathiri whereas for biscuit and chapathi, maida and wheat flour respectively were used as the main ingredients. The procedures adopted to prepare standard products are given in 3.5.1.1. to 3.5.1.5.

3.5.1.1. Puttu

Ingredients

Roasted rice flour – 50 g

Coconut (scraped) – 15 g

Salt – to taste

Number of pieces of puttu – 2 no.

Procedure

Rice was soaked in cold water for 4 to 6 hours and water was drained. Then, soaked rice was spread over a clean cloth to remove excess water. Rice was powdered and sieved using a medium fine sieve and roasted slightly.

After cooling, flour was moistened by sprinkling salt water and lumps formed were crushed. Moistened flour and scraped coconut were filled in puttu maker in alternate layers and steamed for 5 to 7 minutes (Pasricha and Rebello, 1989).

3.5.1.2. Ada

Ingredients

Roasted rice flour – 50 g
Sugar - 20 g
Grated coconut – 20 g
Cardamom - 1 no.
Salt - as required
Water – as required
Number of ada – 2 nos.

Procedure

Rice was soaked in cold water for 5 hours and water was drained. Then, soaked rice was spread over a clean cloth to remove excess water. Rice was powdered and sieved using a fine mesh sieve and roasted nicely.

Sugar and cardamom were added into grated coconut and mixed well. Boiled water was added to roasted rice flour. Salt was added to taste. This was stirred well to make a thick dough. A thin uniform layer of this was spread on a banana leaf. The sugar-coconut mix was spread above it. Then, the leaf was folded and cooked by steaming (Vargheese, 2008).

3.5.1.3. Pathiri

Ingredients

Roasted rice flour - 100 g
Water – as required
Salt - as required
Number of pathiri – 6 nos.

Procedure

The rice flour was prepared as explained in 3.4.1.2. Water was boiled in a pan. Roasted rice flour was slowly added into the pan in simmering flame and stirred well to avoid the formation of lumps. After removing from fire the dough was kneaded well and made into small balls. They were flattened into circular shape and rice flour was smeared during the process. It was cooked in an iron pan (Vargheese, 2008).

3.5.1.4. Biscuit

Ingredients

Maida – 50 g
Powdered sugar – 30 g
Butter – 25 g
Salt – a pinch
Baking powder – a pinch
Vanilla essence – 2 to 3 drops
Number of biscuits – 12 nos.

Procedure

Maida, salt and baking powder were mixed together and sieved twice in a fine mesh sieve. Sugar and butter were creamed together and folded with sieved ingredients and

rolled. Cut the biscuit using a mould and baked at 218°C for 25 minutes. (Pasricha and Rebello, 1989).

3.5.1.5. Chapathi

Ingredients

Wheat flour – 75 g
Ghee – 7.5 g
Salt – to taste
Water – 60 ml
Number of chapathi – 3 nos.

Procedure

Dough was prepared with wheat flour by sprinkling salt water to it. Then, the dough was divided into three balls and rolled into chapathi. Little ghee was applied and folded into a circular shape and rolled again. It was placed on a hot tawa and both the sides were cooked by applying small quantity of ghee. (Pasricha and Rebello, 1977).

3.5.2. Preparation of products incorporating cycas seed flour

Puttu, ada, pathiri, biscuit and chapathi were prepared by incorporating cycas seed flour at different levels and exclusively with cycas seed flour also. The products explained in 3.5.1.1. to 3.5.1.5. were taken as control. The treatments adopted for preparation of products are given in Table 1.

3.5.3. Selection of judges

A series of organoleptic trials were carried out using simple triangle test at laboratory level to select a panel of 10 judges between the age group of 18 – 35 years as suggested by Jellinek (1985).

Table 1. Percentage of flour used for the preparation of products

Treatments	Percentage of main ingredients (rice flour, maida, wheat flour)	Percentage of cycas seed flour
T_1	100	–
T_2	–	100
T_3	70	30
T_4	60	40
T_5	50	50
T_6	40	60
T_7	30	70

Design – CRD

Treatment – 7

Replication – 3

All the treatments were prepared using the procedures given in 3.5.1.1 to 3.5.1.5. Cycas seed flour for puttu, ada and pathiri was used after roasting.

3.5.4. Preparation of score card

The sensory evaluation of the products was carried out using score card method (Swaminathan, 1974). Score card containing six quality attributes such as appearance, colour, flavour, taste, texture and over all acceptability was prepared in a nine point hedonic scale for the evaluation of products. The score card used for the evaluation of products is given in Appendix I.

3.5.5. Organoleptic evaluation of the products

The organoleptic evaluation of the products was carried out in the morning time by the selected panel of ten judges using the score card containing nine point hedonic scale.

3.6. Computation of nutritive value of the products

Protein, energy, crude fibre, fat, calcium, iron and phosphorous content of the five products were computed using the nutritive value of cycas seed flour obtained from the present study. The nutritive value of other ingredients was taken from food composition table suggested by Gopalan *et al.*, (1989). The nutrients present in different treatments were expressed per serving and the percentage of RDA met was computed.

3.7. Statistical Analysis

The observations recorded were tabulated and the data were analysed statistically using 't' test. For organoleptic evaluation, Kendall's coefficient of concordance (W) was used to assess the degree of agreement among the judges. Percentage relative increase was calculated for the enumeration of microbes.

Result

4. RESULT

The results pertaining to the study entitled "Evaluation of cycas seed flour for product development" are presented in this section under the following headings.

4.1. Chemical constituents of cycas seed flour during storage

4.2. Enumeration of microbial population and insect infestation of cycas seed flour during storage

4.3. Organoleptic evaluation of products prepared using cycas seed flour

4.4. Computation of nutritive value of products

4.1. Chemical constituents of cycas seed flour during storage

The chemical constituents of cycas seed flour was estimated initially and after three months of storage. The constituents like moisture, protein, starch, total carbohydrates, crude fibre, fat, calcium, phosphorous, sodium, potassium and iron were estimated. The antinutritional/ toxic factors in the flour such as crude alkaloids, cycasin and hydrocyanic acid were also analysed. The different chemical constituents of cycas seed flour and changes in the chemical constituents during storage are presented in Table 2.

4.1.1. Moisture

The initial moisture content of cycas seed flour was found to be 11.03 g $100g^{-1}$ which decreased to 7.83 g $100g^{-1}$ after three months of storage. Statistical analysis was not performed for moisture, because the standard error of the difference was zero.

4.1.2. Protein

The protein content of cycas seed flour was found to be 9.43 g $100g^{-1}$ initially which decreased to 8.97 g $100g^{-1}$ after three months of storage and the decrease in the protein content after storage was found to be statistically insignificant.

Table 2. Chemical composition of cycas seed flour during storage (Per 100g)

Constituents	Initial	Final	t value
Moisture (g)	11.03 ± 0.145	7.83 ± 0.145	—
Protein (g)	9.43 ± 0.220	8.97 ± 0.114	1.893
Starch (g)	24.20 ± 0.476	16.85 ± 1.003	4.967*
Total Carbohydrates (g)	59.22 ± 0.617	47.11 ± 0.799	12.77*
Crude fibre (g)	2.57 ± 0.033	2.16 ± 0.095	5.856*
Fat (g)	5.05 ± 0.053	2.60 ± 0.053	45.875*
Calcium (mg)	21.33 ± 0.764	21.06 ± 0.216	0.290
Phosphorous (mg)	0	0	0
Sodium (mg)	6.20 ± 0.200	6.20 ± 0.100	0
Potassium (mg)	25.53 ± 0.233	24.63 ± 0.202	2.162
Iron (mg)	0.25 ± 0.058	0.23 ± 0.030	0.194
Crude alkaloid (mg)	0.53 ± 0.017	0.44 ± 0.009	4.768*
Hydrocyanic acid (□g)	0	0	0

* Significant at 5% level

4.1.3. Starch

The fresh cycas seed flour had a starch content of 24.20 g $100g^{-1}$ which decreased to 16.85 g $100g^{-1}$ after three months of storage. A significant decrease was observed in the starch content of cycas seed flour at the end of storage.

4.1.4. Total carbohydrates

The total carbohydrate content of fresh cycas seed flour was found to be 59.22 g $100g^{-1}$ which decreased during the third month of storage. The total carbohydrate content was found to be 47.11 g $100g^{-1}$ after third month of storage. The decrease observed in the carbohydrate content of cycas seed flour was found to be statistically significant.

4.1.5. Crude fibre

The crude fibre content of the fresh flour was found to be 2.57 g $100g^{-1}$ which decreased to 2.16 g $100g^{-1}$ after three months of storage. The decrease was found to be statistically significant.

4.1.6. Fat

The cycas seed flour had a fat content of 5.05 g $100g^{-1}$ initially and 2.60 g $100g^{-1}$ at the end of storage. When analysed statistically the decrease in the fat content was found to be significant.

The effect of storage on the moisture, protein, starch, total carbohytdrate, crude fibre and fat content of cycas seed flour are illustrated in Fig.1.

4.1.7. Calcium

The initial calcium content of cycas seed flour was found to be 21.33 mg $100g^{-1}$ and after storage the calcium content was found to be 21.06 mg $100g^{-1}$. The decrease was found to be statistically insignificant.

4.1.8. Phosphorous

Phosphorous content was found to be '0' in the cycas seed flour.

4.1.9. Sodium

The cycas seed flour had a sodium content of 6.20 mg $100g^{-1}$ initially and after three months of storage.

4.1.10. Potassium

The initial potassium content of cycas seed flour was found to be 25.53 mg $100g^{-1}$. After three months of storage, the potassium content decreased slightly to 24.63 mg $100g^{-1}$ and the decrease was found to be statistically insignificant.

4.1.11. Iron

The iron content of the fresh cycas seed flour was found to be 0.25 mg $100g^{-1}$ which gradually decreased during storage. By the end of third month of storage, the iron content of the flour reduced to 0.23 mg $100g^{-1}$ and the decrease was found to be statistically insignificant.

The effect of storage on the mineral constituents of cycas seed flour is presented in Fig.2.

4.1.12. Crude alkaloid

The cycas seed flour had a crude alkaloid content of 0.53 mg $100g^{-1}$ initially and 0.44 mg $100g^{-1}$ at the end of storage. When analysed statistically the decrease in the crude alkaloid content was found to be significant.

4.1.13. Hydrocyanic acid

Hydrocyanic acid was not present in cycas seed flour

4.1.14. Cycasin

Cycasin content in the cycas flour was determined by following the procedure as detailed in 3.3.14. The cycasin content could not be estimated using Methyl β-D glucopyranoside as standard.

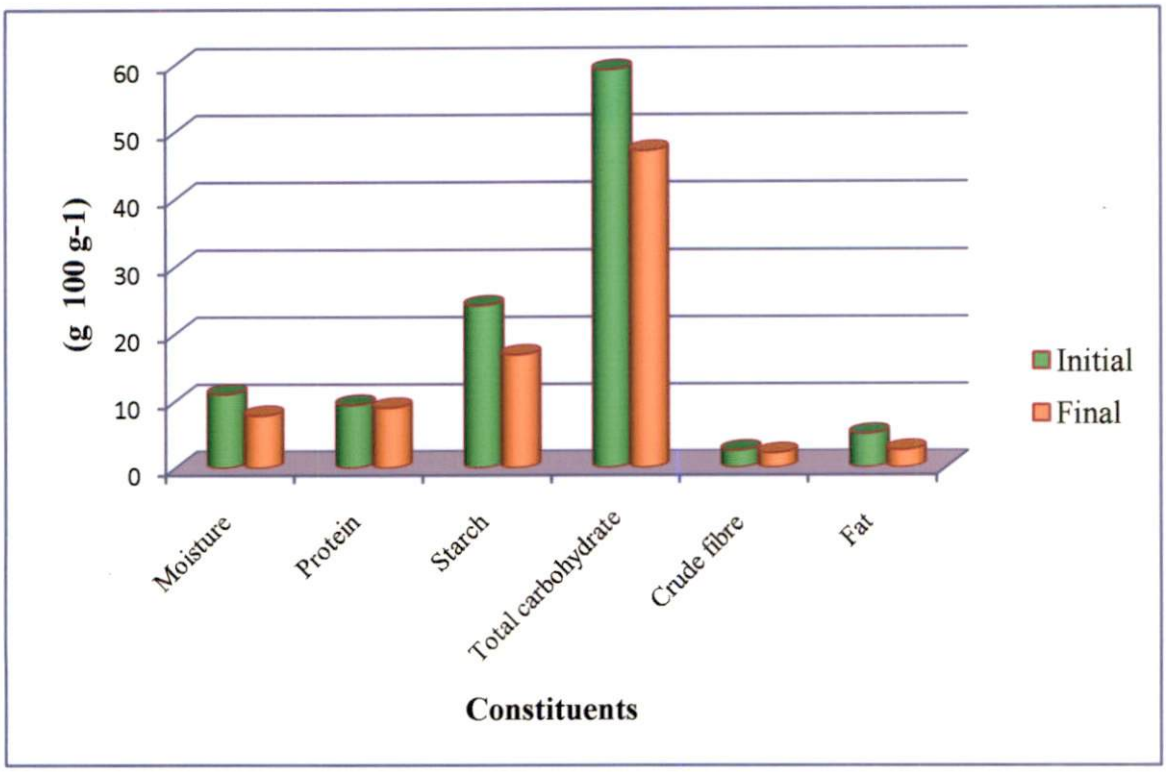


Fig.1. Effect of storage on the moisture, protein, starch, total carbohytdrate, crude fibre and fat content of cycas seed flour

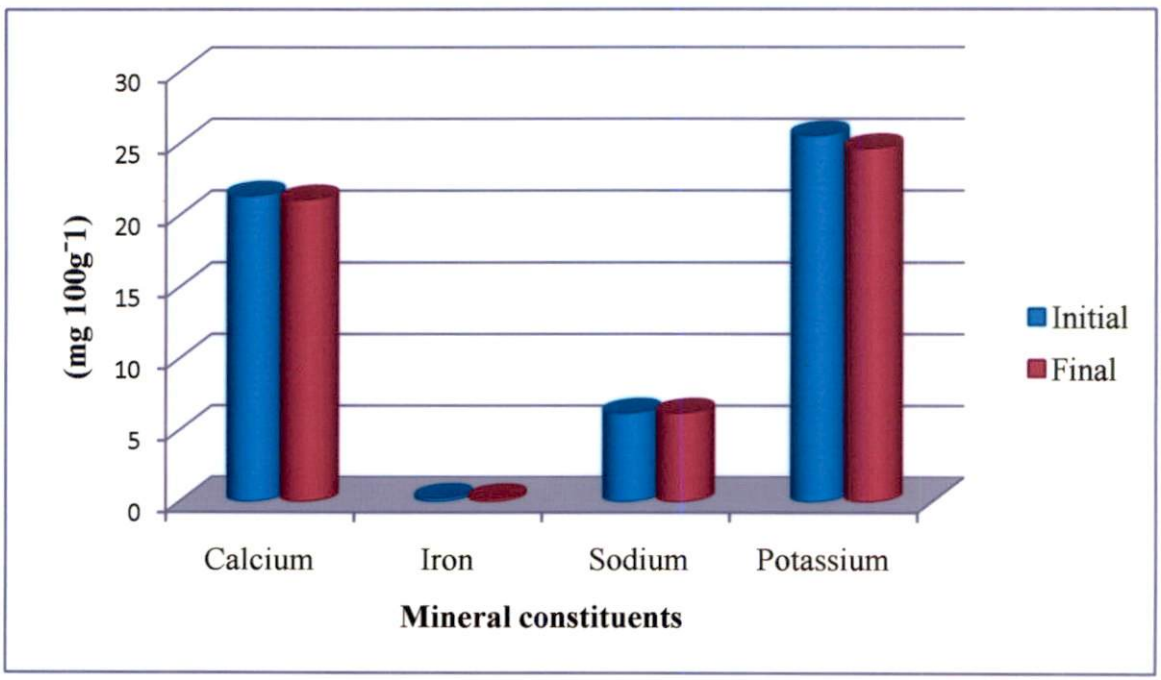


Fig.2. Effect of storage on the mineral constituents of cycas seed flour

4.2. Enumeration of microbial population and insect infestation of cycas seed flour during storage

4.2.1. Mean microbial count of cycas seed flour during stoage

The cycas seed flour was evaluated for bacteria, fungi and yeast initially and after three months of storage and results pertaining to microbial enumeration are presented in Table 3.

Table 3. Mean microbial count of cycas seed flour during storage

Microbial population (cfu g^{-1})	Initial	Final	Percentage relative increase
Bacteria (x 10^5)	3.44 x 10^5	4.44 x 10^5	29.07
Fungus (x 10^3)	3.33 x 10^3	4.55 x 10^3	36.64
Yeast (x 10^3)	3.22 x 10^3	3.99 x 10^3	23.91

The initial bacterial load in cycas seed flour was found to be 3.44 x 10^5 cfu g^{-1} which increased to 4.44 x 10^5 cfu g^{-1} after three months of storage. The percentage relative increase of bacterial count was observed to be 29.07 per cent.

The initial fungal growth was found to be 3.33 x 10^3 cfu g^{-1} initially and it increased to 4.55 x 10^3 cfu g^{-1} at the end of storage. About 36.64 per cent relative increase was noticed in fungal count.

The initial yeast growth in cycas seed flour was found to be 3.22 x 10^3 cfu g^{-1} which increased to 3.99 x 10^3 cfu g^{-1} during storage. The percentage relative increase of yeast count was found to be 23.91 per cent.

The effect of storage on the microbial count of cycas seed flour is presented in Fig.3.

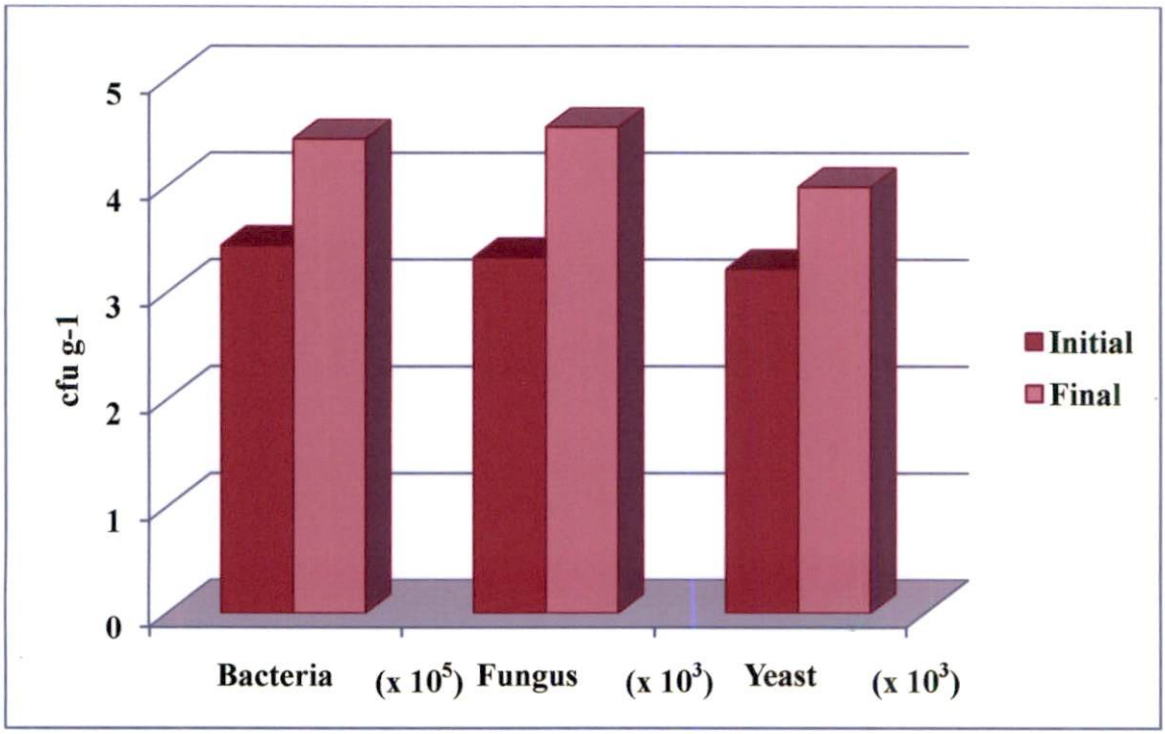


Fig.3. Effect of storage on the microbial count of cycas seed flour

4.2.2. Insect infestation of cycas seed flour during storage

Insect infestation in cycas seed flour was also evaluated initially and at the end of three months of storage and insect infestation was not detected under both stages.

4.3. Organoleptic evaluation of products prepared using cycas seed flour

Five different products namely puttu, ada, pathiri, biscuit and chapathi were prepared incorporating cycas seed flour in different proportions along with the main ingredient for respective products and were evaluated organoleptically for different quality attributes like appearance, colour, texture, flavour, taste and overall acceptability using score card. Each treatment was ranked for all these quality attributes based on mean rank scores using Kendall's (W) test. The results of the organoleptic evaluation of different products are presented in this section.

4.3.1. Puttu

The mean scores obtained for the different quality attributes of puttu prepared using different combinations of rice flour and cycas seed flour are given in Table 4.

The mean score for appearance of puttu varied from 8.00 to 8.50 with a mean rank score in the range of 3.55 to 4.92. Puttu prepared exclusively with rice flour (T_1) had a maximum score of 8.50 and the highest mean rank score of 4.92. The mean scores obtained for appearance of puttu prepared with different proportions of rice flour and cycas seed flour were found to be 8.27 (T_3), 8.13 (T_4 & T_5) and 8.00 (T_6 &T_7). The mean rank scores of the above treatments were 4.23, 3.95, 3.92, 3.55 and 3.57 respectively. Puttu prepared with 100 per cent cycas seed flour obtained a mean score of 8.10 and rank score of 3.87.

Among the different treatments, puttu prepared with 100 per cent rice flour obtained the highest mean score (8.47) and mean rank score (4.57) for colour. The mean score of puttu prepared with 100 per cent cycas seed flour was found to be 8.27 with a mean rank

score of 4.18. The mean score of puttu prepared with rice flour and cycas seed flour in different proportions varied from 7.97 (T_6) to 8.33 (T_4 &T_5) with a mean rank score in the range of 3.27 to 4.37.

The mean score for texture and flavour of puttu prepared with 100 per cent rice flour was found to be 8.57 and 8.33 respectively. Puttu prepared with 100 per cent cycas seed flour obtained a mean score of 7.50 for texture and 7.63 for flavour. The mean scores for texture of puttu was found to be 8.13 (T_3), 7.93 (T_4), 8.57 (T_5), 7.80 (T_6) and 7.77 (T_7). For flavour the scores obtained for these treatments were 8.13 (T_3), 7.70 (T_4), 7.97 (T_5), 7.80 (T_6) and 7.73 (T_7). The mean rank scores on the basis of Kendall's co-efficient of variation with respect to texture and flavour for puttu prepared with 100 per cent rice flour was found to be 5.30 and 5.05 respectively. The mean rank scores of puttu prepared with different proportions of rice flour and cycas seed flour varied from 2.68 to 5.33 for texture and 3.23 to 4.67 for flavour.

Mean score for taste was found to be high (8.60) for the puttu prepared with equal proportions of rice flour and cycas seed flour followed by T_1 (8.50), T_3 (8.47), T_4 (8.30), T_6 (8.03), T_7 (7.77) and T_2 (7.67). The mean rank scores were 4.63 (T_1), 2.67 (T_2), 4.73 (T_3), 4.38 (T_4), 5.23 (T_5), 3.57 (T_6) and 2.78 (T_7).

The overall acceptability of puttu was high for T_5 (8.57) which was prepared with equal proportions of rice flour and cycas seed flour. The overall acceptability of puttu prepared exclusively with cycas seed flour was found to be 7.70 with a rank score of 2.68. Puttu prepared with rice flour obtained a mean and rank scores of 8.53 and 4.82 respectively for overall acceptability. The mean scores obtained for T_3, T_4, T_6 and T_7 were found to be 8.37, 8.30, 7.97 and 7.93 with a rank score of 4.38, 4.37, 3.27 and 3.28.

Based on Kendall's (W) value, the agreement among the judges in the evaluation of organoleptic qualities like appearance, colour, texture, flavour, taste and overall acceptability of puttu was found to be statistically significant.

The organoleptic scores of different quality attributes of puttu are given in Fig.4. Puttu prepared with different proportions of rice flour and cycas seed flour is depicted in Plate 2.

4.3.2. Ada

The mean and rank scores obtained for the organoleptic evaluation of ada prepared with different proportions of roasted rice flour and cycas seed flour are given in Table 5.

As revealed in the Table, the mean score for appearance of ada prepared using seven treatments varied from 7.80 to 8.50 with mean rank scores in between 2.70 to 4.77. The highest mean score of 8.50 was obtained in T_1 and T_3 with the rank scores of 4.77 and 4.68 respectively. Ada prepared with 100 per cent cycas seed flour obtained the lowest mean (7.80) and rank scores (2.70). The mean scores for T_4, T_5, T_6 and T_7 were found to be 8.40, 8.33, 8.06 and 8.20 respectively with the rank scores of 4.33, 4.25, 3.38 and 3.88 respectively.

Among the different treatments, ada made exclusively with rice flour (T_1) obtained the highest mean (8.53) and rank scores (5.08) for colour, followed by T_3 (8.50), T_5 (8.17), T_4 & T_7 (8.10), T_6 (8.00) and T_2 (7.67). The mean rank scores of colour were found to be 2.75, 4.98, 3.80, 4.02, 3.52 and 3.85 respectively for T_2, T_3, T_4, T_5, T_6 and T_7.

For texture, ada prepared with rice flour and cycas seed flour in the ratio of 70:30 (T_3), and ada prepared exclusively with rice flour (T_1) obtained the maximum mean score of 8.33 followed by T_5 (8.23), T_4 (8.06), T_6 (7.80) and T_7 (7.73). The mean and rank scores of ada made with 100 per cent cycas seed flour were found to be 7.57 and 2.80 respectively.

The mean score for flavour and taste of ada prepared with 100 per cent rice flour was found to be 8.43 and 8.63 respectively. Ada prepared with 100 per cent cycas seed flour had a mean score of 7.50 for flavour and 7.43 for taste. The mean scores for flavour of

Table 4. Mean scores for different quality attributes of puttu

Treatments	Characters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
T_1	8.50 (4.92)	8.47 (4.57)	8.57 (5.30)	8.33 (5.05)	8.50 (4.63)	8.53 (4.82)
T_2	8.10 (3.87)	8.27 (4.18)	7.50 (2.68)	7.63 (3.23)	7.67 (2.67)	7.70 (2.68)
T_3	8.27 (4.23)	8.20 (3.78)	8.13 (4.13)	8.13 (4.67)	8.47 (4.73)	8.37 (4.38)
T_4	8.13 (3.95)	8.33 (4.37)	7.93 (3.77)	7.70 (3.47)	8.30 (4.38)	8.30 (4.37)
T_5	8.13 (3.92)	8.33 (4.37)	8.57 (5.33)	7.97 (4.18)	8.60 (5.23)	8.57 (5.20)
T_6	8.00 (3.55)	7.97 (3.27)	7.80 (3.37)	7.80 (3.78)	8.03 (3.57)	7.97 (3.27)
T_7	8.00 (3.57)	8.03 (3.47)	7.77 (3.42)	7.73 (3.62)	7.77 (2.78)	7.93 (3.28)
Kendall's (W) value	0.090**	0.081**	0.287**	0.145**	0.287**	0.251**

Figures in parenthesis indicate mean rank scores ** Significant at 1% level

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

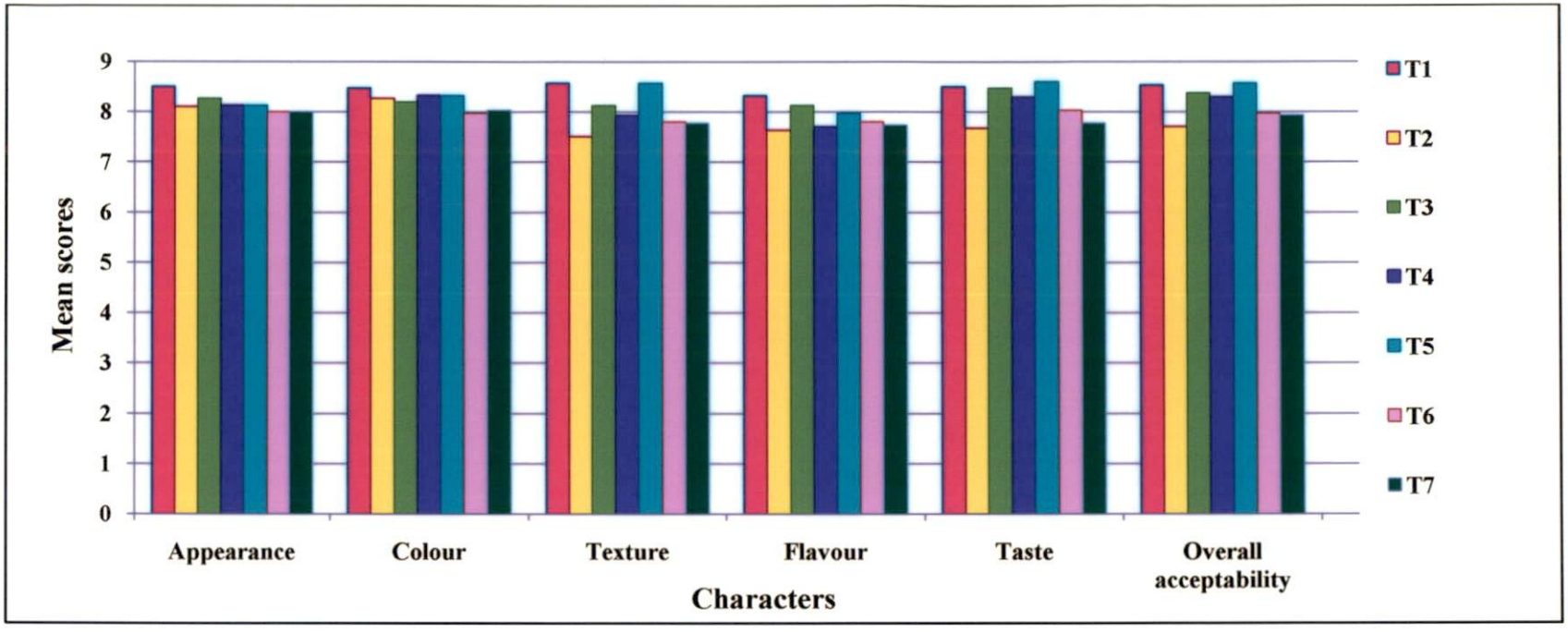


Fig. 4. Organoleptic scores obtained for different quality attributes of puttu

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

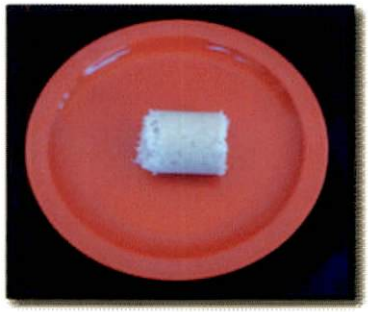
T_7 - 30% rice flour + 70% cycas seed flour

T_1 - 100% RF

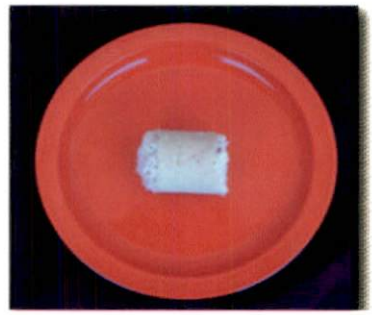
T_2 - 100% CF

T_3 - 70% RF + 30% CF

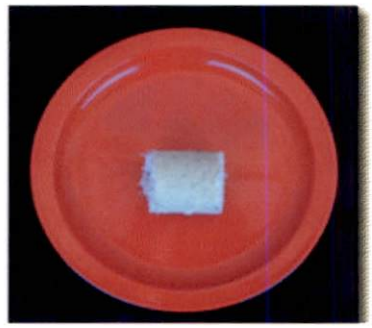
T_4 - 60% RF + 40% CF



T_5 - 50% RF + 50% CF



T_6 - 40% RF + 60% CF



T_7 - 30% RF + 70% CF

Plate 2. Puttu prepared by different proportions of rice flour and cycas seed flour

RF-Rice flour CF- Cycas flour

ada prepared with different proportions of rice flour and cycas seed flour was found to be 8.40 (T_3), 8.26 (T_4), 8.13 (T_5), 7.70 (T_6) and 7.93 (T_7). The mean scores obtained for taste were found to be 8.20 (T_3 & T_4), 8.33 (T_5), 7.73 (T_6) and 8.03 (T_7). The mean rank scores for flavour and taste for ada prepared with 100 per cent rice flour was 5.08 and 5.30 respectively. Ada made with 100 per cent cycas seed flour obtained the lowest rank score of 2.55 and 2.50 for flavour and taste respectively. The mean rank scores of ada prepared with different combinations of rice flour and cycas seed flour varied from 2.95 to 4.82 for flavour and 3.17 to 4.52 for taste.

For overall acceptability, ada prepared with 100 per cent rice flour (T_1) obtained the highest mean score of 8.53 followed by T_5 (8.40), T_3 (8.37), T_4 (8.23), T_7 (8.10), T_6 (7.83) and T_2 (7.50). The mean rank scores on the basis of Kendall's co-efficient of variance with respect to overall acceptability were found to be 5.05, 2.40, 4.67, 4.20, 4.62, 3.18 and 3.88 for T_1, T_2, T_3, T_4, T_5, T_6 and T_7 respectively.

Based on Kendall's (W) value, the agreement among the judges in the evaluation of organoleptic qualities like appearance, colour, texture, flavour, taste and overall acceptability of ada was found to be statistically significant.

The organoleptic scores of different quality attributes of ada are given in Fig.5. Ada prepared with different proportions of rice flour and cycas seed flour is depicted in Plate 3.

4.3.3. Pathiri

The mean and rank scores obtained for various quality attributes like appearance, colour, texture, flavour, taste and overall acceptability of pathiri are given in Table 6.

As revealed in the Table, the appearance of pathiri prepared exclusively with rice flour had a maximum score of 8.8 and the highest mean rank score of 6.37. The mean and rank scores of pathiri prepared exclusively with cycas seed flour were found to be 7.53 and

Table 5. Mean scores for different quality attributes of ada

Treatments	Characters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
T_1	8.50 (4.77)	8.53 (5.08)	8.33 (4.98)	8.43 (5.08)	8.63 (5.30)	8.53 (5.05)
T_2	7.80 (2.70)	7.67 (2.75)	7.57 (2.80)	7.50 (2.55)	7.43 (2.50)	7.50 (2.40)
T_3	8.50 (4.68)	8.50 (4.98)	8.33 (4.92)	8.40 (4.82)	8.20 (4.33)	8.37 (4.67)
T_4	8.40 (4.33)	8.10 (3.80)	8.06 (4.10)	8.26 (4.53)	8.20 (4.23)	8.23 (4.20)
T_5	8.33 (4.25)	8.17 (4.02)	8.23 (4.50)	8.13 (4.17)	8.33 (4.52)	8.40 (4.62)
T_6	8.06 (3.38)	8.00 (3.52)	7.80 (3.37)	7.70 (2.95)	7.73 (3.17)	7.83 (3.18)
T_7	8.20 (3.88)	8.10 (3.85)	7.73 (3.33)	7.93 (3.90)	8.03 (3.95)	8.10 (3.88)
Kendall's (W) value	0.197**	0.217**	0.209**	0.247**	0.226**	0.238**

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

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

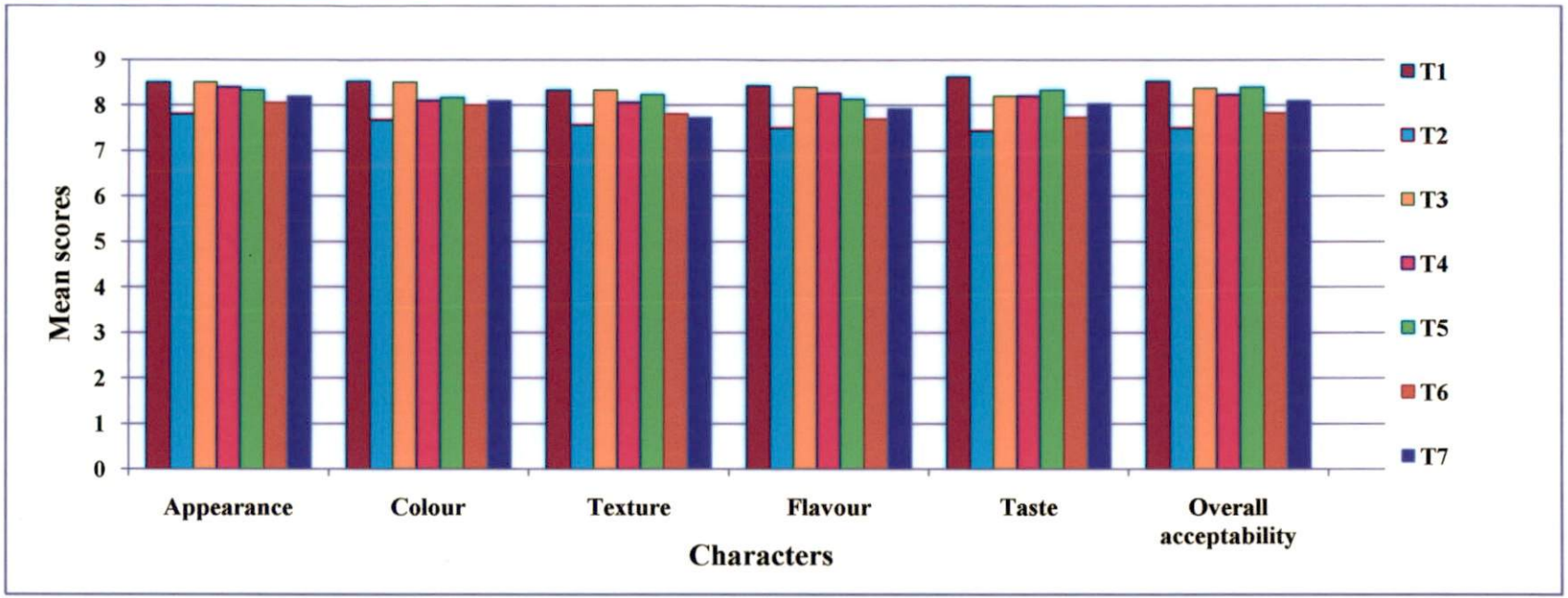


Fig.5. Organoleptic scores obtained for different quality attributes of ada

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

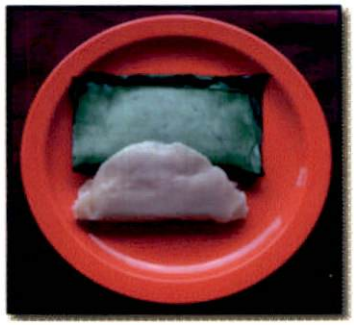
T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

T_1 - 100% RF

T_2 - 100% CF



T_3 - 70% RF + 30% CF

T_4 - 60% RF + 40% CF

T_5 - 50% RF + 50% CF

T_6 - 40% RF + 60% CF

T_7 - 30% RF + 70% CF

Plate 3. Ada prepared by different proportions of rice flour and cycas seed flour

RF-Rice flour CF- Cycas flour

3.03 respectively. The mean score of pathiri prepared with different proportions of rice flour and cycas seed flour was found to be 7.93 (T_3), 7.80 (T_4), 7.90 (T_5), 7.63 (T_6) and 7.50 (T_7) with the mean rank scores of 4.17, 3.87, 4.07, 3.43 and 3.07 respectively.

Among the seven treatments, pathiri prepared exclusively with rice flour obtained the highest mean score (8.70) and mean rank score (6.33) for colour. Pathiri prepared with 100 per cent cycas seed flour obtained a mean score of 7.30 and rank score of 3.12 for colour. The mean score of colour of pathiri prepared with rice flour and cycas seed flour in the ratio of 70:30 (T_3) was found to be 7.80 which was followed by T_4 (7.77), T_5 (7.73), T_6 (7.37) and T_7 (7.13). The mean rank scores for colour of different treatments were found to be 4.27 (T_3), 4.25 (T_4), 4.08 (T_5), 3.27 (T_6) and 2.68 (T_7).

For texture, pathiri prepared with 100 per cent rice flour obtained a mean score of 8.73. The mean rank score was found to be 6.32. Pathiri prepared exclusively with cycas seed flour had a mean and rank scores of 7.16 and 2.57 respectively. The mean score for the texture of pathiri prepared with different proportions of rice flour and cycas seed flour varied from 7.30 to 7.93 with a mean rank score in between 3.03 to 4.53. Among the different treatments, the highest mean and rank scores were observed in T_1 and the lowest in T_2.

For flavour, pathiri prepared with 100 per cent rice flour obtained the highest mean score of 8.50 which was followed by T_3 (7.70), T_5 (7.63), T_4 (7.57), T_6 (7.33) and T_2 &T_7 (7.30). The mean rank scores of the treatments varied from 3.15 to 5.87.

Among the different treatments, pathiri made with 100 per cent rice flour obtained the highest mean (8.67) and rank scores (6.15) for taste followed by T_3 (7.83), T_5 (7.80), T_4 (7.67), T_6 (7.37), T_7 (7.30) and T_2 (7.20).

The overall acceptability of pathiri was highest in T_1 which was prepared with 100 per cent rice flour. Pathiri prepared with 100 per cent cycas seed flour had the lowest score

of 7.16 with a mean rank score of 2.60. Among T_3 to T_7 which were prepared with different combinations of rice flour and cycas seed flour, T_3 had the highest mean and rank scores of 7.93 and 4.58 respectively followed by T_4 (7.90 & 4.53), T_5 (7.80 & 4.32), T_6 (7.40 & 3.12) and T_7 (7.13 & 2.57).

Based on Kendall's (W) value, the agreement among the judges in the evaluation of organoleptic qualities like appearance, colour, texture, flavour, taste and overall acceptability of pathiri was found to be statistically significant.

The organoleptic scores of different quality attributes of pathiri are given in Fig.6. Pathiri prepared with different proportions of rice flour and cycas seed flour is depicted in Plate 4.

4.3.4. Biscuit

The results pertaining to the organoleptic qualities of biscuits prepared using different combinations of maida and cycas seed flour are given in Table 7.

Among the seven treatments tried, biscuit prepared with 100 per cent maida obtained the highest mean score of 8.10 with a mean rank score of 4.40 for appearance. Biscuit prepared with 100 per cent cycas seed flour obtained a mean score of 7.80 and rank score of 3.90. The mean scores for appearance of biscuit prepared with different proportions of maida and cycas seed flour were found to be 8.07 (T_3), 8.23 (T_4), 7.50 (T_5), 7.83 (T_6 & T_7). The mean rank scores of these treatments were 4.33, 4.93, 2.82, 3.78 and 3.83 respectively.

The mean score for colour and texture of biscuit prepared exclusively with maida was found to be 8.23 and 7.97 respectively. Biscuit prepared with 100 per cent cycas seed flour obtained a mean score of 7.63 for colour and 7.60 for texture. The mean scores for colour and texture of biscuits prepared using different combinations of maida and cycas seed flour

Table 6. Mean scores for different quality attributes of pathiri

Treatments	Characters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
T_1	8.80 (6.37)	8.70 (6.33)	8.73 (6.32)	8.50 (5.87)	8.67 (6.15)	8.70 (6.28)
T_2	7.53 (3.03)	7.30 (3.12)	7.16 (2.57)	7.30 (3.38)	7.20 (2.78)	7.16 (2.60)
T_3	7.93 (4.17)	7.80 (4.27)	7.67 (3.68)	7.70 (4.28)	7.83 (4.27)	7.93 (4.58)
T_4	7.80 (3.87)	7.77 (4.25)	7.87 (4.38)	7.57 (3.92)	7.67 (3.88)	7.90 (4.53)
T_5	7.90 (4.07)	7.73 (4.08)	7.93 (4.53)	7.63 (4.20)	7.80 (4.33)	7.80 (4.32)
T_6	7.63 (3.43)	7.37 (3.27)	7.53 (3.48)	7.33 (3.20)	7.37 (3.30)	7.40 (3.12)
T_7	7.50 (3.07)	7.13 (2.68)	7.30 (3.03)	7.30 (3.15)	7.30 (3.28)	7.13 (2.57)
Kendall's (W) value	0.389**	0.425**	0.430**	0.293**	0.355**	0.514**

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

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

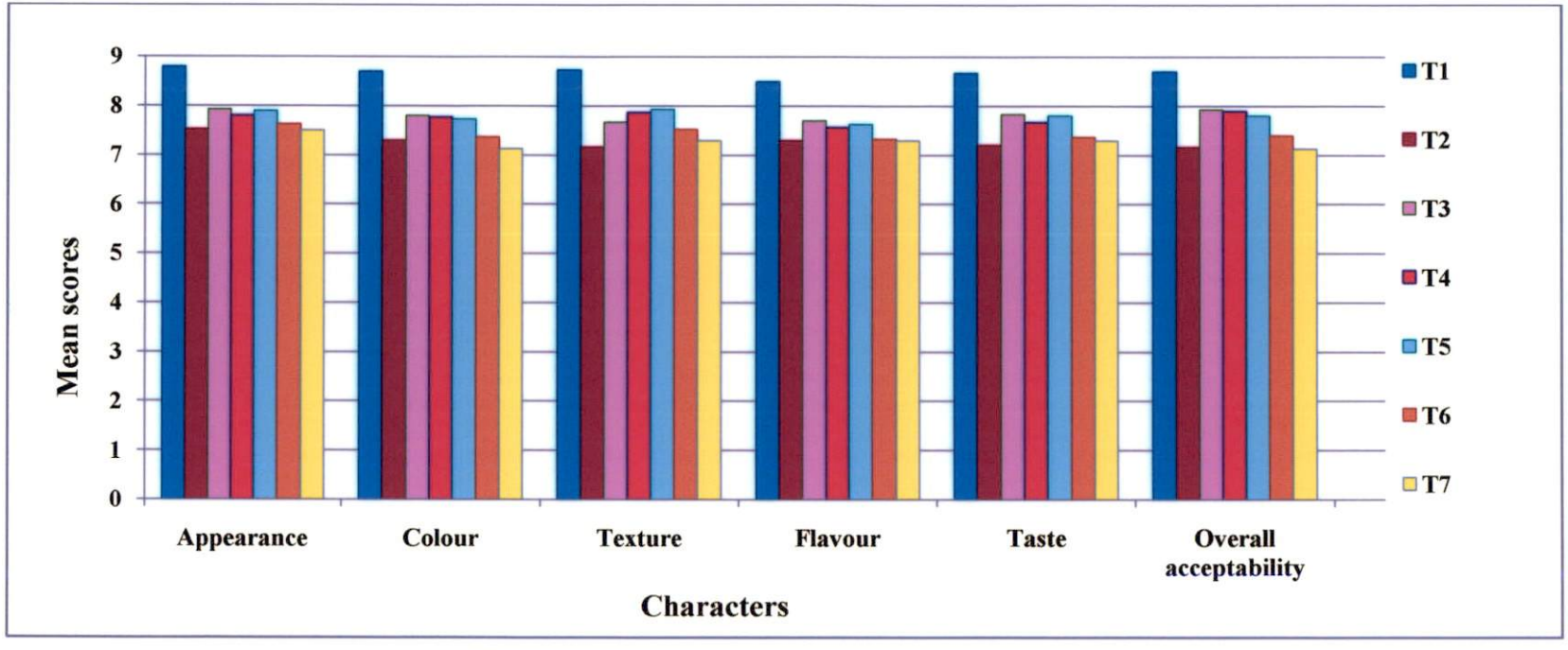


Fig.6. Organoleptic scores obtained for different quality attributes of pathiri

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

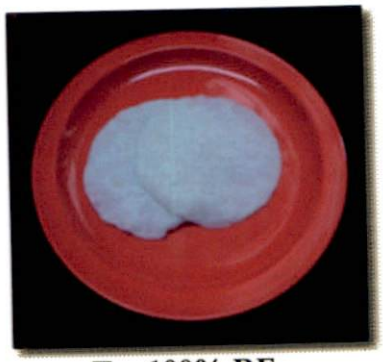
T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour



T_1 - 100% RF

T_2 - 100% CF

T_3 - 70% RF + 30% CF

T_4 - 60% RF + 40% CF

T_5 - 50% RF + 50% CF

T_6 - 40% RF + 60% CF

T_7 - 30% RF + 70% CF

Plate 4. Pathiri prepared by different proportions of rice flour and cycas seed flour

RF- Rice flour CF- Cycas flour

varied from 7.43 to 8.13 and 7.67 to 8.4 respectively. The mean rank scores for biscuit prepared exclusively with maida was found to be 4.67 for colour and 4.30 for texture. The mean rank scores for colour of biscuits prepared with different combinations of maida and cycas seed flour were found to be 4.65 (T_3), 4.53 (T_4), 2.68 (T_5), 4.00 (T_6) and 3.95 (T_7). For texture, the rank scores were found to be 4.90 (T_3), 5.13 (T_4), 3.33 (T_5), 3.50 (T_6) and 3.52 (T_7).

The mean score for flavour was high for biscuit prepared with 100 per cent maida. The mean score of biscuit prepared with 100 per cent cycas seed flour was found to be 7.70 with a rank score of 3.63. The mean scores for flavour of biscuit in other treatments varied from 7.77 to 8.03 with mean rank scores in between of 3.53 to 4.20.

For taste, biscuit prepared with 100 per cent maida obtained the mean score of 7.93 and mean rank score of 3.98. Biscuit prepared exclusively with cycas seed flour had a mean score of 7.60 with a rank score of 3.15. The highest mean (8.37) and rank scores (5.13) were found to be in T_3 which was prepared using 70 per cent maida and 30 per cent cycas seed flour.

The mean scores for overall acceptability of biscuit varied from 7.70 to 8.37 with mean rank scores in between 3.23 to 5.05. Among the different treatments, biscuit prepared with 70 per cent maida and 30 per cent cycas seed flour (T_3) obtained the highest mean score (8.37) and rank score (5.05) for overall acceptability. Biscuit prepared exclusively with cycas seed flour had the lowest mean (7.70) and rank scores (3.23). The overall acceptability of biscuit prepared using different proportions of maida and cycas seed flour varied from 7.83 to 8.37 with a mean rank score in between 3.42 to 5.05.

Significant agreement among the judges was noticed in the evaluation of organoleptic qualities of biscuit prepared exclusively with maida, cycas seed flour and with different combinations of maida and cycas seed flour.

The organoleptic scores of different quality attributes of biscuit are illustrated in Fig.7. Biscuits prepared with different proportions of maida and cycas seed flour are depicted in Plate 5.

3.4.5. Chapathi

The mean and rank scores obtained for the various quality attributes of chapathi prepared using different combinations of wheat flour and cycas seed flour are given in Table 8.

The mean and rank scores of chapathi prepared with 100 per cent wheat flour was found to be 8.23 and 6.77. Chapathi made exclusively with cycas seed flour obtained a mean and rank scores of 2.23 and 1.48. Chapathi prepared with different proportions of wheat flour and cycas seed flour obtained a mean score of 7.37 (T_3), 6.00 (T_4), 5.30 (T_5), 3.40 (T_6) and 2.27 (T_7) for appearance. The mean rank scores of the above treatments were 5.93, 4.82, 4.13, 2.50 and 2.37 respectively.

Among the different treatments, chapathi prepared with 100 per cent wheat flour had a maximum score of 8.43 with the highest mean rank score of 6.82 for colour. The mean score of chapathi prepared with 100 per cent cycas seed flour was found to be 3.07 with a mean rank score of 1.37. The mean score of chapathi made with wheat flour and cycas seed flour in different proportions varied from 4.00 to 7.07 with a mean rank scores in the range of 2.23 to 5.75.

The mean score for texture was found to be high (8.10) for chapathi prepared with 100 per cent wheat flour (T_1) followed by T_3 (6.20), T_4 (5.50), T_5 (4.70), T_6 (2.90) and T_7 (2.77). The lowest mean and rank scores were obtained in T_2 which was prepared exclusively with cycas seed flour. The mean rank scores of chapathi made with wheat flour and cycas seed flour in different proportion were found to be 5.57 (T_3), 5.02 (T_4), 4.27 (T_5), 2.42 (T_6) and 2.33 (T_7).

Table 7. Mean scores for different quality attributes of biscuit

Treatments	Characters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
T_1	8.10 (4.40)	8.23 (4.67)	7.97 (4.30)	8.20 (4.70)	7.93 (3.98)	8.03 (3.97)
T_2	7.80 (3.90)	7.63 (3.52)	7.60 (3.32)	7.70 (3.63)	7.60 (3.15)	7.70 (3.23)
T_3	8.07 (4.33)	8.13 (4.65)	8.33 (4.90)	8.03 (4.13)	8.37 (5.13)	8.37 (5.05)
T_4	8.23 (4.93)	8.10 (4.53)	8.40 (5.13)	8.03 (4.20)	8.03 (4.27)	8.27 (4.65)
T_5	7.50 (2.82)	7.43 (2.68)	7.67 (3.33)	7.77 (3.53)	7.77 (3.68)	7.83 (3.42)
T_6	7.83 (3.78)	7.83 (4.00)	7.77 (3.50)	8.00 (4.10)	7.93 (4.03)	8.03 (4.03)
T_7	7.83 (3.83)	7.87 (3.95)	7.77 (3.52)	7.87 (3.70)	7.83 (3.75)	7.93 (3.65)
Kendall's (W) value	0.155**	0. 183**	0.197**	0.074**	0.120**	0.165**

Figures in parenthesis indicate mean rank scores ** Significant at 1% level

T_1 - 100% maida (control)

T_2 - 100% cycas seed flour

T_3 - 70% maida + 30% cycas seed flour

T_4 - 60% maida + 40% cycas seed flour

T_5 - 50% maida + 50% cycas seed flour

T_6 - 40% maida + 60% cycas seed flour

T_7 - 30% maida + 70% cycas seed flour

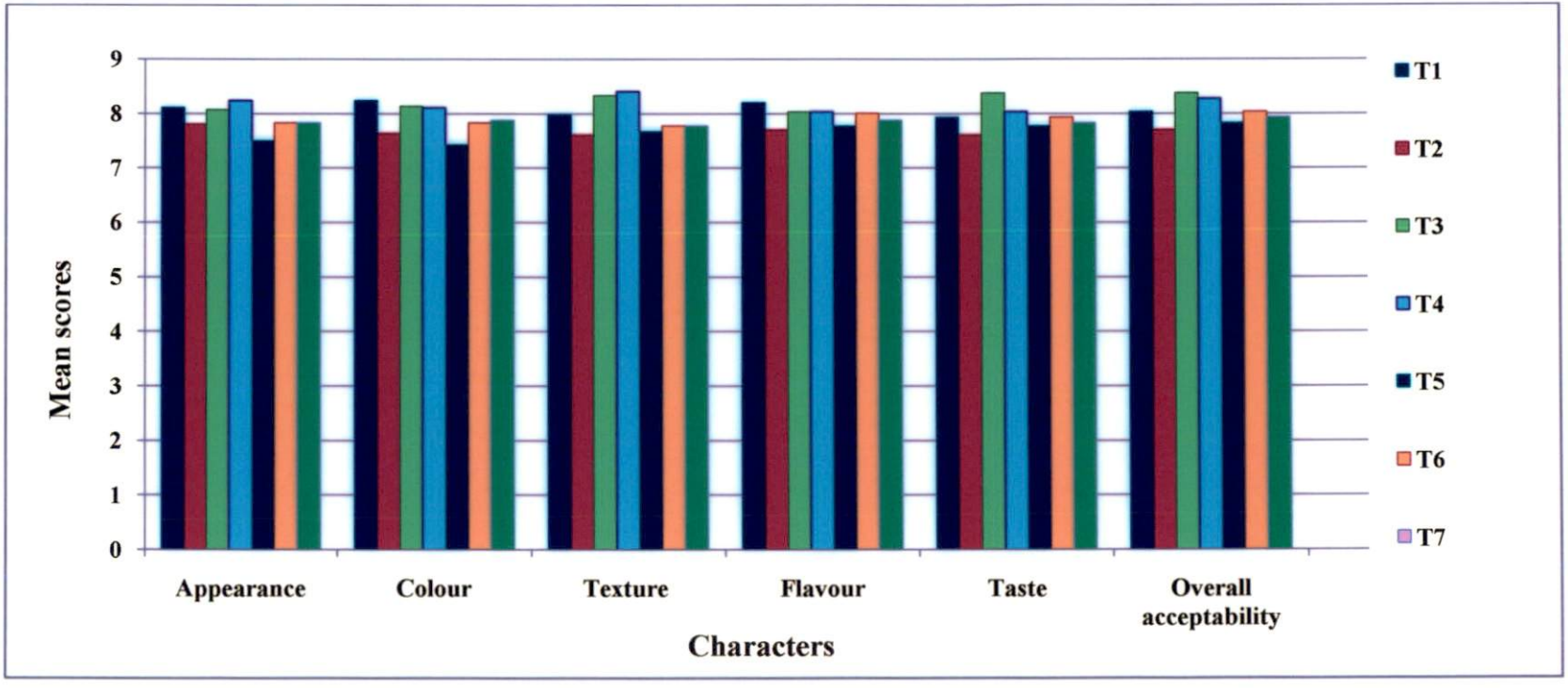


Fig.7. Organoleptic scores obtained for different quality attributes of biscuit

T_1 - 100% maida (control)

T_2 - 100% cycas seed flour

T_3 - 70% maida + 30% cycas seed flour

T_4 - 60% maida + 40% cycas seed flour

T_5 - 50% maida + 50% cycas seed flour

T_6 - 40% maida + 60% cycas seed flour

T_7 - 30% maida + 70% cycas seed flour

T_1 - 100% M

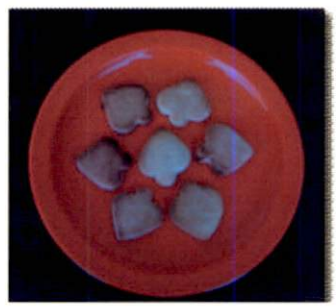
T_2 - 100% CF

T_3 - 70% M + 30% CF

T_4 - 60% M + 40% CF

T_5 - 50% M + 50% CF

T_6 - 40% M + 60% CF



T_7 - 30% M + 70% CF

Plate 5. Biscuit prepared by different proportions of maida and cycas seed flour

M – Maida CF- Cycas flour

The flavour of chapathi was highest in T_1 (8.10) which was prepared exclusively with wheat flour. Chapathi prepared exclusively with cycas seed flour had the lowest score of 2.27 with a mean rank score of 1.48. Among T_3 to T_7, the mean scores for flavour varied from 3.07 to 6.77 with mean rank scores in between 2.25 to 5.88.

For taste, chapathi prepared with 100 per cent wheat flour obtained a maximum score of 8.20. The mean rank score was found to be 6.93. Chapathi prepared with 100 per cent cycas seed flour had a mean score of 1.87 and rank score of 1.40 for taste. The mean scores of chapathi prepared using different proportions of wheat flour and cycas seed flour were found to be 6.60 (T_3), 5.20 (T_4), 4.70 (T_5), 2.93 (T_6) and 2.87 (T_7). The mean rank scores obtained for these treatments were found to be 5.83, 4.68, 4.22, 2.53 and 2.50 respectively.

The overall acceptability of chapathi made with 100 per cent wheat flour obtained the highest mean and rank scores of 8.30 and 6.97 respectively. The overall acceptability of chapathi prepared exclusively with cycas seed flour was found to be very low with a mean score of 2.03 and mean rank score of 1.28. The mean and rank scores of chapathi prepared with different combinations of wheat flour and cycas seed flour were found to be 6.87 and 5.92 (T_3), 5.67 and 4.85 (T_4), 4.90 and 4.10 (T_5), 2.23 and 2.65 (T_6) and 2.87 and 2.23 (T_7).

The agreement among judges on evaluating the different quality attributes like appearance, colour, texture, flavour, taste and overall acceptability of chapathi were found to be statistically significant based on Kendall's (W) value.

The organoleptic scores of different quality attributes of chapathi are given in Fig.8. Chapathi prepared with different proportions of wheat flour and cycas seed flour is depicited in Plate 6.

Table 8. Mean scores for different quality attributes of chapathi

Treatments	Characters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
T_1	8.23 (6.77)	8.43 (6.82)	8.10 (7.00)	8.10 (6.98)	8.20 (6.93)	8.30 (6.97)
T_2	2.23 (1.48)	3.07 (1.37)	1.87 (1.40)	2.27 (1.48)	1.87 (1.40)	2.03 (1.28)
T_3	7.37 (5.93)	7.07 (5.75)	6.20 (5.57)	6.77 (5.88)	6.60 (5.83)	6.87 (5.92)
T_4	6.00 (4.82)	6.20 (4.68)	5.50 (5.02)	5.73 (4.82)	5.20 (4.68)	5.67 (4.85)
T_5	5.30 (4.13)	5.60 (4.20)	4.70 (4.27)	4.67 (3.82)	4.70 (4.22)	4.90 (4.10)
T_6	3.40 (2.50)	4.50 (2.95)	2.90 (2.42)	3.50 (2.77)	2.93 (2.53)	2.23 (2.65)
T_7	2.27 (2.37)	4.00 (2.23)	2.77 (2.33)	3.07 (2.25)	2.87 (2.50)	2.87 (2.23)
Kendall's (W) value	0.884**	0.852**	0.920**	0.904**	0.901**	0.943**

Figures in parenthesis indicate mean rank scores ** Significant at 1% level

T_1 - 100% wheat flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% wheat flour + 30% cycas seed flour

T_4 - 60% wheat flour + 40% cycas seed flour

T_5 - 50% wheat flour+ 50% cycas seed flour

T_6 - 40% wheat flour + 60% cycas seed flour

T_7 - 30% wheat flour + 70% cycas seed flour

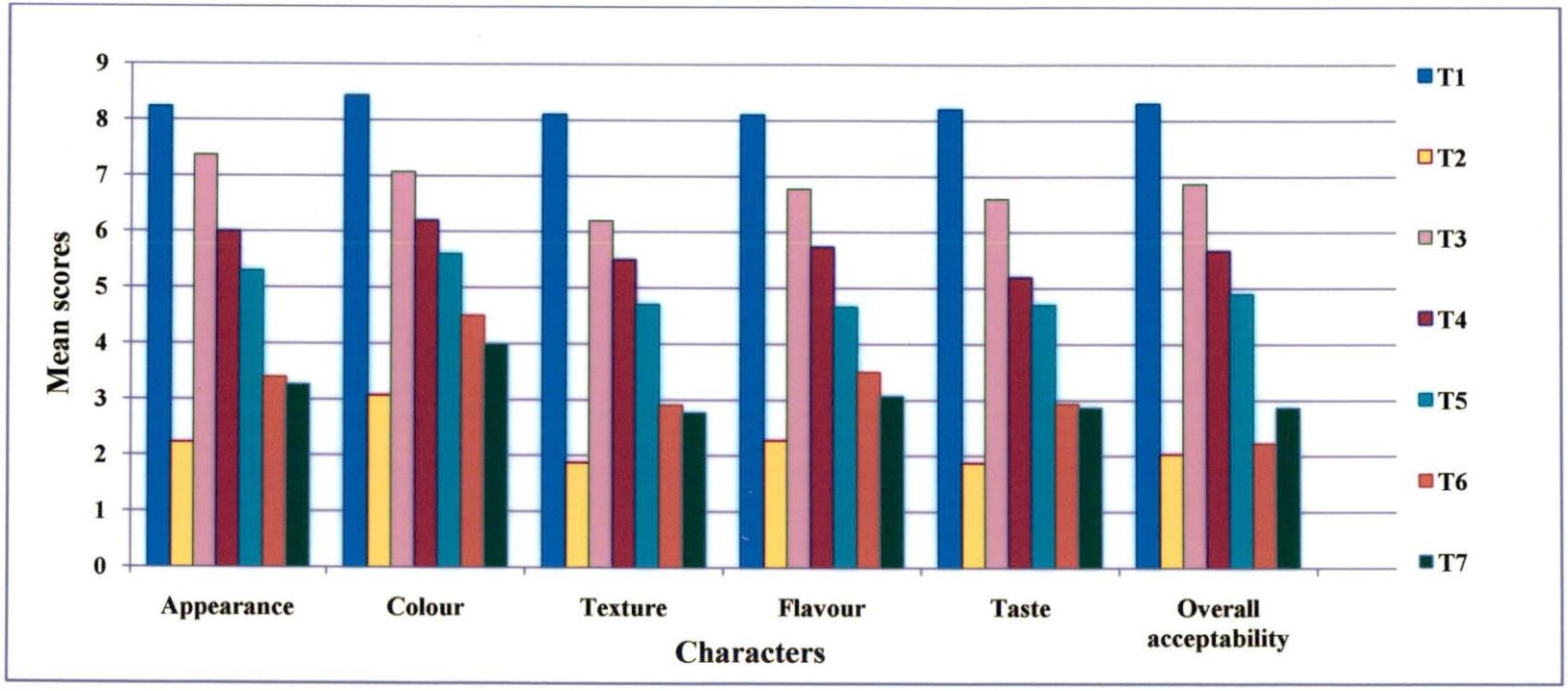


Fig.8. Organoleptic scores obtained for different quality attributes of chapathi

T_1 - 100% wheat flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% wheat flour + 30% cycas seed flour

T_4 - 60% wheat flour + 40% cycas seed flour

T_5 - 50% wheat flour + 50% cycas seed flour

T_6 - 40% wheat flour + 60% cycas seed flour

T_7 - 30% wheat flour + 70% cycas seed flour

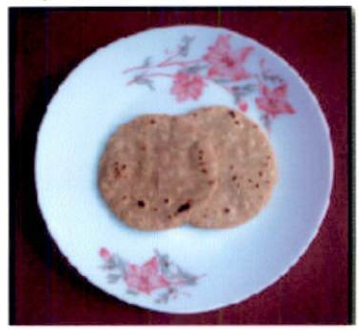
T_1 - 100% WF

T_2 - 100% CF

T_3 - 70% WF + 30% CF

T_4 - 60% WF + 40% CF

T_5 - 50% WF + 50% CF



T_6 - 40% WF + 60% CF

T_7 - 30% WF + 70% CF

Plate 6. Chapathi prepared by different proportions of wheat flour and cycas flour

WF- Wheat flour CF- Cycas flour

4.4. Computation of nutritive value of products

Nutritive value of puttu, ada, pathiri, biscuit and chapathi per serving prepared by different combinations were computed with respect to protein, energy, crude fibre, fat, calcium, iron and phosphorous using the food composition table (Gopalan *et al.*, 1989). The nutritive value of cycas seed flour obtained in the present study was also taken to compute the nutritive value of different combinations. The results are presented in Tables 9 to 13. One serving of puttu, ada, pathiri, biscuit and chapathi was taken as 2 pieces, 1 no, 6 nos, 4 nos and 3 nos respectively. The percentage of Recommended Dietary Allowances (RDA) of the above nutrients met from one serving of the different items on the basis of RDA for reference woman is also given in this section. The RDA of nutrients suggested by ICMR (2010) was taken as the base to compute the percentage of RDA met per serving.

4.4.1. Puttu

Nutritive value of puttu per serving prepared using different combinations of cycas seed flour and rice flour and the percentage of RDA met per serving are presented in Table 9.

The protein content of puttu per serving varied from 4.08 g to 5.39 g (Table 9). Highest protein content was noticed in the puttu prepared with 100 per cent cycas seed flour (T_2) and the lowest in 100 per cent rice flour (T_1). About 7.42 to 9.80 per cent of protein requirement per day was met from one serving of puttu prepared with different proportions of rice flour and cycas seed flour.

The energy content of puttu prepared with 100 per cent rice flour (T_1) and 100 per cent cycas seed flour were found to be 239 KCal and 227 KCal per serving. The energy content of puttu prepared with different combinations of cycas seed flour and rice flour varied from 230 KCal (T_7) to 235 KCal (T_3). From Table 9, it can be seen that puttu made with different combinations met about 10 per cent of RDA of energy for a reference woman.

The crude fibre content of puttu prepared exclusively with rice flour and cycas seed flour was found to be 0.64 g (T_1) and 1.83 g (T_2) respectively. The crude fibre content of other treatments varied from 1.00 g (T_3) to 1.47 g (T_7) per serving. About 1.60 to 4.58 per cent of fibre requirement was met from one serving of puttu prepared with different combinations of cycas seed flour and rice flour.

The fat content of one serving of puttu was found to be 6.49 g for control (T_1). Puttu made exclusively with cycas seed flour (T_2) had a fat content of 8.77 g. Puttu made with 100 per cent rice flour as well as cycas seed flour provided 25.96 per cent and 35.08 per cent RDA of fat.

The calcium content of puttu per serving varied from 6.50 mg to 12.17 mg. Puttu prepared exclusively with cycas seed flour had the maximum calcium content and the lowest was observed in T_1 which was prepared exclusively with rice flour. From Table 9, it is seen that puttu made with 100 per cent cycas seed flour provided 2.03 per cent of RDA of calcium while from other treatments about 1.37 per cent (T_3), 1.46 per cent (T_4). 1.56 per cent (T_5), 1.65 per cent (T_6) and 1.75 per cent (T_7) of RDA were met. Puttu prepared with 100 per cent rice flour supplied only 1.08 per cent of RDA for calcium.

The iron content of puttu varied from 0.39 mg to 0.61 mg with the highest content in T_1 (100% rice flour) and lowest in T_2 (100% cycas seed flour). The iron content of puttu prepared with different combinations of rice flour and cycas seed flour were found to be 0.55 mg (T_3), 0.52 mg (T_4), 0.5 mg (T_5), 0.47 mg (T_6) and 0.44 mg (T_7) respectively. Only 1.86 per cent of iron requirement was met from puttu prepared with 100 per cent cycas seed flour (T_2). The percentage of RDA met from other treatments was 2.90 per cent (T_1), 2.62 per cent (T_3), 2.48 per cent (T_4), 2.38 per cent (T_5), 2.24 per cent (T_6) and 2.1 per cent (T_7).

The phosphorous content of puttu prepared with 100 per cent rice flour was 116 mg which was followed by 92 mg in T_3, 84 mg in T_4, 76 mg in T_5, 68 mg in T_6, 60 mg in T_7 and 36 mg in T_2. From Table 9, it can be seen that puttu prepared with 100 per cent rice

flour provided 19.33 per cent of RDA of phosphorous and from other treatments about 6 to 15.33 per cent of RDA of phosphorous was met.

4.4.2. Ada

Nutritive value of ada per serving prepared using different proportions of cycas seed flour and rice flour and the percentage of RDA met per serving are presented in Table 10.

The protein content of ada prepared exclusively with rice flour and cycas seed flour was found to be 2.30 g and 2.82 g respectively. The protein content of other treatments varied from 2.50 g (T_3) to 2.76 g (T_7) per serving. About 4.18 to 5.13 per cent of protein requirement was met from the ada prepared with different combinations of cycas seed flour and rice flour.

The energy content of ada per serving varied from 164 KCal to 177 KCal. Ada prepared with 100 per cent rice flour had the maximum energy content and the lowest was observed in T_2 which was prepared with 100 per cent cycas seed flour. From Table 10, it is seen that ada made with 100 per cent cycas seed flour supplied 7.36 per cent of energy requirement while from other treatments about 7.87 per cent (T_3), 7.84 per cent (T_4), 7.81 per cent (T_5), 7.79 per cent (T_6) and 7.76 per cent (T_7) of energy requirement was met. Ada prepared with 100 per cent rice flour provided 7.95 per cent of RDA for energy.

The crude fibre content of ada varied from 0.42 g to 1.01 g. Highest crude fibre content was noticed in the ada prepared exclusively with cycas seed flour (T_2) and the lowest in control (T_1) which was prepared exclusively with rice flour. About 1.05 to 2.53 per cent of crude fibre requirement per day was met from one serving of ada prepared with different proportions of cycas seed flour and rice flour.

Table 9. Nutritive value of puttu (per serving of 2 pieces)

Treatments	Nutrients						
	Protein (g)	**Energy (KCal)**	**Crude fibre (g)**	**Fat (g)**	**Calcium (mg)**	**Iron (mg)**	**Phosphorus (mg)**
T_1	4.08 (7.42)	239 (10.71)	0.64 (1.60)	6.49 (25.96)	6.50 (1.08)	0.61 (2.90)	116 (19.33)
T_2	5.39 (9.80)	227 (10.18)	1.83 (4.58)	8.77 (35.08)	12.17 (2.03)	0.39 (1.86)	36 (6.00)
T_3	4.47 (8.13)	235 (10.54)	1.00 (2.50)	7.17 (28.68)	8.20 (1.37)	0.55 (2.62)	92 (15.33)
T_4	4.60 (8.36)	234 (10.49)	1.11 (2.78)	7.40 (29.60)	8.77 (1.46)	0.52 (2.48)	84 (14.00)
T_5	4.73 (8.60)	233 (10.45)	1.23 (3.08)	7.63 (30.52)	9.33 (1.56)	0.50 (2.38)	76 (12.67)
T_6	4.86 (8.84)	232 (10.40)	1.35 (3.38)	7.86 (31.44)	9.90 (1.65)	0.47 (2.24)	68 (11.33)
T_7	5.00 (9.09)	230 (10.31)	1.47 (3.68)	8.08 (32.32)	10.47 (1.75)	0.44 (2.10)	60 (10.00)
RDA	**55**	**2230**	**40**	**25**	**600**	**21**	**600**

Figures in parenthesis represent the percentage of RDA met from one serving of puttu

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

The fat content of ada prepared with 100 per cent rice flour was found to be 4.3 g per serving. The fat content of ada prepared with different combinations of rice flour and cycas seed flour were found to be 5.43 g (T_2), 4.64 g (T_3), 4.75 g (T_4), 4.87 g (T_5), 4.98 g (T_6) and 5.09 g (T_7). From Table 10, it can be seen that ada made with 100 per cent cycas seed flour provided 21.72 per cent of RDA of fat while other treatments provided 18.56 per cent (T_3), 19.00 per cent (T_4), 19.48 per cent (T_5), 19.92 per cent (T_6) and 20.36 per cent (T_7) of RDA. Ada prepared with 100 per cent rice flour supplied only 17.20 per cent of RDA of fat.

The calcium content of one serving of ada was found to be 4.90 mg for T_1 which was followed by 7.54 mg (T_2), 6.89 mg (T_7), 6.60 mg (T_6), 6.32 mg (T_5), 6.04 mg (T_4) and 5.75 mg (T_3). As revealed in Table 10, ada prepared with 100 per cent rice flour provided 0.82 per cent of RDA while from other treatments like T_2, T_3, T_4, T_5, T_6 and T_7, 1.26 per cent, 0.96 per cent, 1.01 per cent, 1.05 per cent, 1.10 per cent and 1.15 per cent of RDA of calcium were met from one serving of ada.

The iron content of ada prepared exclusively with rice flour was found to be 0.38 mg which was followed by 0.34 mg (T_3), 0.33 mg (T_4), 0.32 mg (T_5), 0.31 mg (T_6), 0.29 mg (T_7) and 0.25 mg (T_2) respectively. Ada prepared exclusively with rice flour supplied 1.81 per cent of RDA and the other treatments provided 1.19 per cent (T_2), 1.62 per cent (T_3), 1.57 per cent (T_4), 1.52 per cent (T_5), 1.48 per cent (T_6) and 1.38 per cent (T_7) of RDA.

The phosphorous content of one serving of ada was found to be 67.30 mg for control (T_1). Ada made exclusively with cycas seed flour (T_2) had a lowest phosphorous content of 24.10 mg per day. About 4.02 to 11.22 per cent of phosphorous requirement per day was met from one serving of ada prepared with different proportions of rice flour and cycas seed flour.

Table 10. Nutritive value of ada (per serving of 1 no)

Treatments	Nutrients						
	Protein (g)	Energy (KCal)	Crude fibre (g)	Fat (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
T_1	2.30 (4.18)	177 (7.95)	0.42 (1.05)	4.30 (17.20)	4.90 (0.82)	0.38 (1.81)	67.30 (11.22)
T_2	2.82 (5.13)	164 (7.36)	1.01 (2.53)	5.43 (21.72)	7.54 (1.26)	0.25 (1.19)	24.10 (4.02)
T_3	2.50 (4.55)	175 (7.87)	0.59 (1.48)	4.64 (18.56)	5.75 (0.96)	0.34 (1.62)	55.30 (9.22)
T_4	2.56 (4.65)	175 (7.84)	0.65 (1.63)	4.75 (19.00)	6.04 (1.01)	0.33 (1.57)	51.30 (8.55)
T_5	2.63 (4.78)	174 (7.81)	0.71 (1.78)	4.87 (19.48)	6.32 (1.05)	0.32 (1.52)	47.30 (7.88)
T_6	2.69 (4.89)	173 (7.79)	0.77 (1.93)	4.98 (19.92)	6.60 (1.10)	0.31 (1.48)	43.30 (7.22)
T_7	2.76 (5.02)	173 (7.76)	0.83 (2.08)	5.09 (20.36)	6.89 (1.15)	0.29 (1.38)	39.30 (6.55)
RDA	**55**	**2230**	**40**	**25**	**600**	**21**	**600**

Figures in parenthesis represent the percentage of RDA met from one serving of ada

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

4.4.3. Pathiri

Nutritive value of pathiri per serving of 6 pathiri and the percentage of RDA met per serving is presented in Table 11.

The protein content of pathiri prepared with rice flour and different combinations of rice flour and cycas seed flour was found to be 7.34 g (T_1), 9.44 g (T_2), 8.14 g (T_3), 8.40 g (T_4), 8.66 g (T_5), 8.92 g (T_6) and 9.18 g (T_7). From the table it can be seen that pathiri made with 100 per cent rice flour provided 13.35 per cent of RDA while from other treatments about 17.16 per cent (T_2), 14.8 per cent (T_3), 15.27 per cent (T_4), 15.75 per cent (T_5), 16.22 per cent (T_6) and 16.69 per cent (T_7) of RDA of protein were met from one serving of pathiri.

The energy content of pathiri prepared exclusively with rice flour and cycas seed flour was found to be 373 KCal and 320 KCal respectively. The energy content of other treatments varied from 355 KCal (T_7) to 365 KCal (T_3) per serving. About 16.73 per cent of energy requirement was met from one serving of pathiri prepared with 100 per cent rice flour. The percentage of RDA met from pathiri made with different combinations of rice flour and cycas seed flour varied from 15.92 (T_7) to 16.37 (T_3) per cent. Pathiri made exclusively with cycas seed flour provided about 14.35 per cent of energy.

The crude fibre content of pathiri per serving varied from 0.22 g to 2.58 g. Pathiri prepared exclusively with cycas seed flour had the maximum crude fibre content and the lowest was observed in T_1 which was prepared exclusively with rice flour. It is seen that pathiri made with 100 per cent cycas seed flour provided 6.45 per cent of RDA while from other treatments about 2.30 per cent (T_3), 2.90 per cent (T_4), 3.50 per cent (T_5), 4.10 per cent (T_6) and 4.70 per cent (T_7) of RDA were met. Pathiri made with 100 per cent rice flour provided only 0.55 per cent of RDA for crude fibre.

The fat content of pathiri per serving varied from 0.54 g to 5.06 g. Highest fat content was noticed in the pathiri prepared with 100 per cent cycas seed flour (T_2) and the lowest in pathiri prepared with 100 per cent rice flour (T_1). The percentage of RDA met from pathiri prepared with 100 per cent rice flour and cycas seed flour was found to be 2.16 and 20.24 per cent respectively. About 7.60 (T_3) to 14.88 (T_7) per cent of fat requirement per day was met from one serving of pathiri prepared with different proportions of rice flour and cycas seed flour.

The calcium content of pathiri prepared with 100 per cent cycas seed flour was 21.34 mg followed by 18.74 mg (T_7), 17.60 mg (T_6), 16.46 mg (T_5), 15.34 mg (T_4), 14.20 mg (T_3) and 10.80 mg (T_1). From Table 11, it can be seen that pathiri prepared with 100 per cent cycas seed flour supplied 3.56 per cent of RDA of calcium while from other treatments 1.80 per cent (T_1), 2.37 per cent (T_3), 2.56 per cent (T_4), 2.74 per cent (T_5), 2.93 per cent (T_6) and 3.12 per cent (T_7) of RDA for calcium was met.

The iron content of pathiri per serving varied from 0.25 mg (T_2) to 0.76 mg (T_1). Control had the maximum iron content and the lowest was in T_2 which was prepared exclusively with cycas seed flour. About 3.62 per cent of iron requirement was met from pathiri prepared with 100 per cent rice flour. The percentage of RDA provided from other treatments prepared using different combinations of rice flour and cycas seed flour were 2.90 per cent (T_3), 2.76 per cent (T_4), 2.48 per cent (T_5), 2.33 per cent (T_6) and 2.05 per cent (T_7). Pathiri prepared with 100 per cent cycas seed flour provided only 1.19 per cent of RDA for iron.

The phosphorous content of one serving of pathiri was found to be 172.80 mg for control and '0' mg for T_2 which was prepared exclusively with cycas seed flour. Phosphorous content of pathiri prepared with different combinations of rice flour and cycas seed flour were found to be 124.80 mg (T_3), 108.80 mg (T_4), 92.80 mg (T_5), 76.80 mg (T_6) and 60.80 mg (T_7) respectively. Pathiri made with 100 per cent rice flour provided 28.80 per cent phosphorous and pathiri made with 100 per cent cycas seed flour did not provide

any phosphorous. The percentage of RDA met from other treatments were 20.80 per cent (T_3), 18.13 per cent (T_4), 15.47 per cent (T_5), 12.80 per cent (T_6) and 10.13 per cent (T_7).

4.4.4. Biscuit

Nutritive value of biscuit per serving of four numbers prepared using different combinations of maida and cycas seed flour and the percentage of RDA from one serving are presented in Table 12.

The protein content of biscuit prepared with 100 per cent maida (T_1) and 100 per cent cycas seed flour (T_2) was found to be 1.84 g and 1.58 g per serving. The protein content of biscuit prepared with different proportions of cycas seed flour and maida varied from 1.66 g (T_7) to 1.76 g (T_3). As revealed in Table 12, percentage of RDA of protein provided from a serving of biscuit was found to be 3.35 per cent (T_1), 2.87 per cent (T_2), 3.20 per cent (T_3), 3.16 per cent (T_4), 3.11 per cent (T_5), 3.05 per cent (T_6) and 3.02 per cent (T_7).

The energy content of biscuit varied in the range of 154 KCal (T_2) to 159 KCal (T_1) per serving. About 7.11 and 6.90 per cent of RDA of energy were met from biscuit prepared with 100 per cent rice flour and cycas seed flour respectively. Percentage of RDA of energy provided from a serving of biscuit from other treatments was found to be 7.05 per cent (T_3), 7.03 per cent (T_4), 7.01 per cent (T_5), 6.98 per cent (T_6) and 6.96 per cent (T_7).

The crude fibre content of biscuit varied from 0.05 g (T_1) to 0.43 g (T_2) with the highest content in the one prepared with 100 per cent cycas seed flour and the lowest in biscuit prepared with 100 per cent maida. The crude fibre content of biscuit prepared with different combinations of maida and cycas seed flour were found to be 0.16 g (T_3), 0.2 g (T_4), 0.24 g (T_5), 0.28 g (T_6) and 0.31g (T_7) respectively. About 1.08 per cent of crude fibre requirement was met from biscuit prepared with 100 per cent cycas seed flour. The

percentage of RDA provided from other treatments was 0.13 per cent (T_1), 0.40 per cent (T_3), 0.50 per cent (T_4), 0.60 per cent (T_5), 0.70 per cent (T_6) and 0.78 per cent (T_7).

The fat content of biscuit prepared exclusively with maida and cycas seed flour were found to be 6.90 g and 7.59 g respectively. The fat content of other treatments varied from 7.11 g (T_3) to 7.38 g (T_7) per serving. About 27.6 to 30.36 per cent of RDA of fat was provided from the biscuit prepared with different combinations of cycas seed flour and maida.

The calcium content of biscuit per serving varied from 4.76 mg (T_2) to 5.03 mg (T_1). Biscuit prepared with 100 per cent maida had the maximum calcium content and the lowest was observed in T_2 which was prepared with 100 per cent cycas seed flour. Only 0.84 per cent of calcium requirement was met from biscuit made with 100 per cent maida. The percentage of RDA provided from other treatments was found to be 0.79 per cent (T_2), 0.83 per cent (T_3), 0.82 per cent (T_4 & T_5) and 0.81 per cent (T_6 & T_7).

The iron content of biscuit prepared exclusively with maida (T_1) was 0.47 mg which was followed by 0.34 mg (T_3), 0.30 mg (T_4), 0.26 mg (T_5), 0.22 mg (T_6), 0.18 mg (T_7) and 0.06 mg (T_2). From the Table, it can be seen that biscuit prepared with 100 per cent maida provided 2.24 per cent of RDA and other treatments provided 0.29 per cent (T_2), 1.62 per cent (T_3), 1.43 per cent (T_4), 1.24 per cent (T_5), 1.05 per cent (T_6) and 0.86 per cent (T_7) of RDA.

The phosphorous content of biscuit per serving varied from 0.10 mg to 20.27 mg. Highest phosphorous content was noticed in T_1 which was prepared with 100 per cent maida and the lowest was noticed in biscuit prepared with 100 per cent cycas seed flour. About 1.03 to 2.37 per cent of phosphorous requirement per day was met from one serving of biscuit made with different proportions of maida and cycas seed flour. Biscuit prepared with 100 per cent maida and cycas seed flour supplied 3.38 per cent and 0.02 per cent of phosphorous respectively.

Table 11. Nutritive value of pathiri (per serving of 6 nos)

Treatments	Nutrients						
	Protein (g)	Energy (KCal)	Crude fibre (g)	Fat (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
T_1	7.34 (13.35)	373 (16.73)	0.22 (0.55)	0.54 (2.16)	10.80 (1.80)	0.76 (3.62)	172.80 (28.80)
T_2	9.44 (17.16)	320 (14.35)	2.58 (6.45)	5.06 (20.24)	21.34 (3.56)	0.25 (1.19)	0
T_3	8.14 (14.80)	365 (16.37)	0.92 (2.30)	1.90 (7.60)	14.20 (2.37)	0.61 (2.90)	124.80 (20.80)
T_4	8.40 (15.27)	362 (16.23)	1.16 (2.90)	2.36 (9.44)	15.34 (2.56)	0.58 (2.76)	108.80 (18.13)
T_5	8.66 (15.75)	360 (16.14)	1.40 (3.50)	2.82 (11.28)	16.46 (2.74)	0.52 (2.48)	92.80 (15.47)
T_6	8.92 (16.22)	357 (16.01)	1.64 (4.10)	3.28 (13.12)	17.60 (2.93)	0.49 (2.33)	76.80 (12.80)
T_7	9.18 (16.69)	355 (15.92)	1.88 (4.70)	3.72 (14.88)	18.74 (3.12)	0.43 (2.05)	60.80 (10.13)
RDA	**55**	**2230**	**40**	**25**	**600**	**21**	**600**

Figures in parenthesis represent the percentage of RDA met from one serving of pathiri

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

Table 12. Nutritive value of biscuit (per serving of 4 nos)

Treatments	Nutrients						
	Protein (g)	Energy (KCal)	Crude fibre (g)	Fat (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
T_1	1.84 (3.35)	159 (7.11)	0.05 (0.13)	6.90 (27.6)	5.03 (0.84)	0.47 (2.24)	20.27 (3.38)
T_2	1.58 (2.87)	154 (6.90)	0.43 (1.08)	7.59 (30.36)	4.76 (0.79)	0.06 (0.29)	0.10 (0.02)
T_3	1.76 (3.20)	157 (7.05)	0.16 (0.40)	7.11 (28.44)	4.95 (0.83)	0.34 (1.62)	14.22 (2.37)
T_4	1.74 (3.16)	157 (7.03)	0.20 (0.50)	7.18 (28.72)	4.92 (0.82)	0.30 (1.43)	12.20 (2.03)
T_5	1.71 (3.11)	156 (7.01)	0.24 (0.60)	7.25 (29.00)	4.89 (0.82)	0.26 (1.24)	10.18 (1.70)
T_6	1.68 (3.05)	156 (6.98)	0.28 (0.70)	7.32 (29.28)	4.87 (0.81)	0.22 (1.05)	8.17 (1.36)
T_7	1.66 (3.02)	155 (6.96)	0.31 (0.78)	7.38 (29.52)	4.84 (0.81)	0.18 (0.86)	6.15 (1.03)
RDA	**55**	**2230**	**40**	**25**	**600**	**21**	**600**

Figures in parenthesis represent the percentage of RDA met from one serving of biscuit

T_1 - 100% maida (control)

T_2 - 100% cycas seed flour

T_3 - 70% maida + 30% cycas seed flour

T_4 - 60% maida + 40% cycas seed flour

T_5 - 50% maida + 50% cycas seed flour

T_6 - 40% maida + 60% cycas seed flour

T_7 - 30% maida + 70% cycas seed flour

4.4.5. Chapathi

Nutritive value of chapathi per serving prepared using different combinations of wheat flour and cycas seed flour and the percentage of RDA met per serving are presented in Table 13.

The protein content of chapathi per serving varied from 7.07 g to 9.08 g. Chapathi prepared exclusively with wheat flour had the maximum protein content and the lowest was observed in T_2 which was prepared exclusively with cycas seed flour. It can also be seen that chapathi made with 100 per cent wheat flour provided 16.51 per cent of RDA while other treatments provided about 15.16 per cent (T_3), 15.04 per cent (T_4), 14.67 per cent (T_5), 14.31 per cent (T_6) and 14.20 per cent (T_7) of RDA. Chapathi prepared with 100 per cent cycas seed flour (T_2) supplied 12.85 per cent of RDA for protein.

The energy content of chapathi prepared with 100 per cent wheat flour was found to be 321 KCal followed by 317 KCal (T_3), 316 KCal (T_4), 315 KCal (T_5), 314 KCal (T_6), 313 KCal (T_7) and 308 KCal (T_2) respectively. Chapathi prepared with 100 per cent wheat flour supplied 14.39 per cent of RDA and other treatments supplied 13.81 per cent (T_2), 14.22 per cent (T_3), 14.17 per cent (T_4), 14.13 per cent (T_5), 14.08 per cent (T_6) and 14.04 per cent (T_7) of RDA.

The crude fibre content of chapathi made exclusively with wheat flour (T_1) and cycas seed flour (T_2) were found to be 1.43 g and 1.93 g respectively. The crude fibre content of chapathi prepared with different proportions of wheat flour and cycas seed flour varied from 1.61 g (T_3) to 1.74 g (T_7). Chapathi prepared exclusively with wheat flour and cycas seed flour provided 3.58 per cent and 4.83 per cent RDA of crude fibre.

The fat content of chapathi per serving varied from 8.78 g (T_1) to 11.29 g (T_2). Highest fat content was noticed in the chapathi prepared with 100 per cent cycas seed flour (T_2) and the lowest in 100 per cent wheat flour (T_1). About 45.16 per cent of fat

requirement was met from chapathi prepared with 100 per cent cycas seed flour. The percentage of RDA met from other treatments was found to be 35.12 per cent (T_1), 38.8 per cent (T_3), 39.12 per cent (T_4), 40.12 per cent (T_5), 41.12 per cent (T_6) and 41.48 per cent (T_7).

The calcium content of chapathi prepared exclusively with wheat flour and cycas seed flour were found to be 36.00 mg and 16.00 mg respectively. The calcium content of other treatments varied from 23.33 mg (T_7) to 28.67 mg (T_3) per serving. About 2.67 to 6.00 per cent of calcium requirement was met from the chapathi prepared with different combinations of wheat flour and cycas seed flour.

The iron content of one serving of chapathi was found to be 3.68 mg and 0.19 mg for T_1 and T_2 respectively. It is seen that chapathi made with 100 per cent wheat flour and cycas seed flour provided 17.52 per cent and 0.90 per cent of iron. About 7.00 to 11.43 per cent of iron requirement per day was met from one serving of chapathi prepared with different combinations of wheat flour and cycas seed flour.

The phosphorous content of chapathi varied from '0' mg (T_2) to 266.25 mg (T_1). The phosphorous content of chapathi prepared with different proportions of wheat flour and cycas seed flour were found to be 168.63 mg (T_3), 159.75 mg (T_4), 133.13 mg (T_5), 106.50 mg (T_6) and 97.63 mg (T_7). Chapathi prepared with 100 per cent wheat flour supplied 44.38 per cent of RDA of phosphorous. About 16.27 per cent (T_7) to 28.11 per cent (T_3) of phosphorous requirement was met from the chapathi made with different combinations of cycas seed flour and wheat flour.

Table 13. Nutritive value of chapathi (per serving of 3 nos)

Treatments	Nutrients						
	Protein (g)	**Energy (KCal)**	**Crude fibre (g)**	**Fat (g)**	**Calcium (mg)**	**Iron (mg)**	**Phosphorus (mg)**
T_1	9.08 (16.51)	321 (14.39)	1.43 (3.58)	8.78 (35.12)	36.00 (6.00)	3.68 (17.52)	266.25 (44.38)
T_2	7.07 (12.85)	308 (13.81)	1.93 (4.83)	11.29 (45.16)	16.00 (2.67)	0.19 (0.90)	0
T_3	8.34 (15.16)	317 (14.22)	1.61 (4.03)	9.70 (38.80)	28.67 (4.78)	2.40 (11.43)	168.63 (28.11)
T_4	8.27 (15.04)	316 (14.17)	1.63 (4.08)	9.78 (39.12)	28.00 (4.67)	2.28 (10.86)	159.75 (26.63)
T_5	8.07 (14.67)	315 (14.13)	1.68 (4.20)	10.03 (40.12)	26.00 (4.33)	1.93 (9.19)	133.13 (22.19)
T_6	7.87 (14.31)	314 (14.08)	1.73 (4.33)	10.28 (41.12)	24.00 (4.00)	1.58 (7.52)	106.5 (17.75)
T_7	7.81 (14.20)	313 (14.04)	1.74 (4.35)	10.37 (41.48)	23.33 (3.89)	1.47 (7.00)	97.63 (16.27)
RDA	**55**	**2230**	**40**	**25**	**600**	**21**	**600**

Figures in parenthesis represent the percentage of RDA met from one serving of chapathi

T_1 - 100% wheat flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% wheat flour + 30% cycas seed flour

T_4 - 60% wheat flour + 40% cycas seed flour

T_5 - 50% wheat flour+ 50% cycas seed flour

T_6 - 40% wheat flour + 60% cycas seed flour

T_7 - 30% wheat flour + 70% cycas seed flour

Discussion

DISCUSSION

The discussion pertaining to the study entitled "Evaluation of cycas seed flour for product development" is presented in this section under the following headings.

5.1. Chemical constituents of cycas seed flour and effect of storage on the chemical constituents

5.2. Shelf life of cycas seed flour

5.3. Acceptability and nutritive value of cycas seed flour supplemented products

5.1. Chemical constituents of cycas seed flour and effect of storage on the chemical Constituents

Moisture content of fresh cycas seed flour was found to be 11.03 g $100g^{-1}$. Anitha (2011) indicated a slightly lower moisture content of 10.74 g $100g^{-1}$ in fresh cycas seed flour. Campbell *et al.* (1966) indicated a very low moisture content of 6.5 per cent in the dried cycas flour. However, Miller *et al.* (1993) reported a very high moisture content of 29.3 per cent in the seeds of *Cycas armstrongii*. Thus, wide variation in the moisture content of cycas seeds was reported by various authors. The variation in the moisture content of cycas seed flour observed might be due to the drying adopted for the cycas seed flour after processing the seeds. In the present study, the flour prepared after processing cycas seeds was dried till it attained a moisture content in the range of 10 to12 per cent.

It was also seen that during storage the moisture content of cycas seed flour decreased to 7.83 g $100g^{-1}$ from the initial content of 11.03 g $100g^{-1}$. Thus, a decrease of 29 per cent moisture occurred in the cycas seed flour during storage (Table 14). Bhatiwada (2007) also reported a decrease in the moisture content of grain amaranth flour during three months of storage. This decrease might be due to the low relative humidity of the storage vicinity during summer season.

Cycas seed flour had a protein content of 9.43 g $100g^{-1}$. The protein content of the cycas seed flour in the present study was found to be higher than the protein content of cycas seeds reported by Fysh *et al.* (1960), Harris (1975), Beaton (1977), White (1979), James (1985), Beck (1992) and Miller *et al.* (1993). The authors indicated a protein content in the range of 4 to 5.8 g in the seeds of different Australian cycas species. Anitha (2011) also indicated a protein content in the range of 6.90 to 8.17 g $100g^{-1}$ in processed cycas seed flour. Thus, the protein content of the flour of cycas seeds in the present study was found to be slightly higher than the protein content of other species of cycas. This variation might be due to the difference in the species of cycas seeds.

During storage, protein content of the cycas seed flour decreased to 8.97 g $100g^{-1}$. Thus, about 4.82 per cent decrease in the protein content occurred during storage (Table 14) and the decrease observed might be due to the browning reaction taken place during storage as reported by Sharif *et al.* (2003). The decrease in the protein content of cycas seed flour during storage was found to be in close agreement with the findings reported by Leelavathi *et al.* (1984), Upadhyay *et al.* (1994) and Mirsa and Kulshrestha (2003) in wheat flour, suji and potato flour respectively. Bhatiwada (2007) also indicated a decrease of 5.4 per cent protein in grain amaranth flour during three months of storage. Studies conducted by Sharon (2010), Lakshmy (2011) and Raj (2011) also indicated a loss of protein in food mixtures, tempeh flour and weaning foods during storage.

The cycas seed flour had a starch content of 24.2 g $100g^{-1}$. Anitha (2011) indicated a slightly higher starch content in the range of 33 to 53 g $100g^{-1}$ in cycas seed flour prepared by different processing methods. The author also reported a significant decrease in the starch content of cycas seed flour with an increase in the number of washings given to the cycas seeds. The low starch content observed in the present study is due to the leaching out of soluble starch content from cycas seeds due to the repeated washings employed during processing.

During storage, the starch content of the flour decreased significantly. About 31 per cent of starch was lost from the cycas seed flour during three months of storage (Table 14). Bhatiwada (2007) also indicated a gradual decrease in the starch content of grain amaranth flour during three months of storage. This finding is in accordance with the findings of Lakshmy (2003), Sharon (2010) and Lakshmy (2011) in banana flour, fermented and unfermented food mixtures and tempeh flour. The decrease in the starch content of cycas seed flour during storage might be due to the hydrolysis of polysaccharides to simple sugars as reported by Upadhyay *et al.* (1994) and Pillai (2001).

The total carbohydrate content of cycas seed flour was found to be 59.22 g $100g^{-1}$ and it decreased to 47.11 g $100g^{-1}$ during storage. The carbohydrate content of 59.22 g $100g^{-1}$ noticed initially is in line with the findings reported by Anitha (2011) in which the author indicated a carbohydrate content in the range of 37 to 66 g $100g^{-1}$ in the cycas seed flour prepared by different processing methods.

A decrease of about 20 per cent was occurred for the carbohydrate content of cycas seed flour during storage (Table 14). The decrease could be due to the lowering of hydrocarbon content of seed flour during storage as indicated by Losser (1987). Kungu *et al.* (2003) also observed a decrease in the total carbohydrate content of the flour prepared with millets, sorghum, cow pea and green gram during storage. The decrease observed in the carbohydrate content of cycas seed flour during storage is also in close agreement with the findings reported by Raj (2011) in grain amaranth based weaning foods.

The crude fibre content of cycas seed flour was found to be 2.57 g $100g^{-1}$ initially which decreased to 2.16 g $100g^{-1}$ at the end of storage. The crude fibre content of cycas seed flour was found to be slightly higher than the crude fibre content in the range of 1.67 to 2.25 g $100g^{-1}$ reported by Anitha (2011) in processed cycas seed flour.

About 16 per cent loss of crude fibre occurred during storage (Table 14). This loss in crude fibre content during storage might be due to the degradation of hemicellulose and

other structural polysaccharide materials in the flour during storage as reported by Mirsa and Kulshrestha (2003) and Sharif *et al.* (2003). The decrease in fibre content of the flour during storage is in line with the findings of Bhatiwada (2007) and Raj (2011) in grain amaranth flour and weaning foods prepared using grain amaranth flour.

The fat content of cycas seed flour was found to be 5.05 g $100g^{-1}$. This was found to be slightly higher than the fat content observed by Anitha (2011) in processed cycas seed flour. However Campbell *et al.* (1966) and Miller *et al.* (1993) indicated very low fat content of 0.4 and 0.8 g $100g^{-1}$ in two different species of cycas namely *Cycas armstrongii* and *Cycas circinalis* respectively.

During storage, the fat content of the flour decreased to 2.60 g $100g^{-1}$. Thus, about 49 per cent loss in the fat content of cycas seed flour occurred during three months of storage (Table 14). This decrease in fat content during storage may be attributed to the lypolytic activity of enzymes like lipase and lipoxidase (Sharif *et al.*, 2003). Haridas *et al.* (1983) and Leelavathi *et al.* (1984) also indicated a decrease in the fat content of wheat flour during storage. Bhatiwada (2007) and Raj (2011) also revealed a slight decrease in the fat content of grain amaranth flour and weaning foods prepared using grain amaranth flour during storage.

The calcium content of cycas seed flour was found to be 21.33 mg $100g^{-1}$ before storage and a slight decrease of 1.27 per cent calcium was noticed in the flour after three months of storage (Table 14). The decrease observed in the calcium content during storage was found to be statistically insignificant. The calcium content observed initially was found to be higher than the content of 8 to 14 mg reported by Anitha (2011) in cycas seed flour prepared by processing the seeds of *Cycas circinalis*. However, Miller *et al.* (1993) indicated almost similar calcium content of 21 mg in *Cycas armstrongii* an indigenous food consumed in Australia.

The slight decrease observed in the calcium content of cycas seed flour during storage might be due to the utilisation of nutrients by the microbes growing in the flour. This view has been suggested by Rangaswami and Bagyaraj (2000) who reported that microbes in food stuffs utilise the nutrients from the food for their needs. Bhatiwada (2007) and Hanmant (2010) also indicated a slight decrease in the calcium content of grain amaranth flour and mango seed kernel flour during storage. Lakshmy (2003 and 2011), Sharon (2010) and Raj (2011) also reported a decrease in the calcium content of banana flour, tempeh flour, food mixtures and weaning foods during storage.

Phosphorous content was not present in cycas seed flour. Anitha (2011) also observed absence of phosphorous in the flour of cycas seeds collected both from forest and non forest areas.

Initially, the sodium and potassium contents of cycas seed flour were found to be 6.2 mg and 25.53 mg $100g^{-1}$ respectively. Though, a slight decrease in the potassium content was noticed during storage, all the sodium present in the flour was retained during storage.

The sodium content noticed in the present study was found to be in line with the sodium content of processed cycas seed flour reported by Anitha (2011) in which the author reported a sodium content in the range of 6.40 mg to 8.00 mg $100g^{-1}$ in the flour of cycas seeds collected from non forest areas. Miller *et al.* (1993) also indicated a sodium content of 5 mg $100g^{-1}$ in *Cycas armstrongii.*

The potassium content of cycas seed flour observed in the present study was lower than the potassium content reported by Anitha (2011) in which the author indicated a potassium content in the range of 17.77 to 154 mg in the flour of processed cycas seeds. Miller *et al.* (1993) also indicated 66 mg potassium in *Cycas armstrongii.* The low potassium content observed in the present study might be due to the leaching of potassium in the water used for washing the seeds. High potassium and low sodium content noticed in

cycas seed flour could be considered as an ideal food for those who wants to reduce the sodium intake through diet especially those who are suffering from hypertension and cardiovascular diseases.

During storage, a slight decrease (3.52 per cent) in the potassium content was noticed in cycas seed flour (Table 14). This finding is in line with the observations reported by Lakshmy (2003), Bhatiwada (2007) and Lakshmy (2011) in which the authors indicated a slight but insignificant decrease in the potassium content of banana flour, grain amaranth flour and tempeh flour during storage.

The iron content of cycas seed flour was found to be 0.25 mg which is lower than the iron content indicated by Anitha (2011) in raw as well as in the flour of processed cycas seeds. The author indicated an iron content in the range of 1.22 to 1.82 mg $100g^{-1}$ in the flour of cycas seeds prepared by different processing methods. However, Miller *et al.* (1993) indicated an higher iron content of 4.6 mg $100g^{-1}$ in *Cycas armstrongii*. Very low iron content observed might be due to the loss of iron during repeated washings of cycas seeds during processing.

The iron content of cycas seed flour decreased slightly during storage and the iron content was found to be 0.23 mg $100g^{-1}$ at the end of three months of storage. About 8 per cent of iron was lost during storage (Table 14). Rubin *et al.* (1997), Misfa *et al.* (2000) and Sharif *et al.* (2003) observed a reduction in the iron content of wheat flour during storage. Lakshmy (2003), Bhatiwada (2007), Hanmant (2010), Sharon (2010), Lakshmy (2011) and Raj (2011) also observed a slight reduction in the iron content of banana flour, grain amaranth flour, mango seed kernel flour, food mixtures, tempeh flour and weaning foods during storage.

The crude alkaloid content of cycas seed flour was found to be 0.53 mg 100^{-1}. After storage, the crude alkaloid content decreased to 0.44 mg 100^{-1}. Anitha (2011) indicated a crude alkaloid content of 1.56 mg and 1.60 mg in the flour of cycas seeds collected from

forest and non forest areas. About 17 per cent of crude alkaloids were lost during storage. The low amount of crude alkaloids noticed in the cycas seed flour might be due to the leaching of crude alkaloids during the repeated soaking and washing of cycas seeds while processing. Anitha (2011) also indicated a decrease in the crude alkaloid content of processed cycas seeds. The author indicated a loss of 7 to 25 per cent crude alkaloids when the cycas seeds were processed by simply soaking the seeds in water for 12 to 24 hours. The author also indicated increased loss of crude alkaloids with an increase in the soaking time, temperature of soaking as well as with an increase in the number of washings of cycas seeds. Thus, it could be concluded that the low amount of alkaloids in the cycas seed flour is due to the leaching out of alkaloids in water. Nwosu (2010) reported soaking helped in the removal of the soluble antinutrients like alkaloids in Asparagus bean flour and with an increase in the time of soaking, the loss of antinutrients also increased. This result was in agreement with the report of Phillips and Abbey (1989) and Ijeh *et al.* (2010) in which the authors indicated that steeping hydrates the grain and induces the leaching out of water soluble antinutrients such as alkaloids. Nwaoguikpe *et al.* (2011) reported reduced concentration of alkaloids in *Mucuna pruriens* seeds during soaking.

5.2. Shelf life of cycas seed flour

Initially, cycas seed flour had a microbial load of 3.44×10^5 cfu g^{-1} of bacteria, 3.33×10^3 cfu g^{-1} of fungi and 3.22×10^3 cfu g^{-1} of yeast. In wheat flour and chick pea flour, a bacterial load of 5×10^4 cfu g^{-1} and 110×10^4 cfu g^{-1} respectively were observed by Livingstone *et al.* (1992). Bhaskar (2000) and Tsav-Wvo *et al.* (2004) also observed a bacterial load of 6×10^6 cfu g^{-1} and 2.7×10^7 cfu g^{-1} in banana powder and fermented cassava flour.

When the cycas seed flour was stored for three months, the count of bacteria, fungi and yeast increased to 4.44×10^5 cfu g^{-1}, 4.55×10^3 cfu g^{-1} and 3.99×10^3 cfu g^{-1} respectively. Thus, about 29 per cent, 37 per cent and 24 per cent increase in the count of bacteria, fungi and yeast respectively occurred during storage. The microorganisms already

present in the flour might have multiplied during storage due to the various favourable environmental factors and storage conditions. Various extrinsic and intrinsic factors like moisture, relative humidity, storage temperature, type of samples, storage containers etc. might have affected the microbial count of flour during storage. It was also seen that different nutritional constituents also decreased during storage in the cycas seed flour. The microorganisms might have utilised the nutrients for their growth and thus increased the microbial load.

Table 14. Percentage decrease in the chemical constituents of cycas seed flour during storage

Constituents	Percentage decrease
Moisture (g)	29.00
Protein (g)	4.82
Starch (g)	31.00
Total Carbohydrates (g)	20.00
Crude fibre (g)	16.00
Fat (g)	49.00
Calcium (mg)	1.27
Sodium (mg)	0
Potassium (mg)	3.52
Iron (mg)	8.00
Crude alkaloid (mg)	17.00

Bera *et al.* (2001) indicated that the growth of bacteria and fungi in the food sample are influenced by moisture content, high or low humidity, temperature of storage and type of sample. Sharon (2003) reported a bacterial count of 5.2×10^6 cfu g^{-1} initially in bread fruit flour which increased to 8.9×10^6 cfu g^{-1} at the end of third month of storage. Bhatiwada (2007) also observed an increase in bacterial count from 2.6 to 8.8×10^6 cfu g^{-1}

in grain amaranth flour and Hanmant (2010) observed an increase of 2.03 x 10^6 cfu g^{-1} to a maximum count of 4.24 x 10^6 cfu g^{-1} in mango seed kernel flour during storage. An increase in the bacterial count from 1 x 10^5 cfu g^{-1} to 2 x 10^5 cfu g^{-1} in unroasted bamboo seed flour was noticed by Kunhimon (2010) after three months of storage.

In the case of fungi and yeast also, different studies conducted by Sharon (2003), Bhatiwada (2007), and Hanmant (2010) indicated an increase in the fungal count of bread fruit flour, grain amaranth flour and mango seed kernel flour during storage. The authors reported an increase of 4.6 x 10^4 cfu g^{-1} to 8.3 x 10^4, 1.8 x 10^3 cfu g^{-1} to 5.8 x 10^3 cfu g^{-1} and zero to 1.83 x 10^3 cfu g^{-1} in the flour during storage. Bhatiwada (2007) observed an increase in yeast count from 1.5 to 5.3x10^3 cfu g^{-1} in grain amaranth flour during storage.

Insect infestation was not detected in cycas seed flour through out the storage period. This could be due to the proper drying of the flour and appropriate storage conditions used for the study. Insect infestation was not observed by Bhatiwada (2007) and Kunhimon (2010) in grain amaranth flour and roasted and unroasted bamboo seed flour during storage.

5.3. Acceptability and nutritive value of cycas seed flour supplemented products

Five products namely puttu, ada, pathiri, biscuit and chapathi were prepared by incorporating cycas seed flour in different proportions along with the main ingredients for respective products. Thus, puttu, ada and pathiri were prepared using rice flour as the main ingredient. For chapathi and biscuit, wheat flour and maida were used respectively as the main ingredients. All the products were prepared by substituting the main ingredient with cycas seed flour and with 100 per cent cycas seed flour. The product prepared with 100 per cent main ingredient was taken as the control. The nutritive value of each product per one serving was also computed.

Puttu prepared with 100 per cent rice flour, 100 per cent cycas seed flour as well as those prepared with different combinations of rice flour and cycas seed flour obtained a mean score of above 7.50 for different quality attributes as well as for overall acceptability. Among the different treatments tried, T_2 which was prepared exclusively with 100 per cent cycas seed flour obtained the lowest overall acceptability score of 7.7 with a rank score of 2.68. Among the different combinations tried, puttu prepared with equal proportions of rice flour and cycas seed flour (T_5) obtained the highest mean and rank scores for texture, taste and overall acceptability. Puttu prepared with 100 per cent rice flour (T_1), 70 per cent rice flour and 30 per cent cycas seed flour as well as 50 per cent rice flour and 50 per cent cycas seed flour obtained a mean score of above 8.00 for almost all quality attributes.

For almost all combinations, a decreasing trend in the mean scores of puttu was observed for different quality attributes and overall acceptability with an increase in the quantity of cycas seed flour especially in T_5 & T_6. However, puttu prepared with different combinations of cycas seed flour and rice flour obtained a score of above 7.93 with a mean rank score in the range of 3.28 to 4.38 for overall acceptability, indicating the acceptability of cycas seed flour supplemented puttu among the judges.

In the case of ada and pathiri, which were also prepared with rice as the main ingredient, those prepared with 100 per cent rice flour (T_1) was found to be more acceptable. This treatment obtained highest mean and rank scores for overall acceptability as well as for different quality attributes like appearance, colour, texture, flavour and taste. Among the different treatments tried by substituting rice flour with cycas seed flour (T_3 to T_7), ada prepared with equal proportion of rice flour and cycas seed flour obtained the highest mean and rank score for taste and overall acceptability. For appearance, colour, texture and flavour, T_3 which was prepared with 70 per cent rice flour and 30 per cent cycas seed flour obtained maximum scores. For pathiri also T_3 obtained the maximum scores for different quality attributes except texture. For texture, T_5 had the highest mean and rank scores. A decreasing trend was also observed in the mean and rank scores for overall acceptability in the case of pathiri with an increase in the quantity of cycas seed flour.

Better acceptability noticed for ada and pathiri prepared exclusively with rice flour might be due to the familiarity and preference given by the judges for products prepared with rice flour, the staple food of Keralites. The unpleasant odour of cycas seed flour also might have influenced the lower acceptability of cycas seed flour supplemented products. Bhatiwada (2007) also indicated better acceptability for products prepared exclusively with rice flour when compared to products prepared with rice flour and grain amaranth flour in different proportions. However, it can also be seen that all the treatments in which cycas seed flour was supplemented for rice flour as well as the one tried exclusively with 100 per cent cycas seed flour obtained a score of above 7.00 for ada and pathiri indicating the acceptability of cycas seed flour supplemented products among the judges.

Biscuits prepared by incorporating cycas seed flour with maida at different proportions obtained lower scores for all quality attributes except T_3 and T_4 when compared to biscuit prepared exclusively with maida. This may be due to the poor texture of biscuits prepared by incorporating cycas seed flour. However, biscuits prepared by substituting different proportions of cycas seed flour as well as the one prepared exclusively with cycas seed flour obtained a score of above 7.5 out of 10 for different quality attributes including overall acceptability. Even biscuits prepared with 60 per cent maida and 40 per cent cycas seed flour (T_4) obtained maximum mean and rank scores for appearance, texture, taste and overall acceptability when compared to biscuits prepared exclusively with maida.

Thus, it could be concluded that cycas seed flour could also be used to prepare acceptable biscuits. The better preference obtained for biscuits prepared with maida could be due to the familiarity of judges for maida biscuits. Studies conducted by Seralathan *et al.* (1991), Bhuvaneshwari (1995) and Bhatiwada (2007) in the preparation of cakes and biscuits by substituting maida with grain amaranth flour also indicated better acceptability for products prepared exclusively with maida. However, the authors also observed better acceptability for cakes and biscuits prepared even with 25 to 50 per cent substitution of grain amaranth flour.

In the case of chapathi, which was prepared with wheat flour as the main ingredient, it was seen that all the treatments prepared by substituting cycas seed flour for wheat flour especially T_4 to T_7 as well as T_2 were not at all acceptable to the judges. T_2 which was prepared exclusively with cycas seed flour obtained the least score of 2.03 with a least mean rank score of 1.28 for overall acceptability. A decreasing trend in the scores of chapathi was noticed for different quality attributes with an increased proportion of cycas seed flour. Chapathi prepared with 100 per cent wheat flour obtained the highest mean and rank scores for different quality attributes including overall acceptability. The lower acceptability of chapathi prepared exclusively with cycas seed flour as well as wheat flour in combination with different proportions of cycas seed flour is due to the poor texture of chapathi. The formation of gluten which is the important protein in wheat will be reduced with an increase in the quantity of cycas seed flour. This might have affected the texture of chapathi and influenced the organoleptic scores for different quality attributes. Thus, it could be concluded that cycas seed flour is not suitable to prepare acceptable chapathi.

When the nutritive value of products prepared with rice flour as the main ingredient, namely puttu, ada and pathiri was computed per serving, it was seen that the protein, crude fibre, fat and calcium content increased with an increase in the quantity of cycas seed flour. However, energy, iron and phosphorous content of these three products decreased with an increase in the quantity of cycas seed flour. This is mainly due to the relatively high amount of protein, crude fibre, fat and calcium in cycas seed flour when compared to rice flour. The other three constituents namely energy, iron and phosphorous were found to be comparatively low in cycas seed flour. Among the different treatments tried to prepare puttu, ada and pathiri, maximum amount of protein, crude fibre, fat and calcium was found to be in T_2 in which the products were prepared exclusively with cycas seed flour.

In the case of biscuits and chapathi which were prepared respectively with refined wheat flour (maida) and whole wheat flour as the basic ingredients, except crude fibre and fat all the other constituents namely protein, energy, calcium, iron and phosphorus

decreased with an increase in the quantity of cycas seed flour used to prepare biscuits and chapathi. Thus, T_2 in which biscuits and chapathi were prepared exclusively with cycas seed flour had the lowest content of protein, energy, calcium, iron and phosphorous. Highest amount of these constituents was found in T_1. This is due to the relatively high amount of protein, energy, calcium, iron and phosphorous in maida and wheat flour when compared to cycas seed flour. However, crude fibre and fat content of cycas seed flour were relatively high when compared to maida and wheat flour. So, these two constituents increased in treatments with an increased supplementation of cycas seed flour.

The overall quality of products prepared with different combinations of main ingredient and cycas seed flour (T_3 to T_7) and exclusively with the main ingredient (T_1) and cycas seed flour (T_2) was computed on the basis of total mean scores obtained for different quality attributes namely appearance, colour, texture, flavour and taste, overall acceptability score and the index of RDA. Index of RDA was computed as the sum of the percentage of RDA met for different nutrients. The details are given in Tables 15 to 19.

On the basis of total mean score, overall acceptability score and the index of RDA computed for puttu (Table 15), T_5, which was prepared with 50 per cent rice flour and 50 per cent cycas seed flour was found to be the best combination. This treatment obtained the highest mean and overall acceptability scores of 8.32 and 8.57 and 69.26 as the index of RDA. Puttu prepared with 100 per cent cycas seed flour obtained a score of 8.47 and 8.53 respectively for quality attributes and overall acceptability, and 69 as the index of RDA. The acceptability score also decreased with an increase in the incorporation of cycas seed flour. This could be due to the lack of familiarity of cycas seeds as a food ingredient in the daily diet. Thus, to familiarise cycas seed flour, it is desirable to incorporate rice flour upto 50 per cent in cycas seed flour for the preparation of puttu.

For ada, which was prepared with rice flour as the basic ingredient T_3 prepared with 70 per cent rice flour and 30 per cent cycas seed flour obtained the highest total mean score for different quality attributes and overall acceptability when taken together (16.76)

followed by T_5 in which the total score was found to be 16.64. T_3 also obtained 44.26 as the index of RDA (Table 16). Thus, it could be seen that to prepare ada it is desirable to incorporate 70 per cent rice flour along with cycas seed flour.

Table 15. Overall quality of puttu on the basis of organoleptic scores and index of RDA

Treatments	Mean scores		Index of RDA*
	Quality attributes	Overall acceptability	
T_1	8.47	8.53	69.00
T_2	7.83	7.70	69.53
T_3	8.24	8.37	69.17
T_4	8.08	8.30	69.17
T_5	8.32	8.57	69.26
T_6	7.92	7.97	69.28
T_7	7.86	7.93	69.25

*Index of RDA computed as the sum of percentage of RDA met for nutrients

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

For pathiri also, T_3 obtained maximum mean score for different quality attributes (7.89), overall acceptability (7.93) and index of RDA (67.14) indicating that it is ideal to incorporate 70 per cent rice flour in cycas seed flour (Table 17) to prepare pathiri.

In the case of biscuit, in which maida was used as the basic ingredient, T_3 had the maximum mean score for different quality attributes as well as overall acceptability and index of RDA (Table 18). Thus, it is desirable to incorporate 70 per cent maida in cycas seed flour to prepare biscuit.

Table 16. Overall quality of ada on the basis of organoleptic scores and index of RDA

Treatments	Mean scores		Index of RDA*
	Quality attributes	Overall acceptability	
T_1	8.48	8.53	44.23
T_2	7.59	7.50	43.21
T_3	8.39	8.37	44.26
T_4	8.20	8.23	44.25
T_5	8.24	8.40	44.30
T_6	7.86	7.83	44.33
T_7	8.00	8.10	44.30

*Index of RDA computed as the sum of percentage of RDA met for nutrients

Table 17. Overall quality of pathiri on the basis of organoleptic scores and index of RDA

Treatments	Mean scores		Index of RDA*
	Quality attributes	Overall acceptability	
T_1	8.68	8.70	67.01
T_2	7.30	7.16	62.95
T_3	7.89	7.93	67.14
T_4	7.74	7.90	67.29
T_5	7.80	7.80	67.36
T_6	7.45	7.40	67.51
T_7	7.31	7.13	67.49

*Index of RDA computed as the sum of percentage of RDA met for nutrients

T_1 - 100% rice flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% rice flour + 30% cycas seed flour

T_4 - 60% rice flour + 40% cycas seed flour

T_5 - 50% rice flour + 50% cycas seed flour

T_6 - 40% rice flour + 60% cycas seed flour

T_7 - 30% rice flour + 70% cycas seed flour

Table 18. Overall quality of biscuit on the basis of organoleptic scores and index of RDA

Treatments	Mean scores		Index of RDA*
	Quality attributes	Overall acceptability	
T_1	8.09	8.03	44.65
T_2	7.67	7.70	42.31
T_3	8.19	8.37	43.91
T_4	8.16	8.27	43.69
T_5	7.63	7.83	43.48
T_6	7.87	8.03	43.23
T_7	7.83	7.93	42.98

*Index of RDA computed as the sum of percentage of RDA met for nutrients

T_1 - 100% maida (control)

T_2 - 100% cycas seed flour

T_3 - 70% maida + 30% cycas seed flour

T_4 - 60% maida + 40% cycas seed flour

T_5 - 50% maida + 50% cycas seed flour

T_6 - 40% maida + 60% cycas seed flour

T_7 - 30% maida + 70% cycas seed flour

Chapathi prepared with different combinations of wheat flour and cycas seed flour obtained very low scores for different quality attributes and overall accepatability. When compared to T_1, the index of RDA also was found to be very low for T_2 to T_7 (Table 19). Thus, it is seen that cycas seed flour is not an ideal ingredient to prepare chapathi.

Table 19. Overall quality of chapathi on the basis of organoleptic scores and index of RDA

Treatments	Mean score		Index of RDA*
	Quality attributes	Overall acceptability	
T_1	8.21	8.30	137.50
T_2	2.26	2.03	80.22
T_3	6.80	6.87	116.53
T_4	5.73	5.67	114.57
T_5	4.99	4.90	108.83
T_6	3.45	2.23	103.11
T_7	3.00	2.87	101.23

*Index of RDA computed as the sum of percentage of RDA met for nutrients

T_1 - 100% wheat flour (control)

T_2 - 100% cycas seed flour

T_3 - 70% wheat flour + 30% cycas seed flour

T_4 - 60% wheat flour + 40% cycas seed flour

T_5 - 50% wheat flour+ 50% cycas seed flour

T_6 - 40% wheat flour + 60% cycas seed flour

T_7 - 30% wheat flour + 70% cycas seed flour

Summary

SUMMARY

The present study entitled "Evaluation of cycas seed flour for product development" was undertaken with the aim of evaluating the quality of cycas seed flour and to develop cycas seed flour supplemented products and to evaluate the nutritional and organoleptic qualities of the developed products.

Cycas seeds and other ingredients required for the study were procured from the market. To prepare the cycas seed flour, cycas seeds were soaked in cold water for six hours, stirred and drained off the foamy water. This washing process was repeated seven times. Thereafter, the seeds were partially dried in sunlight and powdered for the preparation of flour. The prepared flour was dried in a cabinet drier at 60 ± 5°C till the flour attained a moisture content of 10-12 per cent and stored in glass bottles for a period of three months under ambient conditions.

The prepared flour was analysed for different constituents namely moisture, protein, starch, total carbohydrate, crude fibre, fat, calcium, phosphorous sodium, potassium and iron. The antinutritional/ toxic factors in the flour such as crude alkaloids, cycasin and hydrocyanic acid were also analysed.

The moisture content of cycas seed flour was found to be 11.03 g $100g^{-1}$ which decreased to 7.83 g $100g^{-1}$ after three months of storage. The protein content of cycas seed flour was found to be 9.43 g $100g^{-1}$ initially which decreased to 8.97 g $100g^{-1}$ during storage.

A significant decrease in the starch, total carbohydrate, crude fibre and fat content of cycas seed flour was observed during storage. The fresh cycas seed flour had a starch content of 24.2 g $100g^{-1}$ which decreased to 16.85 g $100g^{-1}$ and total carbohydrate decreased from 59.22 g $100g^{-1}$ to 47.11 g $100g^{-1}$ during storage. The crude fibre content of the fresh flour was found to be 2.57 g $100g^{-1}$ which decreased to 2.16 g $100g^{-1}$ after three

months of storage. The fat content also decreased from the initial value of 5.05 g $100g^{-1}$ to 2.60 g $100g^{-1}$ at the end of storage.

The initial calcium content of cycas seed flour was found to be 21.33 mg $100g^{-1}$ and after storage the calcium content was found to be 21.06 mg $100g^{-1}$. Phosphorous was not present in the cycas seed flour. The cycas seed flour had a sodium content of 6.2 mg $100g^{-1}$ initially and this was retained in the flour during storage. The initial potassium content of cycas seed flour was found to be 25.53 mg $100g^{-1}$. After three months of storage, the potassium content decreased slightly to 24.63 mg $100g^{-1}$. The iron content also decreased slightly from the intial content of 0.25 mg $100g^{-1}$ to 0.23 mg $100g^{-1}$ during storage. The decrease observed in these mineral constituents was found to be statistically insignificant.

A significant decrease was noticed in the crude alkaloid content of cycas seed flour during storage. The cycas seed flour had a crude alkaloid content of 0.53 mg $100g^{-1}$ initially and 0.44 mg $100g^{-1}$ at the end of storage. Hydrocyanic acid was not present in the cycas seed flour.

Microbial enumeration of flour with respect to bacteria, fungi and yeast were conducted initially and after three months of storage. A gradual increase in the microbial count was noticed during storage.

The initial bacterial load in cycas seed flour was found to be 3.44×10^5 cfu g^{-1} which increased to 4.44×10^5 cfu g^{-1} after three months of storage. The percentage relative increase of bacterial count was observed to be 29.07 per cent. The initial fungal growth was found to be 3.33×10^3 cfu g^{-1} and it increased to 4.55×10^3 cfu g^{-1} at the end of storage. About 36.64 per cent relative increase was noticed in fungal count. The initial yeast growth in cycas seed flour was found to be 3.22×10^3 cfu g^{-1} which increased to 3.99×10^3 cfu g^{-1} during storage. The percentage relative increase of yeast count was found to be 23.91 per cent.

Insect infestation in cycas seed flour was also evaluated initially and at the end of three months of storage and insect infestation was not observed in the flour.

Five different products namely puttu, ada, pathiri, biscuit and chapathi were prepared by incorporating cycas seed flour in different proportions along with the main ingredient for respective products and were evaluated organoleptically for different quality attributes like appearance, colour, texture, flavour, taste and overall acceptability using score card. Thus, puttu, ada and pathiri were prepared using rice as main ingredient. For chapathi and biscuit, wheat flour and maida were used respectively as the main ingredients. The product prepared with 100 per cent main ingredient was taken as the control. T_2 was prepared with 100 per cent cycas seed flour. T_3 was 70 per cent main ingredient and 30 per cent cycas seed flour. From T_4 to T_7, the main ingredient decreased proportionally by 10 per cent while cycas seed flour increased by 10 per cent. The nutritive value of each product per one serving was also computed.

The mean score for appearance of puttu varied from 8.00 (T_6 & T_7) to 8.50 (T_1) with a mean rank score in the range of 3.55 to 4.92. Among the different treatments, puttu prepared with 100 per cent rice flour obtained the highest mean score (8.47) and mean rank score (4.57) for colour. The mean score for texture and flavour of puttu prepared with 100 per cent rice flour was found to be 8.57 and 8.33 respectively. The lowest scores of 7.50 and 7.63 for texture and flavour was observed in puttu prepared with 100 per cent cycas seed flour (T_2). The highest mean scores for taste (8.60) and overall acceptability (8.57) was found to be high for the puttu prepared with equal proportions of rice flour and cycas seed flour (T_5).

The mean score for appearance of ada prepared using seven treatments varied from 7.80 (T_2) to 8.50 (T_1 & T_3) with mean rank scores in between 2.70 to 4.77. Ada made exclusively with rice flour (T_1) obtained the highest mean (8.53) and rank scores (5.08) for colour. For texture, ada prepared with rice flour and cycas seed flour in the ratio of 70:30

(T_3), and ada prepared exclusively with rice flour (T_1) obtained the maximum mean score of 8.33. The mean score for flavour and taste of ada prepared with 100 per cent rice flour was found to be 8.43 and 8.63 respectively. The highest scores were observed in T_1 and lowest in T_2. For overall acceptability, ada prepared with 100 per cent rice flour (T_1) obtained the highest mean score of 8.53.

The appearance of pathiri prepared exclusively with rice flour (T_1) had a maximum score of 8.8 and the highest mean rank score of 6.37. For colour also maximum score (8.70) and mean rank score (6.33) was observed for T_1. For texture, pathiri prepared with 100 per cent cycas seed flour obtained the lowest mean score of 7.16. The mean rank score was found to be 2.57. Pathiri prepared with 100 per cent rice flour obtained the highest mean score of 8.50 for flavour and 8.67 for taste. The overall acceptability of pathiri was also found to be high in T_1.

Among the seven treatments tried, biscuit prepared with 100 per cent maida obtained the highest mean score of 8.10 with a mean rank score of 4.40 for appearance. The highest mean score for colour and flavour of biscuit prepared exclusively with maida were 8.23 and 8.20 respectively. The mean score for texture was high (8.40) for biscuit prepared with 60 per cent maida and 40 per cent cycas seed flour (T_4). For taste, the highest mean (8.37) and rank scores (5.13) were found to be in T_3 which was prepared using 70 per cent maida and 30 per cent cycas seed flour. The overall acceptability was also found to be high in T_3. Biscuit prepared exclusively with cycas seed flour had the lowest mean (7.70) and rank scores (3.23) for overall acceptability.

Among the different treatments tried for chapathi, the highest mean and rank scores for all quality attributes was found to be in T_1 which was prepared with 100 per cent wheat flour. The lowest mean and rank scores for different quality attributes including overall acceptability was obtained in T_2 which was prepared exclusively with cycas seed flour. Among the different treatments tried with wheat flour and cycas seed flour also, the mean and rank scores were found to be very low.

All the products except chapathi prepared by supplementing cycas seed flour was found to be acceptable to the judges.

When the nutritive value of puttu, ada and pathiri per serving was computed, it was seen that protein, crude fibre, fat and calcium increased with an increase in the quantity of cycas seed flour. The energy, iron and phosphorous content decreased with an increase in the quantity of cycas seed flour. Among the different treatments tried, maximum amount of protein, crude fibre, fat and calcium was found in puttu, ada and pathiri prepared exclusively with cycas seed flour.

In the case of biscuits and chapathi, in which maida and wheat flour were used as the basic ingredients, all constituents except crude fibre and fat namely protein, energy, calcium, iron and phosphorous decreased with an increase in the quantity of cycas seed flour. Here, T_2 which was prepared exclusively with cycas seed flour had the lowest protein, energy, calcium, iron and phosphorous. Crude fibre and fat increased with an increased supplementation of cycas seed flour in biscuits and chapathi.

Cycas seed flour was found to be rich in various nutrients especially carbohydrate, crude fibre, fat and mineral constituents. As gluten is not present in cycas seed, it can be recommended for people with gluten allergy. Cycas seed flour can be incorporated to prepare acceptable products like puttu, ada, pathiri and biscuits.

Future work can be carried out to develop value added bakery and confectionery products and fermented foods using cycas seeds.

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*originals not seen

Appendix

APPENDIX I

Score card for organoleptic evaluation of cycas seed flour supplemented products

Name of the judge:
Date :

Characteristics	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Appearance							
Colour							
Texture							
Flavour							
Taste							
Overall acceptability							

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature:

EVALUATION OF CYCAS SEED FLOUR FOR PRODUCT DEVELOPMENT

By

LIJITHA, S
(2009 16-102)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE AND NUTRITION)

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2012

ABSTRACT

The study entitled "Evaluation of cycas seed flour for product development" was undertaken to evaluate the chemical constituents and shelf life of processed cycas seed flour. The study also envisaged to develop cycas seed flour supplemented products and to evaluate the nutritional and organoleptic qualities of the developed products.

Cycas seeds and other ingredients required for the study were procured from the market. Cycas seeds were processed by soaking in cold water for six hours and draining the soaked water, repeatedly for seven times prior to the preparation of the flour. The cycas flour thus prepared was dried in a cabinet drier at 60 ± 5°C to a moisture content of 10-12 per cent and stored in glass bottles for a period of three months under ambient conditions.

The constituents like moisture, protein, starch, total carbohydrates, crude fibre, fat, calcium, phosphorous, sodium, potassium and iron were estimated initially and after three months of storage. The antinutritional/ toxic factors in the flour such as crude alkaloids, cycasin and hydrocyanic acid were also analysed. Shelf life of cycas seed flour was also evaluated during storage.

The processed cycas seed flour was found to be rich in carbohydrate and macro and micro minerals with ideal sodium - potassium ratio. The alkaloid content in processed cycas flour was found to be low. A significant decrease in the constituents like starch, total carbohydrate, crude fibre, fat and crude alkaloids was noticed during storage. A gradual increase in the microbial count was observed during storage. Insect infestation was not detected in cycas seed flour through out the period under study.

Five products namely puttu, ada, pathiri, biscuit and chapathi were prepared by incorporating cycas seed flour in different proportions along with the main ingredient for respective products. The products were evaluated organoleptically for different quality attributes like appearance, colour, texture, flavour, taste and overall acceptability using score card. Rice was used as the main ingredient for the preparation of puttu, ada and pathiri. For chapathi and biscuit, wheat flour and maida were used respectively as the main

ingredients. The product prepared with 100 per cent main ingredient was taken as the control. All products were prepared exclusively with cycas seed flour. The cycas flour was also incorporated into the basic ingredient at 30 to 70 per cent for the preparation of the products. Among the different products prepared by supplementing cycas seed flour, except chapathi, all products were found to be acceptable to the judges.

The nutritive value of the products prepared by supplementing cycas flour was computed per serving. In puttu, ada and pathiri, the nutrients like protein, crude fibre, fat and calcium content increased with increase in the quantity of cycas seed flour. In the case of biscuit and chapathi, increased supplementation of cycas seed flour improved the crude fibre and fat content. Incorporation of cycas flour at the rate of 30 to 50 per cent with rice flour and maida was found to be ideal for the preparation of acceptable products.