DEVELOPMENT OF AN INSTANT FRIED RICE

BY

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99/A/AS/025

Thesis submitted in partial fulfillment of the requirements for the

Degree of Bachelor of Science

In

Food science and technology

Faculty of Applied sciences

Sabaragamuwa University of Sri Lanka

Buttala

Sri Lanka

2003

DECLARATION

The work described in this thesis was carried out by me at Mr.Hop Lanka Foods (PVT) Ltd. and the Faculty of Applied sciences under the supervision of Mr.K.K.Kithsiri and Mr.M.A.Jagath Wansapala. A report on this has not been submitted to any other University for another degree.

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AFFECTIONATELY DEDICATEDTO MY EVERLOVING

PARENTS, TEACHERS, SISTERS

AND FRIENDS.

ACKNOWLEDGEMENT

First and foremost I wish to express my deepest gratitude to my internal supervisor Mr. M.A. Jagath Wansapala, Course coordinator Food Science and technology, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka for his guidance, encouragement, supervision and his valuable time to make this study a success.

I express my sincere gratitude to my external supervisor Mr. K.K.Kithsiri, The managing Director of Mr. Hop Lanka Foods (Pvt.) Ltd., for his excellent guidance, encouragement, advice and supervision throughout my study.

My deepest gratitude is expressed to Dr.D.B.M.Wickramaratna, The Dean, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka and Prof. M.Rupasinghe, Head, Department of Natural Resources Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, for directing and leading me towards a successful complete.

I am heavily indebted to all the staff members at Mr. Hop Lanka foods (Pvt.) Ltd., providing me their equipment and their numerous help.

My special thanks to Mrs.Deepika Priyadarshani, and Mrs.C.H. Rathnaweera Lecturers, Faculty of Applied Sciences, for providing me significant guidance and information in numerous ways.

I also extend my thanks to all laboratory staff members of Faculty of Applied Sciences, for their assistance and support.

At last but not least, I wish to forward my special word of thank to my batch mates and other colleagues, for their invaluable helps given to me at all the time I needed to make this venture a success.

ABSTRACT

The daily diet in Sri Lankans generally consists of principal meal, in which rice accompanied by supportive curries, form the bulk. The preparation of such a meal is significantly time-consuming task when compared to the complex life style of the people especially in the urban sector.

Instant fried rice would have the potential to become popular as a highly palatable, nutritious and affordable convenience food.

By carrying out a preliminary market survey, consumer perceptions on the instant fried rice were obtained.

The process modification of instant rice involved several unit operations. Preheat treatment step developed cracks in grains while soaking step facilitated hydration. Complete gelatinization in grains was obtained by cooking and steaming steps. Over gelatinization was avoided by subsequent wash in cold water. Rapid freezing promoted ice crystal formation thereby developing porous structure inside the grains. The thawing step prevented grains from sticking together. The porous structure was maintained during drying to facilitate the penetration of water upon reconstitution.

Thus, modified instant rice, which can be reconstituted with in a few minutes, could be prepared using a range of unit operations.

Dehydrated vegetables, ghee, organoleptically accepted mixture of spices and other additives were used instead of having number of curries to prepare instant rice as a meal for the consumption.

Instant fried rice can be prepared for consumption with in 7 minutes, boiling in water.

No detectable mould growth in instant rice occurred after three months storage.

Sensory characteristics were comparable for prepared instant fried rice before and after storage.

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CHAPTER 1.

INTRODUCTION

1.1 Introduction

Rice is one of the most important cereal grains of the world. It is grown in more than 100 countries and on every continent except Antarctica. In the world economy rice is an extremely important food, second only to wheat in total world production, and its yield per hectare exceeds that of wheat (Hui, 1992).

Rice provides most of the food for over half the human population of the earth, most of them living in the orient where some 94% of the world's rice is produced and consumed. In some countries of the orient, the per capita consumption of rice is 200 to 400 lb. (90 to 180 kg) per year (Ensminger *et al,* 1994).

Rice provides one-third to one-half of the daily caloric intake in many Asian countries. It is also the major source of protein for the masses of Asian people. In many African and South American countries rice is rapidly becoming the staple food for much of the population (Hui, 1992).

Sri Lanka is one among many countries in Asia where rice has long been the staple food of the people (Edirisinghe and Poleman, 1976).

The population of Sri Lanka is about 18 million. Approximately 99% of them consume rice as their major food source (Sri Lanka Department of Census and statistics, Census of population and Housing- 2001).

Most of the Sri Lankans have traditional rice preparations. They usually consume rice as whole grains after cooking.

Raw rice ordinarily must be cooked for 20 to 30 minutes to be edible. Milled white rice, depending on variety and grain size (long, medium or short) requires from 20-35 minutes to be cooked to a satisfactory culinary acceptability; when boiled according to usual recipe directions. Raw brown rice requires from 45to 60 minutes to be cooked. Parboiled rice requires a much longer time (Luh, 1980).

In addition, careful attention is required in de-stoning and washing of rice before cooking. The cooking procedure also requires careful attention and proper temperature control to prevent sticking of the soft grain and obtain a fluffy, non-gummy product.

On the other hand, rice is not acceptable to be eaten alone. It is normally eaten with curries. Generally, people do not satisfy with a single curry; habitually they prepare several items in order to have a palatable and nutritious meal.
Thus, the rice preparation for the consumption as a meal requires a total attention time of around two hours.

In the modern world, mainly due to urbanization, the day today lives of people are becoming more and busier. The inconvenience and difficulty in home preparations and the relatively long cooking time has discouraged the consumption of rice among most of the busy people.
Therefore, the traditional rice preparations are being brought out in ready-to-cook or instant preparation forms. The demand for instant products such as noodles, macaroni, bread and instant rice is increased more and more rapidly, particularly among the urban sector of the population.

Instant rice also known as quick-cooking rice is one of the rice-based products. It is pre-cooked or gelatinised rice that can be easily and quickly prepared for serving, since it needs a relatively short cooking time. It should be cooked with in 3 to 5 minutes and the cooking method should be simple.

After cooking, the product should match the characteristic flavour, taste and texture of conventionally cooked rice. It should be rich in nutrients, well balanced in composition and easily processed in mass quantities.
The finish product should consist of dry, individual kernels, substantially free of lumps or aggregates, and should have approximately 1.5-3.0 times the bulk volume of the raw rice. The boiling water used in the final preparation of the rice should penetrate the rice grains in a relatively short time (Luh, 1980).

Other advantages of instant rice are that it is resistant to insect attack, and has a long shelf life compared with ordinary rice.

One form of instant rice is known as instant fried rice. This may contain meat, vegetables and spices, but its preparation does not actually involve frying. Instant fried rice has been manufactured and marketed in other countries, but there is scope for a product that could be prepared using methods and raw materials that are readily available in Sri Lanka; and that would suit the taste and texture preferences of the Sri Lankan market.

I have therefore developed and evaluated instant fried rice using long grain; white rice with dehydrated vegetables, spices, ghee and some other additives and have paid particular attention to consumer acceptability.

The investigation involved a preliminary market survey to find out consumer perceptions for the product and the development of instant rice that has less re-cooking time, determining some of the product qualities of the product, after storage period of three months.

1.2 OBJECTIVES

The main developmental objective is to produce highly palatable, nutritious and affordable product of instant fried rice that has similar characteristics to conventional fried rice, such as aroma, taste, texture and appearance and is quick and easy to prepare.

Specific objectives:

- Reduction of cooking time of rice by modifying the processing technology.
- Enhancing the sensory attributes and palatability by adding dehydrated vegetables, ghee, mixture of spices and other additives and thereby eliminating the need of a supportive curry.
- Evaluation of the product qualities after storage.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Rice

2.1.1 Origin and history

Rice originated from wild species indigenous to South-eastern Asia, where wild types still persist, although there is some evidence of an African centre of domestication (Ensminger *et al*, 1994).

2.1.2 Rice culture

Rice is an aquatic plant, which is a usually grown on flooded soil. Most of the varieties of this grain require a long, warm weather-growing season (about 180 days. Irrigation is usually needed in areas, which do not have heavy rainfall (Ensminger *et al*, 1994).

2.1.3 Plant morphology

Rice plant varies in height from 2 to 6 ft (0.6 to 1.8) (Hui, 1992). The principal parts of the rice plant are a fibrous root system extends outward and downward from the base of the plant. The culm and leaves develop from the plumule. The culm consists of the nodes, which have solid centres, and the inter nodes, which are hollow. The leaves are flat and range from 7 to 20 mm wide. The mature foliage leaf consists of the sheath at the base, which surrounds the culm for some distance; the blade, which is set at an angle with the sheath; the ligule; and the auricles. The panical of most varieties is fairly dense and drooping (Hui, 1992).

2.1.4 Botanical aspects

Rice belongs to the family *Gramineae*, tribe *Oryzeae*, and genus *Oryza L.* There are approximately 20 species in yhe genus *Oryza* distributed in tropical and sub tropical regions around the earth. Most cultivated varieties are in the species *Oryza sativa Linn.* , Although varieties of the species *O.glaberrima Steud.* are grown on a limited scale in Africa (Hui, 1992).

Morphologically *O. glaberrima* differs from *O.sativa* in having shorter ligules, absence of secondary branching on the panicals, glabrous glumes and glabrous to slightly scabrid leaves, although the geographic distribution of the two cultivated species appears distinct. (Luh,1980).

The species *Oryza sativa* furnishes virtually all the rice of the world. (Ensminger *et al,* 1994). Therefore, most of the commercial varieties grown are in the species *O.sativa* and are generally classified as *Japonica (Sinica), Javonica (Bulu)* and *Indica.* There are many morphologic differences between typical *Japonica, Javonica* and *Indica* varieties and progenies of hybrids are intermediate in many respects (Hui, 1992).

2.1.5 Rice varieties

Thousands of rice varieties are available around the world. But, the commercially important varieties are limited in number (Hui, 1992).

There are two types of cultivated rice. Upland rice mainly grows in Africa, Asia and South America. They produce relatively low yields. Lowland rice mainly grows in United States. They produce a high yield (Ensminger *et al*, 1994).

Rice varieties are classified for trading purposes, by grain size and shape into three types, long-, medium-, and short-grain (Hui, 1992). This refers to the length width ratio of kernels of rice that are unbroken. Most long grain rice has high amylose content, which causes them to cook dry, with the kernels separated from each other. But long-grain rice costs more because many of the long kernels break during milling and must be removed. Most short grain rice has lower amylose content and is sticky when cooked. Medium grain rice has cooking qualities similar to short-grain varieties (Ensminger *et al*, 1994).

Rice breeders grouped rice varieties according to the gelatinization temperature (GT) in to three classes, low (<70^0c), intermediate (70-74^0c) and high (>74^0c). The end point of the gelatinization temperature range of rice starch, traditionally defined by rice researchers as its "gelatinization temperature" (GT) varies from about 55^0c to 79^0c. Various changes undergone by rice flour slurry upon gelatinization; starch granule alteration, increase viscosity, increase in light transmittance, and solubalization of amylose, as well as the swelling and degradation of rice kernels (Bhattacharya, 1979).

Varieties are also classified by growing season (very early, early, midseason and late maturing), and by starch composition; [high amylose (25-33%) amylose content), intermediate amylose (20-25%), low amylose (10-20%) and waxy (less than 2%)].

Other varietals characteristics of importance are plant height, straw strength, disease resistance, hull pubescence, and colour of various plant parts (Hui, 1992).

2.1.6 Structure of the rice grain

The rice grain (rough rice or paddy) consists of an outer protective covering, the hull, and the rice caryopsis (brown rice or de-hulled rice or de husked rice) (Juliano 1985).

The outer most layer; the hull is formed from the two flowering glumes; the lemma, which covers the dorsal part of the grain, and the palea, which covers the ventral portion. The lemma and palea are loosely joined together longitudinally. In the dry grain there is space between the hull and the caryopsis. The caryopsis consists of bran (the soft embryo and several histological identifiable soft layers) surrounding the hard starchy endosperm (milled rice).

The outermost bran layer is the pericarp. Beneath the pericarp is the seed coat and nucellus. The cells in these layers are rich in oil and protein. The endosperm is covered by the aleurone layer, which differs in both function and morphology from the starchy endosperm. The cells in the aleurone layer are high in oil, protein, vitamins, phosphorus, magnesium, and potassium and contain relatively little starch.

The starchy endosperm is divided in to two regions, the sub-aleurone, located just beneath the aleurone, and the central core region, which is mainly starch. The protein content of the endosperm is highest in the outer layers. In the central core the starchy cells are hexagonal in shape. Between the centre and the outside they become elongated radiating outward. The embryo is located on the ventral side at the base of the grain and is bounded on the outside by a single layer of endosperm cells and the pericarp, nucellus, and seed coat. The germ is separated from the starchy endosperm proper by the scutellum (Hui, 1992).

Table2.1 Approximate grain size and properties of the principal parts comprising the mature kernel of rice.

Grain weight (mg)	Embryo %	Scutellum %	Pericarp %	Aleurone %	Endosperm %
23-27 (26)	2-3	1.5	1.5	4-6	89-94

Source: Cereals '78-Y. Pomeranz.

2.1.7 Composition of rice

The proximate composition of rice varies with rice variety, growing location, cultural practices, weather, storage conditions and unit operations and of processing.

A typical brown rice contains 7% protein, 66% starch, 1% crude fibre, 2% neutral detergent fibre, 3% fat and 1%ash. (14% moisture basis) (Hui, 1992).

Table 2.2 Proximate composition of rice (percent dry basis)

Constituent	**Rough rice**	**Brown rice**	**Milled rice**	**Hulls rice**	**Bran rice**	**Embryo Rice**	**Polish rice**
Protein (Nx5.95)	6.7-8.3	8.3-9.6	7.3-8.3	2.3-3.2	13.2-17.3	17.7-23.9	13.0-14.4
Crude fat	2.1-2.7	2.1-3.3	0.4-0.6	0.4-0.7	17.0-22.9	19.3-23.8	11.7-14.4
Crude fibre	8.4-12.1	0.7-1.2	0.3-0.6	40.1-53.4	9.5-13.2	2.8-4.1	2.7-3.7
Crude ash	3.4-6.0	1.2-1.8	0.4-0.9	15.3-24.4	9.2-11.5	6.8-10.1	6.1-8.5
Starch	62.1	77.2	90.2	1.8	16.1	2.4	48.3-55.4
Dietary fibre	19.1	4.5	2.7	77.3	27.6-33.3		

Source: Hui, 1992.

2.1.8 Rice starch

Starch is localised mainly in the endosperm of the mature rice grain. The endosperm cells are thin-walled and packed with amyloplasts containing 3-9 micrometers compound starch granules (Juliano, 1986).

Rice is classified based on amylose (linear fraction of rice starch) content. (Described under 2.1.5 Rice varieties) Extruded noodles and expanded rice products (puffed rice) are prepared from high amylose rice. Intermediate amylose rice is used in canned rice and rice cakes. Rice puddings and dry breakfast cereals are prepared from low amylose rice. Waxy rice is commonly used for sweets and desserts (Juliano, 1986). The amylose content of the starch varies according to the type of grain. (Described under 2.1.5 Rice varieties) Long grain types contain up to 17.5% while some of the coarser types are devoid it (Grist, 1975).

Starch in waxy (or glutinous) rice is reported to consist mainly of amylopectin (branched fraction of starch), the most easily and completely digestible of the two types of grain starches (Grist, 1975).

Rice starch granules also differ in final gelatinization temperature-GT. (Described under 2.1.5 Rice Varieties). Not all combination of amylose content and GT are known; waxy starch is mainly low GT, with some high GT as with low amylose starch. High GT is rare among intermediate and high amylose rice (Juliano, 1986).

2.1.9 Rice proteins and amino acids

Rice compares favourably with other cereals in amino acid content and digestibility of the proteins is high; being 96.5% for the whole grain 98% for milled rice (Grist, 1975).

Rice bran is richer in protein than milled rice. Bran proteins are rich not only in the lysine-rich proteins, albumin (water-soluble) and globulin (salt-Soluble), but also in anti-nutrition factors-trypsin inhibitor and hemagglutinin or lectin, mainly in the embryo.

By contrast, milled rice (endosperm) is rich in glutelin (~ 80% of total), 15% albumin-globulin, and less than 5% prolamin (alcohol-soluble). Crystalline protein bodies are rich in albumin-globulin, whereas spherical protein bodies are rich in prolamin (Juliano, 1986).

The nutritive value of the protein depends on its amino acid content (Grist, 1975).

Table 2.3Amino acid content of whole rice.

Amino acid	**Whole rice**	
	In dry matter percent	**In protein percent**
Arginine	0.64	9.02
Aspartic acid	0.34	4.85
Cystine	0.12	1.71
Glutamic acid	0.82	11.69
Glycine	0.45	6.41
Histidine	0.22	3.13
Isoleucine	0.34	4.84
Leucine	0.56	7.98
Lysine	0.26	3.74
Methionine	0.23	3.27
Phenylalnine	0.31	4.43

Proline	0.30	5.27
Serine	0.30	4.56
Threonine	0.27	3.85
Tryptophan	0.09	1.28
Tyrosine	0.29	4.13
Valine	0.50	7.13

Source: Grist, (1975)

2.1.10 Miner constituents

The other constituents of rice include lipids, vitamins, minerals, sugars, Enzymes, pentosans and Lignins etc. The lipid content of rice is mainly in the bran fraction (20% dry basis), but about 1.5-1.7% is present in milled rice, mainly as non-starch lipids. Protein bodies particularly the core, are rich in lipids, which are readily extracted. Starch lipids are mainly monoacyl lipids (fatty acids and lysophosphatides) complexes with amylose. The lipid content of starch is lowest for waxy starch granules (about 0.2%) and highest for intermediate-amylose rice. (1.0%) and may be slightly lower in high-amylose rice. Non-starch lipids are involved in fat rancidity, since amylose protects starch lipids from oxidation (Juliano, 1986).

Vitamin content of rice is as follows. (The values calculated as mg per kg, 14% moisture basis, except cyanocobalamin)

Table 2.4 Vitamin content of rice

Vitamin	Brown rice	Milled rice	Rice polish	Rice bran
Retinol A	0.06	Trace	0.4	1.8
Thiamine	4.5	0.6	11.0	18.0
Riboflavin	0.9	0.4	2.0	3.0
Niacin	44.0	18.0	306.0	383.0
Pyridoxine	7.0	8.0	18.0	18.0
Pantothenic acid	12.0	5.0	40.0	41.0
Biotin	0.07	0.04	0.4	0.4
Inositol, total	1000.0	100.0	3800.0	6000.0
Choline, total	950.0	680.0	1060.0	1190.0
P-aminobenzoic acid	0.3	0.13	0.6	0.65

Folic acid	0.3	0.08	1.4	0.9
Cyanocobalamin (Micro grams/kg)	4.0	1.4	3.0	0.4
Alpha-tocopherol	17.0	Trace	70.0	78.0

Source: Matz S.A., (1991)

Comparison of the mineral composition of husked and polished rice is given in the following table.

Table2.5 Mineral content of rice (Percentage)

Mineral	Husked	Polished
Chlorine	0.2863	0.048
Phosphorus	0.393	0.380
Calcium	0.0927	0.014
Magnesium	0.0778	0.036
Sodium	0.0542	0.022
Potash	0.1421	0.072
Sulphur	0.0023	0.0038
Iron	0.003177	0.00102

Source: Grist, (1975)

The main sugar of rice embryo is sucrose together with small amounts of raffinose, glucose and fructose. The total sugar content of rice germ varies from 8% to 25%. Reducing sugars range from 1% to 11.63% (Luh, 1980).

Rice bran is abundant in various enzyme systems. Some of them are as follows. Alpha-amylase, Beta-amylase, Catalase, Lipase, Maltase, Pectinase, Peroxidase, Ascorbic acid oxidase, Alpha and Beta-glucosidase etc. (Luh, 1980).

Pentosans and Lignins are mainly in the rice bran, polish and germ (Luh, 1980).

2.1.11 Factors affecting the nutritive value of rice

Loss of rice nutrients as a result of faulty storage is self-evident. Prolonged storage of rice under dad conditions affects cooking quality, probably as a result of changes in the starch fraction. Loss of vitamins appears to be inseparable with storage under normal conditions. Cold storage for two and a half years did not cause any significant loss of vitamins, the average percentage losses in the whole kernels kept at room temperature for the same period were 24.9 thiamine, 5.3 riboflavin and 3.9 niacin (Grist, 1975).

Loss of nutrients resulting from milling and polishing rice is very considerable. The degree of milling and polishing determines the amount of nutrients removed (Grist, 1975). During milling 5% of its starch, 89% of its crude fibre, 80% of its neutral detergent fibre, 83% of its fat, and 68% of its ash and up in the bran by products (Hui, 1992). The effect of washing is to dissolve some of the nutrients from the rice grain; the amount removed depending on the degree of milling and the amount of washing. The use of excess water causes the most depletion of vitamins. Excess washing of uncooked rice and discarding the cooking water result in a very serious loss of nutrients and calories. The losses resulting from the washing and cooking methods commonly used, were calories 15%, proteins 10%, iron 75%, and calcium and phosphorus50 % (Grist, 1975).

2.1.12 Deficiency diseases

Beri beri is the best known of the deficiency diseases caused by rice (Grist, 1975). This ancient nutritional disease results from a severe deficiency of thiamine (vitamin B1) (Ensminger *et al*, 1994).

2.2 Processed rice products

2.2.1 Conventional rice products and rice by products

Table 2.6 Conventional rice products and rice by products

Product	**Description**	**Uses**
Brown rice	Rice with the hulls removed, but with the bran left on.	▪ Provide more protein and vitamins than white rice. ▪ Prevent beri beri ▪ Livestock feed
Milled rice	Kernels, after removing hulls, bran and germ.	▪ Cooking, mostly by boiling
Polished rice	Consists of white, starchy endosperm, with fragments of the aleurone layer.	▪ Cooking, mostly by boiling. ▪ Quick cooking rice (instant rice), a convenience food, some types of which can be cooked in 5 minutes. ▪ Canned rice ▪ Rice beer (sake)
Parboiled rice	Rough or paddy rice (in the hull) soaked in warm	▪ Cooking, same as polished rice.

	water, steamed under pressure, and dried before milling.	▪ Lessens beriberi.
Enriched rice	Polished parboiled rice enriched by spraying with vitamins.	▪ Prevent beri beri and other nutritional diseases.
Ang-khak	A product prepared in China by culturing a red pigment producing fungus on rice kernels.	▪ Food colouring agent, for colouring cheese, fish, red wine and other foods.
Bran	The layer beneath the hull, containing outer bran layers and parts of the germ.	▪ Oil extraction ▪ Decrease the body's absorption of fat. ▪ Livestock feed.
Breakfast foods: Puffed rice, Rice crispies, Rice flakes	Made from quality-milled rice, which is pre-cooked, dried, flaked and puffed or expanded.	▪ Ready-to-eat breakfast cereals.
Brewers' rice (Chipped rice, Broken rice)	Small, broken rice segments, separated out in the grading process.	▪ Raw material for rice flour. ▪ For brewing industry.
Flour	Two types 1. Made from regular rice, raw or parboiled. 2. Waxy rice flour	▪ Thickening agent in gravies and sauces. ▪ Limited usage in confectionery and baking purposes.
Rice baby foods	Flaked rice	▪ As baby foods.
Rice oil	Extruded from rice bran.	▪ Used in margarine, salad oil, and cooking oil.
Polishing	Inner white bran, protein rich aleurone layers, and starchy endosperm.	▪ In many baby foods. ▪ Prevent and cure beri beri.
Wild rice	Kernels, high in protein and low in fat.	▪ Highly esteemed for its unique taste.
Protex	De-fatted mixture of rice bran, germ and polish.	▪ Base for breakfast cereals, pasta and milk like beverages.
Rough rice or paddy rice	Ground grains, including hulls.	▪ Livestock feed.
Rice hull	Outer covering of rice (Lemma and Palea)	▪ Livestock feed ▪ Animal litter (bedding) ▪ Insulation, fuel and commercial fertiliser.
Straw	Stalks remaining after threshing grains.	▪ Livestock feed ▪ For making papers, mates, hats and baskets ▪ Sheltering roofs.

Source: Ensminger *et al*, (1994)

2.2.2 Quick cooking rice products and processes

Much research has been directed towards developing quick cooking rice products and processes.

1. Soak-Boil-Steam-Dry methods

Raw milled rice is soaked to about 30% moisture and cooked in hot water to 50-60% moisture. Then it is boiled or steamed to 69-70% moisture so that a porous structure is attained.

The cause generally attributed to the loss of nutrients during water cooking is excessive swelling and bursting of the starch granules on the surface of the rice, which occurs during the latter stages of cooking (Daniels, 1970). A modification is to use a dry heat treatment to fissure the grains before cooking and drying (Hui, 1992).

Ozai-Durrani (1948) developed "Minute rice" by a soak-boil-steam-dry method. It was marketed as the first convenience rice of this type. Roberts (1952) developed another process of this type. Patents were granted to Hollis *et al* (1958) and to Autrey and Lynn (1965). Yasumatsu et al (1971) used a two-step soak-steam method (Luh, 1980).

De Silva (1991) developed a soak-steam-dry method without boiling prior to steaming step (De Silva.1991).

The Rice Processing Research and Development Centre (RPRDC), Sri Lanka, developed a process of this type with a dry heat treatment before cooking (Technical report, R.P.R.D.C, Anuradhapura, 1996).

2. Gelatinize-Dry-Puff

Rice is soaked, boiled and steamed or pressure cooked to gelatinize the starch, dried at low temperature to give a dense, glassy grain and then puffed at high temperature to produce a porous structure (Hui, 1992).

Roberts (1955) patented a process of this type. Wayne (1963) modified the method (Luh, 1980).

3. Gelatinize-roll or Bump-Dry

The grain is gelatinized, rolled or bumped to flatten the grain, and dried to a hard glassy product. The thin cross section provides relatively quick rehydration (Hui, 1992).

A Unilever Ltd. Patent (1957) describes the preparation of quick cooking rice by this method, for use in dry soup mixes (Luh, 1980).

3. Dry Heat Treatment

Milled or brown rice heated in hot air (57-82 0 c) for 10-30 minutes or 272 0c for 17 seconds). No boiling or steaming is applied. The heat-fissured grains rehydrate in 10 minutes for milled rice and 15 minutes for brown rice (Hui, 1992).

Alexander (1954) and Bardet and Giesse (1961) described dry heating process (Luh, 1980).

5. Freeze-Thaw process

Cooked rice (70% moisture) is frozen at 0^0C to promote formation of large ice crystals, then deep-frozen, thawed and dried (Hui, 1992).

Keneaster and Newlin (1957) improved a process of this type. Ozai Durrani's patent (1965) also described a similar freeze-thaw process (Luh, 1980).

6. Gun-Puffing

Rice is preconditioned to 20-22% moisture content, heated and pressurized with steam, and those explosive puffed.

A process to produce quick cooking rice by gun puffing the rice in to an expansion chamber at atmospheric pressure was patented by Flynn and Ricker (1961) (Luh, 1980).

7. Freeze-drying

Cooked rice is frozen; the moisture is removed by freeze-drying and the freeze-dried rice is heated in hot air (150-315 ^{0}c) (Hui, 1992).

Wayne (1963) patented an improved and somewhat more economical freeze-drying approach (Luh, 1980).

8. Chemical treatments

Lewis and Lewis (1965) described a sodium chloride treatment method. Li *et al* (1976) described an enzyme-sodium hydroxide treatment (Luh, 1980).

9. Combination of two or more of the above methods.

Ozai Duraani (1960) obtained a patent for a combination of five methods described earlier (Luh, 1980).

10. Miscellaneous methods

Other methods include fabricating quick cooking rice grains from broken grades of rice, drying cooked rice rapidly with microwave energy to produce slightly puffed, fissured grains, quick cooking rice made from parboiled rice; and centrifugal fluidized bed drying (Hui, 1992).

Huxsoll and Morgan (1968) presented utilization of microwave energy for producing quick cooking rice (Luh, 1980).

2.3 Dehydration

Dehydration is the unit operation in which nearly all the water normally presents in foodstuff is removed by evaporation or sublimation as a result of the application of heat under controlled conditions.

Dehydration of foods results in savings in weight and, usually bulk to be carried, per unit food value, and in products with extend shelf lives as compared with fresh material (Brennan *et al*, 1974).

2.3.1 Dehydration of vegetables

2.3.1.1 Blanching

The exception of onions and garlic it is necessary to blanch vegetables before they are dehydrated. Blanching is desirable because it aids in preserving vitamins during drying; it makes for better keeping quality of the dried product; it improves the colour of pigmented vegetables; it aids in more rapid reconstitution of the dried product; it increases the drying rate; it expels at least part of the oxygen from the tissues, and it decreases the bacterial population (Loeseke, 1998-99).

2.3.1.2 Sulphyting

Sulphur dioxide (SO_2) is able to stabilise the colour of fresh and processed vegetables. It also inhibits the activity of common oxidising enzymes and has antioxidant properties; that is; it is an oxygen acceptor. Further SO_2 reduces non-enzymatic Millard type browning by reacting with aldehyde groups of sugars so that they are no longer free to combine with amino acids. Sulphur dioxide also interferes with microbial growth.

However, some people are severely allergic to SO_2; thus, the FDA has prohibited the use of SO_2 on fresh produce and has required that uses in processed products be limited to a residual of less than 10 parts per million or appropriately labelled so that sensitive individuals can avoid expose (Potter and Hotchkiss, 1996).

2.3.2 Rehydration

Rehydration is the replacing of water in dehydrated foods. Synonymous terms are "refreshing", "recovery", "restoration', and "reconstitution".

Through the process of rehydration a large percentage of the original water present is assimilated. Not all products reconstitute to 100% of their original state because of inherent differences in their chemical composition. Probably the most important class of substances affecting rehydration are pectins, whose action varies with the degree of methylation. Storage temperature also has an effect on the extent of rehydration of dehydrated vegetables.

There is no standard method for measuring rehydration. The percentage of rehydration is calculated as below (Loesecke, 1998-99).

$$\text{Percentage of Rehydration} = \frac{\text{Weight of the sample after reconstitution} - \text{weight of the dehydrated sample} * 100}{\text{Weight of the dehydrated sample}}$$

2.4 Food additives

Food additives are defined as a substance or a mixture of substances other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage, or packaging. The term does not include chance contaminants.

There are obviously many recognised benefits to be derived from additives. Some of the major benefits are a safer and more nutritious food supply, a greater choice of food supply, a greater choice of food products, and a lower-priced food supply (Branen *et al*, 1990).

2.4.1 Salt (sodium chloride)

Sodium chloride is used to enhance flavour and to prevent spoilage of foods. It is more commonly used in combination with other antimicrobials or preservation methods.

The antimicrobial activity of sodium chloride is related to its ability to reduce water activity (a_W) and create unfavourable conditions for microbial growth (Branen *et al*, 1990).

2.4.2 Sugar (sucrose)

Sugar is used as sweetener. It also has many functional properties in food that make it useful as a bulking agent, texture modifier, and mouths feel modifier and preservative (Branen *et al*, 1990).

2.4.3 Citric acid

Citric acid is one of the major acidulants; imparting a tangy citrus flavour. It is used commercially as a synergist for antioxidants and retardant of browning reactions.

Citric acid and its salts have been investigated for their effects on inhibition of bacteria, yeast and molds. (Application range- 0.05%- 0.10%) (Branen *et al*, 1990).

2.4.4 Monosodium glutamate (MSG)

This is the best known and most widely used flavour enhancer. A flavour enhancer is a substance that is added to a food to supplement or enhance its original taste or flavour (Branen *et al*, 1990). MSG also intensifies and enhances flavour. In the quantities normally used, it does not add any flavour of its own. MSG is effective in enhancing the flavour of foods in parts per thousand. (Application range- 0.01%-1.5%) (Furia, 1972).

2.4.5 Spices

The term spice means any aromatic vegetable substance in the whole, broken, or ground form, except for those substances which have been traditionally regard as foods, such as onions, garlic and celery; whose significant function in food is seasoning rather than nutritional; no portion of any volatile oil or other flavouring principle has been removed (Farrel, 1999).

Table2.7 Spices (Botanical names and functional groups)

Commodity	**Botanical name**	**Functional groups**
Chillies	*Capsicum annuum*	Capsaicin
Turmeric	*Curcuma longa*	Methoxy cinnamoyl methane
Pepper	*Piper nigrum*	Monoterpenes
Cumin	*Cuminum cyminum*	Cuminaldehyde
Fennel	*Foeniculum vulgare*	Anethole, Fenchine
Cinnamon	*Cinnamomum zelanicum*	Cinnamic aldehyde
Cardamom	*Elettaria cardamommum*	Cineole,Terpenyl acetate
Cloves	*Eugenia caryophyllus*	Euginol
Coriander	*Coriandrum sativum*	Linalool, Terpinene
Curry leaves	*Murraya koenigii*	Glucosiside koeningin

Source: Ferrel, (1999)

2.4.6 Ghee

Ghee is a very important traditional milk product. Its main use is for frying of food and its main advantage over butter from which it is traditionally prepared is its superior keeping quality derived from the almost complete removal of water during the making process (FAO Animal products and health paper.85, 1990).

2.5 Food packaging

2.5.1 Importance of food packaging

Food packing is an essential technique for preserving food quality minimising food wastage, and reducing the use of chemical additives and stabilisers.

The food packaging serves the functions of containing the food, providing protection against chemical and physical damages, providing convenience in using the product, and covering product information to the consumers.

It protects the food by acting as a barrier against transfer of oxygen, moisture, chemical components, and microorganisms that are detrimental to the quality of foods. It provides consumers with convenient features such as microwavability, resealability, and ease of opening. It conveys useful information such as the description of food contents, weight to volume ratio, manufacturer's name directions for preparation, and nutrition values. It serves as an effective marketing tool for promoting product identification and selling the product (Hui, 1991).

2.5.2 Packaging material for dehydrated foods

Dehydrated foods obviously require an excellent water vapour barrier, and in most instances, as a good gas barrier, especially when the formulation involves fatty components.

In some products a reduced level of biochemical activity continues after packaging, the most significant being oxidative rancidity, which can also lead to browning and off-flavour phenomena. Simple cooked cereals require little in the way of barrier, but processed ones, and especially those containing other constituents such as sugar; require a good water vapour barrier.

With any of these products which have been established by dehydration, it is obviously necessary to retain these stable conditions, and whole range of laminates and single materials is used, ranging from LDPE-coated paper to LDPE/Al foil/LDPE/paper (Palling, 1980).

2.5.3 Aluminium foil as a packaging material

The advantages of foil include a good appearance, dead folding, and ability to reflect radiant energy and an excellent barrier to moisture and gases. Foil (more than 0.015mm thick) is totally impermeable to moisture, gases light and microorganisms. It is widely used for wraps (0.009mm), bottle caps (0.05mm) and trays for frozen and ready meals (0.05-0.1mm). Foil is also used as the barrier material in laminated films and aluminium is used to 'metalise' flexible films (Fellows, 1998).

2.6 New food product development

The new food product development is either the development and introduction of a product not previously manufactured by accompany in to the market place or the presentation of an old product into a new market not previously explored by a company (Fuller, 1994).

There is no single process for the development of new food products. The process may be considerably changed, consisting of four stages (Graf and Saguy, 1991).

1. Genesis and evaluation
2. Early development
3. Introduction
4. In-market evaluation and advanced development

2.7 Sensory evaluation

Sensory evaluation has been defined as a scientific method to evoke, measure, analysis and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing.

Sensory tests are almost always conducted on a blind- labelled basis. That is, product identity is usually obscured, other than the minimal information that allows the product to be evaluated in the proper category (Lawless and Heymann, 1999).

2.8 Shelf life of a food

Shelf life of a food product may be defined as the time between the production and packaging of the product and the point at which it becomes unacceptable under defined environmental conditions (Man, 2000).

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Location

The preliminary market survey was carried out within the urban sector of the Colombo District, and the experiments were carried out at the quality control laboratory of Mr. Hop Lanka Foods (PVT) Ltd. and the Food Science and Crop Science laboratories of the faculty of Applied Sciences of Sabaragamuwa University of Sri Lanka.

3.2 Materials

3.2.1 Preliminary market survey

Selected group of rice consuming middle class consumers

Standard questionnaire (Refer appendix 1)

3.2.2 Production of instant fried rice

3.2.2.1 Process modification of instant rice

Long grain, white rice variety (1kg)

Aluminium sauce pan (Capacity 1kg of rice)

Gas cooker (Domestic scale)

Thermometer

Metal spoon

Sieve

Steamer (Domestic scale, capacity 1kg)

Deep freezer (Domestic scale, refrigerator with small freezer)

Metal tray

Air drier/Cabinet drier (With 48 stainless steel trays; each has 3081cm^2 area)

Packaging material (Metalized polyethylene)

Electric sealing machine (Manually operated)

3.2.2.2 Dehydration of vegetables

Leeks (1kg)

Carrot (1kg)

Cabbage (1kg)

B-Onions (1kg)

Tomato (1kg)

Garlic (1kg)

Knife

Chopping board

Saucepans

Gas cooker

Grinder (Domestic scale)

Air drier/cabinet drier

Packaging material (Metalized polyethylene)

Sealing machine

Reagents

0.1% Sodium Metabisulfide

Water

3.2.2.3 Development of spice formula

Dried red chilli powder

Dried turmeric powder

Dried pepper powder

Dried cumin seeds

Dried fennel seeds

Dried cardamom

Dried cinnamon

Dried clove buds

Dried coriander

Dried curry leaves

Powdered salt

Sugar

Monosodium Glutamate (Ajino-moto)

Citric acid

Ghee (Cow-brand)

Red onions
Grinder (Domestic scale)
Frying pan

3.2.2.4 Sensory evaluation on reconstituted instant fried rice
A sample of instant fried rice reconstituted with in 3 minutes
A sample of instant fried rice reconstituted with in 5 minutes
A sample of instant fried rice reconstituted with in 7 minutes
Saucers
Spoons
Water glasses
Biscuits (Cream crackers)
Ballot papers (Refer appendix 3)
Pens

3.2.3 Proximate analysis

3.2.3.1 Determination of moisture

<u>Apparatus</u>

Stainless steel moisture dish with a lid
Electrical oven maintained at 105°c
Desiccator
Electronic balance

3.2.3.2 Determination of total fat

<u>Apparatus</u>

Beaker (50ml)
Separating funnel
Suckling tube
Electronic balance
Desiccator
Oven
Water bath

Reagents

Ether

Petroleum ether

95% Ethanol

Conc. Hydrochloric acid

Distilled water

3.2.3.3 Determination of total ash

Apparatus

Electrical burner

Muffle furnace (500^0C)

Electronic balance

Desiccator

Porcelain crucible/dish

3.2.3.4 Determination of protein

Apparatus

Kjeldal apparatus (6 units)

Cotton wool

Kjeldal distillation apparatus

Volumetric flask (Borosil 150 ml)

Burette (Borosil 50ml)

Burette stand and white porcelain tile

Conical flask (100ml)

Measuring cylinder (100ml)

Reagents

Kjeldal tablets

0.04M HCl

40% solution of NaOH

Distilled water

Methelene blue and methyl red indicators

4% Boric acid solution

Sodium thio sulphate solution

3.2.3.5 Determination of crude fibre

Apparatus

Round bottom flask (150 ml)

Reflux condenser

Grooch crucible

Desiccator

Heating mental

Electronic balance

Suction pump

Muffle furnace

Litmus papers

Reagents

Ether/Petroleum ether

Sodium hydroxide

Dilute sulphuric acid

3.2.4 Shelf life evaluation

3.2.4.1 Total plate count

Apparatus

Petridishes

Pipettes (1ml, 10ml)

Conical flask (Borosil, 150ml)

Aluminium foil

Cotton plugs

Test tubes and test tubes holder

Autoclave

Laminar flow

Incubator

Colony counter

Reagents

Alcohol

Potato Dextrose Agar medium (Refer appendix 6)

3.2.4.2 Sensory evaluation

A sample of instant fried rice (After three months storage)

A sample of instant fried rice (Freshly processed)

Spoons

Water glasses

Biscuits (cream crackers)

Ballot papers (Refer appendix 7)

Pens

3.3 Methodology

3.3.1 Preliminary market survey

Target consumer group (Refer 3.2.1) was consisted of thirty members and questionnaire was filled personally by interviewing them.

3.3.2 Production of instant fried rice

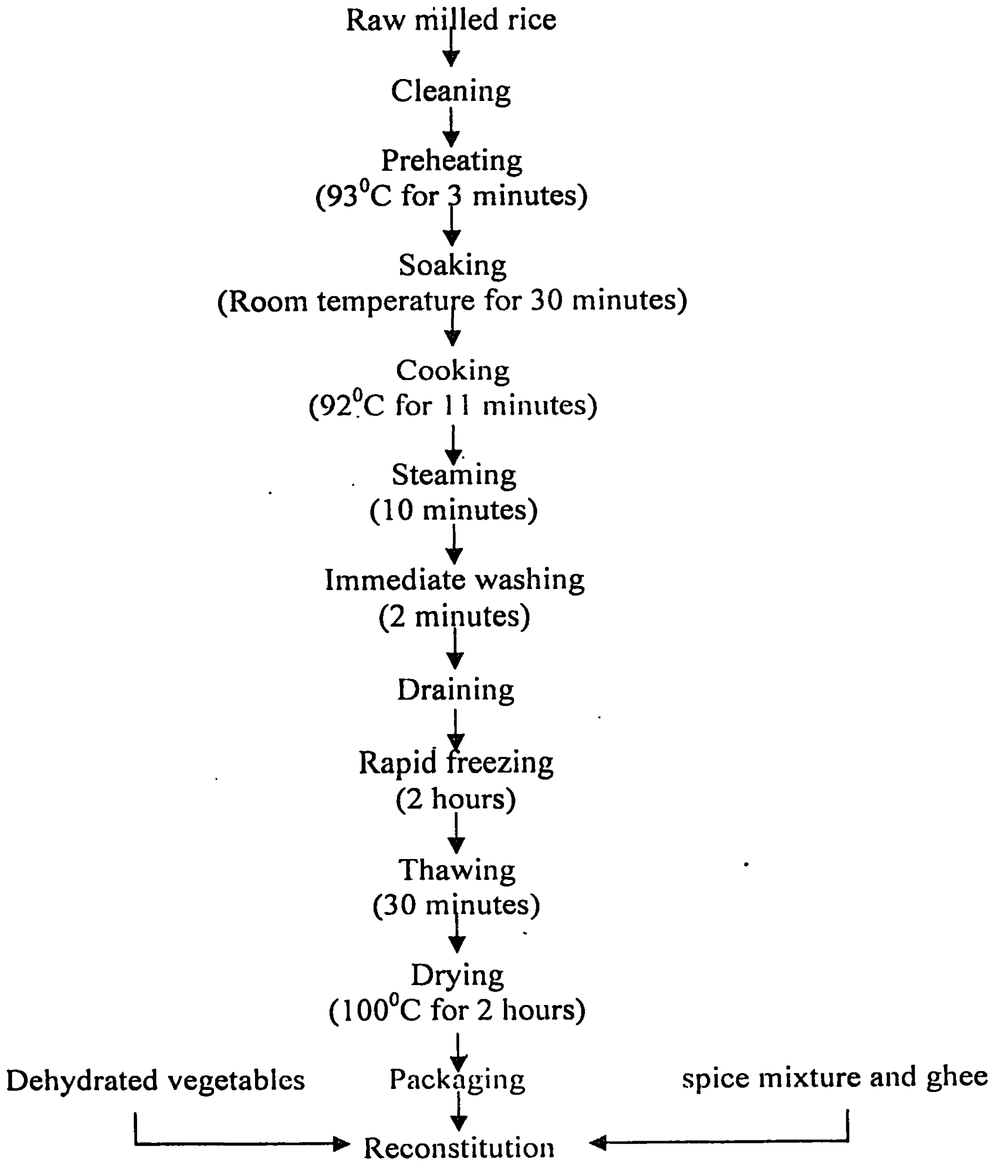

Figure 3.1 Production process of instant fried rice

3.3.2.1 Process modification of instant rice

In order to optimize the process flow of instant rice, five experiments were carried out modifying the processing steps.

Table 3.1 Process modification of instant rice

Processing step	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Preheating (93^0C/5min.)			*		*
Soaking (Room temp./30min)	*		*	*	*
Cooking (92^0C/min)	*	*	*	*	*
Steaming (10 min)		*		*	*
Immediate washing	*	*	*	*	*
Freezing (2 hr.)		*			*
Thawing (30min)		*			*
Drying (100^0C/2hrs)	*	*	*	*	*

Each of the experiment was included the unit operations mentioned by ' * ' mark.

3.3.2.2 Reconstitution of instant rice

Samples of instant rice processed by five experimental steps were reconstituted using boiling water. For 20 g of sample, 50 ml of boiling water was used. The time requirement for reconstitution at an acceptable level was measured. Five trained panellists from Mr. Hop Lanka Foods (PVT) Ltd. were participated in that study.

3.3.2.3 Dehydration of vegetables

Table 3.2 Dehydration of vegetables

Unit operation	Leeks	Carrot	Cabbage	Onions	Garlic	Tomato
Cleaning	*	*	*	*	*	*
Washing	*	*	*	*	*	*
Slicing	*	*	*	*	*	*
Rinsing in clean water				*		
Hot water blanching (2 min.)	*	*	*			*
Sulphyting	*	*	*			
Draining	*	*	*	*	*	*
Drying (80^0C/4-6hrs)	*	*	*	*	*	*
Screening	*	*	*	*		
Powdering					*	*

Vegetables were subjected in to each of the unit operation mentioned by the '* ' mark.

Mixture of dehydrated vegetables 5g /100g of instant rice was packed individually for each rice packet. The vegetable mixture consisted of leeks (50%), carrots (30%), cabbage (10%), and onions (10%).

3.3.2.4 Development of spice formula

Five judges were participated in optimizing the spice formula that suits the flavour, colour and aroma preferences of the Sari Lankan consumers. The quantities of selected ingredients were changed at an acceptable level in order to be sufficient to 100g of instant rice.

The selected amounts of ingredients were blended thoroughly. The mixture of spices 10g/100g of instant rice was packed individually for each rice packet.

(Initially, dried cardamom, cinnamon, cloves, coriander and curry leaves were ground in to powder. Dried cumin and fennel seeds were fried in a pan.)

The optimized spice formula was included the following ingredients.

Table 3.3 Optimized spice formula

Ingredient	Amount
Salt	48%
Chilli powder	8%
Pepper powder	8%
Cumin/Fennel	4%
Garlic powder	4%
Tomato powder	4%
Turmeric powder	3.6%
Citric acid	0.4%
Monosodium glutamate	4%
Sugar	12%
Cardamom	0.8%
Coriander	0.8%
Cinnamon	0.8%
Cloves	0.8%
Curry leaves	0.8%

Then, sliced red onions were fried in ghee until becomes golden colour and give a 'fried' flavour and aroma. 10g/100g of instant rice were packed individually for each rice packet.

3.3.2.5 Sensory evaluation on reconstituted instant fried rice

A sensory evaluation was carried out on reconstituted instant fried rice. [For 125g of sample including instant rice (100g), dehydrated vegetables (5g), spice mixture (10g) and ghee (10g), 200ml of boiling water was used.]

It was intended to compare the consumer preference on the instant fried rice reconstituted with in 3, 5 and 7 minutes of time. An untrained panel of thirty students from the Sabaragamuwa University of Sri Lanka was participated in that study. The test was conducted in individual booths. Panellists were assigned three samples for evaluation. Each of them was served one saucer of each of the three samples of instant fried rice, and asked to judge each one for its flavour, aroma, texture, colour and overall acceptability using a five-point category scale. They were provided with a ballot paper.

The three samples used for compare were coded with three digit random numbers.

561 – Sample reconstituted with in 3 minutes

750 – Sample reconstituted with in 5 minutes

387 – Sample reconstituted with in 7 minutes

Experimental data were statistically analysed by Minitab. (Kruskal Wallis Test) The significant deferences were tested at 5% level of significant.

3.3.3 Proximate analysis

3.3.3.1 Determination of moisture

Sample (5.01g of instant rice) in moisture dish was placed in oven for 4 hours. It was cooled in desiccator and weighed. The process of drying, cooling and weighing was repeated at 30 minutes intervals until the difference between the two consecutive weighing did not exceed 1 milligram. The lowest mass was recorded and calculated the moisture content.

$$\text{Moisture percent by mass} = \frac{(M2-M3) * 100}{(M1-M2)}$$

M1- mss of the dish with the sample before drying

M2- mass of the dish with the sample after drying

M3- mass of the empty dish

3.3.3.2 Determination of total fat

Sample (2.0312g of instant rice) was placed in beaker. 2ml of ethanol and 10 ml of HCl. (which was prepared by adding 25 ml of Conc. HCl and 1ml of water) were added. The content was mixed thoroughly. Then the beaker was placed in water bath and stirred for 30-50 minutes frequently. Beaker was removed from water bath and cooled in atmosphere. 10 ml of ethanol was added to it and transferred the mixture in to separating funnel. The beaker was washed with 25 ml of ether in 3 parts of washing and added it in to the separating funnel. The separating funnel was stopped with its lid and shaken vigorously for about few minutes and 25ml of petroleum ether was added and shaken again.

The separating funnel was kept vertically until a clear layer of petroleum ether was appeared. The upper ether layer was taken in to a clean previously weighed drier flask using suckling tube. It was dried in water bath at about 90^0C until the constant weight was obtained.

$$\text{Total fat percentage} = \frac{\text{Weight of fat}}{\text{Weight of sample}} * 100$$

3.3.3.3 Determination of total ash

Sample (5.01g of instant rice) was weighed accurately in a clean dry porcelain dish. Then it was ignited slowly, using an electrical burner until no more fumes are evolved. Crucible was transferred to the muffle furnace. It is incinerated until free from black carbon particles. (Usually approximately 3 to 4 hours.) The process was repeated, igniting, cooling and weighing at half-hour intervals until the difference between two successive weighing is less than 1mg. The lower mass was recorded.

$$\text{Total ash percentage} = \frac{M1 - M2}{M3} * 100$$

M1 - mass of the dish with ash

M2 - mass of empty dish

M3 – mass of sample

3.3.3.4 Determination of protein

Sample (90 mg of instant rice) was carefully transferred in to Kjeldal digestion flask. One Kjeldal tablet and 10 ml of Conc.H_2SO_4 were added. Sample was digested for 4 hours with a blank digestion also. Digested sample was dissolved in distilled water and transferred in to Kjeldal distillation apparatus. 8ml of NaOH / $Na_2S_2O_3$ solution was added to it.5 ml of Boric acid and 3 drops of indicator were taken in to titration flask, kept at the end of the distillation apparatus. Steam was passed through the flask until about 15 ml of distillate was received. Resulted solution was titrated with HCl solution. End point was pink colour. Blank titration was also done.

$$\text{Nitrogen percentage} = \frac{(\text{Sample titre-Blank titre}) * 0.5603 * 100}{\text{Sample weight}}$$

$$\text{Protein percentage} = \text{Nitrogen percentage} * 6.25$$

3.3.3.5 Determination of crude fibre

100 ml of dil. H_2SO_4 was boiled in round bottom flask connected to reflux condenser. Initially 5.75g of instant rice were defatted. The defatted sample was also placed in it and boiling was continued for 30 minutes. Mixture was filtered through grouch crucible and washed with boiling water until the washings no longer acidic to litmus.100 ml of NaOH was boiled under reflux condenser and boiled with sample for 30 minutes. Again the mixture was filtered and washed with boiling water. Washed residue was dried at 600°C in muffle furnace. Crucible with ash was cooled and weighed.

$$\text{Fibre percentage} = \frac{\text{Loss in weight on incineration} * 100}{\text{Weight of the sample before defatting}}$$

3.3.4 Shelf life evaluation

Samples of instant fried rice were stored for three months by packaging them in to metalized polyethylene packets, which were then sealed and stored in ambient temperature.

Mould growth was measured after storage. Sensory evaluation was carried out using a sample of freshly processed and a sample stored three months of time.

3.3.4.1 Total plate count

Two steril petri dishes were taken. 1ml of the initial suspension of the test sample of instant rice was transferred to each dish using a steril pipette. Two another steril petri dishes were taken. 1ml of the first dilution of the initial suspension was transferred again to each dish using a fresh steril pipette. The procedure was repeated with other dilution using a fresh steril pipette for each dilution.

About 15 ml of the previously melted and maintained at 45^{0}C, potato dextrose agar medium was poured in to each petri dish. (The elapsing between the end of the preparation of initial suspension and the moment when the medium was poured in to the dishes was not exceeding 39 minutes.)
The inoculum was carefully mixed with the medium and allowed to solidify. A control plate was also prepared with 15 ml of medium to check its sterility. (All the steps were carried out under laminar flow.)

All the dishes were incubated at 25^{0}C. Mould colonies were counted using colony counter after 3,4 and 5 days of incubation.

3.3.4.2. Sensory evaluation

A sensory evaluation was carried out on re-cooked instant fried rice same as the method 3.2.2.3 described. It was intended to compare the consumer preference of the instant fried rice before and after the storage of three months. Panellists were assigned two samples for evaluation. Each of them was served one saucer of each of the two samples of instant fried rice, and asked to judge each one for its flavour, aroma, colour, texture and overall acceptability using a five-point category scale. They were provided with a ballot paper. (Refer appendix 7)

The two samples used for compare were coded with three digit random numbers.

832-Instant fried rice (after three months storage)

593-Instant fried rice (freshly processed)

Experimental data were statistically analysed using Minitab. (Wilcoxon Signed rank Test) The significant deferences were tested at 5% level of significant.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Preliminary market survey

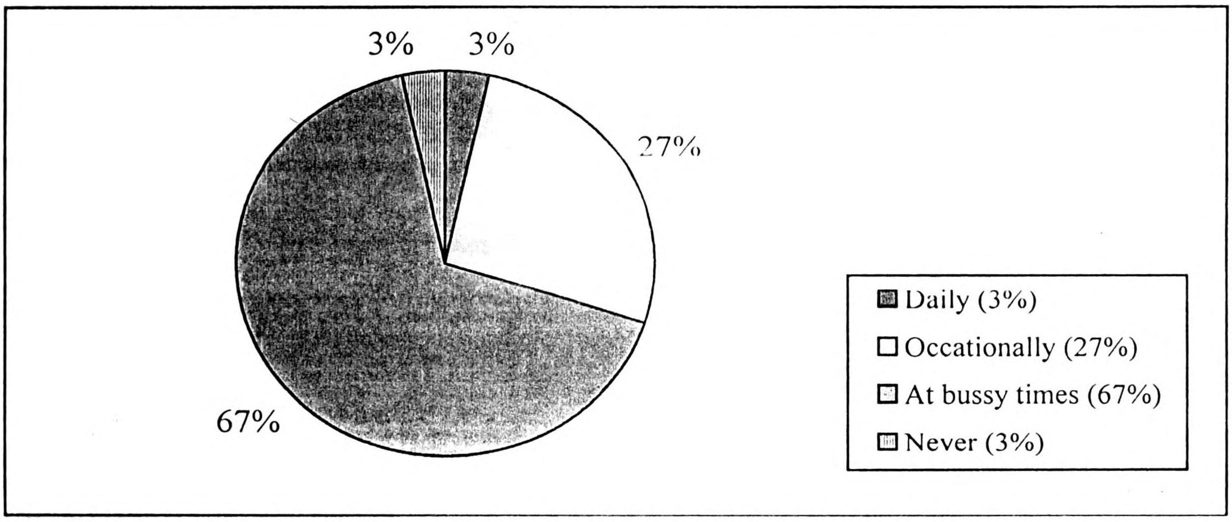

Figure 4.1 Frequency of the consumption

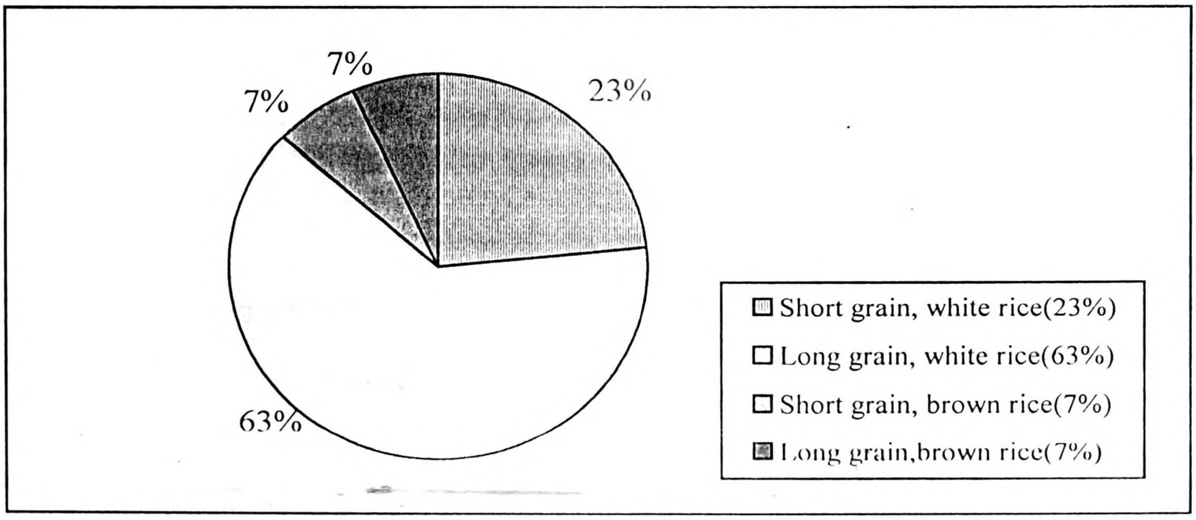

Figure 4.2 Consumer preferences on the rice variety

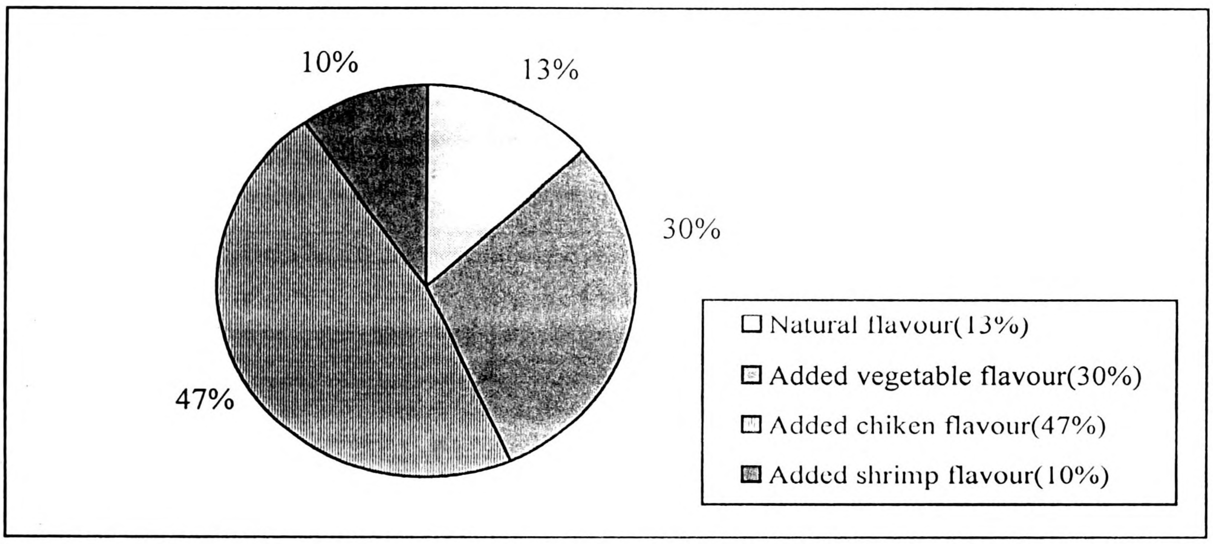

Figure 4.3 Consumer preferences on the flavour

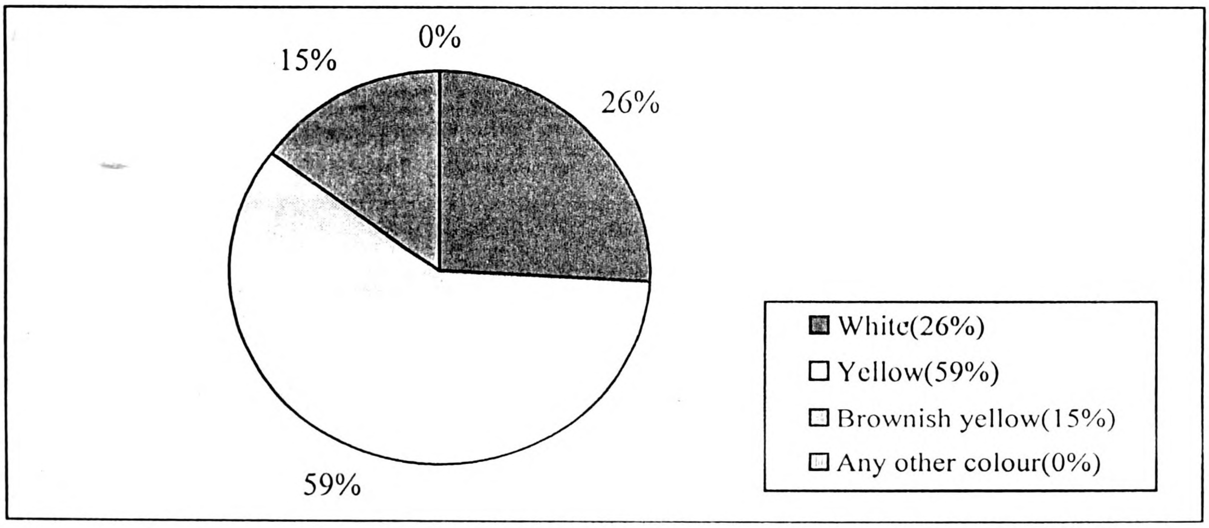

Figure 4.4 Consumer preferences on the colour

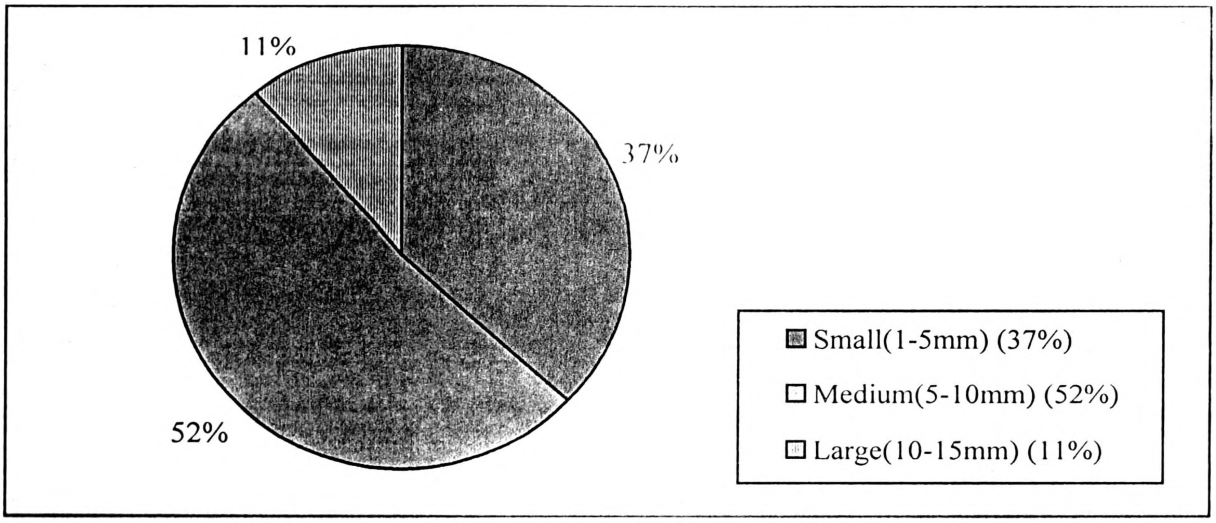

Figure 4.5 Consumer preferences on the size of vegetable pieces

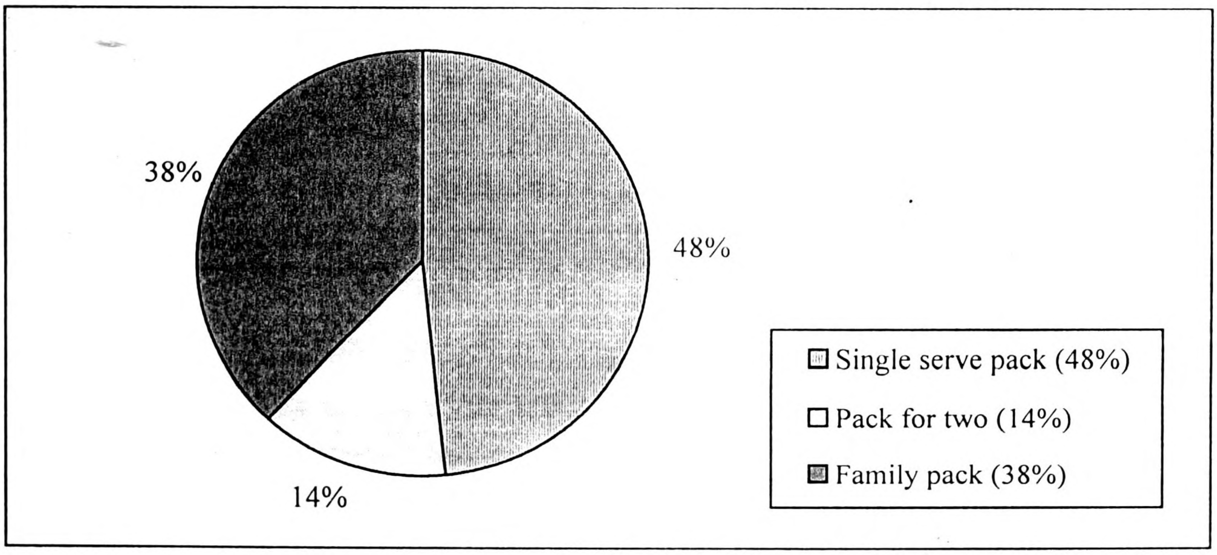

Figure 4.6 Consumer preference type of packaging

Table 4.1 Ranked characteristics according to consumer preference

Rank	Characteristic
1	Preparation time
2	Nutritional value
3	Flavour
4	Price
5	Colour
6	Aroma

Characteristics were arranged by using totals of ranks. Characteristic, which got lower total rank, arranged as first and characteristic, which got highest total rank, was arranged as fifth.
(For the calculation refer appendix 2)

4.1.2 Results of process modification and reconstitution of instant rice

Time requirements for reconstitution for the resulted instant rice by experimental steps are as follows.

Table 4.2 Results of instant rice reconstitution.

Experiment No.	Time requirement for reconstitution(minutes)
1	12
2	8
3	6
4	10
5	5

4.1.3 Results of sensory evaluation on reconstituted instant fried rice

There were significant difference ($P<0.05$) on texture, aroma and overall acceptability on three samples, reconstituted with in 3,5 and 7 minutes. The sample reconstituted with in 7 minutes had scored the highest average of rank on those parameters. But there were no significant difference ($P>0.05$) among three samples on flavour and colour. (Refer appendix 4)

Plate 4.1Reconstituted instant fried rice

4.1.4 Results of proximate analysis

Table 4.3 Results of proximate analysis

Nutrient component	Result (percent by mass)
Moisture	9.3
Total fat	0.414
Total ash	0.459
Protein	7.394
Crude fiber	0.365

(For the calculation refer appendix 5)

4.1.5 Shelf life evaluation

4.1.5.1 Results of total plate count

Table 4.4 Results of total plate count

Incubation period	Number of colonies
3	Less than 10
4	Less than 10
5	Less than 10

4.1.5.2 Results of sensory evaluation

There is not a significant difference ($P>0.05$) between two samples of instant fried rice, before and after storage. (Refer appendix 8)

4.2 Discussion

4.2.1 Preliminary market survey

The aim of the market survey is to look at instant fried rice through consumer eye and to collect ideas about consumer preferring characteristics and level of the characteristics etc. about the product. Most of the consumers prefer to have instant fried rice only at busy times in their day today lives. There is a high demand for instant fried rice processed by long grain white rice variety as a single serve pack (125g) with added chicken flavour, yellow in colour with medium sized (5-10mm) dehydrated vegetables. They highly insist on less preparation time for the product. As a whole, the consumer preference for the product characteristics can be ranked as preparation time, nutritional value, flavour, price, colour and aroma respectively.

4.2.2 Process modification of instant rice

The literature shows that long grain rice varieties become soften and produce separate kernels when cooked. It is due to the high amylose content (25-33%) in long grain rice. But most of the short grain rice varieties contain lower amylose content and are sticky when cooked.

The swelling property of rice is related to its amylose content. The higher its percentage of amylose, the greater it's swelling ability. Therefore, a variety of long grain rice was selected in this study, to prevent sticking and obtain a fluffy, non-gummy product. Long grain, white rice was the preferred variety for instant fried rice by the consumers according to the market survey also.

When the processing of instant rice, the raw rice should be subjected to a range of unit operations. First, raw milled rice was cleaned to remove all the undesirable matters like hulls, damaged and broken grains, sand stones, metal particles and other seeds.

Pre heat treatment step produces numerous small cracks or fissures extending inwardly from the surfaces of the rice grain. Insufficient heating, as manifested by too low a final grain surface temperature will not produce sufficient cooking or fissuring to effect the desired improvement in the cooking properties of the rice. Excessive heating, as manifested by too high a final grain surface temperature results in undue breakage of the grains and scorching. Therefore, raw rice was subjected to a hot air flow of 93^{0}C for 3 minutes.

The soaking step provides an inexpensive method for hydration by increasing the moisture content of raw rice. 30 to 60 minutes of soaking appears to be sufficient to reach the Equilibrium State. On heating the rice, as by using steam, partial or complete gelatinization may be affected depending upon duration of such treatment.

Literature shows that the gelatinization temperature of rice varies from about 55^{0}C to 79^{0}C. Rice can be partially gelatinized by immersing them in water at a temperature above that required for the gelatinization. (2.1.5) Therefore, soaked rice was then immersed in water at 92^{0}C and cooked for about 11 minutes. Cooking of rice by immersion in water, if extended for a long period, would result in a completely gelatinized product. But it leads for nutritional losses, excessive swelling and bursting of the starch granules. (2.2.1)

Therefore, partially gelatinized rice was removed from cooking in excess water and then subjected to steam cooking for 10 minutes. In the presence of a limited amount of water and heat supplied by the steam, the excessive swelling and bursting of the starch granules is prevented, and at the same time uniform gelatinization of the starch throughout the rice grain is achieved. Gelatinization of starch granules is one of the two key steps in the quick cooking process. Since gelatinization of the starch is irreversible, it is only necessary to rehydrate fully gelatinized dried rice to prepare it for serving.

Immediately following the steaming step, it is desirable to wash the rice to prevent further gelatinization. Immersing in cold water for about 2 minutes is sufficient to halt the cooking process and to remove undesirable matters like gelatines which come out from rice and leads sticking grains together after drying.

The drained rice is then subjected in to rapid freezing and maintained at around -12^{0}C for 2 hours. During this period, large ice crystals are formed which breakdown the colloidal starchy structure and produce a porous kernel. The product can thus absorb water readily during the re-cooking step. The frozen rice is then thawed under non-drying conditions to prevent the grains from sticking together and to obtain the desired characteristics in the final product. Thawing is accomplished by holding the frozen rice at room temperature for about 30 minutes.

The thawed product is then dried. The porous structure must be maintained during drying to facilitate the penetration of water upon rehydration. Hot airflow of 100^{0}C for 2 hours was adequate to dry the rice sample. Hot air drier/ cabinet drier was used in this step. The object of effective drying is to remove the particle water from the surface of the rice grain at a rate, which will also permit water to diffuse rapidly from the interior surfaces. Shrinkage is to be kept at a minimum.

Thus for the process modification of instant rice, there was no any chemical used.

4.2.3 Reconstitution of instant rice

Comparative study on reconstitution time of the instant rice resulted by several experiments showed that the rice sample subjected to all the unit operations (experiment No. 5) required 5 minutes to complete reconstitution, which was the shortest duration.

4.2.4 Sensory evaluation on reconstituted instant fried rice

The developed instant fried rice can be prepared for consumption, as a mixture of instant rice (100g), dehydrated vegetables (5g), spice mixture (10g) and ghee (10g), by boiling it in water (200ml). The prepared fried rice was soft, palatable and highly acceptable foodstuff.

The best time duration for the reconstitution of instant fried rice is around 7 minutes. That time was suit for the reconstitution of dehydrated vegetables also. That's why the highest score for overall acceptability had been obtained by the sample reconstituted with in 7 minutes.

Using different amounts of boiling water, according to the consumer acceptability of the final texture and appearance of the product can do reconstitution. If a heat treatment is used for the reconstitution the amount of water should be increased in order to prevent scorching and sticking in to the pan.

4.2.5 Proximate analysis

There is no significant difference between the results of proximate analysis of instant rice when compared to the composition of raw milled rice. (Refer table 2.6) It shows the unit operations carried out in processing instant rice, do not significantly affect to the nutritive value.

4.2.6 Shelf life evaluation

If the stability of nutrient components were measured after three months storage, it would be best for the shelf life evaluation of the product.

Peroxide value of the product also should be measured after three months storage to check whether there was any rancidity.

Though there was such a reaction occurred, it would not produce a discernible rancid flavour in instant fried rice, owing to the relatively low fat content of rice and masking effects of the spices.

4.2.6.1 Total plate count

Total plate count results are negligible therefore no high risk about microbial activity of the product after three months storage.

It is because the dried product didn't provide a substrate as well as the desired water activity (a_w) for the microbial growth. It may be due to the protection that provided by the packaging material, which is an excellent barrier of water, gases and light.

But it is recommended to the determination of a_w and the effect of packaging material on the product qualities after three months storage.

4.2.6.2 Sensory evaluation

There were no significant different ($P>0.05$) for the five sensory parameters (flavour, colour, aroma, texture and overall acceptability) of the product after three months storage.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

It is evident that highly acceptable instant rice, capable of reconstitution in 5 minutes by boiling water, can be prepared using a range of unit operations. Thereby the cooking time of rice can be reduced.

There is no significant difference of nutritional qualities of instant rice, when compared to the composition of raw milled rice (depending on the accuracy of proximate analysis).
Dehydrated vegetables, mixture of spices and ghee enhance the nutritive value, flavour and aroma of the product.

The final product of instant fried rice can be prepared for consumption as a meal at an acceptable level with in 7 minutes of time.

There is a high microbial safety of instant rice with in three months of storage period.
The sensory evaluation gave comparable results for the product before and after the storage.

There is significantly high market demand for the product due to the complex life style. A single serve pack of instant fried rice would be successfully marketed at a reasonable price. It will be compatible with the living standard of busy lives of the people.

5.2 Recommendations

- Supplementation of instant rice with developed recipes of dehydrated or preserved curry formula and fortification of instant rice with vitamins in order to increase the nutritive value.
- Evaluation of the effect of packaging material on product qualities and carrying out the shelf life studies further more.

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Appendix 1

MARKETING RESEARCH ABOUT THE CONSUMER ACCEPTABILITY OF INSTANT FRIED RICE.

(1) If there is a product of instant fried rice available in the market, how often do you consume it?
   1. Daily 2. Occasionally
   3. At busy times 4. Never

(2) What is the variety of rice that is most suitable for fried rice?
   1. Short grain, white rice 2. Long grain, white rice
   3. Short grain, brown rice 4. Long grain, brown rice

(3) Which flavour do you prefer for fried rice?
   1. Without artificial flavours 2. Added vegetable flavour
   3. Added chicken flavour 4. Added shrimp flavour

(4) Which colour do you prefer for fried rice?
   1. White 2. Yellow
   3. Brownish yellow 4. Any other colour

(5) What do you think about the size of vegetable pieces?
   1.Very small size (1-5mm) 2. Medium size (5-10 mm)
   3. Large size (10-15mm) 4. Size is not important

(6) Which type of pack (for instant fried rice) do you like?
   1. Single serve pack 2. Pack for two
   3. Family pack

(8) Renumber the below characteristics according to your preference
   ( ) Flavour
   ( ) Colour
   ( ) Aroma
   ( ) Nutritional value
   ( ) Preparation time
   ( ) Price

Thank you.

Appendix 2

Preference levels of the characteristics of instant fried rice.

Consumer	Flavour	Colour	Aroma	Nutritional value	Preparation time	Price
1	4	6	5	1	2	3
2	2	3	5	1	4	6
3	4	5	6	1	3	2
4	5	6	4	1	2	3
5	3	5	4	1	2	6
6	5	4	6	3	1	2
7	4	6	5	2	1	3
8	3	6	5	2	1	4
9	3	4	5	2	1	6
10	3	4	6	2	1	5
11	4	6	5	2	1	3
12	1	4	5	6	2	3
13	2	3	5	4	1	6
14	1	5	6	3	2	4
15	3	6	4	2	1	5
16	1	5	6	3	2	4
17	2	6	4	3	1	5
18	1	4	5	6	2	3
19	3	5	6	4	2	1
20	2	4	3	6	1	5
21	5	6	3	4	2	1
22	3	5	6	1	2	4
23	2	5	6	3	1	4
24	3	5	6	2	1	4
25	4	5	6	3	1	2
26	4	5	6	3	2	1
27	4	5	6	3	1	2
28	4	6	5	2	1	3
29	4	6	5	1	2	3
30	2	6	5	3	1	4
Total	91	151	158	78	47	110

Appendix 3

SENSORY EVALUATION FOR THE FIVE POINT HEDONIC SCALE

Product: Instant fried rice.

Instructions:

- Indicate how much you like or dislike each sample after tasting.
- Assess the sample individually.
- Rinse your mouth with water after tasting each sample.
- Give numerical values ranking from like very much (5) to dislike very much (1) as given below.

POINT SCALE	POINT
Like very much	5
Like slightly	4
Neither like nor dislike	3
Dislike slightly	2
Dislike very much	1

SENSORY ASPECTS	Sample code 562	750	387
Flavor	...	...	...
Aroma	...	...	...
Colour	...	...	...
Texture	...	...	...
Overall acceptability	...	...	...

Specific comments:

Name: Date:

THANK YOU.

Appendix 4

Kruskal-Wallis Test

Kruskal-Wallis Test on Flavour

Sample	N	Median	Ave Rank	Z
1	30	4.000	47.2	0.44
2	30	4.000	45.3	-0.06
3	30	4.000	44.0	-0.38
Overall	90		45.5	

H = 0.23 DF = 2 P = 0.893
H = 0.27 DF = 2 P = 0.875 (adjusted for ties)

Kruskal-Wallis Test

Kruskal-Wallis Test on Texture

sample	N	Median	Ave Rank	Z
1	30	2.000	29.1	-4.20
2	30	3.000	40.2	-1.35
3	30	4.000	67.1	5.55
Overall	90		45.5	

H = 33.53 DF = 2 P = 0.000
H = 35.95 DF = 2 P = 0.000 (adjusted for ties)

Kruskal-Wallis Test

Kruskal-Wallis Test on Aroma

sample	N	Median	Ave Rank	Z
1	30	3.000	37.4	-2.09
2	30	3.000	44.7	-0.19
3	30	4.000	54.4	2.28
Overall	90		45.5	

H = 6.40 DF = 2 P = 0.041
H = 6.79 DF = 2 P = 0.034 (adjusted for ties)

Kruskal-Wallis Test

Kruskal-Wallis Test on Overall acceptability

sample	N	Median	Ave Rank	Z
1	30	3.000	38.7	-1.73
2	30	3.000	42.5	-0.77
3	30	4.000	55.2	2.50
Overall	90		45.5	

H = 6.56 DF = 2 P = 0.038
H = 6.93 DF = 2 P = 0.031 (adjusted for ties)

Kruskal-Wallis Test

Kruskal-Wallis Test on Colour

sample	N	Median	Ave Rank	Z
1	30	4.000	46.3	0.21
2	30	4.000	44.9	-0.15
3	30	4.000	45.3	-0.06
Overall	90		45.5	

H = 0.05 DF = 2 P = 0.977
H = 0.05 DF = 2 P = 0.973 (adjusted for ties)

Appendix 5

Calculation of moisture

Weight of the sample = 38.6063g-33.6623g

= 5.01g

Moisture content in the sample (Weight loss) = 38.6723g-38.2063g

= 0.466g

Moisture percentage = $\frac{0.466 * 100}{5.01}$

= 9.301%

Calculation of total fat

Sample weight = 2.0312g

Weight of dry empty flask = 107.2296g

Total fat + flask weight = 107.2380g

Total fat amount in the sample = 107.238g – 107.2296g

= 0.0084g

Total fat percentage = $\frac{0.0084 * 100}{2.0312}$

= 0.414%

Calculation of total ash

Sample weight = 5.01g

Dish + lid (dry weight) = 37.6304g

Dish + lid + sample (after ashing) = 37.6534g

Ash content of the sample = 37.6534g-37.6304g

= 0.023g

Total ash percentage = $\frac{0.023 * 100}{5.01}$

= 0.459%

Calculation of protein

Sample weight = 90mg

Sample titre – blank titre = 1.9ml

Percentage of nitrogen = $\frac{1.9 * 0.5603 * 100}{90mg}$

= $\frac{106.457}{90}$

Protein percentage = 1.183 * 6.25

= 7.394%

Calculation of crude fiber

Sample weight = 5.750g

Sample + crucible + lid (before ashing) = 78.469g

Sample + crucible + lid (after ashing) = 78.448g

Weight loss during ashing = 78.469g - 78.448g

= 0.021g

Percentage of crude fiber = $\frac{0.021*100}{5.750}$

= 0.365%

Appendix 6

Preparation of Potato Dextrose agar (PDA) medium

<u>Ingredients:</u>

Peeled potato	-	200g
Dextrose	-	20g
Agar	-	20g
Distilled water	-	800ml

<u>Method of preparation</u>

The Skin of potato tubers were peeled off and cut in to small pieces and 200g were weighed. Then it was boiled in distilled water for 30 minutes. The tubers were mashed and filtered. Then agar and dextrose were added to the filtrate and boiled until agar was dissolved. The mixture was autoclaved for 15 minutes at 15 lbs/sq inch.

Appendix 7

SENSORY EVALUATION FOR THE FIVE POINT HEDONIC SCALE

Product: Instant fried rice.

Instructions:

- Indicate how much you like or dislike each sample after tasting.
- Assess the sample individually.
- Rinse your mouth with water after tasting each sample.
- Give numerical values ranking from like very much (5) to dislike very much (1) as given below.

POINT SCALE	POINT
Like very much	5
Like slightly	4
Neither like nor dislike	3
Dislike slightly	2
Dislike very much	1

Sample code

SENSORY ASPECTS	832	593
Flavor	....	....
Aroma	....	....
Color	....	....
Texture	....	....
Overall acceptability	....	....

Specific comments:

Name: Date:

THANK YOU.

Appendix 8

Wilcoxon Signed Rank Test for flavour

Test of median = 0.000000 versus median not = 0.000000

	N	N for Test	Wilcoxon Statistic	P	Estimated Median
C3	30	15	35.0	0.164	0.000E+00

Wilcoxon Signed Rank Test for aroma

Test of median = 0.000000 versus median not = 0.000000

	N	N for Test	Wilcoxon Statistic	P	Estimated Median
C3	30	18	85.5	1.000	0.000E+00

Wilcoxon Signed Rank Test for colour

Test of median = 0.000000 versus median not = 0.000000

	N	N for Test	Wilcoxon Statistic	P	Estimated Median
C3	30	23	128.0	0.773	0.000E+00

Wilcoxon Signed Rank Test for texture

Test of median = 0.000000 versus median not = 0.000000

	N	N for Test	Wilcoxon Statistic	P	Estimated Median
C3	30	22	103.5	0.465	0.000E+00

Wilcoxon Signed Rank Test for overall acceptability

Test of median = 0.000000 versus median not = 0.000000

	N	N for Test	Wilcoxon Statistic	P	Estimated Median
C3	30	22	93.0	0.284	0.000E+00

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