PHYSIO CHEMICAL PROPERTIES OF JACKFRUIT (*Artocarpus heterophyllus* Lam.) SEED FLOUR AND ITS PROSPECTS FOR USE IN CATTLE FEED

By

G. SRI KRISHNA

THESIS

submitted in partial fulfilment of the requirements for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

Department of Processing Technology

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2005

DECLARATION

I, hereby declare that this thesis entitled **"Physio chemical properties of jackfruit *(Artocarpus heterophyllus* Lam.) seed flour and its prospects for use in cattle feed"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

G. Srikri

G. Sri Krishna

CERTIFICATE

Certified that this thesis entitled **"Physio chemical properties of jackfruit *(Artocarpus heterophyllus* Lam.) seed flour and its prospects for use in cattle feed"** is a bonafide record of research work done independently by **Mr. G. Sri Krishna** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara

Dr. K.B. Sheela
(Major Advisor, Advisory Committee)
Associate Professor
Department of Processing Technology
College of Horticulture
Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Sri. G. Sri Krishna,** a candidate for the degree of **Master of Science in Horticulture**, with major field in Processing Technology, agree that the thesis entitled **"Physio chemical properties of jackfruit *(Artocarpus heterophyllus* Lam.) seed flour and its prospects for use in cattle feed"** may be submitted by **Sri. G. Sri Krishna**, in partial fulfillment of the requirement for the degree.

31/10/05
Dr. K.B. Sheela
(Chairperson, Advisory Committee)
Associate Professor
Department of Processing Technology
College of Horticulture
Vellanikkara.

31/10/05
Dr. P. Jacob John
Associate Professor and Head
Department of Processing Technology
College of Horticulture
Vellanikkara.

Dr. K. M. Syam Mohan
Assistant Professor
Department of Animal Nutrition
College of Veterinary and Animal Sciences, Mannuthy.

31/10/05
Dr. P.K. Sudha Devi
Associate Professor (Hort.)
Pineapple Research Centre
Vellanikkara.

31/10
Dr. T.N. Balamohan
Professor and Head
Department of Pomology
Horticultural College and Research Institute, TNAU, Coimbatore

(EXTERNAL EXAMINER)

ACKNOWLEDGEMENT

It is with great respect and devotion, I place on record my deep sense of gratitude and indebtedness to my major advisor ***Dr. K.B. Sheela****, Associate Professor, Department of Processing Technology and chairperson of my Advisory Committee for her sustained and valuable guidance, constructive suggestions, unfailing patience, friendly approach, constant support and encouragement during the conduct of this research work and preparation of the thesis. I gratefully remember her knowledge and wisdom which nurtured this research project in right direction without which fulfillment of this endeavor would not have been possible.*

I place a deep sense of obligation to ***Dr. P. Jacob John****, Associate Professor and Head, Department of Processing Technology, College of Horticulture and member of my Advisory Committee for the help and co-operation received from him during the entire programme. He in spite of a busy schedule has offered constructive suggestions for the betterment of this manuscript.*

I am deeply indebted to ***Dr. K.M. Syam Mohan****, Assistant Professor, Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy and member of my Advisory Committee for his unstinted support, critical comments and valuable suggestions during the preparation of this manuscript.*

I am very thankful to ***Dr. P.K. Sudha Devi****, Associate Professor (Hort.), Pineapple Research Centre, Vellanikkara for kindly providing facilities and timely help at various stages of my work.*

I am very thankful to Dr. V.K. Raju, Associate Professor (Hort.) and Managing Director of Plantation Corporation of Kerala (on deputation) for the guidance he extended, the encouragement he showered is of great value to me. His uncompromising attitude towards work and working culture enabled me to learn great strides in my professional career.

I am extremely delighted to place on record my profound sense of gratitude to Dr. P.B Pushpalatha, Assistant Professor, Department of Processing Technology for her unbounded support, valuable suggestions and whole- hearted co-operation towards the satisfactory fulfillment of this endeavor

I extend my profound thanks to Dr. G.S.L.H.V. Prasada Rao, Professor and Associate Dean i/c, College of Horticulture for his unclenching support during the fledging stages of my M.Sc course.

I am extremely grateful to Dr.K. Jesy Thomas, Associate Professor, Department of Agricultural Ecomomics for her valuable help during the course of study

My sincere thanks are due to Dr. S. Mini, Associate Professor, AICRP on medicinal plants, College of Horticulture, for the valuable help and advice rendered during the course of my study.

I express my wholehearted gratitude and sincere thanks Dr. Ganga Devi, Associate Professor & Head, Livestock Farm, Mannuthy, for timely help extended during the feed trial.

With deep respect I express my heartfelt gratitude and unforgettable indebtedness to Dr.T.V. Viswanathan, Professor & Head, Department of Animal nutrition, College of Veterinary & Animal Sciences, his precious help during the course of my study.

I' am greatly thankful to Dr. K. Rajendra Kumar, Assoc. Professor and Head, Dairy Plant, Mannuthy for his timely assistance for milk analysis during the course of study.

I am genuinely indebted to Sri. S. Krishnan, Assistant Professor, Department of Agricultural Statistics for his valuable assistance and guidance during the statistical analysis of the data.

I take this opportunity to thank my seniors Sunil kumar sir, Dinesh Kumar sir, Ramesh sir, Ramesh anna, Evalin chechi, Vidhu chechi, Gopinath, Bhavani, Chandru, Anisha, Vijay, Rajan, Manikandan, Roby chetan, soman chetan,Kuchala rani chichi and Bhaskar Reddy for their support and encouragement.

Words cannot really express the true friendship that I relished from Ramu, Vinu, Mohan, Shankar, John Kutty, Sreejith, Jaisal babu,Eldo, SaiJyothi, Ampily, Habeeba, Sujatha, Malini, Sherin, Anupama chechi, Safeera, Reena, Nashath, Femina, Prathiba and Renitha for the heartfelt help, timely suggestions and back-up which gave me enough mental strength to get through all mind-numbing circumstances.

Ineffable thanks to my dearest Pulla Reddy, Harsha, A.S. Rao, K.S. Rao, Guptha, Rajeswar Reddy, Nary, Anju, Shamanth, Srinu and Subbu for their eternal support and honest guidance.

I express my sincere thanks to Sri. Krishnan chetan , Ms. Mini and Radha chechi of the Department of Processing Technology for the timely and whole hearted co-operation and assistance they always accorded me during the course of investigation.

I am happy to place on record my sincere thanks to my dear juniors Vishnu, Arun, Satish, Savesh, Suja G. Nair, Shibi Vargheese, Sarala Grace, Jyothi and Smitha Sara for their immeasurable help and support during the course of this study.

I thankfully acknowledged Shri. Santhosh for his valuable help in computer work.

I deeply indebted to my Amma, Nana and family members without whose moral support, blessings and affection this would not have been a success.

The award of KAU junior research fellowship is greatly acknowledged

Finally I bow my head before THE ALMIGHTY whose blessings enabled me to undertake this venture successfully.

G .Sri Krishna

To Amma, Nana and Family

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

INTRODUCTION

Jackfruit (*Artocarpus heteropyllus* Lam.) is a popular fruit indigenous to India. It is hardly recognized as a commercial crop in India even though it is widely distributed in Assam, Kerala, Bihar, Tamil Nadu, Karnataka and Foothills of Himalayas in North India. In Kerala, jackfruit is grown in an area of 92,861 ha. and is an invariable component of homesteads and grown as a shade crop for coffee, areca nut and cardamom and as a standard crop in pepper plantations.

Even though there is immense potential for utilization of jackfruit either in the fresh market or processing sector, it has not been exploited so far. The major components of jackfruit include edible bulbs (24.4 per cent), rind and perigones (48.3 per cent), core (10.7 per cent) and seed (16.5 per cent). Compared to other tropical fruits processing waste is high (75.6 per cent) in jackfruit. The Bulbs are used both in unripe and ripe stages. Apart from table purpose, the ripe bulbs can also be used for making canned products, nectar, preserves, jam, jelly, squash, fruit bar and candy. Unripe green jack bulbs are used for making chips and *pappadams*. Rind and perigones, which are rich in pectin, are utilized to a limited extent for preparation of jelly.

Seeds make-up around 10 to 16 per cent of the total weight of the fruit and have high carbohydrate (75.6 per cent), minerals (2.4 per cent), fat (1.05 per cent) and protein content (12.2 per cent). Seeds are normally discarded after consumption of sweet edible bulbs or steamed and eaten as a snack or can be used in many local dishes. Attempts for processing of jackfruit will become successful only if methods are developed for utilizing carbohydrate rich jackfruit seed for product development and value addition.

As fresh seeds have poor keeping quality, seed flour can be an alternative product, which is used in some products. However seed flour is prone to various deteriorative changes such as lumping, caking, rancidity, microbial spoilage and insect attack due to absorption of moisture from external environment. To avoid this adequate packaging will be a prerequisite for safe storage of the flour without moisture reabsorption, mould infection and other qualitative deterioration.

Animal husbandry in India is closely associated with agriculture and is the second most important agricultural activity representing 21.3 per cent of total out put from agriculture. India has a fabulous cattle wealth and is the second largest producer of milk in the world. Feed accounts for 65 to 75 per cent of the total cost of livestock production. Now country demand for total feed is 42 million tones. Acute shortage of quality feeds and fodders is one of the major constraints in the development of economic livestock farming in India. Crop residues are presently used as roughage in our country, of which paddy straw forms the bulk. The shortage of essential feed ingredients and the escalating prices of feedstuffs are the two main problems faced by the feed industry today. It is the challenging need of the day to explore all potential alternate feed sources and to evaluate them in terms of quantity and quality so as to improve the nutritional status of Indian livestock. In tropical countries, promoting the use of alternative feed resources, derived from crops which are more "environmentally friendly" will lead to more sustainable development and will increase self-reliance (FAO, 1998).

In this context the present study was taken up with the following objectives:

a) Evaluation of the physio chemical characteristics of jackfruit seed flour collected from different locations of Kerala.
b) Study of keeping quality of jackfruit seed flour under different conditions of packaging.
c) Utilization of jackfruit seed flour for value addition
d) Assessment of the suitability of incorporation of jackfruit seed flour in compounded cattle feed.

Review of literature

REVIEW OF LITERATURE

Jackfruit is one of the popular fruit of Kerala, used unripe and sometimes quite immature. For most desserts, or where only the aril surrounding the seeds is used, the fruit should be fully ripe. The seeds are edible and nutritious. They contain 74 per cent carbohydrates, 12.2 per cent proteins and 1.05 per cent fat. Owing to its numerous culinary uses and its availability in plenty during the heavy monsoon rains, jackfruit has earned well-deserved name "the poor man's food" (Samaddar, 1990).

Research findings already reported by various workers on physio chemical attributes of jackfruit seed and its utilization are reviewed here under the following headings.

2.1 PHYSIO CHEMICAL ATTRIBUTES OF JACKFRUIT

2.1.1 Physical characters

The fruit consist of four parts *viz.*, bulb (27-40 per cent), derived from fleshy perianth consisting the edible portion, perigones (18-20 per cent), the unfertilized or aborted flowers, rind (20-22 per cent) and seeds (20-23 per cent) (Sharma, 1964).

Srinivasan (1970) described a variety namely "*Muttam Varikka*" which produced fruits of average weight of 7.0Kg with 46cm length and 23cm width.

Hussain and Haque (1977) compared the jackfruits from different trees and observed that the average fruit weight ranged from 3.34 to7.39 Kg, weight of pulp and seed being 0.57 and 0.39 Kg respectively in the smallest fruit and 2.70 and 1.01 Kg respectively in the largest fruit. Skin colour ranged from yellow and pale green to brown.

and 1.01 Kg respectively in the largest fruit. Skin colour ranged from yellow and pale green to brown.

Bhore *et al.* (1980) identified a highly promising jack type in Ajra village of Kolhapur district of Maharastra, which is high yielding, and highly pulpy containing more protein, fat, mineral matter and carbohydrate than local jackfruit. The fruits are small and weighing between 1 to 3 Kg and uniform in size and shape.

The average weight of jackfruit varied from 3.24 to 17.39 Kg which in turn depends on the variety, location and climatic conditions (Berry and Kalra, 1988).

Guruprasad and Thimmaraju (1989) reported the seed and spine characters of three types of jackfruit (*Artocarpus heterophyllus* Lam) *viz.* Yellow-bulb, Light Yellow-bulb and Orange-bulb. The light yellow type had the highest seed weight (7.56 g), seed length (3.23 cm), seed breadth (2.10 cm) and average total weight of seeds per fruit (913.21 g). The yellow type had more seeds per fruit (124.6) and the highest pulp to seed ratio (4.24).

Narasimham (1990) reported that many cultivated jackfruit types are available under various local names *viz.*, Gulabi, Champa, Hazeri, Varikka *etc.* These are broadly classified into two groups by consumers as soft flesh and hard flesh.

Sharma *et al.* (1997) studied the fruiting behavior, yield and physio chemical characters of local jackfruit germplasm in the lower Bramhaputra valley zone of Assam. Agronomic and botanical characters of 12 genotypes identified during the course of survey were described. Significant variations were observed in yield and physio chemical composition of different genotypes.

Jackfruit exhibit lot of variability in fruit characters in evergreen forests of Western Ghats, Gorakhpur, Dewaria (40 kg sized fruits) and Allahabad (small with white, juicy and soft pulp) districts of Uttar Pradesh. Some of these types produce small to medium sized fruits with small seeds and thin skin, offering a great potential for varietal improvement. Jackfruit collections NJT 1,2,3 and 4 from Faziabad had the large fruits of excellent quality with bulbs having low fibre. NJC, 1,2,3 and 4 had small to medium sized fruits with thin rind and soft flesh. *Varikka, Koozha* and *Navarikka (Pazam Varikka)* types are available in Kerala, Tamil Nadu, and Karnataka with maximum density in Wynad plateau in the Western Ghats (Chadha, 1990).

Jackfruit being a cross-pollinated crop and mostly seed propagated, exhibits great variation particularly in its fruit characteristics. There is wide variation in density of spikes on the rind, bearing size, shape, quality and period of maturity (Bose *et al.*, 1999).

2.1.2 Chemical characters

Seeds of jackfruit constituting 8-15 per cent total weight of the fruit, which are enclosed in a white aril and are fairly rich in starch and carbohydrates (Winton and Winton, 1935).

Bobbio *et al.* (1978) isolated starch from jackfruit seed and reported the physio chemical properties. The chemical analysis of peeled seed (cotyledons) revealed that starch and proteins are the main components of the seed. The chemical composition of the purified starch portion revealed that the non-carbohydrate matter was 1.18 per cent; 99.1 per cent of the hydrolyzed starch was D-glucose. They reported protein, crude lipid and carbohydrate content of jackfruit seeds as 31.9, 1.3 and 66.2 per cent respectively on dry weight basis.

Jackfruit seeds are having water-soluble sugar content and some low molecular weight compounds (Wills *et al.*, 1986; Hussain *et al.*, 1990).

Kumar *et al.* (1988) studied the proximate composition of seeds of two varieties of jackfruit *viz.*, 'Katheri' and 'Bharat Baramasi'. Results revealed that seeds are good sources of carbohydrates (76.1 per cent on dwb), proteins (6.25 – 6.75 per cent) and minerals (1.16-1.27 per cent). The overall variability in quality components may be due to the variety chosen for analysis and agro-climatic factors under which they were grown. 'Kathari' variety was observed to be nutritionally excelling than the 'Bharat Baramasi' on the basis of most of the constituents analyzed.

Singh *et al.* (1991) reported the functional properties of jackfruit seed flour. Crude protein, crude lipid, total carbohydrate and crude fibre contents on dry weight basis were 17.2, 2.2, 74.0 and 3.06 per cent respectively.

According to Subburamu *et al.* (1992) jackfruit waste contributes 74.2 per cent of total fruit weight. The fruit perianth, rind, core and seed contained 6.9,6.2,7.6 and 4.5 per cent ash, 28.9,24.0,20.5 and 62.5 per cent carbohydrates, 10.3,8.7,10.6 and 10.2 per cent crude protein, 7.3,1.7,3.2,1.5 per cent crude fat and 12.7,17.3,15.9,2.8 per cent crude fibre respectively.

Rahman *et al.* (1995) reported microscopic and chemical changes occurring during the ripening of two forms of jackfruit. Trees known to produce two distinct textural forms of jackfruit, in which the fruit remained firm when ripe or became soft and pulpy, were sampled when fruits were immature (10-11 weeks after anthesis) and when judged ripe (15-16 weeks after anthesis). Increase in dry matter and starch content of perianth and seed with maturity was observed. The magnitude of increase was high in firm as compared to soft type.

Chowdhury and Raman (1997) reported the distribution of free sugars and fatty acids (both free and bound form) present in different parts of the fruit (including the seeds). Fructose, glucose and sucrose were the major sugars in all parts of the fruit, except in the outer spiny rind, which was devoid of glucose. Capric, myristic, lauric, palmitic, oleic, stearic, linoleic and arachidic acids were major fatty acids, with varying proportions in different parts of the fruit.

Seeds of jackfruit are rich source of nutrients and also form a popular ingredient in many culinary preparations. It can be relished as boiled and roasted (Krishnankutty, 1998).

Rahman *et al.* (1998) reported variation in carbohydrate composition in soft and firm fleshed jackfruit with maturity and climatic conditions. The dry matter content of perianth and seed of soft and firm varieties increased from 10.0 to 32.0 per cent and 19.0 to 52.0 percent respectively, while ash content decreased from 5.7 to 2.0 per cent and 4.9 to 1.5 per cent respectively on dry matter basis. The free sugars of jackfruit samples increased with maturity from 1.5 to 10.5 per cent and 1.4 to 5.2 % in their dry matter of soft and firm varieties respectively. In both chemical and histological studies, it appeared that the starch content of both perianth and seed of soft and firm varieties of jackfruit samples gradually increased with maturity. The difference in composition of seed flours for carbohydrates could be contributed by variety difference, maturation of seeds and environmental conditions.

A systematic study of proximate composition and functional properties of jackfruit seed by Rajarajeswari and Prakash (1999) revealed that seed is to be a good source of protein, carbohydrate, starch and minerals.

The medicinal and nutritional properties of jackfruit and its medicinal and culinary uses were highlighted by Roy *et al.* (2000).

Jackfruit is a rich source of Vitamin A, C and minerals, it also supplies carbohydrates. The flakes, seeds, sterile flowers, skin and core contain calcium pectates 4.6, 1.6,3.7,3.2 and 2.1 per cent respectively. They are considered as good source of pectate (Chadha, 2001).

Singh and Singh (2001) reported about the composition and products produced from the jackfruit.

Tulyathan *et al.* (2001) studied some physio chemical properties of jackfruit seed flour and starch. The flour composition of seed showed that major components were carbohydrates (78.0 per cent). The proximate analysis showed that flour had protein (11.2 per cent on dwb) and lipids (0.99 per cent on dwb).

Swamy (2003) reported that seeds of jackfruit (*Artocarpus heterophyllus* Lam) are rich in total carbohydrates and proteins. Jakacalin, the major protein from jackfruit seed has proved to be a useful tool for the evaluation of the immune status of patients infected with HIV. Chinese considered the jackfruit seed and pulp useful in overcoming the effects of alcohol. In India too, the jackfruit seed is an important ingredient in antidote preparation for heavy alcohol drinkers.

2.2 STORAGE OF FRUIT AND SEED FLOURS

Sharma *et al.* (1974) studied the production and storage behaviour of dried mango powder. They reported that during the storage period of one year at room temperature of 31 $\pm$ 1^0C, there was no perceptible change in colour, flavour and reconstitution of the product but there was progressive increase in moisture content.

Vaidehi and Sunanda (1982) reported that potato flour could be safely stored in polyethylene pouches for six months without any fungal or insect infestation and also there occurred no changes in colour, flavour and odour.

Gvozdenovic *et al.* (1983) reported that optimum quality retention of tomato powder was achieved with paper/ polyethylene/ aluminium foil/ polyethylene laminate. The packaging retained the nutrient contents in a better way.

Singh (1983) standardised the procedure for preparation of mango powder .The flour stored in polyethylene and polypropylene bags remained in good condition up to 190 days .The mango powder contains 28.5 per cent TSS, 23.15 per cent total sugars and 12 per cent reducing sugar. The powder was utilized for the preparation of *payasam*.

2.3 VALUE ADDITION OF JACKFRUIT

2.3.1 Jackfruit flour

In a study conducted by Singh (1983) the fruit of jackfruit, *Varikka* variety were peeled, seeds were removed and flakes made into small pieces of 2 to 2.5 centimeters thickness. This was soaked in water containing 2000ppm KMS for two hours and then mechanically dried at 65 ± 5^0C for 24 hours and powdered to get flour. This flour remained unspoiled up to 130 days in polypropylene bags. The flour contained 47 per cent TSS, 29.5 per cent total sugars and 16.4 per cent reducing sugars.

In a study conducted at College of Horticulture, Vellanikkara, it was found that dehydrated jackfruit bulbs or dried flakes were suitable for making different products like *chappathi*, *pappads, roti, etc.* Incorporation of jackfruit seed flour (25 per cent) was found to give good products (KAU, 1991).

A systematic study of proximate composition and functional properties of jackfruit seed (*Artocarpus heterophyllus* Lam.) by Rajarajeswari and Prakash

(1999) revealed that seed flour is a good source of protein having solubility near neutral pH .It had low water and fat absorption capacities. Incorporation of jackfruit seed into two deep fat fried products reduced their fat absorption. In the savoy product none of the sensory attributes were affected whereas in sweet product texture and flavour were affected. It was concluded that the incorporation of jackfruit seed into savoy products can be recommended because of its low fat absorption capacity. Since jackfruit seeds are comparatively cheap, the cost of the product can be brought down by addition of this nutrient rich by-product. They removed the outer peel of jackfruit seeds and dried and powdered it and two products namely 'Khara Sev' and 'Jamun' were prepared using this flour.

Roy *et al.* (2000) reported the medicinal and nutritional properties of jackfruit and suggested that a number of acceptable products could be prepared from this fruit.

Jackfruit is known as a close relative of breadfruit and various parts of this fruit are utilized for value addition (Falcao, 2001).

Maini and Singh (2001) studied the composition and processing of jackfruit and concluded that fruit waste (cone, peel and seed) are potential sources of essential oils, pectin, starch, food colourants and biogas.

Tulayathan *et al.* (2001) reported that the jackfruit seed flour had good capacity for water absorption (205 per cent) and oil absorption (63 per cent) substitution of wheat flour with the seed flour at the level of 5, 10 and 20 per cent markedly reduced the strength of mixed dough .The Brabender amylogram (6 per cent concentration, db) of starch showed its pasting temperature was 81^0C and its viscosity was moderate, remained constant during a heating cycle and retrograded slightly on cooling.

According to Swamy (2003) seeds of jackfruit are rich in carbohydrate and protein. Moreover, the incorporation of seeds to deep fat fried products was found to reduce the fat absorption to a remarkable extent.

Mukaprasirt and Sajjaanantakul (2004) studied the physio chemical properties of seed flour and starch from jackfruit and compared with modified starches. The results from the study suggested that native starch from jackfruit seed could be used as an alternative for modified starches in a system needing starch with high thermal and / or mechanical shear stability.

2.3.2 Utilisation of seed flour from other crops

Greenwall (1947) reported that taro flour can be prepared from raw or precooked tubers. Flour that obtained from precooked tubers is considered better. The flour can be mixed in soup and in making pancakes, biscuits and bread. It is excellent for gravies and pudding, as it is not glutinous like wheat flour. Tarolactin and Taromalt were prepared from flour was used as an infant feed.

According to Esuoso and Bamiro (1995) wheat flour can be supplemented with 50 per cent breadfruit seed flour. Breadfruit flour had a high starch content of 80.9 per cent, 4.2 per cent crude fibre and 1.6 per cent ash content, 4.5 per cent protein. Blends recorded best pasting characteristics in terms of starch stability and gelatinisation index.

Chellamal (1995) standardized the procedure for preparation of sweet potato flour. The flour along with soy flour and milk powder in the ratio 2:1:1 was used for the preparation of weaning food. Noodles and wafers were also prepared from sweet potato flour with suitable blending materials.

Full fat African breadfruit flour was used to replace 70 per cent of sweet potato flour. Composite flour had good foaming capacity but lacked foaming stability. It is suggested that low bulk density of the composite flour will be an advantage in preparations of food weaning formulations (Akubor, 1997).

Deshpande *et al.* (2001) reported that full fat soy flour can be blended with cereal or pulse flour to make a variety of common Indian traditional products namely *chapatti*, *pakoda*, burfi and extruded snacks. These recipes were evaluated for acceptability and other quality parameters. From the mean score values, it was observed that all the products were liked and were acceptable by the judges. These products were devoid of off flavour and had acceptable characteristics.

Boiled potatoes were peeled, grated and dried in tray drier at 55^{0}C for 24 hours. After drying it was ground in an electric grinder and powdered in a Brabender unit. The flour stored safely up to six months both at room and refrigerated temperatures. The flour was used in various recipes and food products instead of fresh potatoes especially during the off-season (Mishra and Kulshretha, 2002).

Tokusoglu *et al.* (2003) observed that sesame seed flour contained high value of crude protein, ether extract, crude fibre, reducing sugars and total carbohydrates which can be effectively used in bakery such as bread, biscuit, *halva etc.*.

2.4 SCOPE FOR UTILIZATION OF AGRICULTURAL WASTE AS CATTLE FEED

Ranjhan (1993) studied the utilization of various by-products from food processing industry as livestock feed in India. The chemical properties of each by-product feed were studied. The value of typical grains, hays and oilseeds were compared. Wheat bran and corn gluted meal had high protein content and high level of readily fermentable carbohydrates. Rice bran and urban food wastes were high in fat as well as readily fermentable carbohydrates.

2.4.1 Jackfruit waste as a animal feed

Jackfruit waste, the discarded portion of the fruit after the removal of the edible portion has been reported to contain 21.1 dry matter, 7.9 crude protein, 5.7 ether extract, 7.0 total ash, 0.5 acid insoluble ash, 0.80 calcium and 0.10 phosphorous on percentage basis. When fed as the sole ingredient in the ration, the cattle were found to consume up to 1.7 per cent of the body weight. The material possessed a digestible crude protein and total digestible nutrients of 1.2 per cent and 19.9 per cent respectively on fresh weight basis (Ananthasubramaniam *et al.*, 1978)

Begum *et al.* (1989) studied the effect of partial replacement of cereal in rice and ragi diets by jackfruit seed flour on nutritive value of diets. The growth of albino rats fed diets based on rice or ragi was compared with that of rats given similar diets with 25 per cent of cereal replaced by jackfruit seed flour. Considerable increase in growth and development of rats fed with jackfruit seed flour than fed with cereal (ragi) and rice was observed.

Ravindran and Ravindran (1996) reported the nutritive value of jackfruit seed (*Artocarpus heterophyllus* Lam.) and suggested its use as poultry meal due to its high nutrient profile.

Maini and Singh (2001) studied the composition and processing of jackfruit and its waste utilization and suggested that fruit wastes are potential sources of cattle feed due to richness of its carbohydrates and proteins.

2.4.2 Mango seed kernel

Patel *et al.* (1970) reported that mango seed kernel contained (percentage basis) 5.8 crude protein, 13.2 ether extract, 1.3 crude fibre, 76.7 nitrogen free extract, 3.0 ash, 0.8 silica, 0.27 phosphorous and 0.25 calcium. It was found that mango seed kernel could be incorporated up to 10 percent level in the ration of dairy cattle, without any adverse effect on milk yield. Patel *et al.* (1971a) observed that mango seed kernel could be incorporated up to 20 per cent in the experimental concentrate mixture fed to growing calves without affecting the growth rate. The use of mango seed kernel has therefore been suggested as a means of alleviating the shortage of feed concentrates in India.

Patel *et al.* (1971b) conducted an experiment with two matched groups of six lactating Kankrej cows which received (1) a conventional concentrate mixture or (2) a mixture of 75 per cent conventional mixture and 25 per cent of a mixture of feed of sickle senna (*Cassia tora* L.), mango seed kernels and tomato waste. All animals received a basic feed of five kg *lucern* and churodi hay *ad lib.* From the experiment it was concluded that 25 per cent of the conventional concentrate could be safely replaced by these products in rations for dairy cows without affecting the yield and fat percentage.

2.4.3 Coffee waste

Ananthasubramaniam *et al.* (1977) carried out growth studies in calves fed with coffee husk replacing half of the portion of rice bran (10 per cent) in a concentrate mixture as against a control ration with 20 per cent rice bran. No significant difference ($P< 0.05$) between groups in respect of gain in body weight was reported and indicated that coffee husk can profitably incorporated up to 10 per cent level in the ration of growing calves.

Ledger and Tillman (1973) conducted a feed trial on 32 bullocks to study the effect of replacing maize in a highly concentrated fattening diet with 10, 20 or 30 per cent coffee husk. Feed intake and feed conversion were not affected by addition of 10 or 20 per cent, but 30 per cent reduced them.

2.4.4 Tea waste

The tea waste possessed digestible crude protein of 9.7 per cent and total digestible nutrient of 43.0 per cent. The total tannins present in the material was only 1.9 per cent. Results from the feeding trials indicated that tea waste can form a potential feed source for live-stock .The material has been found to be fairly palatable to cattle as much as the animals consumed the material upto 1.5kg/day (Ananthasubramaniam and Maggie, 1977).

2.4.5 Banana waste

The effect of incorporating commercially dried banana meal in concentrates for dairy cows was studied by Rihs and Isler (1976). Cows, continuously on pasture, were given concentrate with 50 per cent maize, 50 or 90 per cent banana meal. The banana meal was prepared from commercially dried, chopped unpeeled green rejects of bananas. The other ingredients were cotton seed cake, molasses, calcium sulphate, coconut cake and rice bran except in the third group, which had urea. Results indicated that there was no significant difference between the groups for intake of concentrate, milk output and quality of milk.

2.4.6 Pulped potato waste

Nicholson and Curtis (1960) conducted a feeding trail in which grass silage was partially or completely replaced by pulped potato to provide an equivalent amount of dry matter. A significant increase in fat content was noticed when grass silage was completely replaced by potato pulp. When the protein content in the ration was increased to 15 to 20 per cent an increase in the fat corrected milk and solids-not-fat yield was noticed. Cows on the high protein – potato ration maintained body weight while greatest losses were found in the un-replaced ration.

2.4.7 Beet pulp waste

The feeding of sugar beet to cows was found to increase the fat content of milk, and to decrease the lactose content, but the differences were not statistically significant. Protein and ash contents and the fat: solid non-fat ratio remained unchanged (Saito and Tanno, 1962).

The feeding value of beet pulp for milk production has been studied by Bhattacharya and Sleiman (1971). There was no significant difference in fat corrected milk yield or change in body weight between cows fed on experimental concentrate ration containing 55 per cent beet pulp and controls fed with a concrete ration containing 57 per cent ground barley. In another experiment, addition of four per cent tallow to a fat-deficient concentrate ration containing 50 per cent beet pulp and 19 per cent wheat bran resulted in a significant increase ($P < 0.01$) in four per cent fat corrected milk than in the control animals receiving un supplemented concentrate.

Castle (1972) concluded after conducting an experiment that for practical purposes dried sugar beet pulp and barley are interchangeable on an equal weight basis in dairy cow feeds without affecting the milk yield, solids not fat or protein.

The study on the utilization of wet potato pulp and dried beet pulp as dairy cattle feed was conducted by Hashisume *et al.* (1974). Results revealed that the yield of four per cent fat corrected milk was significantly greater with dried beet pulp than with wet potato pulp, but there was no difference in fat, protein or solids-non-fat contents. Also there was no effect on the health, blood or urine of the cows.

2.4.8 Tomato waste

Ralo *et al.* (1964) replaced palm kernel meal (25 per cent of concentrates) by dried tomato pressings in the ration of dairy cows and found that there was no significant effect on either milk yield or composition.

2.4.9 Water melon seed

In a feeding trial conducted on cows in Haryana, it was observed that *Bijada* cake, a by-product obtained from water melon seeds after extraction of the oil, had no adverse effects on milk yield, fat per cent or protein when fed at a level of 500 g/day. It was recommended that the cake could be fed at 20 per cent level for growing calves and lactating cows (Sastry *et al.*, 1973).

2.4.10 Cassava waste

In comparison to maize, cassava included in the concentrate mixture was found to give higher milk yields, four per cent fat corrected milk and solids corrected milk. Milk of cows given cassava had significantly more solids-non-fat than that of cows getting maize, but there was no significant difference in fat or protein content (Olaloku *et al.*, 1971). Ananthasubramaniam (1972) suggested that tapioca leaf meal can be incorporated in the rations of dairy animals at a level of 0.4 per cent of their body weight without affecting the daily milk yield, body weight gain or total butter fat production.

2.4.11 Sunflower heads

The chemical composition and the *in vitro* digestibility values of sunflower head indicated its potential to be used as livestock feed resource. Earlier sunflower head has been successfully incorporated in complete feeds at different levels *i.e.* 20 per cent in lactating cows without affecting their production performance (Rao *et al.*, 1999).

The proximate composition of sunflower head in terms of protein, crude fibre, fat and neutral detergent fibre was superior to many of commonly used roughages like ragi straw, paddy straw, sorghum stover, maize stover (Anandan *et al.*, 2001).

2.4.12 Horse gram pod

In a feeding trail based on horse gram pod shells animals readily consumed the shells there by indicating the palatability. The average consumption was around 9 to 10 Kg per day while the dry matter intake was 1.86 Kg per 100 Kg body weight. The nutritive value in terms of digestible crude protein, starch equivalent and total digestible nutrients was 2.99, 24.87 and 49.00 per 100 kg dry matter respectively (Amrithkumar *et al.*, 1975).

2.4.13 Guar meal

Weight by weight substitution of guar-meal (*Cyamopsis psoralioides*) for groundnut cake in the concentrate mixture of six lactating Sahiwal cows did not significantly affect the milk yield. There was no change in the flavour of the milk from cows fed with a guar meal mixture (Thatte *et al.*, 1967).

2.4.14 Soy bean meal

An experiment was conducted by Macgregor *et al.*, (1976) to find out the effect of increasing the fibre content in the ration with soybean mill run on digestibility and lactation performance. Soy bean mill run was used as replacement for corn grain in the concentrate mixture in such a way to get the crude fibre content in the complete ration as 13,18 and 23 per cent .The treatments did not significantly affect the dry matter intake, digestible dry matter intake production of 4 per cent fat concentrate milk, milk fat test (4.1 average) dry matter digestibility and rumen volatile fatty acids. When soybean mill run was used for replacing 53.71 per cent of the corn in the concentrate mixture no adverse effect on lactation performance and health status was noticed.

2.4.16 Silk cotton seed

Effect of feeding silk cotton seed cake on milk production by replacing 50 or 100 per cent of the gingelly oil cake by silk cotton seed cake helped to support the maintenance of the body weight, butter fat production and milk yield (Muniyappa, 1972).

Materials and Methods

MATERIALS AND METHODS

The present investigation on "Physio chemical properties of jackfruit (*Artocarpus heterophyllus* Lam.) seed flour and its prospects for use in cattle feed" was carried out in the Department of Processing Technology, College of Horticulture and Livestock farm, College of Veterinary and Animal Sciences, Mannuthy.

The project had four phases *viz.*,

1) Collection of samples and study of physio chemical properties
2) Storage studies of seed flour under different packaging materials
3) Utilization of seed flour for value addition
4) Assessment of suitability of seed flour as cattle feed

3.1 COLLECTION OF SAMPLES AND STUDY OF PHYSIO CHEMICAL PROPERTIES

3.1.1 Collection of samples

Thirty fruit samples were collected from different localities in Kerala (4 from Thrissur district, 2 each from the other 13 districts).

3.1.2 Study of physio chemical properties

Samples collected as detailed under 3.1.1 were evaluated for their physio chemical attributes.

3.1.2.1 Physical characters

3.1.2.1.1 Fruit weight

The weight of fruit was recorded by using a balance and expressed in kilograms.

3.1.2.1.1 Percentage contribution of fruit components.

Weight of the fruit components like bulbs, rind, perigones, core and seed were recorded separately with the help of a balance and expressed in percentage.

3.1.2.1.2 Recovery percentage of dry seed

The recovery of dried seed was calculated on the initial weight basis as suggested by Srivastava and Tandon (1968) and expressed as percentage.

$$\text{Recovery percentage} = \frac{\text{Final weight}}{\text{Initial weight}} \times 100$$

3.1.2.2 Chemical characters

Biochemical analysis was carried at the Department of Processing Technology, Department of Plantation Crops and Spices and Radio Tracer Laboratory, College of Horticulture, Vellanikkara.

Experimental Material

After removing the white cotyledon cover, the seed samples were dried in a mechanical drier at 65 ^{0}C. Brown endosperm of the seed was removed, dried and then powdered. The powdered flour was used for estimation of total carbohydrates, crude fibre, digestible carbohydrates, total minerals and fat content.

3.1.2.2.1 Total carbohydrates

The total carbohydrates were determined using Anthrone method (Sadasivam and Manickam, 1996).

The dried and powdered sample was hydrolyzed with 5 ml of 2.5 N HCl and then cooled to room temperature. The residue was then neutralized with solid sodium carbonate until the effervescence ceased. Made up the volume to 100 ml and centrifuged. Pipetted 0.5 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes cooled rapidly and the intensity of green colour was read at 630 nm. A standard graph was prepared using standard glucose at serial dilutions and glucose content was found out from the standard graph and converted to fresh weight basis.

3.1.2.1.3 Crude fibre

Crude fibre content was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

Two grams of the dried and powdered seed sample was boiled with 200 ml of 1.25 per cent sulphuric acid for thirty minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide for thirty minutes. Again, it was filtered through a muslin cloth and washed with sulphuric acid, water and alcohol. The residue was transferred to a pre weighed ashing dish, dried, cooled and weighed. The residue was then ignited for thirty minutes in a muffle furnace at 600°C, cooled in desiccators and reweighed. The fibre content of the sample was calculated from the loss in weight on ignition and then converted to fresh weight basis.

3.1.2.1.4 Digestible Carbohydrates

Digestible carbohydrates was estimated by subtracting crude fibre from total carbohydrates and expressed in percentage.

3.1.2.1.5 Fat content

Total fat content in the samples was estimated by Soxhlet extraction using petroleum ether (40-60 °C) as solvent (AOAC, 1970).

Five gram of the sample was weighed accurately into a thimble and placed in a soxhlet apparatus and extracted with anhydrous ether until the sample was completely extracted by the solvent. The ether extract was filtered into a weighed conical flask and the ether was then removed by evaporation. The flask with the residue was dried in an oven at 80-100°C, cooled and weighed. Fat content of the sample was calculated from the weight of the ether extract, and expressed in percentage.

3.1.2.1.6 Mineral content

Weighed two grams of sample in a previously weighed silica crucible. Heated crucible first over a low flame to volatilize as much of the organic matter as possible (until no more smoke was given off by the material), and then heated in a muffle furnace (temperature controlled) at about 600°C for 3-4 hours. Cooled in a desiccator and then recorded the weight. To ensure complete ashing, the crucible was again heated in the furnace for 30 minutes and weighed. Mineral content was calculated by using the following formula.

$$\text{Per cent ash (total minerals)} = \frac{\text{Weight of ash}}{\text{Wt. of sample}} \times 100$$

3.2 STORAGE OF SEED FLOUR IN DIFFERENT PACKAGING MATERIALS

Seed flour is highly hygroscopic in nature. This would lead to spoilage of seed flour during the storage. The experiment was carried out with an objective of finding suitable packaging material for storage of seed flour, so as to minimize its quality deterioration, reduce storage losses and also to improve the convenience of its further use.

3.2.1 Preparation of samples for storage

Samples were dried till they recorded constant weight for two consecutive days. Dried samples were powdered in dry grinder.

3.2.2 Treatments

Powdered seed flours were stored in the following packaging materials

T1: Polyethylene cover-200guage
T2: Aluminium foil
T3: Glass bottle with air tight plastic lid
T4: PET clear jar with air tight lid
T5: PET amber coloured jar with air tight lid
T6: Food grade white plastic jar with airtight lid
T7: Stainless steel containers with tight lid
T8: White HDPE covers
T9: Control (open condition)

The experiment was laid out in a completely randomized design with three replications of 100g each.

No. of treatments: 9

No. of replications: 3

Design: CRD

Duration: Six months

3.2.3 Observations

Observations of the stored flour samples were taken at monthly intervals for six months.

3.2.3.1 Weight loss or gain of sample during storage

Weight loss or gain of the sample during storage was estimated by recording the weight difference using electronic balance.

3.2.3.2 Moisture content of stored flour

Moisture content of stored flour was determined at monthly intervals by using AOAC (1980) method.

3.2.3.3 Variation in carbohydrate level

Carbohydrate content of stored samples was estimated by Anthrone method at monthly intervals for six months and variation of carbohydrate level was recorded.

3.2.3.4 Organoleptic evaluation of seed flour

Organoleptic evaluation of the jackfruit seed flour was carried out using score card (Swaminathan, 1974) by a panel of ten selected judges at monthly intervals for a period of six months.

For seed flour, colour, flavour, caking, insect infestation were included as the quality attributes. Each of above mentioned quality attributes was assessed by a five point hedonic scale. The scorecard used for evaluation is given in Appendix. I

3.3 VALUE ADDITION OF SEED FLOUR

3.3.1 Preparation of *chapattis*

Jackfruit seed flour was mixed with previously weighed wheat flour in the ratio of 0, 10, 20, 30 and 40 per cent. This mixture (200 g) was mixed with predetermined amount of water required for optimum dough consistency and kneaded by hand for 2 minutes. The dough was allowed to rest for 30 minutes at room temperature. Dough balls (20g each) were rolled manually into thin *chapattis* (12 cm diameter and 2 mm thickness). The *chapattis* were baked on hot plate (maintained at 250 ± 2^0C) for 15 seconds on each side .The *chapattis* were allowed to cool.

3.3.2 Quality evaluation

The quality evaluation of *chapattis* prepared from jackfruit seed flour was carried out by a panel of 12 judges between the age group of 18 to 35 years. The test panel to judge colour, flavour, texture, taste and overall acceptability of *chapattis* used five Point Hedonic scale.

3.4 JACKFRUIT SEED FLOUR AS CATTLE FEED

An experiment was carried out at the University livestock farm, Mannuthy to study the feasibility of utilizing jackfruit seed flour in compounded cattle feed for dairy cows by replacing part of maize in the concentrate mixture. Animals were divided into two groups of six each, as uniformly as possible with respect to body weight, age, stage and order of lactation. All the animals were kept under identical conditions of management. Details of experimental cows were given in the Table 1.

3.4.1 Rations

The feed ingredients required for the study were procured from the local market. Jackfruit seed was collected from local merchants dried in mechanical drier at 65°C for 18-24 hours and powdered in a flourmill and was used for the feeding trial. Standard concentrate mixtures were compounded with 20 and 40 per cent of seed flour and ingredient composition of two rations are given in the Table 2. Individual feeding of animals using the concentrate mixture (twice daily) and green grass (four times daily) was carried out through out the period of study. The duration of feeding trial was thirty days.

Table.1 Details of experimental cows

S. No	A. No	Breed	Order of lactation	Average daily milk yield (Kg)
Group I				
1	C170	Jersey X Sindhu Crossbred	II	8.5
2	1174	-do-	II	8.5
3	T739	-do-	II	7.0
4	1268	-do-	II	6.5
5	T737	-do-	II	6.0
6	T696	-do-	II	6.0
Average milk yield (Kg) /animal in Group I				7.1
Group II				
1	C094	Jersey X Sindhu Crossbred	II	8.5
2	C187	-do-	II	7.0
3	C191	-do-	II	7.0
4	1242	-do-	II	6.7
5	C061	-do-	II	6.5
6	1294	-do-	II	7.0
Average milk yield (Kg) /animal in Group II				7.1

Table.2 Composition of concentrate mixture used for feeding trial.

Ingredients	Concentrate mixture	
	Ration I (20 % J.S.F*)	Ration II (40 % J.S.F*)
Maize	20	-
Jackfruit seed	20	40
Groundnut cake (deoiled)	12	12
Gingelly oil cake (expeller)	15	15
Rice bran	30	30
Salt	1	1
Mineral mixture	2	2
Total	100	100

*J.S.F=Jackfruit seed flour

3.4.1 Observations

3.4.1.1 Dry matter intake (DMI)

The animals were fed as per the Sen and Ray (1971) feeding standards. Each day fixed quantities of feed from each ration and grass was fed to the two groups of cows. The balance of concentrate mixture as well as grass were recorded to calculate total dry matter intake of the feed and expressed in kilograms.

3.4.1.2 Milk production

Milking was done both in the morning as well as in the evening using milking machines and the daily milk yield of the individual animals were recorded.

3.4.1.3 Fat content

The fat content of the milk was estimated using the Gerber's method as described in Indian Standards, I.S.1224 (1958) and expressed in percentage.

3.4.1.4 Total Solids Content.

The total solids content in the milk was determined by Gravimetric method as per the procedure described in Indian Standards, I.S.1479, Part I (1960) and expressed in percentage.

3.4.1.5 Solids Not Fat

Solids Not Fat content in the milk samples was derived by subtracting the fat percentage from the total solids percentage and expressed in percentage.

3.4.1.6 Statistical analysis

The data obtained from the experiment were statistically analyzed. Statistical analyses were done according to the standard methods (Snedecor and Cochran, 1967).

Results

RESULTS

The results of the study on "Physio chemical properties of Jackfruit (*Artocarpus heterophyllus* Lam.) seed flour and its prospects for the use in cattle feed" are presented under the following major headings in this chapter.

4.1 PHYSIO CHEMICAL CHARACTERS OF JACKFRUIT

4.1.1 Physical Characters

Thirty samples of jackfruit collected from different regions were evaluated for the physical characters like weight of the fruit, percentage contribution of bulbs, rind and perigones, core, seed and recovery percentage of dried seed (Table. 3), (Plate 1,2 and 3).

4.1.1.1 Fruit weight

The samples collected from different regions of Kerala exhibited significant variation for fruit weight (Table 3). Maximum weight of the fruit was observed for S9 (17.2 Kg), followed by S27 (13.5 Kg) and minimum for S6 (4.6 Kg). S28 (11.5 Kg), S18 and S19 (11.4 Kg each) also recorded higher values for fruit weight.

4.1.1.2 Percentage contribution of fruit components

4.1.1.2.1 Edible bulbs

The fruits procured from different localities showed significant variation with respect to recovery of edible bulbs. The recovery of edible bulbs was highest in S9 (29.7 per cent) and lowest in S2 (21.3 per cent). The samples namely S18

Plate 1a. Cross section of the fruit

Plate 1b. Rind, perigones and core

Plate 1c. Seed and edible bulbs

Plate 1. Components of Jackfruit

Plate 2a. Whole seed of jackfruit

Plate 2b. White cotyledone cover and brown endosperm

Plate 2. Seed components of jackfruit

Plate 3a. Drying of seeds in cabinet drier

Plate 3b. Dried seeds of jackfruit

Plate 3. Drying of jackfruit seed

Table.3 Physical characters of jackfruit

Sample	Wt. of the fruit (Kg)	Bulbs (Per cent)	Rind and perigones (Per cent)	Core (Per cent)	Seed (Per cent)	Recovery of dried seed (Per cent)
S1	6.2^{k}	22.0^{gh}	50.6^{b}	18.9^{ad}	9.5^{u}	52.8^{bcd}
S2	4.6^{l}	21.3^{h}	50.6^{b}	19.8^{a}	8.4^{no}	46.2^{ef}
S3	6.5^{k}	23.6^{f}	48.3^{cd}	16.9^{cde}	11.1^{q}	51.5^{bcd}
S4	10.1^{de}	26.1^{c}	43.4^{klm}	17.3^{bc}	13.2^{fg}	52.0^{bcd}
S5	7.6^{i}	24.2^{ef}	46.7^{fg}	17.5^{bcd}	11.6^{m}	53.7^{bc}
S6	4.6^{l}	21.3^{h}	52.9^{a}	17.6^{bcd}	8.4^{no}	44.2^{bcd}
S7	7.4^{ij}	23.6^{f}	47.0^{f}	18.9^{ab}	11.5^{v}	50.8^{cde}
S8	9.4^{fg}	25.5^{cd}	45.0^{ij}	17.2^{cde}	12.3^{j}	51.9^{f}
S9	17.2^{a}	29.7^{a}	42.6^{m}	12.4^{m}	15.4^{b}	59.6^{a}
S10	9.7^{def}	25.7^{cd}	43.7^{kl}	17.6^{bcd}	13.1^{g}	53.5^{ef}
S11	8.8^{gh}	25.4^{cd}	45.9^{gh}	16.7^{cdef}	12.1^{k}	51.8^{bcd}
S12	10.3^{d}	27.2^{b}	43.4^{klm}	16.1^{defgh}	13.4^{f}	53.9^{bc}
S13	6.4^{k}	22.7^{g}	49.9^{g}	17.1^{cde}	10.3^{s}	48.9^{def}
S14	8.4^{h}	25.0^{de}	46.5^{b}	16.6^{cdef}	11.9^{l}	51.3^{bcde}
S15	9.6^{ef}	26.0^{cd}	44.0^{jk}	17.1^{cde}	13.0^{n}	52.8^{bcd}
S16	6.3^{k}	22.4^{g}	50.0^{b}	18.0^{bc}	9.7^{t}	48.6^{def}
S17	6.8^{jk}	23.5^{f}	48.1^{cd}	17.0^{cde}	11.4^{op}	50.8^{bcde}
S18	11.4^{c}	27.8^{b}	43.2^{klm}	14.8^{hijk}	14.3^{c}	53.9^{bc}
S19	11.4^{c}	27.7^{b}	43.2^{klm}	15.0^{ghij}	14.2^{d}	53.5^{bcd}
S20	9.4^{fg}	25.4^{cd}	45.9^{hi}	16.6^{cdef}	12.2^{k}	51.3^{bcd}
S21	8.4^{h}	25.2^{cd}	47.3^{de}	15.6^{efghi}	12.0^{l}	51.8^{bcd}
S22	6.5^{k}	23.9^{f}	48.7^{c}	16.5^{cdefg}	10.9^{r}	52.8^{bcd}
S23	9.2^{fg}	25.4^{cd}	45.7^{i}	16.8^{cdef}	12.2^{k}	52.3^{bcd}
S24	10.3^{d}	27.6^{b}	43.7^{kl}	14.9^{hijk}	13.8^{e}	54.4^{b}
S25	7.4^{ij}	27.6^{b}	47.3^{ef}	13.6^{jklm}	11.6^{mn}	51.7^{bcd}
S26	9.6^{ef}	27.6^{b}	45.0^{j}	14.3^{ijkl}	13.1^{g}	52.0^{bcd}
S27	13.5^{b}	27.6^{b}	42.8^{m}	13.4^{m}	16.2^{a}	53.0^{bcd}
S28	11.5^{c}	27.6^{b}	42.8^{lm}	15.3^{fghi}	14.3^{c}	54.4^{b}
S29	6.6^{k}	27.6^{b}	48.2^{cd}	13.0^{m}	11.2^{p}	52.3^{bcd}
S30	9.5^{fg}	27.6^{b}	44.8^{j}	14.8^{hijk}	12.8^{i}	53.4^{bcd}

Values with different alphabets as superscripts are significantly different (*L*p.005)

(27.8 per cent), S19 (27.7 per cent), S24, S25, S26, S27, S28, S29, S30 (27.6 per cent each) also recorded high recovery of edible bulbs. These samples were on par with each other but differed significantly from other samples with respect to recovery of edible bulbs.

4.1.1.2.2 Rind and Perigones

The relative proportion of rind and perigones to the fruit varied from 42.6 to 52.9 per cent. S9 recorded the lowest value for rind and perigones (42.6 per cent) followed by S28 (42.8 per cent). The proportion of rind and perigones were highest in S6 (52.9 per cent) followed by S1 and S2 (50.6 per cent). The samples from different location differed significantly with respect to the proportion of rind and perigones to the fruit.

4.1.1.2.3 Core

Significant difference was observed with respect to proportion of core among the fruits collected from different regions.

The least value was observed in S9 (12.4 per cent) followed by S29 (13.0 per cent) and highest value in S2 (19.8 per cent) followed by S7 (18.9 per cent).The samples namely S29 (13.0 per cent) and S27 (13.4 per cent) also recorded low value with respect to core content.

4.1.1.2.4 Seed

Seed content of fruit varied significantly between the samples collected from different regions. The lowest seed content was observed in S6 and S2 (8.4 per cent each). The sample S27 had the highest seed content (16.2 per cent) followed by sample S9 (15.4 per cent). The other samples with low seed contents were S1 (9.5 per cent), S16 (9.7 per cent) and S22 (10.9 per cent).

4.1.1.2.5 Recovery percentage of dried seed

There was significant variation among samples for recovery percentage of dried seed. It varied from 44.2 per cent in S6 to 59.6 per cent in S9. The samples with high recovery percentage of dried seeds are S24 and S28 (54.4 per cent), S5, S12 and S18 (53.7 per cent each).

4.1.2 Chemical characters

Thirty samples collected from different districts of Kerala were analysed for total carbohydrates, crude fibre, digestible carbohydrates, total minerals and fat content. The data is presented in Table 4.

4.1.2.1 Total carbohydrates

Significant difference was noticed between the samples with respect to total carbohydrate content of seeds. The highest total carbohydrate content was observed in S4 (79.8 per cent) followed by S23 (77.4 per cent) and lowest in S11 (54.7 per cent) followed by S29 (60.5 per cent). The samples namely S1, S3, S6, S9 and S28 also had high total carbohydrate content (> 73.5 per cent).

4.1.2.2 Crude fibre

Significant difference existed between samples for crude fibre content. Among the different samples S3 recorded the highest crude fibre (3.9 per cent) followed by S20 (3.5 per cent) and S29 recorded the lowest (1.5 per cent) followed by S13 (1.6 per cent). The samples S4, S11 and S28 also had high crude fibre content (>3.0 per cent).

Table.4 Chemical characters of the jackfruit seed

Sample No.	Total carbohydrates (Per cent)	Crude Fibre (Per cent)	Digestible carbohydrate (Per cent)	Mineral content (Per cent)	Fat content (Per cent)
S1	74.5^{bcd}	2.4f^{g}	72.1^{bcd}	1.7^{h}	0.2^{o}
S2	76.7^{abc}	2.5^{fg}	74.3^{abc}	1.3^{i}	0.3^{no}
S3	73.9^{bcde}	3.9^{a}	70.0^{def}	4.9^{a}	0.2^{o}
S4	79.8^{a}	3.4^{bc}	76.4^{a}	3.4^{c}	0.4^{mn}
S5	67.2^{ijkl}	2.9^{de}	64.3^{ijk}	3.3^{cd}	0.5^{klm}
S6	74.2^{bcd}	1.9^{ijk}	72.3^{bcd}	4.9^{a}	0.3^{no}
S7	77.9^{ab}	2.4^{fg}	75.5^{ab}	3.4^{cd}	0.7^{ghij}
S8	71.3^{defgh}	2.5^{fg}	68.9^{defgh}	3.2^{cde}	0.7^{ghi}
S9	74.3^{bcd}	2.7^{ef}	71.6^{bcde}	3.4^{cd}	1.1^{e}
S10	63.8^{klm}	2.1^{hij}	61.7^{klm}	5.0^{a}	0.4^{lmn}
S11	54.7^{n}	3.0^{de}	51.8^{n}	2.5^{g}	0.6^{ijk}
S12	69.8^{fghi}	2.2^{ghi}	67.6^{efghi}	3.3^{cd}	1.5^{c}
S13	64.3^{jklm}	1.6^{lm}	62.7^{jkl}	4.7^{a}	0.7^{hij}
S14	68.0^{hijk}	2.3^{ghi}	65.7^{ghijk}	3.2^{cde}	0.8^{gh}
S15	72.1^{defg}	2.4^{fg}	69.7^{defg}	1.4^{hi}	0.8^{fgh}
S16	67.5^{hijk}	1.8^{jklm}	65.7^{ghijk}	2.9^{f}	0.6^{jkl}
S17	67.4^{hijk}	2.5^{fg}	64.9^{ghijk}	3.4^{cd}	1.5^{c}
S18	69.5^{ghij}	3.3^{bc}	66.2^{fghij}	2.6^{g}	1.3^{d}
S19	73.4^{cdef}	2.5^{fg}	70.9^{cde}	3.0^{ef}	1.5^{c}
S20	73.4^{cdef}	3.5^{b}	69.9^{defg}	4.8^{a}	1.0^{ef}
S21	71.5^{defgh}	1.7^{klm}	69.8^{defg}	2.6^{g}	1.9^{a}
S22	68.6^{ghijk}	2.4^{fg}	66.2^{fghi}	4.1^{b}	1.6^{bc}
S23	77.4^{abc}	3.2^{bcd}	74.2^{abc}	3.1^{def}	0.8^{gh}
S24	76.5^{abc}	1.9^{jkl}	74.7^{abc}	4.0^{b}	1.8^{a}
S25	71.2^{defgh}	2.3^{gh}	68.9^{defgh}	3.4^{cd}	1.5^{c}
S26	61.5^{lm}	3.1^{cd}	58.4^{m}	2.5^{g}	1.2^{de}
S27	64.8^{jklm}	2.5^{fg}	62.4^{jklm}	3.4^{cd}	0.9^{fg}
S28	73.7^{bcdef}	3.0^{de}	70.7^{cde}	2.6^{g}	1.7^{ab}
S29	60.5^{m}	1.5^{m}	59.0^{lm}	3.1^{cdef}	0.8^{gh}
S30	65.4^{jkl}	2.0^{hijk}	63.4^{jk}	4.2^{b}	0.8^{fgh}

Values with different alphabets as superscripts are significantly different (<P 0.05)

4.1.2.3 Digestible Carbohydrates

Among the thirty samples, the highest digestible carbohydrate content was observed in S4 (76.4 per cent) followed by S7 (75.5 per cent) and the lowest in S11 (51.8 per cent) followed by S26 (58.4 per cent). The samples S2, S23 and S24 also had comparatively high digestible carbohydrate content (>74.2 per cent).

4.1.2.4 Mineral content

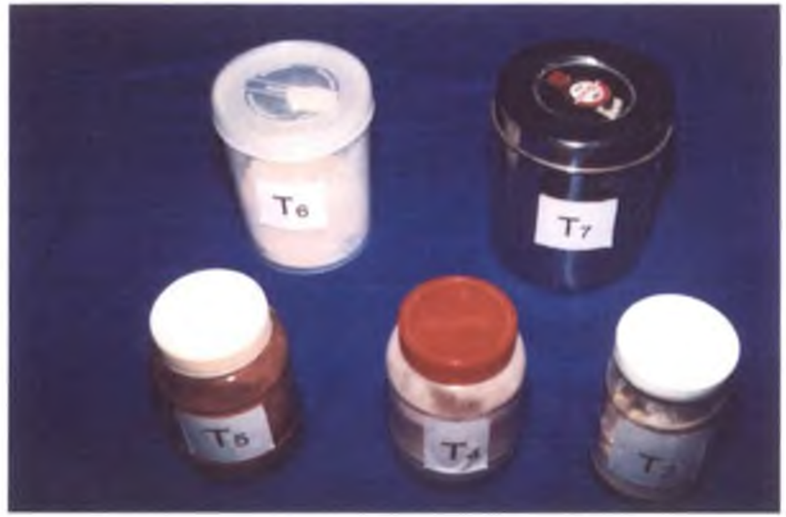
All the thirty samples differed significantly with respect to mineral content of seed. The highest mineral content was observed in S10 (5.0 per cent) followed by S3 (4.9 per cent) and lowest in S2 (1.3 per cent). Mineral content of seed was relatively high in samples S6 (4.9 per cent), S20 (4.8 per cent) and S13 (4.7 per cent).

4.1.2.5 Fat content

The fat content of different samples varied significantly. The highest fat content was observed in S21 (1.9 per cent) followed S24 (1.8 per cent) and the minimum fat content in S1 and S3 (0.2 per cent each). S12, S17, S19 and S25 also had high fat content (1.5 per cent) and were on par with each other.

4.2 STORAGE STUDY OF JACKFRUIT SEED FLOUR

The experiment was carried out to study the effect of eight packaging materials on quality of jack seed flour. (Plate. 4).



T1: Polyethylene cover - 200 guage
T2: Aluminum foil
T3: Glass bottle with air tight lid
T4: PET clear jar with air tight lid

T5: PET amber coloured jar with air tight lid
T6: Food grade white plastic jar with air tight lid
T7: Stainless steel containers with air tight lid
T8: White HDPE covers

Plate 4. Jackfruit seed flour stored in different packaging materials

4.2.1. Weight loss or gain during storage

Weight of the stored seed flour samples in different packaging materials increased gradually with the storage time (Table 5). The initial weight of all the samples was 100g.

Significant difference was observed between treatments for weight gain or loss of seed flour from second month to sixth month after storage. Weight gain was recorded only in T9 (storage under open condition) when observed one month after storage. At the end of second month of storage the seed flour packed in T6 (Food grade white plastic jar with airtight lid) and T8 (white HDPE cover) registered a slight decrease in weight where as T1, T2, T7 and T9 registered an increase in weight. Neither weight gain nor weight loss was noted for T3 (glass bottle with air tight lid), T4 (PET clear jar) and T5 (PET amber colour jar). Three months after storage all treatments except T5 recorded either increase or decrease in weight. Irrespective of the packaging material all the samples recorded gain in weight at the end of fourth and sixth month of storage. Maximum gain in weight was observed in T9 (111.1 g) and minimum in T3 (100.9 g) at the end of storage study.

4.2.2 Moisture content

The initial moisture content of the sample was 5.52 per cent. The seed flour samples registered an increase in moisture content throughout the storage period (Table 6). Maximum increase was observed in T9 (control). Increase in moisture content was the least in T3 (Glass bottle with air tight lid) at six months after storage. However at the end of storage period least increase in moisture was also noticed in T1 (polyethylene cover-200 gauge) and T2 (aluminium foil).

Table. 5 Weight loss or gain of seed flour during storage

Treatments	Weight loss or gain of seed flour (g)						
	0MAS	1MAS	2MAS	3MAS	4MAS	5MAS	6MAS
T1	100.0^{a}	100.0^{a}	100.2^{b}	101.5^{c}	101.6^{c}	101.7^{c}	101.8^{c}
T2	100.0^{a}	100.0^{a}	100.1^{d}	100.2^{d}	101.2^{d}	100.2^{f}	101.4^{e}
T3	100.0^{a}	100.0^{a}	100.0^{d}	100.1^{d}	100.7^{c}	100.7^{e}	100.9^{e}
T4	100.0^{a}	100.0^{a}	100.0^{e}	100.8^{b}	101.0^{de}	101.0^{e}	103.2^{cd}
T5	100.0^{a}	100.0^{a}	100.0^{d}	100.0^{d}	100.8^{e}	101.8^{c}	102.1^{d}
T6	100.0^{a}	100.0^{a}	99.0^{de}	99.8^{e}	99.9^{g}	100.0^{f}	102.4^{d}
T7	100.0^{a}	100.0^{a}	101.0^{c}	101.2^{c}	101.8^{b}	102.1^{b}	103.9^{c}
T8	100.0^{a}	100.0^{a}	98.6^{e}	99.3^{e}	101.2^{d}	102.1^{b}	104.9^{b}
T9	100.0^{a}	101.1^{b}	104.8^{a}	108.0^{a}	109.7^{a}	110.2^{a}	111.1^{a}

Values with different alphabets as superscripts are significantly different (*L*p.005)

Values are mean of three replications

DMRT column wise comparison

Table.6 Moisture content of stored seed flour

Treatments	Moisture content (percentage)						
	0 MAS	1MAS	2MAS	3MAS	4MAS	5MAS	6MAS
T1	5.52^{a}	5.57^{d}	5.77^{e}	5.83^{e}	5.90^{f}	6.23^{c}	6.30^{d}
T2	5.52^{a}	6.10^{b}	6.10^{d}	6.13^{d}	6.13^{e}	6.16^{c}	6.20^{d}
T3	5.52^{a}	5.54^{e}	5.60^{g}	5.67^{f}	5.77^{f}	5.83^{d}	6.03^{f}
T4	5.52^{a}	6.13^{b}	6.37^{c}	6.53^{c}	6.77^{c}	7.07^{b}	7.27^{c}
T5	5.52^{a}	5.53^{e}	5.57^{f}	5.83^{e}	5.90^{f}	6.10^{c}	6.50^{de}
T6	5.52^{a}	5.52^{f}	5.61^{g}	5.63^{f}	5.83^{f}	6.17^{c}	6.53^{de}
T7	5.52^{a}	6.80^{a}	6.80^{b}	6.90^{b}	7.17^{b}	7.20^{b}	7.33^{c}
T8	5.52^{a}	5.73^{c}	5.80^{e}	5.83^{e}	6.40^{d}	7.13^{b}	8.33^{b}
T9	5.52^{a}	6.13^{b}	7.13^{a}	7.50^{a}	8.67^{a}	9.60^{a}	10.53^{a}

Values with different alphabets as superscripts are significantly different (P 0.05)

Values are mean of three replications

DMRT column wise comparison

4.2.3 Carbohydrate content

The variation in carbohydrate content of the seed flour in different packaging materials was studied at monthly intervals for a period of six months and results presented in Table 7.

Significant variation between treatments in carbohydrate content of the samples was recorded. The initial carbohydrate content of the samples was 75.23 per cent. Irrespective of packaging materials, the samples showed a decreasing trend in carbohydrate content throughout the storage period. The extent of decrease was the maximum in T9 (control with 60.47 per cent) followed by T8 (white HDPE cover). The minimum variation in carbohydrate content was shown by samples packed in T3 (glass bottle with air tight lid) followed by T2 (Aluminium foil).

4.2.4 Organoleptic evaluation of seed flour

The organoleptic evaluation of jackfruit seed flour was conducted by score card method. Each character was scored using five point hedonic scale by a panel of ten judges for four quality attributes namely colour, flavour caking and insect infestation of jackfruit seed flour. The mean scores obtained for organoleptic qualities of seed flour in different packaging materials for a period of six months are furnished in the Table 8.

4.2.4.1 Colour

Highest score for colour (4.0) was observed for samples packed in T1 (polyethylene 200 gauge), T2 (aluminium foil) and T3 (glass bottle with air tight plastic lid) at first, second and third month of storage. A gradual reduction in values for colour was observed with increase in storage period. The lowest score

Table.7 Variation in carbohydrate content of seed flour

Treatments	Variation in carbohydrate content (percentage)						
	0MAS	1MAS	2MAS	3MAS	4MAS	5MAS	6MAS
T_1	75.23^{a}	74.50^{ab}	74.50^{bc}	74.46^{ab}	74.44^{ab}	74.38^{ab}	74.32^{b}
T_2	75.23^{a}	74.57^{ab}	74.57^{ab}	74.52^{ab}	74.45^{ab}	74.39^{ab}	74.33^{b}
T_3	75.23^{a}	74.83^{a}	74.94^{a}	74.97^{a}	74.91^{a}	74.93^{a}	74.93^{a}
T_4	75.23^{a}	72.63^{d}	72.63^{e}	71.09^{de}	71.06^{d}	71.00^{d}	70.83^{d}
T_5	75.23^{a}	74.13^{b}	74.13^{c}	74.10^{b}	74.03^{b}	73.93^{bc}	73.63^{c}
T_6	75.23^{a}	73.50^{c}	73.44^{d}	73.39^{c}	73.35^{c}	73.38^{c}	73.25^{c}
T_7	75.23^{a}	71.80^{e}	71.80^{f}	71.43^{d}	71.07^{d}	70.63^{de}	70.10^{e}
T_8	75.23^{a}	70.90^{f}	70.90^{g}	70.80^{d}	70.60^{d}	70.20^{e}	69.70^{f}
T_9	75.23^{a}	71.07^{f}	68.90^{i}	67.60^{e}	66.40^{e}	63.23^{f}	60.47^{g}

Values with different alphabets as superscripts are significantly different (*L*p.005)

Values are mean of three replications

DMRT column wise analysis

Table.8 Organoleptic evaluation of seed flour

Quality attribute	Storage Period (Months)	T1	T2	T3	T4	T5	T6	T7	T8	T9
Colour	1	4.00	4.00	4.00	4.00	4.00	3.67	3.67	4.00	3.67
	2	4.00	3.00	4.00	3.00	3.67	4.00	3.00	4.00	3.00
	3	4.00	3.00	4.00	3.00	3.67.	3.67	3.00	4.00	2.00
	4	3.67	3.00	3.00	3.67	3.33	4.00	3.00	3.00	2.00
	5	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	1.67
	6	3.00	3.00	3.00	3.00	3.00	2.67	2.67	2.67	1.33
Flavour	1	4.33	5.00	5.00	4.00	4.67	4.33	4.67	4.33	4.00
	2	4.00	5.00	4.00	4.00	3.67	3.67	3.67	4.00	3.33
	3	3.67	4.00	4.00	4.00	3.67	4.00	4.00	3.67	3.00
	4	3.67	4.00	4.00	3.67	3.67	3.67	3.67	4.00	2.33
	5	3.67	4.00	4.00	3.67	3.67	3.67	3.33	3.67	2.00
	6	3.67	4.00	4.00	3.67	3.67	3.67	3.33	3.33	1.33

Table continued

Table continued

Quality attribute	Storage Period (Months)	T1	T2	T3	T4	T5	T6	T7	T8	T9
Caking	1	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00
	2	5.00	5.00	5.00	4.33	5.00	4.67	4.00	5.00	3.33
	3	4.00	5.00	5.00	4.33	5.00	4.67	4.00	4.67	3.00
	4	4.00	4.00	4.33	4.00	4.33	4.33	4.00	4.00	3.00
	5	3.00	4.00	4.00	4.00	4.00	4.00	3.33	4.00	2.67
	6	4.00	3.00	4.00	4.00	3.67	4.00	3.33	3.33	2.00
Insect Infestation	1	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.33
	2	5.00	5.00	5.00	5.00	5.00	4.33	4.00	5.00	4.00
	3	4.67	5.00	5.00	5.00	5.00	4.33	3.33	5.00	3.67
	4	4.67	4.00	5.00	5.00	5.00	4.33	3.00	4.33	3.00
	5	4.67	4.00	4.67	4.33	4.67	4.33	3.00	4.33	2.00
	6	4.00	4.00	4.67	4.33	4.33	4.33	3.00	4.00	1.67

for colour was recorded for T9 throughout the period of storage (1.33 at six months after storage).

4.2.4.2 Flavour

The superior scores (5.0) for flavour was obtained for seed flour packed in T2 (Aluminium foil) at the end of first and second month of storage. It is evident from the Table 8 that flavour retention was maximum (4.00) in T2 and T3 during the entire period of storage. T9 (control) recorded the lowest score (1.33) for flavour after six months of storage.

4.2.4.3 Caking

Seed flour was examined at monthly intervals for recording the degree of caking. (Table 8). Caking was practically absent in all samples except T9 (control) when observed one month after storage. Samples packed in T3 (glass bottle), T4 (PET clear jar with air tight lid) and T5 (PET amber colour jar with air tight lid) did not showed any tendency for caking up to three months of storage. Lowest score (2.00) was recorded by T9 (control) after six months storage.

4.2.3.4 Insect infestation

Visual examination of seed flour samples was done at monthly intervals for recording the intensity of insect infestation. All the samples except T9 (control) were free from insect infestation when observed after one month storage. Samples stored in T1, T2, T3 and T4 were free from insect attack upto fourth month of storage. Towards the end of storage least infestation was observed in T3 (4.67) followed by T1, T2, T4, T5 and T6, which were on par (4.33) and highest in T9 (1.67).

4.3 VALUE ADDITION OF JACKFRUIT SEED FLOUR (JSF)

4.3.1 Utilization of JSF for preparation of *chapattis*

Chapattis were prepared by blending wheat flour (WF) and jackfruit seed flour (JSF) in various proportions *Viz*., 90:10, 80:20, 70:30 and 60:40.

4. 3. 1. 1 Organoleptic evaluation at chapattis

Sensory evaluation of *chapattis* prepared was carried out by a panel of twelve semi- trained persons for quality attributes like colour, texture, flavour, taste and overall acceptability. Significant variation was recorded between the treatments for the quality parameters. The mean scores obtained are furnished in Table 9.

4.3.1.1.1 Colour

Highest score for colour (4.67) was obtained for T5 (wheat flour alone) and T1 (WF 90: JSF 10) followed by T2 (WF 80: JSF 20). Lowest score for colour was observed for T4 (3.27), which was on par with T3 (3.33).

4.3.1.1.2 Flavour

Chapattis prepared by mixing wheat flour and jack seed flour in 90: 10 proportion registered the maximum score (4.67) for the flavour which was on par with T2, T3 and T5. The minimum score (3.33) for this parameter was noted in T4 (WF 60: JSF40).

Table.9 Organoleptic evaluation of *chapattis*

Character / Treatments	Colour	Flavour	Texture	Taste	Overall acceptability
T1	4.67[a]	4.67[a]	4.27[a]	4.17[a]	4.27[a]
T2	4.33[b]	4.33[a]	4.21[a]	4.12[a]	4.13[a]
T3	3.33[c]	4.16[a]	3.10[b]	3.33[b]	3.67[b]
T4	3.27[c]	3.33[b]	2.67[c]	2.67[c]	2.67[c]
T5	4.67[a]	4.33[a]	4.33[a]	4.67[a]	4.67[a]

Values with different alphabets as superscripts are significantly different

DMRT column wise comparison

4.3.1.1.3 Texture

Superior score for the texture was recorded for T5 (4.33), which was on par with T1 (4.27) and T2 (4.21). T4 registered the lowest score for texture (2.67).

4.3.1.1.4 Taste

Taste was the best for T5 (4.67), which was on par with T1 (4.17) and T2 (4.12). The lowest score for taste was registered by T4 (2.67).

4.3.1.1.5 Overall acceptability

Highest score (4.67) for overall acceptability was obtained for T5 (wheat flour alone), which was on par with T1 (4.27) and T2 (4.13) where as the lowest score was for T4 (2.67).

4.4 AGRICULTURAL WASTE AS CATTLE FEED

4.4.1 Jackfruit seed flour as cattle feed

A feeding trial was carried out at the livestock farm, College of Veterinary and Animal Sciences, Mannuthy for evaluation of the suitability of jackfruit seed flour in the ration of dairy cows. The results of the feeding experiment are presented in Tables 10 to 12 and Plate. 5, 6.

4.4.1.1 Dry matter intake (DMI)

The average daily dry matter intake of animals belonging to group I and II were 10.33 ± 0.34 and 10.65 ± 0.42 kg respectively. The average dry matter intake of group II animals were slightly higher (10.20 ± 0.41) than group I (9.60± 0.32) at the end of first week of feeding trial. A gradual increase in DMI of animals

172364

Plate 5. Ingredients of compounded cattle feed

Plate 6a. Ration I

Plate 6c. Ration II

Plate 6b. Experimental cows fed with ration I

Plate 6d. Experimental cows fed with ration II

Plate 6. Feeding trial on experimental cows with compounded cattle feed

Table. 10 Average daily dry matter intake* and milk production* of animals maintained on the experimental rations in the feeding trial.

Weeks	Dry matter intake (Kg/ animal)		Milk production (Kg/ animal)	
	Group I	Group II	Group I	Group II
1	9.60 ± 0.32^{A}	10.20 ± 0.71^{B}	6.80 ± 0.39	6.63 ± 0.72
2	10.30 ± 0.12	10.70 ± 0.43	7.23 ± 0.34	7.11 ± 0.48
3	10.50 ± 0.42	10.80 ± 0.25	7.39 ± 0.27	7.50 ± 0.52
4	10.60 ± 0.51	10.90 ± 0.29	7.46 ± 0.89	7.72 ± 0.25
Mean±SE	10.33 ± 0.34	10.65 ± 0.42	7.22 ± 0.47	7.24 ± 0.49

*Average of six values.

Means with different superscripts in the same row differ significantly. A, B ($P < 0.01$)

Table.11 Composition of milk* from animals maintained on the two experimental rations in the feeding trial

Parameter	Group	Weeks				Means ± SE
		1	2	3	4	
Fat (g %)	I	3.96 ± 0.39	4.35 ± 0.44	4.43^{a} ± 0.16	4.60 ± 0.27	4.33± 0.22
	II	4.05 ± 0.43	4.28± 0.37	4.18^{b} ± 0.13	4.56± 0.42	4.27± 0.33
Total solids (g %)	I	12.74 ± 0.69	12.84± 0.79	12.96 ± 0.63	12.84± 0.73	12.84± 0.70
	II	12.67± 0.62	12.75±0.73	12.78 ± 0.60	12.80± 0.71	12.75± 0.66
Solid not fat (g %)	I	8.78 ± 0.30	8.49± 0.32	8.53 ± 0.18	8.24± 0.25	8.51 ± 0.28
	II	8.62 ± 0.28	8.47± 0.34	8.60 ± 0.20	8.24 ± 0.21	8.48 ± 0.21

*Average of six values

a, b – Means within the sample parameter with different super scripts in the same column vary significantly ($P < 0.05$)

belonging to both the groups were observed throughout the feeding period (Table. 10).

4.4.1.2 Milk production

Milk production by animals in group I and II increased gradually from 6.80 ± 0.39 and 6.63 ± 0.72 kg per animal during first week of feeding to 7.46 ± 0.89 and 7.72 ± 0.25 kg per animal respectively during the fourth week of feeding trial.

4.4.1.3 Milk composition

The composition of milk viz., fat, total solids and solid not fat from animals fed with two rations collected at weekly intervals are given in Table 11.

4.4.1.3.1 Fat content

The fat content of milk of animals belonging to group I and II at the end of first week of feeding was 3.96 ± 0.39 and 4.05 ± 0.43 g percent respectively. This increased to 4.60 ± 0.27 and 4.56 ± 0.42 g percent respectively at the end of fourth week. However the differences observed in fat percentage of milk between the group I and II were not significant.

4.4.1.3.2 Total solids

The average total solids in the milk from animals of the group I and II were 12.84 ± 0.70 and 12.75 ± 0.66 g per cent respectively and the values did not differ significantly.

Table.12 Economics and cost per Kg milk production of animals maintained on the two experimental rations during feed trial

Parameter	Group I	Group II
Total concentrate consumed in 30 days (Kg)	820	870
Total grass consumed in 30 days (Kg)	5100	5150
Total feed consumed in 30 days (Kg)	5920	6020
Total dry matter intake in 30 days (Kg)	1860	1916
Total milk production in 30 days (Kg)	1281	1293
Dry matter intake per Kg milk produced (Kg)	1.45	1.48
Cost of one Kg concentrate (Rs)	9.86	8.12
Cost of one Kg grass (Rs)	0.50	0.50
Total cost of feed (Rs)	10635.2	9639.4
Cost per Kg milk produced	8.30	7.45

4.4.1.3.3 Solids not fat (SNF)

Solids not fat content of the milk of the first group ranged between 8.24 to 8.78 g per cent while in the second group it was between 8.24 to 8.62 g per cent. The average solids not fat in group I and II were 8.51 ± 0.28 and 8.48 ± 0.21 g per cent respectively and the values did not differ significantly. (Table 11)

4.4.1.3.4 Economics of incorporation of jack seed flour in the dairy cattle feed

Experimental animals were fed with concentrate mixture as well as grass for a period of one month. The total concentrate mixture and grass consumed respectively by animals of group I were 820 kg and 5100 kg and by the group II animals were 870 Kg and 5150 Kg. The total feed consumption of animals belonging to group I was 5920 kg and group II was 6020 Kg (Table 12). The cost per kilogram of two experimental rations *viz.*, rations I (20 per cent JSF) and ration II (40 per cent JSF) were Rs. 8.30 and Rs. 7.45 respectively. The milk production during the entire period of feeding trial was 1281 Kg for group I and 1293 Kg for group II. The cost of feed per kilogram of milk produced was estimated as Rs 8.30 and Rs 7.45 for group I and group II respectively.

Discussion

DISCUSSION

Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the popular fruits of Kerala. The ripe fruit contains well-flavoured yellow sweet bulbs and seeds (embedded in the bulbs). Seeds make up around 10 to 15 per cent of the fruit weight and have high carbohydrate content. Presently, carbohydrate requirement of cattle feed is met through cereals. In India per capita requirement of cereals is 165.6 Kg/ annum. But the average annual cereal consumption is hovering around 138.75 Kg/ head (Seetharama and Rao, 2004). Jackfruit is a summer crop which comes to the market when staple food grains are in short supply. During this lean period, the fruits can contribute substantially to the nutrition of the local population and their livestock. As fresh seeds cannot be kept for a long time, seed flour can be used as an alternative product, which can be used in some food products. However, seed flour is prone to various deteriorative changes such as ingress in moisture content, off odour development, caking, insect infestation, *etc.* Proper packaging will help in minimising the quality losses during storage and will ensure quality products under hygienic conditions (Balasubramanyam, 1995).

The results obtained during the course of the study are discussed below.

5.1 PHYSIO CHEMICAL CHARACTERS OF JACKFRUIT

5.1.1 Physical characters

The physical characters studied include weight of the fruit, recovery of edible bulbs, per cent contribution of the rind and perigones, core, seed and recovery percentage of dried seed.

Significant variation with respect to physical characters was observed among the fruits obtained from different localities. Majority of the fruit samples had fruit weight ranging between 6.0 to 9.5 Kg. According to Berry and Kalra

(1988) the average weight of the jackfruit varied from 3.3 to 17.4 Kg which in turn depends on the variety, location and climatic conditions. The fruit samples collected from Malampuzha, Palakkad (S9) recorded the highest value for weight of the fruit (17.2 Kg) and recovery of edible bulbs (29.7 per cent). The percentage contribution of rind and perigones (42.16 per cent) and core (12.4 per cent) was also the lowest in S9 indicating low waste index for this sample. The fruit samples were arbitrarily grouped into four clusters based on fruit weight like cluster I (4-8 Kg), cluster II (8-12 Kg), cluster III(12-16 Kg) and cluster IV(>16 Kg)(Fig.1). Majority of the samples were grouped under Cluster II (with fruits weighing from 8-12 Kg). Hussain and Haque (1977) reported that small fruits had low recovery of edible bulbs as well as seed and large fruits had high values for recovery of edible bulbs and seed content of the fruit. Samples S18, S28, S27 registered high fruit weight (>11.0 Kg) as well as high recovery of edible bulbs (>27.5 per cent) had low proportion of rind and perigones (< 43.3 per cent) and core (<14.8 per cent) (Fig.2). This is in agreement with Mitra (1998) who reported maximum recovery of edible bulbs in larger fruits and vice versa.

The recovery percentage of dried seed was also highest for large fruit (>53.0 per cent) as compared to small fruits. The samples S9, S28 and S27 recorded high recovery percentage of dried seed.

The values for weight of the fruit ranged between 4.6 to 17.2 Kg, proportion of edible bulbs 21.3 to 29.7 per cent, rind and perigone 42.6 to 52.8 per cent, core 12.4 to 19.7 per cent, seed 8.4 to 16.2 per cent and recovery percentage of dried seed 42.2 to 59.6 per cent.

According to Sharma (1964) major components of jackfruit namely edible bulbs, rind, perigones and seeds contributes 27 to 40 per cent, 18 to 20 per cent, 20 to 22 per cent and 20 to 23 per cent respectively to the total weight of the fruit. Muthulaksmi (2003) also reported wide variation among the jackfruits collected from different regions with respect to physical characters of the fruits. Medium

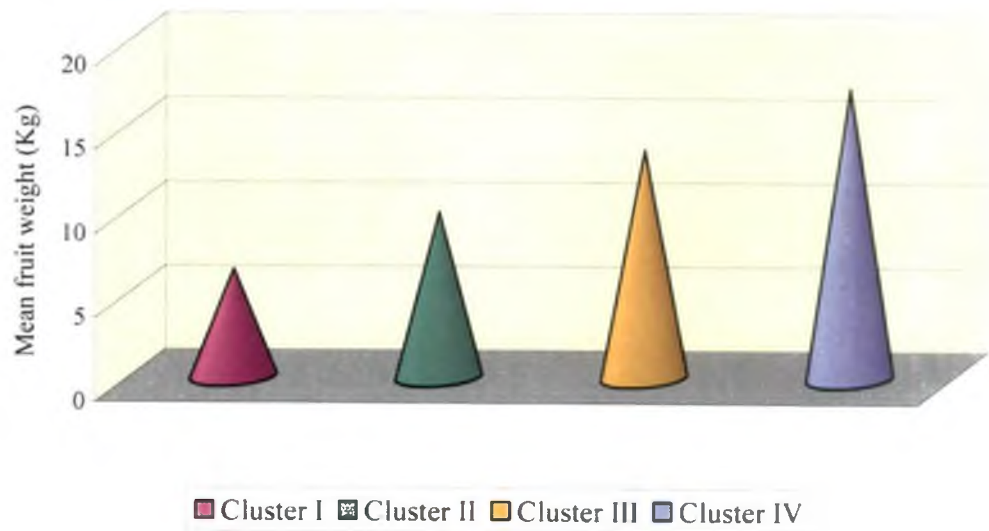


Fig. 1. Mean fruit weight of jackfruit samples

Fig. 2. Mean physical composition of jackfruit samples

sized fruits are generally preferred by small families, because fruits once cut and opened, cannot be kept for longer time since the shelf life is much shorter. Hence, medium sized fruits weighing between 6 to 10 Kg are generally preferred. But for the commercial purposes like making chips, people prefer varieties with high bulb recovery and low waste content.

5.1.2 Chemical characters

Chemical constituent of seed samples of different regions studied are total carbohydrates, crude fibre, digestible carbohydrates, mineral content and fat content.

Significant variation was noticed among samples of jackfruit seed flour with respect to chemical characters. Total carbohydrate content of the samples ranged from 54.7 to 79.8 per cent (Fig.3). Twenty samples recorded total carbohydrate content ranging from 68.5 to 79.7 per cent. This is in accordance with the values reported by Bobbio *et al.* (1978), Singh *et al.* (1991) and Tulyathan *et al.* (2001).

Crude fibre content of different seed samples varied from 1.5 to 3.9 per cent (Fig. 4). Majority of samples recorded crude fibre content ranging from 2.2 to 2.4 per cent, which is in accordance with Singh *et al.* (1991) who reported 2.2 per cent crude fibre in jack seed.

The digestible carbohydrate content of the samples studied ranged from 51.8 to 76.4 per cent (Fig.5). More than eighteen samples recorded the digestible carbohydrate content in the range of 66.6 to 74.2 per cent.

The mineral content of the samples ranged from 1.3 to 5.0 per cent (Fig.6). Majority of the samples had mineral content in the range of 2.8 to 3.4 per cent. Kumar *et al.* (1988) reported a lower mineral content in jackfruit seed (1.16 to

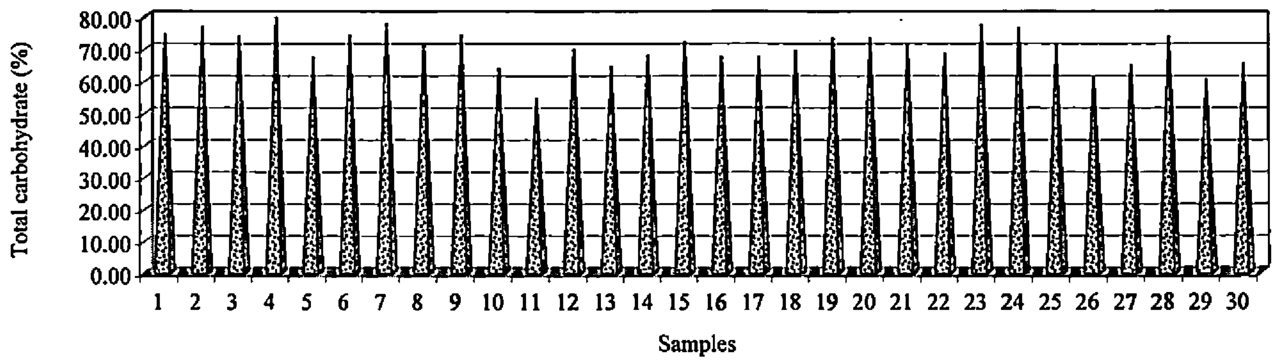


Fig. 3. Total carbohydrate content of seed samples

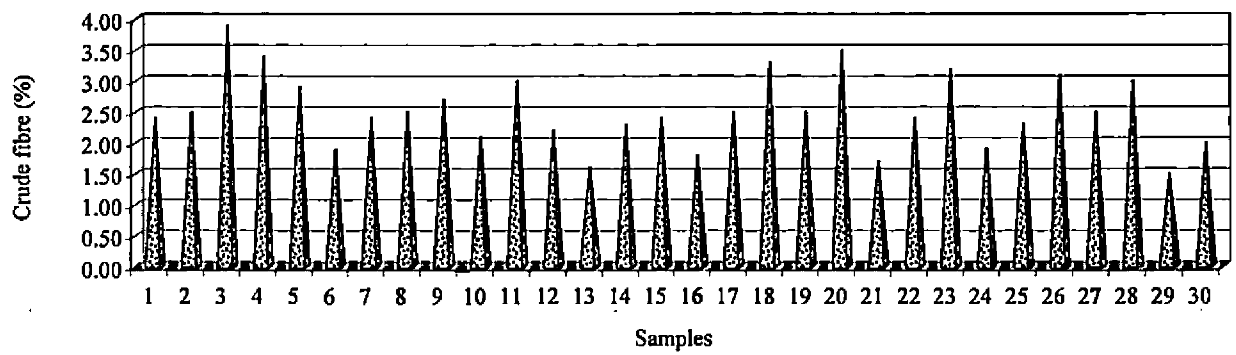


Fig. 4. Crude fibre content of seed samples

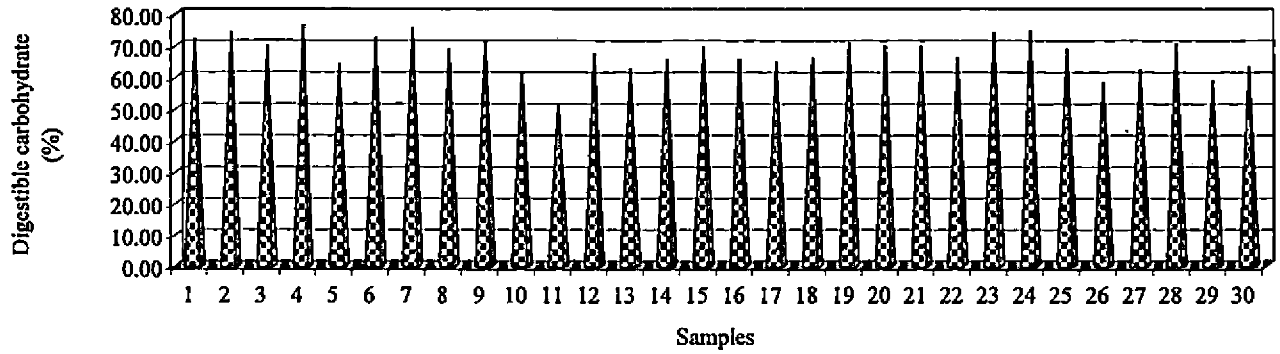


Fig. 5. Digestible carbohydrate content of seed samples

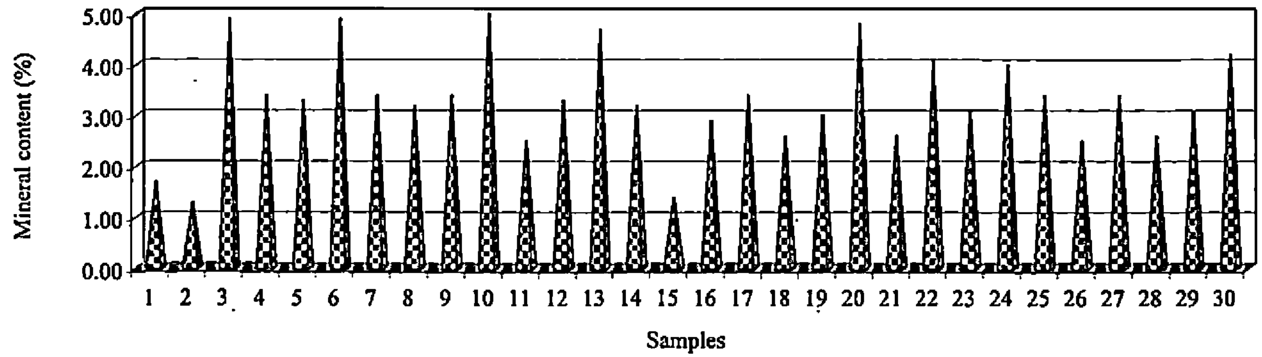


Fig. 6. Mineral content of seed samples

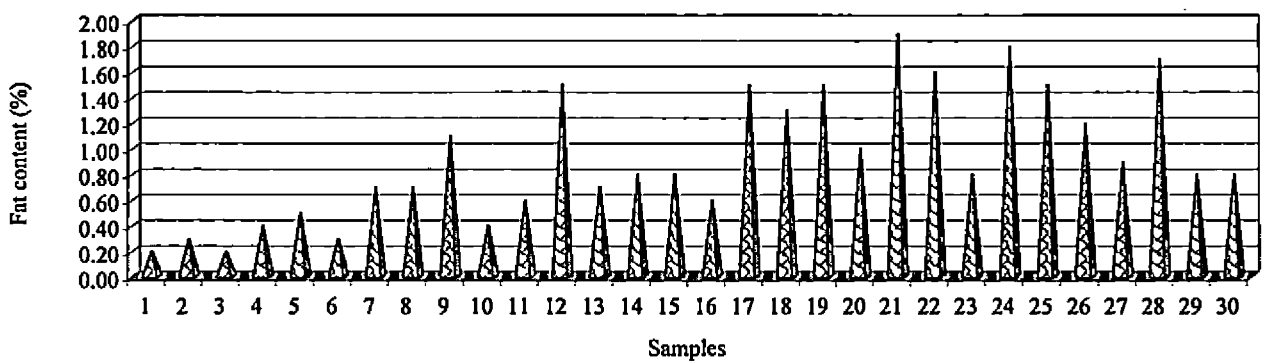


Fig. 7. Fat content of seed samples

1.27 per cent). According to Subburamu *et al.*, (1992) jackfruit seed found to have a mineral content of 4.5 per cent on dry weight basis.

The fat content of seed samples varied from 0.2 to 1.9 per cent (Fig. 7). Majority of the samples had fat content, which ranged between 0.8 to 1.2 per cent. This is in concurrence with the results obtained by Tulyathan *et al.* (2001).

5.2 STORAGE STUDY OF JACKFRUIT SEED FLOUR

5.2.1 Weight loss or gain during the storage.

Significant difference was observed between the seed flour samples stored in different packing materials for six months (Fig. 8). Irrespective of packaging materials, increase in weight of seed flour was observed throughout the period of storage. The minimum weight gain was observed in seed flour stored in glass bottle with air tight lid (T3) followed by aluminium foil (T2). The maximum weight gain was observed in T9 (storage in open condition) followed by white HDPE (T8).The difference in weight gain of seed flours stored in various packing materials may be due to different barrier proofness to the external environment. This can be expected when the relative humidity is higher around the storage vicinity. (Balasubramanyam, 1995). Seed flour stored in polyethylene cover (T1) and PET amber colour jar (T5) also recorded less weight gain (<101.5 Kg) at the end of six months of storage.

5.2.2 Moisture content

Moisture content of seed flour was found to be influenced by the packaging materials as well as storage period (Fig. 9). However, seed flour stored in glass bottle with air tight lid (T3), poly ethylene cover (T1) and aluminium foil (T2) recorded comparatively less moisture content six months after storage indicating that they are comparatively moisture proof. Maximum increase in

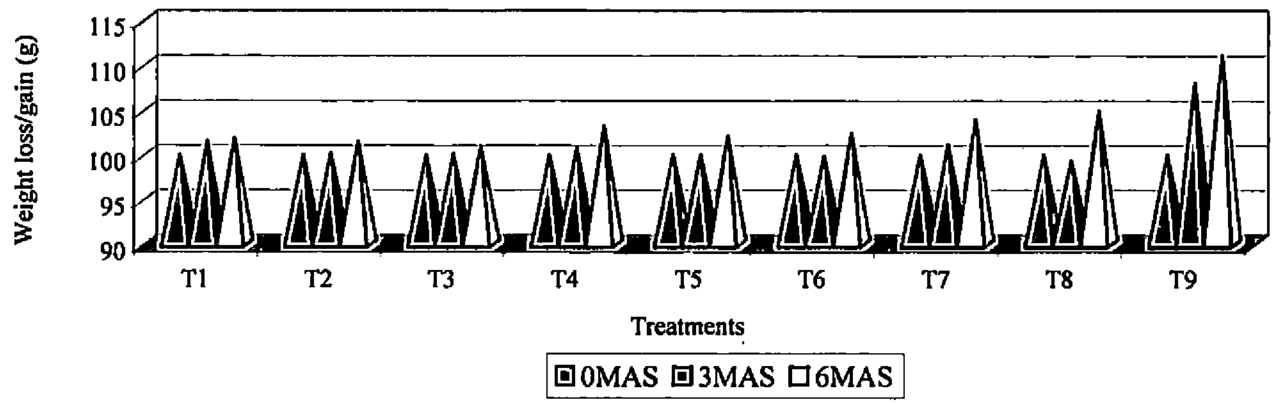


Fig. 8. Effect of packaging on weight loss/gain of jackfruit seed flour during storage

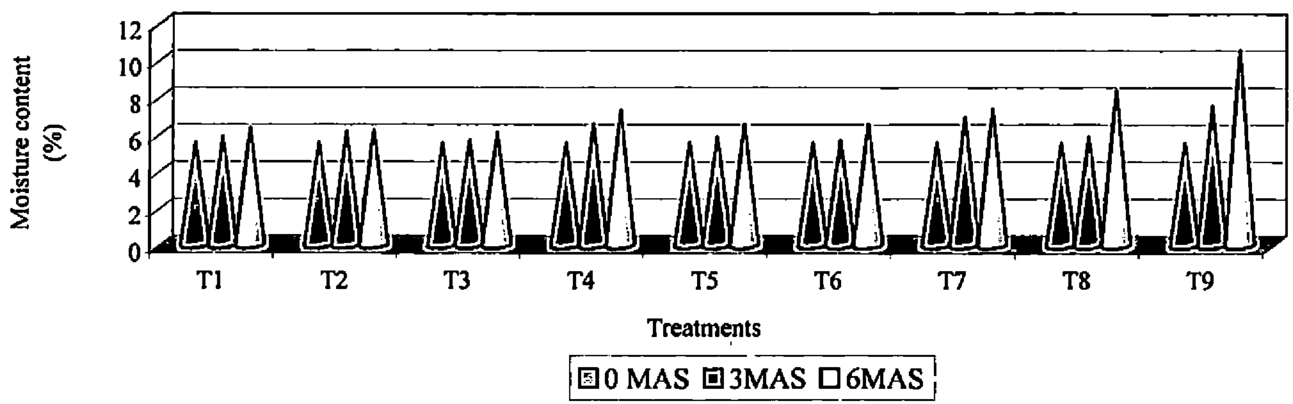


Fig. 9. Effect of packaging on moisture content of jackfruit seed flour during storage

moisture content was noticed in T9 (control). The dehydrated breadfruit chips when powdered to flour reported an increase in moisture content with advancement of storage period (Pillai, 2001). This was similar to the findings of Chellammal (1995) in sweet potato flour and Liya (2001) in taro flour.

5.2.3 Carbohydrate content

The carbohydrate content of the seed flour stored in different packaging materials decreased significantly with the advancement of storage time (Fig. 10). As reported by Adewusi *et al.* (1995) the decrease in carbohydrate content of food products during the storage is due to breakdown of carbohydrates to sugars. The minimum variation in carbohydrate content of seed flour was observed in glass bottle with air tight lid (T3) followed by aluminium foil (T2) and the maximum was in T9 (Control).

5.2.4 Organoleptic evaluation of seed flour

The effect of the different packaging systems on the organoleptic qualities of jackfruit seed flour was evaluated for six months.

There was no change in colour of seed flour stored in polyethylene (T1), aluminium foil (T2) and glass bottle with air tight lid (T3) up to third month of storage. Colour change was observed with the advancement of storage time. At the end of storage period, minimum colour change was observed in T2, T1 and T3 and maximum in T9 (control). This brown discolouration may be due to high moisture absorption of seed flour kept in open condition (control), which might have facilitated Maillard reaction. The commencement of Maillard reaction is strongly influenced by packaging materials as well as storage period (Mauron, 1989). Bhaskar (2000) reported that banana flour when stored showed a slight discolouration during the later periods of storage due to enzymatic browning and ascorbic acid browning.

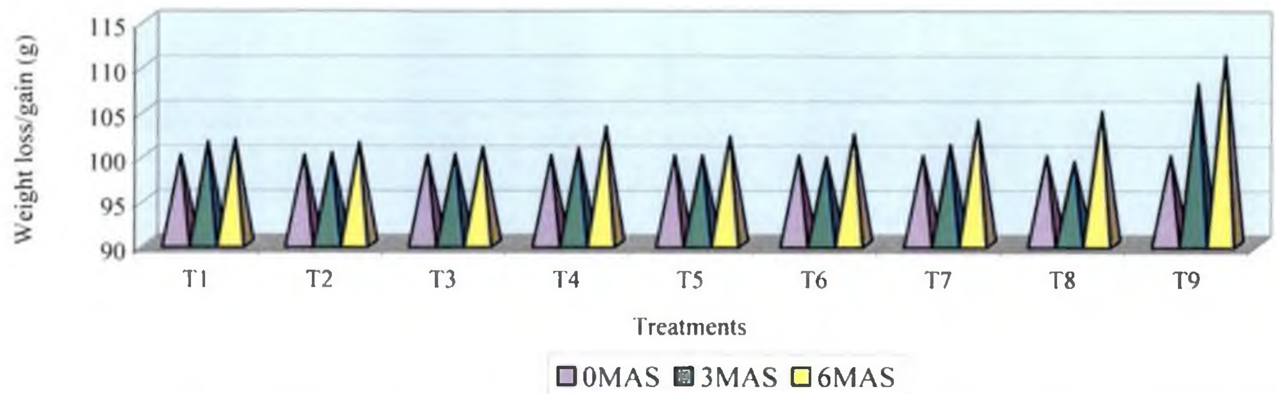


Fig. 8. Effect of packaging on weight loss/gain of jackfruit seed flour during storage

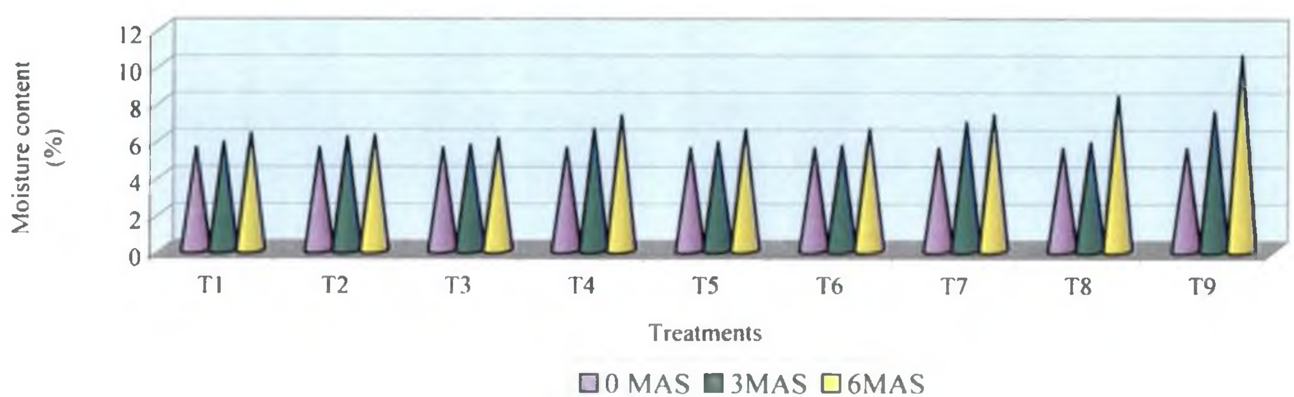


Fig. 9. Effect of packaging on moisture content of jackfruit seed flour during storage

moisture content was noticed in T9 (control). The dehydrated breadfruit chips when powdered to flour reported an increase in moisture content with advancement of storage period (Pillai, 2001). This was similar to the findings of Chellammal (1995) in sweet potato flour and Liya (2001) in taro flour.

5.2.3 Carbohydrate content

The carbohydrate content of the seed flour stored in different packaging materials decreased significantly with the advancement of storage time (Fig. 10). As reported by Adewusi *et al.* (1995) the decrease in carbohydrate content of food products during the storage is due to breakdown of carbohydrates to sugars. The minimum variation in carbohydrate content of seed flour was observed in glass bottle with air tight lid (T3) followed by aluminium foil (T2) and the maximum was in T9 (Control).

5.2.4 Organoleptic evaluation of seed flour

The effect of the different packaging systems on the organoleptic qualities of jackfruit seed flour was evaluated for six months.

There was no change in colour of seed flour stored in polyethylene (T1), aluminium foil (T2) and glass bottle with air tight lid (T3) up to third month of storage. Colour change was observed with the advancement of storage time. At the end of storage period, minimum colour change was observed in T2, T1 and T3 and maximum in T9 (control). This brown discolouration may be due to high moisture absorption of seed flour kept in open condition (control), which might have facilitated Maillard reaction. The commencement of Maillard reaction is strongly influenced by packaging materials as well as storage period (Mauron, 1989). Bhaskar (2000) reported that banana flour when stored showed a slight discolouration during the later periods of storage due to enzymatic browning and ascorbic acid browning.

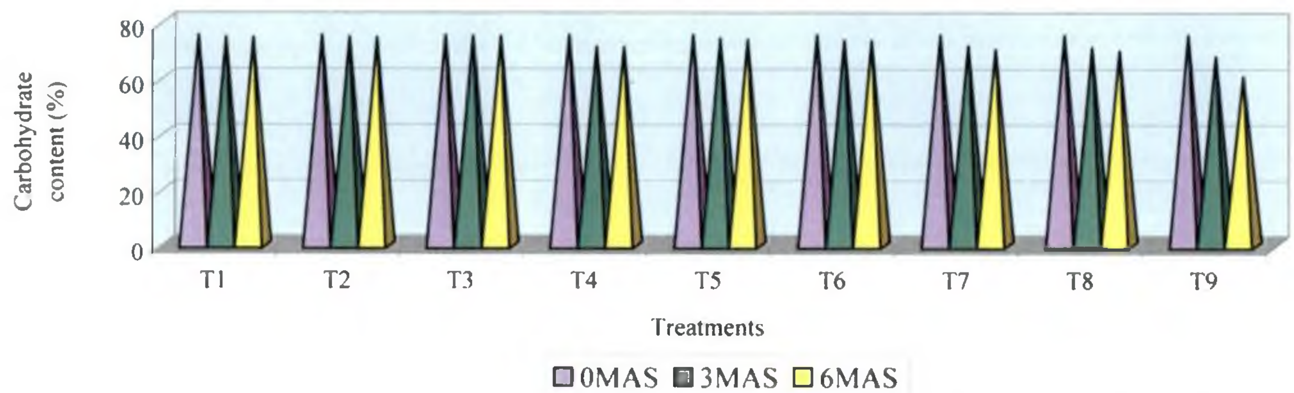


Fig. 10. Effect of packaging on carbohydrate content of jackfruit seed flour during storage

Irrespective of packing materials, a change in the flavour of seed flour was observed only after on month of storage. Maximum flavour retention was observed in samples stored in glass bottle (T3) and aluminium foil (T2) during the entire period of storage. The minimum flavour retention was observed in T9 (control). The flavour loss during the storage might be due to rancidity brought by the high moisture absorption of seed flour. This also depends on the degree of barrier proofness of packaging materials to gas and moisture of external environment.

Towards the end of the storage period, seed flour stored in glass bottle (T3) and aluminium foil (T2) showed the least tendency for caking. The degree of caking was maximum in T9 (control) after sixth month of storage. This can also be attributed to the high moisture absorption of seed flour kept in open condition. As reported by Labuza *et al.* (1977), polymerisation of compounds in maillardard reaction definitely leads to toughening of the stored food products.

Seed flour stored in different packaging materials except T9 (control) was virtually free from insect infestation at the end of one month of storage. During the second month of storage, the flour beetle (*Tribolium sp.*) infestation was observed in all the treatments. But at the end of six months of storage least infestation was observed in glass bottle with airtight plastic lid (T3) followed by aluminium foil (T2). Seed flour stored in open condition (control) was heavily infested with *Tribolium sp.* at the end of storage period.

5.3 VALUE ADDITION OF JACKFRUIT SEED FLOUR (JSF)

5.3.1 Utilization of JSF for preparation of *chapattis*

The *chapattis* made out of different combinations of wheat flour (WF) and jack seed flour (JSF) showed significant difference with respect to organoleptic qualities. Sensory evaluation of *chapattis* revealed that T5 (Wheat flour alone), T1

(WF90: JSF10) and T2 (WF80: JSF20) were on par with regard to colour, flavour, texture, taste and overall acceptability. Thus it is evident that wheat flour can be substituted with jack seed flour up to 20 per cent without affecting the organoleptic qualities of *chapattis*. Tulyathan *et al.* (2001) also reported that the possibility of replacing less than 5 per cent of wheat flour with jackfruit seed flour for making white bread. Deshpande *et al.* (2001) had observed that *chapattis* prepared by replacing wheat flour up to 10 per cent with soy flour had acceptable characteristics. Further the nutritive value of *chapattis* can be improved by incorporation of JSF, which is rich in carbohydrate, fats and minerals. Since the cost of jackfruit seeds are comparatively cheap, the cost of the product can be also be brought down by addition of jack seed flour.

5.4 PROCESSING WASTE AS CATTLE FEED

The processing sector generates waste to the extent of 20-30 per cent of raw material utilized. These waste form important sources of environmental pollution and hence their effective utilization assumes tremendous significance. Feeding of cows with agricultural waste and by-products from processing industry has been receiving considerable importance in recent years. This will not only help to overcome the shortage of cattle feeds in the country but also bring down the cost of milk production. Many published reports are available on the production performance of cows fed with many unconventional feeds and fodders.

5.4.1 Jackfruit seed flour as cattle feed

The amount of inedible portion and consequently the quality of waste generated is comparatively high in jackfruit. The potential of jackfruit waste consisting of rind, perigone and seed as a ruminant feed has been reported by Ananthasubramaniam *et al.* (1978) and Subburamu *et al.* (1992). The seeds of jackfruit rich in total carbohydrates (76.5 per cent), digestible carbohydrates (70.4 per cent), proteins (12.2 per cent), minerals (2.4 per cent) and fat (1.05 per cent) is an ideal material for inclusion in feeding rations of lactating cows. The level of incorporation of jackfruit seed flour in the compounded cattle feed without detrimental effect on milk production has to be standardised. The present study was undertaken to get information regarding milk production as well as quality of cows fed with jackfruit seed flour at 20 and 40 per cent levels in the concentrate mixture.

5.4.1.1 Dry matter intake (DMI)

No significant difference was observed in average dry matter intake of animals fed with the two rations (Fig. 11). However, the DMI of group II animals (fed with ration having 40 per cent JSF) was slightly higher than group I (fed with ration having 20 per cent JSF) during the first week of feeding trial. Since these animals consumed more or less the same quantity of dry matter, it could be assumed that no difference existed between the two experimental rations in terms of palatability. Ananthasubramaniam *et al.* (1978) reported that when jackfruit waste was included as a sole ingredient in the ration of cattle a consumption up to 1.7 per cent of body weight was observed. Ledger and Tillman (1973) could effectively replace maize with coffee husk in a feed concentrate up to 20 per cent without affecting palatability.

5.4.1.2 Milk production

Significant differences in milk production were not observed between animals fed with the two experimental rations (Fig.11) indicating that JSF can be incorporated up to 40 per cent in ration of lactating cows without adversely affecting milk production. Patel *et al* (1970) suggested that mango seed kernel could be incorporated up to 10 per cent level in the ration of dairy cattle without any adverse effect on milk yield.

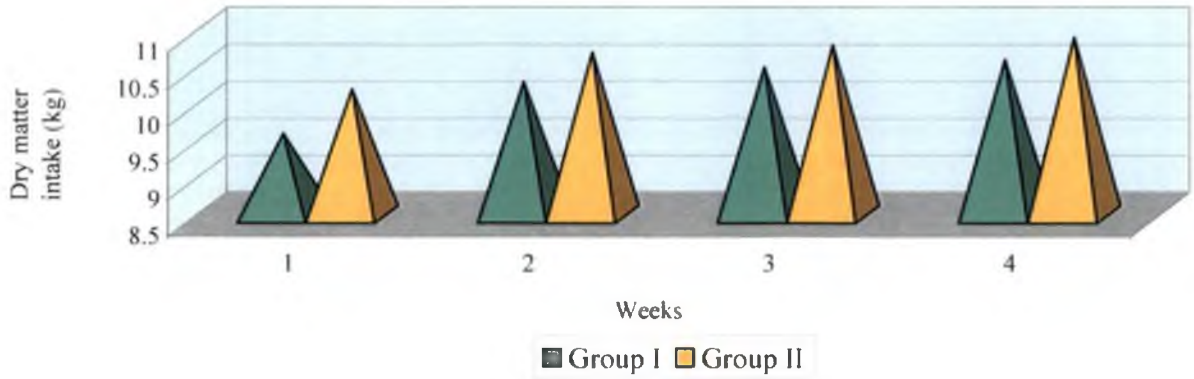


Fig. 11. Average daily dry matter intake of animals maintained on two experimental rations

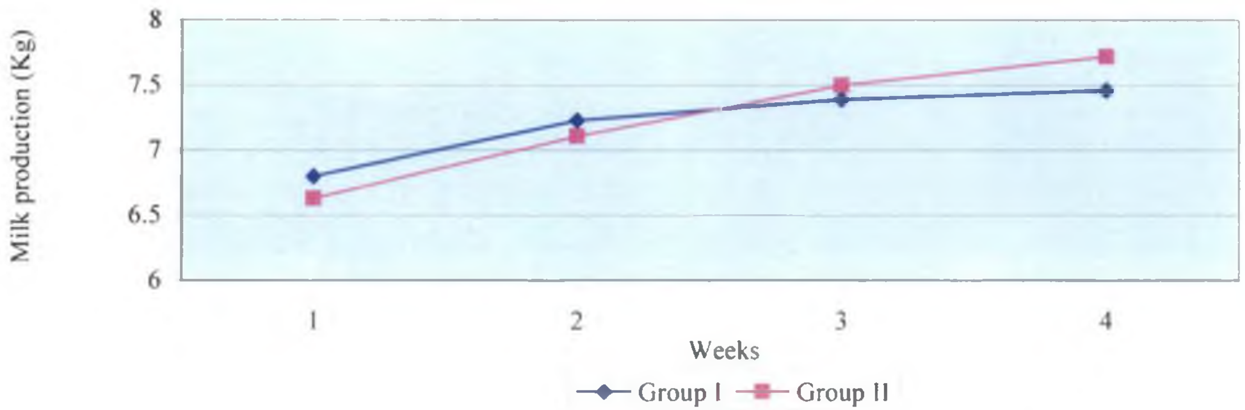


Fig. 12. Average daily milk production of animals maintained on two experimental rations

5.4.1.3 Milk composition

Data on the composition of the milk collected at weekly intervals from the animals maintained on the two treatments (Table 11) indicated that there was no significant difference between the two groups in any of the parameters studied *viz.*, average fat content, total solids and solid not fat throughout the experiment. The average fat, total solids and solids not fat content in milk of animals fed with ration I (20 per cent JSF) were 4.33 ± 0.22 g per cent; 12.48 ± 0.70 g per cent and 8.51 ± 0.28 g per cent respectively. The corresponding figures for animals fed with ration II were 4.27 ± 0.33 g per cent, 12.75 ± 0.66 g per cent and 8.48 ± 0.21 g per cent respectively (Fig.12 to 15). Ananthasubramaniam and Maggie, (1997) also reported similar results in a feeding trial on cows with 15 per cent and 25 per cent tea waste in the ration.

5.4.1.4. Economics of incorporation of jack seed flour in the dairy cattle feed

There was no significant difference in milk production and milk composition between the animals receiving Ration I and Ration II indicating that JSF can be incorporated up to 40 per cent in the feed concentrate without adversely affecting the milk production and milk quality. Feeding contributes the largest item in milk production and hence it is of utmost important that feeding cost is kept at the lowest possible level to make milk production profitable.

The cost per Kg of two experimental rations *viz.*, Ration I (20 per cent JSF) and Ration II (40 per cent JSF) were Rs. 8,30 and Rs. 7.45 respectively (Table.12). The replacement of maize at 40 per cent level (ration II) can save Rs.1000 for one month of feeding trial when compared to 20 per cent (Ration I) without any effect on milk production and milk composition.

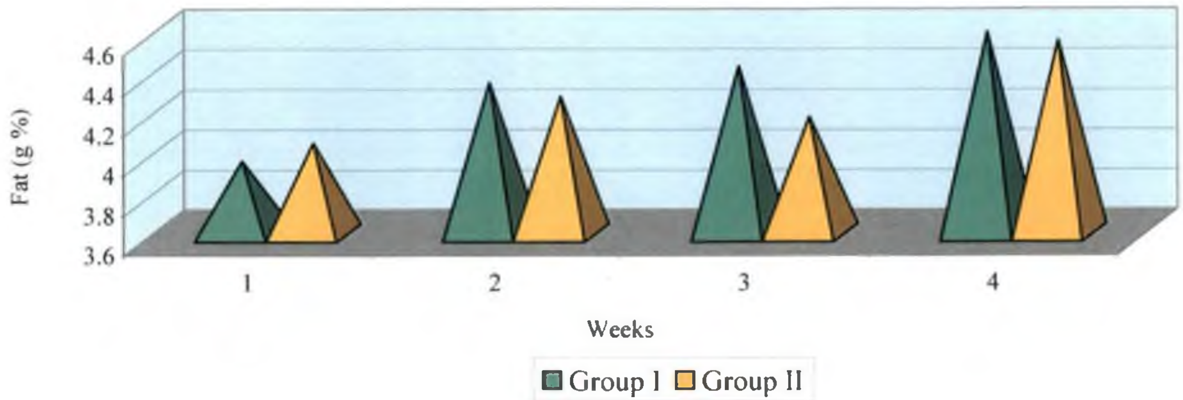


Fig. 13. Average fat percentage in the milk of animals maintained on two experimental rations

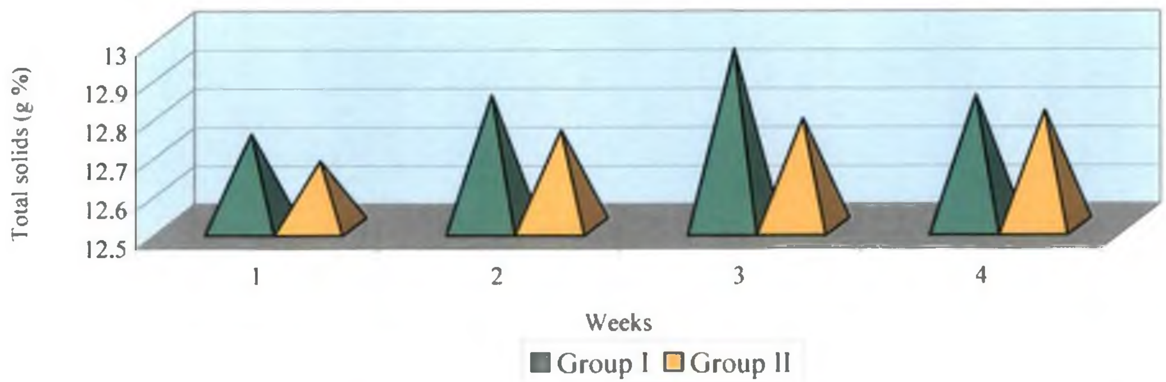


Fig. 14. Average total solids percentage in the milk of animals maintained on two experimental rations

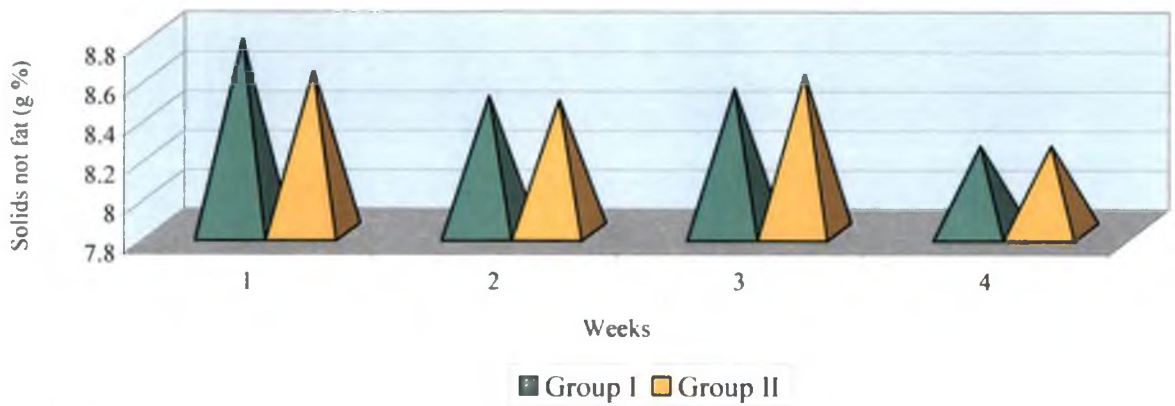


Fig. 15. Average solids not fat in the milk of animals maintained on two experimental rations

From the above results it can be concluded that jackfruit seed flour can be safely and economically incorporated in the concentrate mixture for dairy cattle up to 40 per cent.

Summary

SUMMARY

The study on 'Physio chemical properties of jackfruit (*Artocarpus heterophyllus* Lam.) and its prospects for use in cattle feed' was undertaken at Department of Processing Technology, College of Horticulture during 2003- 05. The objectives of the investigation were to evaluate the physio chemical characteristics of jackfruit seed collected from different regions of Kerala, to study the keeping quality of seed flour under different conditions of packaging and to assess the suitability of seed flour in compounded cattle feed.

Thirty fruit samples collected from different localities of Kerala were evaluated for fruit characters like weight of the fruit and physical composition of fruit. Significant differences were observed between samples for physical characters of fruit. Fruit weight varied from 4.6 to 17.2 Kg. The physical components of fruits were found to range between, edible bulbs 21.3 to 29.7 per cent, rind and perigones 42.6 to 52.8 per cent, core 12.4 to 19.7 per cent, seed 8.4 to 16.2 per cent and seed driage 42.2 to 59.6 per cent. S9 recorded the highest fruit weight and bulb recovery. In general, bulb recovery was higher for large fruits where as proportion of inedible portion was higher for small fruits.

The chemical constituents of the seed studied were total carbohydrate, crude fibre, digestible carbohydrate, mineral and fat content. Significant variation was found between seed samples collected from different localities for all the chemical constituents studied. The range observed for different chemical constituents were, total carbohydrate 54.7 to 79.8 per cent, crude fibre 1.5 to 3.9 per cent, digestible carbohydrate 51.8 to 76.4 per cent; mineral content 1.3 to 5.0 per cent and fat 0.2 to 1.9 per cent. S4 had the highest total carbohydrate (79. 8 per cent), digestible carbohydrate (76.4 per cent) and mineral content (4.9 per cent).

Powdered jackfruit seed flour was stored for a period of six months in eight different packaging materials. Seed flour stored in different packaging materials differed significantly with respect to weight loss or gain, moisture content, carbohydrate content and organoleptic qualities during storage. Irrespective of the packaging materials, all the samples registered an increase in weight an moisture content and a decrease in carbohydrate content during storage. Irrespective of the packaging materials, all the samples registered an increase in weight, moisture content and a decrease in carbohydrate content during storage. Seed flour stored in glass bottles and polythene cover registered less weight gain, least moisture ingress and minimum variation in carbohydrate content as compared to other packaging materials. The organoleptic qualities like better colour and flavour retention, low caking and less insect infestation were also observed in seed flour stored in glass bottles, aluminium foil and polythene cover (200 gauge) at the end of storage period. Polyethylene cover was found to be the most cost effective packaging material for storage of seed flour.

The organoleptic evaluation of *chapattis* made out of different combinations *viz.*, 90:10, 80:20, 70:30 and 60:40 of wheat flour and jackfruit seed flour showed significant difference with respect to colour, flavor, texture, taste and overall acceptability. Sensory evaluation indicated that wheat flour can be replaced with jack seed flour up to 20 per cent without affecting the organoleptic qualities of *chapattis*.

A feeding trial on dairy cows was conducted at University livestock farm, Mannuthy to study the feasibility of utilizing jack seed flour in the compounded cattle feed by replacing part of maize in the concentrate mixture. No significant difference was observed in average dry matter intake of animals fed with the two rations. The average milk production of animals in group I and II were 7.22 ± 0.47 and 7.24 ± 0.49 respectively. The average fat, total solids and solids not fat content in milk of animals fed with ration I (20 per cent JSF) were 4.33 ± 0.22 g per cent, 12.48 ± 0.70 g per cent and 8.51 ± 0.28 g per cent respectively. The corresponding figures for animals fed with ration II were 4.27 ± 0.33 g per cent, 12.75 ± 0.66 g per cent and 8.48 ± 0.21 g per cent respectively. There was no significant difference in milk production and milk composition (fat percentage, total solids and solids not fat) between the animals receiving Ration I (20 per cent jack seed flour in the concentrate mixture) and Ration II (40 per cent jack seed flour in the concentrate mixture) indicating that JSF can be incorporated up to 40 per cent in the feed concentrate without adversely affecting the milk production and milk quality.

References

REFERENCE

*Adewusi, S.R.A., Udio, J. and Osuntogun, B.A. 1995. Studies on the carbohydrate content of breadfruit (*Artocarpus communis* Forest.) from South Western Nigeria. *Starch/ Starke* 47: 289- 294

Akubor, P.I. 1997. Proximate composition and selected functional properties of African breadfruit and sweet potato flour blends. *Plant Fd. Hum. Nutr.* 51: 53-60

Amrithkumar, M.N., Sundareshan, K. and Sampath, S.R. 1975. Chemical composition and nutritive value of Horse gram (*Dolicos biflorus* Linn.) pod shells. *Indian Vet. J.* 52(8): 648-651

Anandan, S., Kumar, G.K.A., Rudraswamy, M.S., Ramana, J.V. and Ramachandra, K.S. 2001. Scope for utilization of sunflower heads as animal feed in Karnataka state. *Indian J. Anim. Sci.* 72(3): 469-471

Ananthasubramaniam, C.R. 1972. All Indian Co-ordinated Research Project for investigation of agricultural by-products and industrial waste materials for evolving economic rations for livestock. *Progress report 1971-72,* College of Veterinary and Animal Sciences, Mannuthy pp. 28-34

Ananthasubramaniam, C.R., James, C.S. and Viswanathan, T.V. 1977. All Indian Co-ordinated Research Project for investigation of agricultural by-products and industrial waste materials for evolving economic rations for livestock. *Progress report 1976-77,* College of Veterinary and Animal Sciences, Mannuthy pp. 10-13

Ananthasubramaniam, C.R. and Maggie, M. 1977. Nutritive value of Tea (*Camillia sinensis* Linn.) waste for cattle. *Kerala J. Vet. Sci.* 8: 37-40

Ananthasubramaniam, C.R., Menachery, M.D. and Nair, A.M.C. 1978. Nutritive value of Jack (*Artocarpus heterophyllus* Lam.) fruit waste for cattle. *Indian J. Nutr. Diet.* 15: 12-16

AOAC, 1970. *Official Methods of Analysis.* Eleventh edition. Association of Official Analytical Chemists, Washington DC. 820 p.

AOAC, 1980. *Official and Tentative Methods of Analysis.* Thirteenth edition. Association of Official Analytical Chemists, Washington DC. 1018 p.

Balasubramanyam, N. 1995. *Profiles of Food Packaging.* Central Food Training and Research Institute publications, Mysore, 183p.

Begum, K., Umapathy, K.P., Daniel, V.A. and Swaminathan, M. 1989. Effect of partial replacement of cereal in rice and ragi diets by jackfruit seed flour on the nutritive value of diets. *Indian J. Nutr. Diet.* 26: 141-143

Bhattacharya, A.N. and Sleiman, P.T. 1971. Beet pulp as a grain replacement for dairy cows and sheep. *J. Diary Sci.* 54: 89-94

Berry, S.K. and Kalra, C.L. 1988. Chemistry and technology of jackfruit (*Artocarpus heterophyllus* Lam.)-A review. *Indian Fd. Packer* 8:63-75

Bhaskar, S. 2000. Storage studies on preservation of banana and its products. M.Tech. thesis, Kerala Agricultural University, Thrissur, 119p.

Bhore, D.P., Ghunke, S.H and Shelke, V.G. 1980. Promising type of jackfruit. *J. Maharashtra agric. Univ.* 5: 81-82

Bobbio, F.O., El-Dash, A.A., Bobbio, P.A. and Rodrigues, L.R. 1978. Isolation and characterization of the physio chemical properties of the starch of jackfruit seeds (*Artocarpus heterophyllus*). *Cereal Chem.* 55: 505-511

Bose, T.K., Mitra, S.K., Farroqui, A.A. and Sadhu, M.K. 1999. *Tropical Horticulture*, Naya Prokash Publishers, Calcutta, 359 p.

Castle, M.E. 1972. A comparative study on the feeding value of the dried beet pulp for milk production. *J. agric. Sci.* 78 (3): 371-377

Chadha, K.L.1990.Fruits of India. *Indian Hort.* 35: 41-45

Chadha, K.L. 2001. *Hand Book of Horticulture*, Indian Council of Agricultural Research, New Delhi, 1030p.

Chellamal, S. 1995. Developing complementary food products based on cassava and sweet potato. Ph. D. thesis, Kerala Agricultural University, Thrissur, 235p.

Chopra, S.L. and Kanwar, J.S. 1978. *Analytical Agricultural Chemistry*, Kalyani Publishers, Ludhiana, 410p.

Chowdhury, F.A. and Raman, M.A. 1997. Distribution of free sugars and fatty acids in jackfruit (*Artocarpus heterophyllus*). *Fd. Chem.* 60(3): 25-28

Deshpande, S.S., Mishra, A. and Mishra, M. 2001. Preparation and organoleptic evaluation of soy blended food products. *J. Fd. Sci. Technol.* 38(3): 291-293

Esuoso, K.O. and Bamiro, F.O. 1995. Studies on the baking properties of non-wheat flours. *Int. J. Fd. Sci. Nutr.* 46: 267-273

*Falcao, M.D.A. 2001. Phenology and yield of breadfruit (*Artocarpus altilis.*) and Jack (*Artocarpus heterophyllus* Lam.) in Central. Amazonia. *Acta-Amozonica* 31:179-191

FAO. 1998. *Tropical Animal Feeding: A Practical Manual for Research Workers Animal Production and Health Paper No. 126* (ed. Preston, T. R.), Food and Agricultural Organisation, Rome, 206p.

Greenwall, A.B.H. 1947. Taro with special reference to its culture and uses in Hucodii. *Economic Bot.* 1: 276-279

Guruprasad, T.R. and Thimmaraju, K.R. 1989. Seed and spine characters in three jackfruit (*Artocarpus heterophyllus* Lam.) types. *Environment Ecol.* 72(4): 511-512

*Gvozdenovic, J., Gurokovic, M. and Vulkovic, I. 1983. Application of laminates in packaging of dried foods. *Hraina Ishrana* (Japanese) 24:209-213

Hashisume, T., Fujita, H., Matsuoka, S., Naganuma, I., Wada, T., Inado, T. and Kawasaki, T. 1974. The utilization of wet potato pulp as dairy cattle feed. *Nutr. Abstr. Rev.* 46: 2564

Hussain, M.K. and Haque, A. 1977. Studies on the physical characteristics of jackfruit. *(Artocarpus heterophyllus* Lam.) *Bangladesh Hort.* 5:9-14

Hussain, M.K., Rahman, A.K.M. and Jabbar, M.A. 1990. Some low molecular weight compounds isolated and characterised from jackfruit *(Artocarpus heterophyllus* Lam.). *J. Bangladesh Acad. Sci.* 14 (1): 49-56

Indian standards: 1224. 1958. *Determination of Fat in Whole milk, Evaporated (unsweetened) milk, Separated milk, Skimmed milk,* Indian Standards Institution, New Delhi, pp.5-10

Indian standards: 1479 Part I. 1960. *Indian Standard Methods of Test for Dairy Industry, Rapid Examination of Milk,* Indian Standards Institution, New Delhi, pp.28-40

KAU 1991. Post-harvest technology; standardization of different recipes utilizing raw jack seed flour. *Kerala Agricultural University Research Report*: 1978-90. pp.194-198

Krishnankutty, C.N. 1998. Timber price trends in Kerala. *Kerala Forest Research Institute Research Report,* 151p.

Kumar, S., Singh, A.B., Abidi, A.B., Upadhyay, R.G. and Singh, A. 1988. Proximate composition of jackfruit seeds. *J. Fd. Sci. Technol.* 25: 308-309

Labuza, T.P., Warren, R.M. and Warmbier, H.C. 1977. *Protein Cross-linking.* Plenum Publishing Corporation. New York, 1379 p.

Ledger, H.P. and Tillman, A.D. 1973. Utilization of coffee husk in cattle fattening rations. *Nutr. Abstr. Rev.* 43(3): 252-253

Liya, S. 2001. Value addition and evaluation of nutritional quality of taro. M.Sc (Hort.) thesis, Kerala Agricultural University, Thrissur, 103p.

Macgregor, C.A., Owen, F.G. and Mc Gill, L.D. 1976. Effect of increasing ration with soybean mill run on digestibility and lactation performance. *J. Dairy Sci.* 59(4): 682-689

Maini, S.B. and Singh, R. 2001. Utilisation of processing waste from tropical and subtropical fruits. *Indian J. Hort.* 58 (12): 183-190

Mauron, J. 1989. Browning reaction products and food quality. *Trends in Food Science and Technology* (eds. Rao, M.R.R., Chandrasekhar, N. and Ranganath, K.A.). Association of Food Scientists and Technologists, Mysore, pp. 667-683

Mishra, A. and Kulshretha, K. 2002. Effect of storage on microbial safety of Potato flour. *J. Fd. Sci. Technol.* 39:517-519

Mitra, S.K. 1998. Genetic diversity in jackfruit (*Artocarpus heterophyllus* Lam.). *Indian Hort.* 43:2-4

Mukaprasirt, A. and Sajjaanantakul, K. 2004. Physico chemical properties of flour and starch from jackfruit seeds (*Artocarpus heterophyllus* Lam.) compared with modified starches . *Int. J. Fd. Sci. Technol.* 39(3):271-276

Muniyappa, M. 1972. Studies on silk cotton seed as a component of concentrate ration for milk production. M.Sc. thesis, University of Calicut, Kerala, India. 120p.

Muthulakshmi, P. 2003. Genetic diversity and canopy management of jackfruit (*Artocarpus heterophyllus* Lam.) Ph.D. thesis, Kerala Agricultural University, Thrissur, 230p.

Narasimham, P. 1990. Breadfruit and jackfruit. *Fruits of Tropical and Subtropical Origin.* (eds Shaw, E. and Wardowski, W.F.) Lake Alfred Florida science source, pp.193-259.

Nicholson, J.W.G. and Curtis, R.J. 1960. The value of potatoes for feeding dairy cows. *Can. J. Anim. Sci.* 40(2): 44-50

Olaloku, E.A., Egbuiwe, A.M. and Oyenuga, V.A. 1971. The influence of cassava in the production ration on the yield and composition of milk of white Fulani cattle. *Nutr. Abstr. Rev.* 43(10): 6898

Patel, B.M., Shukla, P.C. and Patel, C.A. 1970. Studies on feeding of unconventional feeds to milch cows- mango seed kernel. *Indian J. Nutr. Diet.* 7(6): 363-365

Patel, B.M., Patel, C.A. and Talpada, P.M. 1971a. Study of feeding unconventional feeds to milch cows (by-products mixture). *Indian J. Nutr. Diet.* 8(2): 81-84

Patel, B.M., Shukla, P.C., Patel, C.A. and Talpada, P.M. 1971b. Effect of feeding tomato waste to milch cows. *Indian J. Anim. Sci.* 41(7): 542-545

Pillai, K.C. 2001. Shelf life of breadfruit, *Artocarpus altilis* (Park). Forsberg. M. Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur, 85p.

Rahman, A.K.M.M., Huq, E., Mian, A.J. and Chesson, A. 1995. Microscopic and chemical changes occurring during the ripening of two forms of jackfruit (*Artocarpus heterophyllus* L.). *Fd. Chem.* 52(4): 405-410

Rahman, M. A., Nahar, N., Mian, A.J. and Mosihuzzaman, M. 1998. Variation of carbohydrate composition of two forms of fruit from jack tree (*Artocarpus heterophyllus* L.) with maturity and climatic conditions. *Fd. Chem.* 65(1): 91-97

Rajarajeswari, H.S. and Prakash, J. 1999. Jackfruit seed: composition, functionality and use in product formulation. *Indian J. Nutr. Diet.* 36(6): 312-317

Ralo, J.A.C., Antunes, V.S., Ferreira, M.F. and Almeida, M.C.F. 1964. Dried tomato residue in concentrates for dairy cows. *J. Dairy Sci.* 28(6): 178-184

Ranjhan, S.K. 1993. *Agro Industrial Byproducts and Non-conventional Feeds for Live-stock Feeding*, Indian Council of Agricultural Research, New Delhi, 127p.

Rao, K.S., Reddy, M.R. and Reddy, G.V.N. 1999. Utilisation of sunflower crop residues in the rations of dairy cattle. *Indian J. Anim. Nutr.* 16: 155-159

Ravindran, V. and Ravindran, G. 1996. Evaluation of the nutritive value of jack seed (*Artocarpus heterophyllus*) meal for poultry. *J. agric. Sci.* 127(1): 123-130

Rihs, T. and Isler, C. 1976. Incorporation of commercially dried banana meal in concentrates for dairy cows. *Nutr. Abstr. Rev.* 47(6): 3206

*Roy, S.K., Herregods, M., Nicolai, B. and Jager, A. 2000. Promotion of under utilized tropical fruit processing and its impact on world trade. *Acta-Horticulturae* 518 (8): 233-236

Sadasivam, S. and Manickam, A. 1996. *Biochemical Methods for Agricultural Sciences*, New Age International (P) Ltd. and Tamil Nadu Agricultural University, Coimbatore 223p.

Saito, T.I. and Tanno, Y. 1962. Studies on milk production of cows fed with sugar beet roots. *Dairy Sci. Abstr.* 38(8): 46-69

Samaddar, H.N. 1990. Jackfruit. *Fruits: Tropical and Subtropical* (eds Bose T.K, Mitra, S.K and Sanyal, D.) Vol.2, Naya Udyog Publishers, Calcutta. 798p.

Sastry, M.A., Singh, Y.P. and Dutt, B. 1973. Studies on the toxicity of *Bajada* cake. *Indian Vet. J.* 50(7): 685-688

Seetharama, N. and Rao, B.D. 2004. Sustaining nutritional security. *The Hindu Survey of Indian Agriculture 2004.* (ed. Ram, N.) M/s Kasthuri and Sons Ltd. Chennai, 37 p.

Sen, K.C. and Ray, S.N. 1971. *Nutritive Values of Indian Feeds and Feeding of Animals.* Indian Council of Agricultural Research. New Delhi, 25 p.

Sharma, M.R. 1964. Jackfruit. *Proc. Indian Acad. Sci. Soc.* 60:380-393

Sharma, S.P., Bhanumurthy, J.L. and Srinivasan, M.R. 1974. Studies on the production and storage behaviour of spray dried mango powder. *J. Fd. Sci. Technol.* 11:171-174

Sharma, R., Mohan, N.K. and Nath, J.C. 1997. Evaluation of yield potential and physico chemical composition of some local types of jackfruit of Assam. *Hort. J* 10(2): 23-30

Singh, K. 1983. Dehydration, packaging and storage studies of fruits (Banana, Jack and Mango). M.Sc (Hort.) thesis, Kerala Agricultural University, Thrissur, 90p.

Singh, A., Kumar, S. and Singh, I. S. 1991. Functional properties of jackfruit seed flour. *Lebensm – Will U Technol.* 24: 373-374

Singh, I.S. and Singh, R. 2001. Minor fruits and their uses. *Indian J. Hort.* 58 (12): 178-182

Snedecor, G.W. and Cochran, W.G. 1967. *Statistical Methods.* Sixth edition, Oxford and IBH publishing company, New Delhi, 320p.

Srinivasan, K. 1970. *Muttam varikka* –A promising jackfruit variety. *agric. Res. J. Kerala* 8: 51-52

Srivastava, M.P. and Tandon, R.N. 1968. Influence of temperature on *Botryodiploidia* rots of citrus and sapodilla. *Indian Phytopath.* 21:195-197

Subburamu, K., Singaravelu, M., Nazar, A. and Irulappan, I. 1992. A study on the utilization of jackfruit waste. *Bioresource Technol.* 40(7): 85-86

Swaminathan, M. 1974. *Essentials of Food and Nutrition Applied Aspects.* Ganesh and Company publishers, Madras, 256p.

Swamy, K. 2003. Jackfruit nutrition. *Research Bulletin* No.22, IIHR, Bangalore 25p.

Thatte, V.R., Kaduskar, M.R. and Desai, R.T. 1967. Feeding trial on guar- meal. *Indian Vet. J.* 44(8): 701-705

Tokusoglu, O., Unal, M.K. and Alakir, I. 2003. Proximate chemical composition, amino acid and fatty acid profiles of sesame seed flour. *J. Fd. Sci.Technol.* 41: 409-412

Tulyathan, V., Tananuwong, K., Songjinda, P. and Jaiboona, K. 2001. Some physio chemical properties of jackfruit (*Artocarpus heterophyllus* Lam.) seed flour and starch. *Sci. Asia* 28: 37- 41

Vaidehi, M.P. and Sunanda, P.K. 1982. Dehydrated products of potatoes. *J. Indian Potato Ass.* 9:21-27

Wills, R.B.H., Lim, J.S.K. and Greenfield, H. 1986. Composition of Australian food: tropical and sub tropical fruits. *Fd.Technol. Aust.* 38: 118-123

Winton, A.L. and Winton, K.B. 1935. *The Structure and Composition of Foods: Vegetables, Legumes and Fruits*, John Wiley and Sons, New York, 315p.

* Originals are not seen

Appendices

APPENDICES

Appendix 1. Score card for organoleptic evaluation of jackfruit seed flour

S. No.	Character	Description	Score	1	2	3	4	5
1	Colour	White	5					
		Cream	4					
		Creamish yellow	3					
		Creamish brown	2					
		Brown	1					
2	Flavour	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					
3	Caking	Fine powder	5					
		Small clumps	4					
		Medium sized clumps	3					
		Large sized clumps	2					
		Heavy clumps	1					
4	Insect infestation	No infestation	5					
		Very less infestation	4					
		Less infestation	3					
		Medium infestation	2					
		Heavy infestation	1					

Date :

Name :
Signature:

Appendix 2. Score card for organoleptic evaluation of *chapattis*

S. No.	Character	Description	Score	1	2	3	4	5
1	Colour	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					
2	Flavour	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					
3	Texture	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					
4	Taste	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					
5	Overall acceptibility	Excellent	5					
		Like very much	4					
		Neither like nor dislike	3					
		Dislike	2					
		Dislike very much	1					

Date:

Name:
Signature:

PHYSIO CHEMICAL PROPERTIES OF JACKFRUIT (*Artocarpus heterophyllus* Lam.) SEED FLOUR AND ITS PROSPECTS FOR USE IN CATTLE FEED

By

G. SRI KRISHNA

ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirements for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

Department of Processing Technology

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2005

ABSTRACT

The study on "Physio chemical properties of jackfruit (*Artocarpus heterophyllus* Lam.) seed flour and its prospects for the use in cattle feed" was undertaken at the Department of Processing Technology, College of Horticulture, Kerala Agricultural University for evaluating the physio chemical characters of jackfruit as well as seed and utilization of seed flour for compounded cattle feed.

Significant variation existed between thirty fruit samples collected from different locations in Kerala for physical characters of fruit. The contribution of edible bulbs, rind and perigones, core and seed to the fruit were 21.3 - 29.7, 42.6-52.3, 12.4-19.8 and 8.4-16.2 per cent respectively. The samples also differed significantly with respect to chemical constituents of seed. Total carbohydrates, crude fibre, digestible carbohydrates, total minerals and fat content were found to be in the range of 54.7 to 79.8 per cent, 1.5 to 3.9 per cent, 51.8 to 76.4 per cent, 1.3 to 5.0 per cent and 0.2 to 1.9 per cent respectively.

Seed flour stored in different packaging materials differed significantly with respect to weight loss or gain, moisture content, carbohydrate content and organoleptic qualities during storage. Seed flour stored in glass bottles, aluminium foil and polythene cover registered less weight gain, least moisture ingress and minimum variation in carbohydrate content and also had better colour and flavour retention, low caking and less insect infestation during the storage as compared to other packaging materials. Polyethylene cover was found to be the most cost effective packaging material for storage of seed flour.

The product, *chapatti* was prepared by blending wheat flour (WF) and jackfruit seed flour (JSF) in different proportions *viz.*, 90:10, 80:20, 70:30 and 60:40. Organoleptic evaluation revealed that jackfruit seed flour can be blended

with the wheat flour up to the extent of 20 per cent without effecting of quality of *chapatti* with respect to colour, flavour, texture, taste and overall acceptability.

A feeding trial on dairy cows was conducted at University livestock farm, Mannuthy to study the feasibility of utilizing jack seed flour in the compounded cattle feed by replacing part of maize in the concentrate mixture. No significant difference in milk production and milk composition (fat percentage, total solids and solids not fat) between the animals receiving Ration I (20 per cent level JSF) and Ration II (40 per cent level JSF) was observed indicating that JSF can be incorporated up to 40 per cent in the feed concentrate without adversely affecting the milk production and milk quality.