Development and evaluation of ready to drink malted milk powder from Ragi *(Eleucine coracana)*

THESIS

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2015

CERTIFICATE – I

This is to certify that the thesis entitled ***"Development and evaluation of ready to drink malted milk powder from Ragi (Eleucine coracana)"*** *submitted in partial fulfilment of the requirement for the degree of* ***MASTER OF SCIENCE (Ag). in Food Technology*** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bonafide research work carried out by* Suneel kumar Rathour *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

All the assistance and help received during the course of investigation has been duly acknowledged by her.

Place: Jabalpur **Dr. S.S. Shukla**

Date: Chairman of the Advisory Committee

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This is to certify that the thesis entitled ***"Development and evaluation of ready to drink malted milk powder from Ragi (Eleucine coracana)"*** *submitted by* **Suneel kumar Rathour** *to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment towards the requirements for the degree of* ***MASTER OF SCIENCE (Ag). in Food Technology*** *in the Department of* ***Food Science and Technology*** *has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.*

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The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

I, undertake the complete responsibility that any act of misinterpretation, mistakes, and errors of fact are entirely of my own.

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Date:

Place: Jabalpur **Suneel kumar Rathour**

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INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn) also known as *ragi* in Hindi is important millet grown extensively in various regions of India and Africa. It constitutes a staple food for a large segment of the population in these countries. It ranks sixth in production after rice, wheat, maize, sorghum and pearl millet (*bajra*) in India. The crop is mostly grown under dry-cultivation conditions in its regions of adaptation in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra and Goa. In the year 2011-2012, the area under this crop in India was 1.18 million hectare whereas, the total production was 1.92 million tonnes(DAC,GOI).

Finger millet (Ragi) seeds are nearly globular or oval in shape and very small in size weighing 300 to 350 seeds per gram. Brown (brick red-coloured seed coat) is the predominant grain colour in ragi, although a few varieties have white seeds. The seed coat or bran is highly fibrous and forms about 15 per cent of the total seed weight. Nutritionally, finger millet is good source of mineral nutrients especially calcium, phosphorus and other micro nutrients. Finger millet contains about 5-8% protein, 1-2% ether extractives, 65-75% carbohydrates, 15-20% dietary fiber and 2.5-3.5% minerals.Finger millet is comparable to rice with regard to protein and fat and is superior to rice and wheat with respect to mineral and micro-nutrients. The seed coat of the finger millet is an edible component of the kernel and is a rich source of phytochemicals, such as dietary fiber and polyphhenols (0.2 to 3%). The high fiber makes it suitable for diabetic patients due to low glycemic index (GI). The ragi seed contains very high level of calcium and good amount of phosphorus, their availability is limited due to high phytate content. Brown ragi seeds are relatively high in tanin content which affects the protein digestibility Mahanna and Rajashekaran (1969).

Ragi is highly nutritious, non-glutinous foods. It is generally used in the forms of whole meal for preparation of traditional foods, such as *roti* (unleavened bread or pancake), *mudde* (dumpling) and *ambali* (thin porridge) cookies and cakes Swamy et al. (2003).

Evaluation of newly introduced promising ragi cultivars for biochemical composition, quality traits for development of new value added food products for good health are the current research need of today for the well being of the society. Ragi has excellent malting quality. It improves digestibility and increases the availability of nutrients. It has some of the inherent qualities which make it superior compare to other cereals and millets to qualify for malting and preparation of malted foods. It is resistant to fungal infection and help in elaboration of alpha and beta amylase during germination and during roasting/ kilning a desirable aroma is developed, which makes it an ideal grain for preparation of malted foods. Traditionally the ragi malt is utilized for infant feeding purpose and also to prepare beverages either with milk or luke warm water with the addition of sugar. The food recipe may also contains combination of germinated legume along with cooked vegetables and fruits. In the last couple of years it has been observed that the consumer trends towards the consumption of domestically prepared product have been changed to modern ready to eat, ready to drink and ready to processed products due to upcoming new processing technology and products. The acceptance of malted weaning food prepared at domestic level is also been decreased. This calls for development of an appropriate technology for preparation of ready to drink ragi based malted milk powder.

Among the various methods of food processing, the spray drying is one of the most affective processes to extend the shelf life of product. This process offers the advantage of long term preservation, convenience in handling, storage, marketing and consumption of food. Apart from above method freeze-drying is most commonly used technique. However, this is a costlier technique than any other conventional method for drying. Looking for the cost factor and quality of product the entrepreneurs prefers spray-drying technique for production of dried food. The information on physical properties, biochemical composition, malting quality of newly introduced high yielding varieties of ragi, proper blending ratio of malted ragi flour and cow milk, optimum spray drying conditions for malted milk powder, are not available in literature to develop commercially viable product. Therefore the present investigation on Development and evaluation of ready to drink Ragi based malted milk Powder has been undertaken with following objectives.

Objectives:

1. Evaluation of physical properties, biochemical composition and malting quality of new cultivars of Ragi.
2. To optimize the blend ratio of Ragi malt: Cow milk and spray drying conditions for production of malted milk powder.
3. To study the effect of blending ratio and spray drying conditions on physical, chemical and functional properties of spray dried malted milk powder.

REVIEW OF LITERATURE

The past experiences are essential to have retrospective view in the research. Keeping this idea hence forth, an attempt has been made in this chapter to present the available review of literature related to the Nutritional importance of finger millet, physical properties and biochemical composition of finger millet seed, processing and utilization of finger millet for value added products.

2.1 Nutritional importance of finger millet:

Millets are the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes. Millets can be stored for many years without any substantial changes in properties under normal room temperature. Millet contains more fiber, minerals and vitamins, which are normally deficient in the Indian diet and has eight times more calcium than other cereals. Millets are generally converted to flour for the preparation of various food items. They can also be exploited for their nutritional benefits and value added nutritive health foods. Finger millet or ragi is one of the ancient millets in India that is as old as 2300 BC Shobana et al., (2013). In India, among the small millets ragi is one of the important cereals occupies highest area under cultivation

2.2 Physical properties and biochemical composition of finger millet seed

A very meagre information is available on the various aspects of physical attributes of ragi grain and malt.

Winton and Winton (1932) reported the physical structure of the ragi seeds and showed that seeds of ragi are irregularly globular or oval in shape. They are 1.0 to 1.5 mm in diameter with 300 to 450 seeds/g. Brown is the predominant grain colour in ragi although, a few varieties have the white seeds.

Malleshi and Desikachar (1979) reported a very poor germination in Indaf7 and WB1 varieties of ragi in comparison to other recently released high yielding varieties. Germination percentage was reported to range from 67 to 98 per cent.

Kadkol and Swaminathan(1954) and Johnson and Raymond,-(1964) reported the protein content of ragi grain varied from 7 and 10 per cent. Considerable variation has also been reported by researcher reflecting the effect of genotype and environment. Protein contents as low as 5.85 per cent (Adrian and Jaquot, 1964) and as high as 14.2 percent have been reported.

Kadkol and Swaminathan (1954) studied 8 common ragi varieties and obtained the highest protein content in two white-seeded strains and lowest protein content in a brown-seeded type. Mahadeswaran et al. (1966) compared white-seeded ragies with three brown types at Coimbatore. They reported protein levels of 7.89 to 8.7 6 per cent in brown and 9.01 to 11.60 per cent in white types.

Bates (1968) reported 6.06, to 9.94 per cent protein in 10 brown-seeded strains compared with 11.44 per cent protein in the four white-seeded cultivars.

Indira and Naik (1971) and Virupakasha et al. (1975) reported that the prolamine fraction of the ragi protein accounts for about 50 per cent of the total extractable protein. This fraction unlike albumin and globulin is considerably deficient in lysin and has imbalance of other essential amino acids. They also reported that the prolamine and glutelin fractions consitute the major protein fractions. They further reported that white grain varieties have higher prolamine and lower glutelin levels than the brown grain varieties.

Mahanna and Rajashekaran (1969) and Deosthale et al. (1970) reported that digestibility of white ragi is higher than that of brown ragi. Malleshi and Desikachar (1979) while studying the malting quality of new varieties of ragi, reported the protein content in refined malt flour to vary from 3.8 to 5.0 percent as compared to the grains which is 6.3 to 8.3 percent.

Moruzzi (1931) In an analysis of carbohydrates of ragi, reported 61.8% starch, 7.94% cellulose, 0.8% reducing sugar,0.54% dextrin and 4.85% petosans. Other investigators have reported higher contents of starch and. reducing sugar, i.e0.66-2% and 1.2%, respectively.

Kadkol and Swaminathan (1954) reported the carbohydrate content ranging from 68.97 per cent to 73.38 per cent.

Modi et al. (1976) while studying the characteristics of ragi starch reported that the iodine affinity of the starch is 3.08 per cent and gelatinization temperature ranged from 56 to 72°C. They also reported that the ragi starch is stable to heat up to 90°C.

Wankhede et al. (1979) analysed the carbohydrate composition of the finger millet and reported the carbohydrate content from 63 to 70 per cent and consisted of 0.46 to 0.69% free sugar; starch 5 6 to 61%; cellulose 0.7 to 1.8% and pentosans 5.5 to 7.2%. They also reported that 70 per cent eth.anol extractable sugar consisted of xylose 1.5 td 4.3%; fructose 8.6 to 15%; glucose 9.9 to 15%; sucrose 31 to 35% and some other sugars.

Pore and Magar (1979) worked out the carbohydrate content in the hybrid varieties of ragi and reported that 70 per cent of the carbohydrates are starch and only about 20 percent consisted of free reducing sugars.

Kadkol and Swaminathan (1954) reported the fat content ranged from 1.23 to 1.65 per cent in the ragi grain. Mahadevappa and Raina (1978) investigated the lipid profile and fatty acid composition of finger millet and found that total lipid constituting 1.85 to 2.10 percent and further reported that neutral lipid constitute 70 to 72 percent of the total lipid. They also reported that this lipid contains 46 to 62% oleic acid, 8 to 27% linoleic acid, 20 to 35% palmitic acid and trace of linolenic acid.

Garg and Murti (1962) studied the changes in lipid during germination and reported that saponifiable lipids are utilized in early germination, while the unsaponifiable lipids undergo little transformation at first, but this increases in later stages.

Malleshi and Desikachar (1981) reported 1.5% fat in malted weaning food based on ragi. Malleshi and Desikachar (1981) reported that refined white flour is rich in phosphorus and they further reported that the malted weaning food made by ragi containt phosphorus around 210 mg/100 g.

Aykroyd et al. (1963) reported the mineral element composition of ragi grain. The sodium, potassium, copper and sulphur was reported to be 11.0, 408, 0.59 and 160 mg/ 100 g of the ragi grain respectively. Busson (1965) also worked out the mineral element composition of ragi grain and reported the copper, manganese and zinc to be 0.5, 19 and 16 ppm, respectively.

Aykroyd et al. (1963) reported the iron content of ragi grain as 17.4 mg/100 g which comprises 3% iron in the form of ionizable. Deosthale et al. (1970) repo-rted the iron content which varied from 1.3 to 17.6 mg. Balakrishnarao and Mithyantha (1973) also carried out the study on ragi and reported the iron content from 2.5 to 19.9 mg/100 g whereas Kadkol and Swaminathan (19 54) reported a very low range of iron content i.e., 5.1 to 6.0 mg/100 g.

Verma and Patel (2012) Sharma and Kapoor (1997) and Jaybhaye et al., (2014) reported that millet contains high amount of calcium (344 mg 100 g -1in case of ragi millet). This makes ragi based processed food products like malt, biscuits and cakes more suited for the growing children, expectant mothers and elderly who need more calcium and iron in their diet. Millets are also considered to be an ideal food for diabetics because of slow release of sugars to the body. Their high fiber content also checks constipation, high blood cholesterol and intestinal cancer

Verma and Patel (2013) reported that Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents. It is a major source of dietary carbohydrates for a large section of society. Additionally ragi has enormous health benefits and also a good source of valuable micro-nutrients along with the major food components.

Verma and Patel (2013) reported that finger millet is a noble grain with low glycemic index which makes it more suitable for diabetic patients. Additionally, it is a rich source of calcium (344 mg/100g) and helps in supplementing the calcium in human body. Its nutritional value has placed these crops on high preference in select urban market and there is great possibility of further increasing profitability of its cultivation if proper value addition and marketing is ensured.

Patwardhan and Narayana (1930) reported the enzymatic saccharifying power of ragi malt to be superior to that of sorghum and maize but not as good as that of barl malt. They also observed that optimum enzymatic activity occurred at temperatures between 55°C and 60°C and pH

4.86 to pH 5.07. The ragi enzyme was more stable at higher temperatures than the sorghum enzyme. Sastri (1939) worked out a method for the preparation of malt under optimum conditions.

The enzymes of ragi malt were investigated by Chandrasekhara and Swaminathan (1953). They found that ungerminated seeds contained very little amylase, protease and phosphorylase activity but that activity was much increase on germination. Protease activity of malt increased from 0.36 to 1.86 mg/g of amino N as the period of germination increased from 24 hrs to 9 6 hrs of steeping. They also described a method for extracting proteolytic enzymes.

Malleshi and Desikachar (1979) reported that, White ragi is particularly well-suited for making malt. They investigated the malting quality of nine new varieties of ragi and found Indaf3, Indaf9, Indaf1 and Annapurna were having good malting quality, while Indaf7 and WB1 were not found to be suitable because of their poor germinating power and low amylase activity.

Chaudhary and vyas (2014) reported that the protein content of standard and germinated samples were analyzed to be 11.5g/100g and 15.46 g/100g in the 24 h germinated sample; however, in 36 h germinated sample the values were 17.1g/100g and 21.8g/100g after 48 hrs. The calcium content of standard premix was 189.36 mg/100g after 24 hrs of germination it was 206.3 mg/100g; 214.30 mg/100g (36 hrs) and 221.26mg/100g (48 hrs). The iron content of standard premix was 5.60mg/100g and 7.0 mg/100g (24 hrs germination). Thirty sixand 48 hrs germinated premixes had iron content 7.6 mg/100g and 8.66 mg/100g.Phytic acid decreased from an initial average value of 1.88 mg/100gm in non-germinated sample to 0.33mg/100g in 48 hrs germinated sample. Oxalic acid reduced from 25.63 mg per 100 g in control sample to 6.73mg/100g in 48 hours germinated sample.

Sahu (1987) reported that among minor millets, little millet is most nutritive with high carbohydrate, protein and iron content and ranks second to finger millet in terms of utilization The fat from millets contain higher proportion of unsaturated and essential fatty acids.

McDonough et al, (2000) reported that among millets, pearl millet, finger millet and kodo millet are high in lysine while proso millet and barnyard millet have low essential amino acid composition.

Srivastava et al, (2001) reported that the nutritive value of minor millets is comparable with other staple cereals like wheat and rice and some have higher proportion of protein, fat, minerals and fibre

Khader and Maheswari (2012) reported Malting decreased grain length, width, kernel weight (0.45 to 19.0g), volume (0.50 –31.2 ml) and hardness (1.12 to 5.9 kg/cm2), thus reduced the bulk density of the malted mixes. Chemical composition revealed that, the significant increase ($P<0.05$) in fat (2.27 g), carbohydrate (98.0 g) and calorie (396 kcal) content of wheat malted mix. However significant increase was observed in calcium (440 mg), thiamine (0.7 mg) and riboflavin (0.9 mg) content of ragi malted mix. Germinated greengram had significantly higher protein (33.0 g), fibre (11.5 g), iron (8.0 g) and vitamin C (157.8 mg) content. The selected preschool children, pregnant women & lactating women were divided into 3 groups. Group II and III fed with ragi malted mix & wheat malted mix respectively served as the experimental groups and remaining group I served as the control group. Significant increase was observed in weight of preschool children and lactating women after supplementation. Hemoglobin level in pregnant and lactating women significantly increased ($P<0.01$) after supplementation. Considerable reduction (50%) in the incidence of PEM, vitamin A, B vitamins, vitamin C and iron deficiency symptoms in experimental groups. After supplementation, morbidity rate decreased to 50% both the Group II and III.

Karki and Kharel (2012) reported chemical changes during germination and malting characteristics of six Nepalese finger millet varieties (GPU 0025, GE 5016, Dalle, Okhle, Kabre and Juwain) The chemical characteristics of unmalted and malted millets shows, Starch, amylose and amylopectin contents in unmalted millets were between 71.32 to 79.86, 20.39 to 24.13, and 49.11 to 55.72% dry basis (db) respectively; whereas, those of malted millets were 63.74 to 67.12, 16.62 to 19.27 and 44.47 to 50.18% (db) respectively.

Singh and Raghuvanshi (2012) reported chemical composition of finger millet revealed that total carbohydrate content of finger millet range from 72 to 79.5%. Finger millet has nearly 7% protein. The ash content has been found to be nearly 1.7 to 4.13% in finger millet. Calcium content of 36 genotypes of finger millet ranged from 162 to 487 mg %.

Singh and Srivastava (2006) reported the iron content of 16 finger millet varieties ranged from 3.61 mg/100g to 5.42 mg%. Finger millet is the richest source of calcium and iron. Calcium deficiency leading to bone and teeth disorder, iron deficiency leading to anemia can be overcome by introducing finger millet in our daily diet.

Chaudhary and vyas (2014) reported that Ragi based premixes can alternative. The protein content of standard and germinated samples were analyzed to be 11.5g/100g and 15.46 g/100g in the 24 h germinated sample; however, in 36 h germinated sample the values were 17.1g/100g and 21.8g/100g after 48 hrs. The calcium content of standard premix was 189.36 mg/100g after 24 hrs of germination it was 206.3 mg/100g; 214.30 mg/100g (36 hrs) and 221.26mg/100g (48 hrs). The iron content of standard premix was 5.60mg/100g and 7.0 mg/100g (24 hrs germination). Thirty sixand 48 hrs germinated premixes had iron content 7.6 mg/100g and 8.66 mg/100g.Phytic acid decreased from an initial average value of 1.88 mg/100gm in non-germinated sample to 0.33mg/100g in 48 hrs germinated sample. Oxalic acid reduced from 25.63 mg per 100 g in control sample to 6.73mg/100g in 48 hours germinated sample.

2.3 Processing and utilization of finger millet

The primary processing followed widely for finger millets in India and Africa for food uses are milling, popping, flaking, malting and fermentation FAO (1995).

Shukla et al. (1986) evaluated varieties of finger millet for their puffing yield and organoleptic quality. In general brown seeded varieties gave good puffing yield compared to the white seeded, which yielded organoleptically superior quality puff.

Malleshi et al. (1989) studied the expansion volume of popped maize, sorghum, proso millet, kodo millet, pearl millet, finger millet, foxtail millet, little millet and barnyard millet to be 35, 22, 12, 11, 10, 8 7, 7 and 7 ml / g respectively.

Srivastava and Batra (1998) evaluated the popping qualities of various genotypes of foxtail millet, finger millet, barnyard millet and proso millet. Popping per cent of foxtail millet, finger millet and barnyard millet genotypes ranged from 34.41 to 77.94, 55.47 to 87.54 and 48.85 to 54.20 respectively. Among the millets, the highest popping (92.77%) and expansion volume (6.51 mg/g) were observed in proso millet, followed by finger millet, foxtail millet and barnyard millet. Gectu et al. (2003) developed popped pearl millet using salt as heating medium. Ladoo prepared from popped pearl millet flour was found to be organoleptically acceptable.

Obizoba (1998) and Nnam (2001) stated that germination increased amino acid and mineral availability, protein and carbohydrate digestibility, nutrient and energy density of gruels, levels of the B-complex vitamins and decreased toxic and antinutritional factors like phytates, tannins and alpha galactosides.

Malleshi and Klopfenstein (1998) reported that yields of malted flour from sorghum, pearl millet and finger millet were 86, 85 and 78 per cent respectively and (heir protein and fibre contents were 10.4, 15.5, 4.5 and 1.2, 1.0 and 1.8 per cent respectively. The lysine content of finger millet malt flour protein (3.4%) was higher than pearl millet (2.16%) and sorghum (1.45%) malt flour protein.

Nirmala et al. (2000) germinated a newly released hybrid ragi Indaf-15 and reported that the malting loss was maximum (32.5%) at 96 hours while the total reducing sugar content increased from 1.44 to 8.36 per cent whereas the total carbohydrate content decreased from 81 to 58 per cent at 96 hours of germination. Maltose and matotriose were detected after 48 and 72 hours respectively, indicating that Indaf-15 is a potential variety for malting purposes.

Kumari and Srivastava (2000) reported significant changes in nutrient composition, neutral detergent fibre, crude fat and vitamin C in malted flour of finger millet genotypes. Calcium, iron, zinc and vitamin C ranged from 5.16 to 5%. 8.26 to 15.10, 1.66 to 2.22 and 5.08 to 8.74 mg/100 g respectively in the malted finger millet genotypes.

Sebastian et al.(2003)reported that finger millet was incorporated at different levels (5, 15 and 25%) to develop a deep fat fried snack item namely 'chakli' to study its effect on fat absorption and attributes. On incorporation of gelatinized ragi flour (5%) significantly higher sensory scores were obtained for texture, flavour and overall quality of the products in comparison to the control. Higher amount of ragi resulted in a lesser fat uptake

Begum et al. (2003) formulated finger millet papad using 60 per cent finger The sensory evaluation revealed no difference between control and millet based papads calcium was found to be exceptionally higher in papads with fingers millet (156 mg/100g) compared to black gram papads (82 mg / 100g). Naveena and Begum (2003) blended corn starch with black gram dhal at 5 and 10 percent levels in making of papads without much alteration in sensory quality.

An attempt was made by Roopa et al. (2003) to develop a convenient mix of halibai, a traditional sweet meat from wheat and rice using finger millet. The mix with 1:5 water ratio, cooked for 25 minutes resulted in a ready to serve Halibai. The optimized formulation with about 20 per cent millet had a sensory score of 7-8 on a 9 point hedonic scale with 45-48 per cent sugars.

Shukla et al. (2003) developed biscuits from composite flour blends of wheat and ragi and the standardized formulation was made from ragi flour 13 -17g, sugar 27.4 - 29.8 g, fat 22.8 - 25.8 g, skim milk powder 1.52 - 1.84 g. ammonium bicarbonate 0.76 -0.92 g and baking powder 0.44 - 0.53 g per batch of l00g.

Finger millet based cookies were developed by Swamy et al. (2003) using ragi flour, puffed ragi flour, starch, soy flour, mango powder, pudina and coriander in different combinations, providing modified starch, improvement in protein.

Shobana et al., (2013) reported the utilization of finger millet or ragi for development of processed products by milling, malting, fermentation, popping, and decortication. Noodles, vermicilli, pasta, Indian sweet (halwa) mixes, papads, soups, and bakery products.

From the preceding paragraphs, it can be educed that the systematic information on the objectives of the present proposed programme of study is still quite meager. However, there are tremendous opportunities to work for diversified uses at home and commercial scale. Therefore, the present investigation has been undertaken to provide the relevant knowledge in the selected field of study. The findings obtained in various experiments are presented in next chapter.

MATERIALS AND METHODS

This chapter deals with various experimental techniques, materials and methodologies used to study the biochemical composition, malting quality new ragi cultivars and spray dried malted milk powder of finger millet (ragi). The present investigation was carried out in the Department of Food Science and Technology and Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the year 2014-2015.

3.1 Source of raw materials, chemicals glassware, equipments and machines

3.1.1 Procurement of raw material and sample preparation

The samples of different cultivars of finger millet (ragi) viz. AVT 1, AVT5, VL 352 (NC), JNR 852, JNR 1008, and JNR 981 were procured from Department of Plant Breeding and Genetics, College of Agriculture Rewa, JNKVV Jabalpur (MP). The samples were cleaned thoroughly packed in polyethylene bag and stored at ambient room temperature for further quality analysis and spray dried malted milk powder product development.

3.1.2 Experimental materials

The polyethylene bags were purchased from Hira Poly Bags Products, Jabalpur. All the chemicals used in present investigation were of standard analytical grades from BDH (India), E-Merck and Sarabhai, M. Company. The glassware's used in the present investigation were from Qualigens and Borosil Company respectively.

3.1.3 Equipments and machines

Following machines and equipments were used in the research work

S. No	Name of equipments / machine	Source of supply
1.	Water analysis testing kit, model 191E Deluxe	M/S Environmental and Scientific Instruments Corporation, Panchkula, Haryana, India

S. No	Name of equipments / machine	Source of supply
2.	KELPlus,Nitrogen Analyzer	M/s Pelican Equipments, 2ndFloor, 38 Burket T Nagar, Chennai
3.	SOCS Plus, Fat Analyzer	M/s Pelican Equipments, 2ndFloor, 38 Burket T Nagar, Chennai
4.	Fibre Tech Apparatus	M/s Pelican Equipments, 2ndFloor, 38 Burket T Nagar, Chennai
5.	UV Spectrophotometer Shimadzu UV- 1700	M/S Toshwin Analytical Pvt. Ltd. 2A Kirti Mandir , Vadodra
6.	Spray Dryer	S M Scientech 2/2B, Nundy Street, Calcutta (W.B.)
7.	Sensory Evaluation Lab	Godrej Industries Limited. Pirojshanagar, Eastern Express Highway, Vikhroli, Mumbai-400079, India
8.	S.S. Trays, Glass jar, Plastic Basket and Bucket	M/S J.K. Sales & Promoters Gole Bazaar, Write Town, Jabalpur (M.P.)

3.2 Experimental methods

All the experiments reported, were carried out in triplicate and the mean value have been reported.

3.2.1 Preparation of ragi malt

The ragi malt was prepared by following the standard procedure as described by Malleshi and Desikachar (1979) Clean seeds of six varieties of ragi were washed with 0.1% aqueous dispersion of lime and steeped in running water at about 25ºC for 24 hrs. The excess water was drained out and seeds were allowed to germinate for 3 days. Non germinated seeds were removed by sieving. The germinated seeds were dried in a hot air oven at 50ºC for 20 hrs. The rootlets were removed by brushing gently. The seeds were weighed to determine the malting losses. The malted seeds were grind through 80 mesh (B.S.S) and were used for biochemical analyses and spray dried malted milk powder product development.

3.2.2 Spray dried malted milk powder of ragi:

The Ragi malt: cow milk slurry of pre determined concentration was stirred well, filtered through sieves, sterilized and cooled at 4^0C. The ragi malt milk slurries were dried in SMST Lab Model Spray Dryer following to standard procedure. To achieve best quality product, the spray dryer was operated at predetermined, spray drying conditions i.e. air inlet temperatures (175^0C,195 ^{0}C & 205^0C), slurry concentration (10%, 15% & 20%). The Spray dried malted milk powder was collected from stainless steel cyclone in a glass jar. It was packed in glass bottle and stored at room temperature for further analysis.

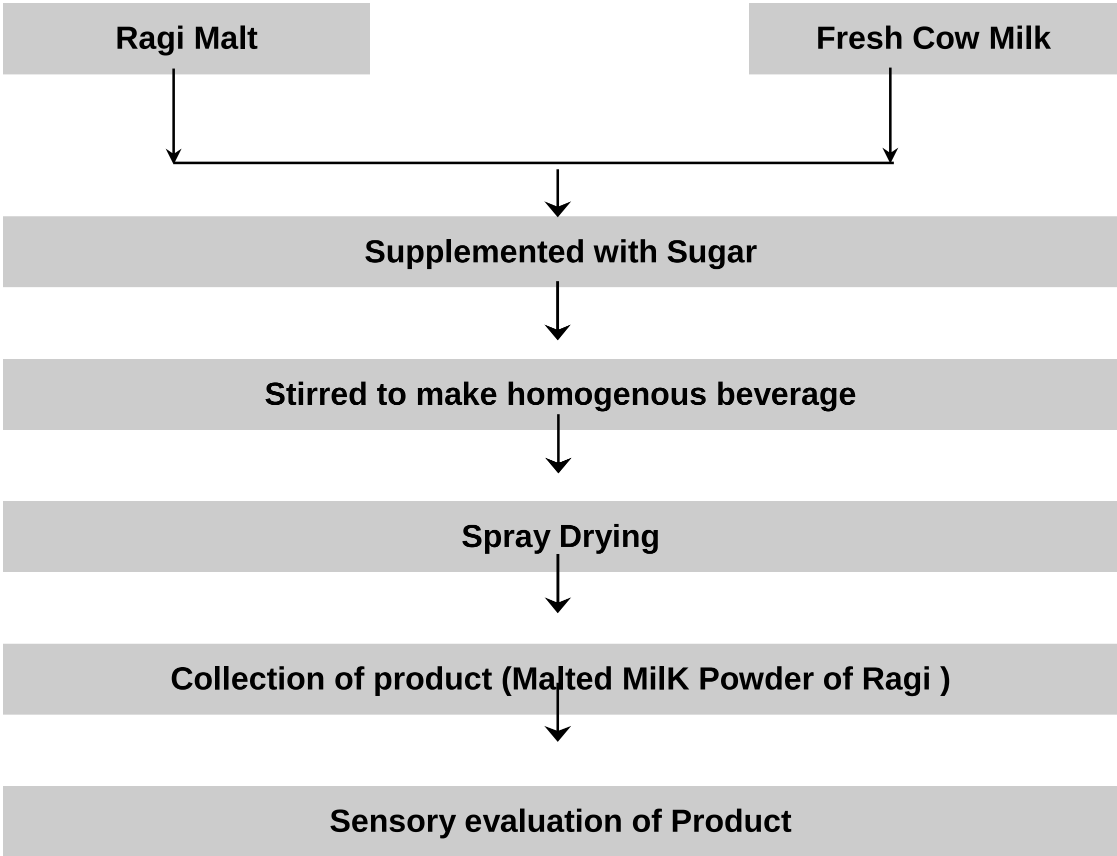
Experimental plan and design

To study the effect of spray drying condition on quality of Ragi malt:cow milk spray dried powder the experiment was planed in Factorial design methodology. The experimental plan consisted of three factor each at three level (Table 3.3) viz temperature (175,190,205 ^{0}C) and slurry concentration (9, 12, 14 %). The spray drying pressure of 3.5 Kg/cm^2 was maintained in all experiments. The experiment was conducted in three replication.

Table 3.3 Experimental variables for production of Spray dried malted milk powder of ragi

Experimental variables				
Expt. No	**Treatment Combination**	**Temperature (^{0}C)**	**Ragi Malt Slurry con. (%)**	**Pressure (Kg/cm^2)**
1	S_1T_1	175	10	3.5
2	S_1T_2	195	10	3.5
3	S_1T_3	205	10	3.5
4	S_2T_1	175	15	3.5
5	S_2T_2	195	15	3.5
6	S_2T_3	205	15	3.5
7	S_3T_1	175	20	3.5
8	S_3T_2	195	20	3.5
9	S_3T_3	205	20	3.5

Flow diagram for manufacturing of Spray dried malted milk powder of ragi



3.3 Analytical Methods

The following methods were used for various determinations.

3.3.1 Physical properties

3.3.1.1 Thousand seed weight

Clean and sound seeds were taken for this parameter. The seeds were weighed on electronic balance.

3.3.1.2 Volume of the ragi seeds

One g of the clean seeds were taken and poured in a 10 ml measuring cylinder having a known amount of water. The increase in volume of the water was recorded.

3.3.1.3 Germination percentage

100 seeds of ragi were spread in a petridish having filter paper soaked with distilled water and maintained at 25 ^{0}C for 3 days the germination percentage was calculated by counting germinated seeds.

3.3.1.4 Density of the ragi seed

Volume of one g seed was measured as mentioned above and the density was calculated by dividing the weight with the volume.

3.3.2 Chemical composition

3.3.2.1 Moisture

The moisture content in the sample was estimated according to the method of AOAC (1984).

The sample (5g) was taken in pre-weighed moisture box, dried at 105ºC for 24hr in hot air oven, cooled in desiccators and weighed. The difference in weight of moisture box represents the moisture content of the sample.

Calculation

$$\text{Moisture \%} = \frac{\text{Difference in weight}}{\text{Weight of sample}} \times 100$$

3.3.2.2 Protein

The protein content in sample was determined by using conventional micro-Kjeldahl digestion and distillation procedure as given in AOAC (1984).

Reagents:

1. Catalyst mixture- A mixture of 100g K_2SO_4, 20g of $CuSO_4$ and 2.5g of SiO_2.
2. Sodium hydroxide solution: 40% (w/v).
3. Boric acid solution: 2% (w/v).
4. Concentrated sulphuric acid AR (sp. gr. 1.81).
5. Mixed indicator: 2 parts of 0.2% (w/v) methyl red and 1 parts 0.2% (w/v) methyl blue in absolute alcohol.
6. Standard sulphuric acid (0.1N).

Procedure

The sample (0.2g) was weighed accurately and transferred to a Kjeldahl flask taking care to see that the material did not stick to the neck of the flask. The catalyst mixture of about 1g and concentrated sulphuric acid (10ml) were added. Then the flask was heated in an inclined position in digestion chamber for about 4-6 hr. till the liquid became clear (green blue colour).

Distillation

The content in the flask were allowed to cool and the digested material was transferred quantitatively to a vacuum jacketed flask of micro Kjeldahl distillation apparatus and the ammonia liberated by the addition of 25ml of 40%NaOH on heating was absorbed in 25ml of boric acid containing 2-3 drops of mixed indicator in 100 ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid. The blank was also run in a similar way.

Calculation

$$N (\%) = \frac{\text{Normality of } H_2SO_4 \text{ x Volume of 0.1N } H_2SO_4 \text{ x } 14}{\text{Weight of sample x } 1000} \text{ x } 100$$

Crude Protein (%) = N % x 6.25

3.3.2.3 Fat

The fat content of the sample was determined by the procedure as described in AOAC (1984). The sample (5g) was weighed accurately, placed in thimble and plugged with cotton. The extractor-containing thimble was placed over a pre-weighed extraction flask (A). Fat content was determined by extracting the sample with solvent petroleum ether (AR grade 60-80°C) for 8hr using soxhlets extraction procedure. After extraction the excess of solvent was distilled off and the residual solvent was removed by heating at 80°C in oven for 4-6 hr. the flask was weighted (B) and the fat content was determined as below:

Calculation

$$\text{Crude fat (\%)} = \frac{\text{Weight of flask (B) - Weight of flask (A)}}{\text{Weight of sample}} \text{ x } 100$$

3.3.2.4 Carbohydrates

Total carbohydrates in the samples were estimated by hydrolysis method as described in AOAC (1984).

Reagents:

1. Conc. HCl (AR sp.gr.1.25).
2. Fehling's solution:

   Fehling's solution A: 34.64g of $CuSO_4.5H_2O$ was dissolved in 500ml of distilled water.

   Fehling's solution B: 173g of sodium potassium tartarate and 50g of sodium hydroxide were dissolved in 500ml of distilled water. The Fehling's solution was prepared by mixing the equal volume of solution A and solution B. It was prepared fresh daily.
3. Sodium hydroxide solution: 40% (w/v).
4. Methyl blue indicator: 0.1% (w/v) in 95% alcohol.
5. 3N HCl-68.18ml concentrated HCl was made up to 250ml with distilled water.
6. Dextrose 1% - 1g of dextrose was dissolved in 100ml distilled water.

Procedure

The sample (2.5g) was taken in the flask and suspended in 200ml of distilled water. Twenty ml of 3N HCl was added and refluxed in an air condenser for 3hr. On cooling, it was neutralized with alkali to pH 7.0, filtered and volume was made to 250ml with distilled water.

The total carbohydrates in the filtrate were determined by titrating it with Fehling's solution (A & B, 5ml each) using 1ml of methyl blue indicator. Factor was worked out by titrating 1% dextrose with Fehling's solution. In each titration Fehling's solution in the conical flask was heated with a constant flame and titration was done with filtrate in the burette until the end point (brick-red colour) was obtained. The total carbohydrate content was calculated as under.

Calculation

$$\text{Factor} = \frac{\text{Titre value x 2.5}}{1000}$$

$$\text{Dextrose \%} = \frac{\text{Factor x 250}}{\text{Titrated value x Weight of sample}} \text{ x 100}$$

$$\text{Total carbohydrates (\%) = Dextrose \% x 0.9}$$

3.3.2.5 Ash

The ash content in the sample was determined by procedure as describe in AOAC (1984). The sample (5g) was placed in pre-weighed crucible. It was burned on gas flame until it was completely charred. The samples were then placed in muffle furnace for combustion at 520°C for 5hr; their-after samples were cooled in desiccators and weighed. The heating in muffle furnace was repeated until constant weight was obtained. The ash content was calculated as under.

Calculation

$$\text{Ash (\%)} = \frac{\text{Initial weight of empty crucible and sample} - \text{Final weight of crucible with ash}}{\text{Weight of sample}} \text{ x 100}$$

3.3.2.6 Crude fiber

The crude fibre was determined by the method as described in AOAC (1984).

Reagents

1. Sulphuric acid 0.255 N
2. Sodium hydroxide 0.313N

Procedure

Dry defatted sample (2g) was transferred in to 500ml conical flask to which 200ml of 0.255 N boiling sulphuric acid was added, then it was boiled for 30 min., kept the volume constant by the addition of water at frequent intervals. The mixture was cooled and filtered through a muslin cloth and the residue was washed with hot water till it was free from acid. The material was then transferred to the same beaker and 200ml of boiling 0.313 N NaOH was added. After boiling for 30 min. the mixture was cooled and again filtered through muslin cloth. The residue was washed with water till it get free from alkali, followed by washing with absolute alcohol and ether to remove the moisture and residue fat. It was then transferred to a weighed crucible and kept in oven at 100 ^oC for 4-6 hr. The crucible was cooled and weighed. The difference in weight represents the crude fibre content in samples.

$$\text{Crude Fibre (\%)} = \frac{\text{Difference in weight of crucible}}{\text{Weight of sample}} \times 100$$

3.3.2.7 Sugar

The sugars content of the sample was determined by the procedure as described by Ranganna (1991).

Reagents:

1. Fehling's solution A.
2. Fehling's solution B.
3. Methylene blue indicator.
4. 45% Neutral Lead Acetate solution: 225gm of neutral lead acetate were dissolved in distilled water and diluted to 500ml.
5. 22% Potassium Oxalate solution: 110 gm of potassium oxalate ($K_2C_2O_4.H_2O$) were dissolved in distilled water and make up to 500ml.
6. Standard invert sugar solution.

Weighed 9.5g of AR grade sucrose into 1 litre volumetric flask. Then added 100ml water and 5ml concentrated HCl. Allowed it to stand for 3 days at 20-25^oC for inversion to take place and then make up to mark with water and its stable for several days. Pipette 25ml of standard invert sugar solution into 100ml volumetric flask and added 50ml water. Added few drops of phenolphthalein indicator and neutralized with 20% NaOH until pink. Then it was acidified with 1N HCl by adding it drop wise until 1 drop causes the pink to disappear. Make unto mark with water (1ml=2.5mg of invert sugar).

1. Standardization of Fehling's solution:

Mix 50ml solutions of Fehling A and 50ml of Fehling B. Pipette 10ml of mixed solution into 250ml conical flask and added 25ml water. Take invert sugar solution prepared by inversion of sucrose in 50ml burette. Add to the mixed Fehling solution almost the whole of the standard invert sugar solution (18-19ml) required to effect the reduction of copper, so that not more than 1ml will required to complete titration. The flask was heat over a hot plate covered with asbestos filled wire gauze. When liquid began to boil, keep in moderate ebullition for 2min.On flame, added three drop of methylene blue and completed titration in 1min, over all 3 min and no interruption. End point were noted which was indicated by the discoloration of indicator (i.e. brick red).

$$\text{Factor for Fehling's solution (g of invert sugar)} = \frac{\text{Titre value x 2.5}}{1000}$$

Preparation of sample:

25g of sample powder was taken and transferred to 250ml flask. Added 100ml water and neutralized with 1NNaOH and then filtered. 2ml of lead acetate solution was added, shaked well and allowed it to stand for 10 min. Added 2ml of potassium oxalate solution to remove excess lead and make up the volume with water and filtered.

(A) Reducing sugar

Pipette 10ml of mixed Fehling solution into 250ml conical flask (5A and 5B). The burette was filled with the sample solution prepared. Then run into the flask almost the whole volume(15-50ml) of solution required to reduce the Fehling solution so that 0.5-1.0ml is require to later complete titration. Mixed the content and was heated to boiling and boiled moderately for 2min.Then added 3 drops of methylene blue and by not touching the sides. Titration was completed within 1min by adding 2-3 drops of sugar solution at 5-10sec intervals, until the indicator is completely decolorized from blue to brick red of cuprous oxide. Noted the volume of the solution required.

Note: End point was determined within 1 drop of sugar and not interrupting the boiling more than few seconds as the indicator undergoes back oxidation rapidly when air has free excess into the flask.

Calculation

$$\text{Reducing sugar \%} = \frac{\text{Factor x Dilution x 100}}{\text{Titer value x Weight of sample}}$$

(B) Total sugar

50ml of the clarified solution was pipette into 250ml flask and added 5g of citric acid and 50ml of water. It was boiled gently for 10 min to complete inversion of sucrose, and then cooled. Transferred it to 250ml flask and neutralized with 1N NaOH using phenolphthalein and make up volume and was titrated with Fehling solution.

Calculation:

$$\text{Total sugar \%} = \frac{\text{Factor x Dilution x 100}}{\text{Titer value x Weight of sample}}$$

Non reducing sugar % = Total sugar - Reducing sugar

3.3.2.8 In-vitro starch digestibility

The in-vitro starch digestibility was determined by the method of Singh and Jambunathan (1982).

Reagents:

1. Pancreatic amylase: 20 mg pancreatic amylase was dissolved in 50ml, 0.2M phosphate buffer (pH 6.9).
2. Di-sodium hydrogen phosphate (0.2M): 35.5 g of Sodium hydrogen phosphate was dissolved in distilled water and its volume was made to one liter.
3. Potassium dihydrogen phosphate (0.2M): 27.2g of Potassium dihydrogen phosphate was dissolved in distilled water its final volume was makeup to one liter.
4. Phosphate buffer (pH 6.9): 50ml of 0.2 M Potassium dihydrogen phosphate was added to 46.8ml Disodium hydrogen phosphate (0.2M) and its final volume was makeup to 100ml with distilled water.
5. 3, 5-Dinitrosalicylic reagent: 10g of dinitrosalicylic acid and 300g of sodium hydroxide was dissolved in CO_2 free water and diluted to

1000ml. The solution was stored in brown bottle and protect from carbon dioxide.

6. Standard maltose solution: 400mg maltose monohydrate was dissolved in distilled water; its final volume was makeup to 100ml.

Procedure

The defatted sample (50gm) was dispersed in one ml 0.2M phosphate buffer (pH 6.9) and 0.5ml of pancreatic amylase was added to sample suspension and incubated in water bath at 37^{o}C for 2hr. After 2hr incubation, added 2ml dinitrosalicylic acid reagents quickly and the mixture was heated for 5min in boiling water bath. After cooling, the volume was made up to 25ml with distilled water and filter prior to measurement of absorbance at 550nm. A blank was also run simultaneously by incubating the sample and adding dinitrosalicylic acid reagent before the addition of enzyme solution.

Maltose was used as standard and expressed the values as mg maltose released per ‘g’ defatted sample. Standard curve was prepared by taking 0.8 mg maltose from a standard maltose solution.

Calculation

$$\frac{\text{Concentration of std.}}{\text{Absorbance of std.}} \times \frac{\text{Abs.of sample}}{1} \times \frac{\text{Vol.make up}}{1000} \times 100$$

3.3.2.9 Estimation of mineral nutrients

Minerals nutrients viz calcium, phosphorus, iron, copper, zinc and manganese were analyzed in diacid digested aliquot of samples, as out-lined below.

One g of powdered sample was taken in a 100 ml conical flask and 15 ml of diacid mixture consisted of HNO and $HClO_4$ in proportion of 5:2. The flask was transferred on a hot plate and digested until a clear aliquot was obtained. The digested material was filtered through Whatman No.1 filter paper and its volume was made to 100 ml. The aliquot was used for the determination of above minerals.

3.3.2.9.1 Calcium

Calcium in the above aliquot was determined by the Versinate titration method as described by Black (1965).

3.3.2.9.2 Phosphorus

Phosphorus content in the diacid digested aliquot was determined by Vanado-molybdo phosphoric acid method of Koenig and Johnson (1942).

3.3.2.9.3 Estimation of Zinc, Iron, Copper, and Manganese

The micronutrients viz., zinc, copper, iron and manganese in the digested aliquot were determined by atomic absorption spectroscopy (Varian techtron model AA-120). The instrument was first calibrated using respective standard solution.

3.4 Physical and functional properties of spray dried ragi based malted milk powder

The physical and functional properties viz Bulk Density, Solubility Index will be determined according to procedure as described by Kumar (1981).

3.4.1 Bulk Density

The known weight of malted milk powder in standard volume (100 ml) was determined. The bulk density was calculated as under,

$$\text{Bulk Density (g/ml)} = \frac{\text{Weight of Product}}{\text{Volume of Water}}$$

3.4.2 Solubility Index

The solubility index of powder was determined by according to procedure described by Kumar (1981). 10 gm spray dried powder was reconstituted in 100 ml distilled water (25^0C). It was stirred well for 90 seconds and allowed to stand for 10-15 min to settle down the foam. The milk sample (50 ml) was centrifuged at 3500 rpm for 5 minutes. The supernatant (25 ml) from above centrifuge tubes was siphoned off carefully without disturbing the sediment layer.

The tubes were again filled with 25 ml distilled water (50 ml, final volume) shaked vigorously and finally centrifuged for 5 minutes. The solubility index of soy cow milk beverage powder was determined by holding the tube in vertical position and reading sediment volume (mm) in graduate scale.

3.4.3 Chemical composition of spray dried ragi based malted milk powder

The moisture, protein, carbohydrates and total ash content in the product were determined by following the procedures as described in by AOAC (1984)

3.4.4 Sensory evaluation of spray dried ragi based malted milk powder

A simple hedonic rating test was used for sensory evaluation of spray dried ragi based malted milk powder. The sensory quality attribute viz., colour, taste, flavor and overall acceptability were evaluated on nine point scale, comprises of liked extremely to disliked extremely. The sensory score for each attributes were recorded and statistically analyzed according to procedure described by Ranganna (1991).

3.5 Statistical analysis of data

The results/data of the chemical analysis of grain quality for different parameters were analyzed statistically to assess the degree of variation within the treatments as compared to the control. The data were subject to analysis of variance (ANOVA) and least significance difference to determine the difference between means, analyzed by Genstat computer package using Completely Randomized Design (CRD) at 5% level of significant following the standard procedure as described by Ranganna (1991). The data obtained from the different experiments planned in factorial design were also processed using statistical package, i.e. Design Expert 7.1.

The skeleton of analysis of variance

S.No.	Source of variance	d.f.	SS	MSS	F calculated	F table value (5%)
1.	Treatments	(t-1)		TSS	TMS	TMS/EMS
2.	Error	(n-t)		ESS	EMS	
	Total	(n-1)				

Where,

t = Number of treatments

n = Number of observations

d.f. = Degree of freedom

T.S.S. = Treatment sum of square

E.S.S. = Error sum of square

T.M.S. = treatment mean sum of square

E.M.S. = Error mean sum of square

$$C.V. = \sqrt{\frac{EMS}{GM}} \times 100$$

$$SE(d) = \sqrt{\frac{2EMS}{r}}$$

C.D. = $t_{(0.05)}$ x SE(d)

Where,

C.V. = Coefficient of variation

S.E.(d) = Standard error of difference

G.M. = Grand mean

C.D. = Critical difference

$t_{(0.05)}$ = t-value at 5% probability level

RESULTS

The present investigation was planned to evaluate biochemical composition and malting qualitative of new varieties of ragi (*Eleucine coracana*) and utilization of ragi malt for production of spray dried malted milk powder. The physical properties viz., 1000 seed weight, seed volume, seed density, germination percentage of ragi grain and biochemical attributes viz proximate principles, crude fibre, In-vitro Starch digestibility, Acidity, Reducing & Non-reducing Sugars, and micro mineral elements of ragi grain and malt were considered as the chief criteria of determination. The sensory evaluation of ragi based spray dried malted milk powder was also conducted. The findings obtained during the course of investigation presented through table 4.1 to 4.3.1.3 as under.

4.1 Physical Characteristics:

4.1.1 1000 seed weight

The result of 1000 seed weight of 6 varieties of ragi is given in the table 4.1 with C.D. values at the bottom. Perusal of the data in Table 4.1 indicates that mean values of 1000-seed weight ranged from 2.78 to 3.20 g. Variety JNR1008 recorded the highest 1000-seed weight, whereas AVT 5 had the lowest. On statistical analysis, it becomes evident that variety JNR1008 with the highest seed weight is significantly superior over JNR 981, AVT 1and VL 352 (NC) whereas the remaining varieties are not significantly differing.

4.1.2 Volume of ragi seeds

Table 4.1 comprises the results of volume of 1000 seeds of six varieties of ragi. An appraisal of the above table indicates that 1000-seed volume varies from 2.33 to 2.80 ml. Ragi variety VL 352 (NC) ranks highest in 1000-seed volume which is significantly higher than the varieties AVT 1 and AVT 5. It was, however, at par in volume with the varieties JNR 981 and JNR 1008.

4.1.3 Density of ragi seeds

The results of seed density of ragi varieties are tabulated in Table 4.1. It is evident from the table that seed density varies from 1.01 to 1.23. The variety JNR 1008 has the heaviest grain in comparison to all other varieties, whereas variety JNR 981 is significantly lighter to all the varieties.

4.1.4 Germination percentage of ragi seeds

Table 4.1 comprises the results of germination percentage of seeds of six varieties of ragi. An appraisal of the table indicates that germination percentage varies from 85.33 to 99.66 %. Ragi variety AVT 5 ranks highest in germination percentage which is significantly higher than the varieties JNR 981, JNR 1008 and JNR 852. It was, however, at par in germination percentage with the varieties VL 352 (NC) and AVT 1.

Table 4.1 Physical properties of ragi cultivars

S. No	Varieties	1000 grain weight (g)	Volume (ml)	Density	Germination %
1.	AVT 1	2.92	2.46	1.18	99.00
2.	AVT 5	2.78	2.54	1.09	99.66
3.	VL 352 (NC)	2.88	2.82	1.02	99.00
4.	JNR 852	2.85	2.33	1.22	85.33
5.	JNR 981	2.98	2.80	1.01	93.00
6.	JNR 1008	3.20	2.60	1.23	96.66
	C.D. at 5%	0.049	0.066	0.069	0.148
	SEm ±	0.014	0.019	0.019	0.042

4.2 Biochemical composition of ragi cultivars and their malt

4.2.1 Moisture content in different cultivars of ragi grain and malt

A cursory review of table 4.2.1 reveals that the moisture content in ragi grain varies from a value of 8.91 to 9.90 percent, whereas that of Ragi malt varied from 8.32 to 9.57 percent. The highest and lowest contents of moisture can be seen in variety AVT 1 and JNR1008 varieties of ragi grain as well as in ragi malt respectively.

A significant difference among the treatment combinations for moisture content in ragi grain and malt has been observed. Among ragi grain variety AVT 1 was at par with AVT 5 and JNR 852 while that in case of ragi malt variety AVT 1 was at par with JNR 981 and AVT 5.

Table 4.2.1 Moisture content of ragi grain and malt

S. No	Moisture content (%)		
	Varieties	**Ragi Grain**	**Ragi Malt**
1.	AVT 1	9.90	9.57
2.	AVT 5	9.69	8.96
3.	VL 352 (NC)	9.25	8.36
4.	JNR 852	9.38	8.79
5.	JNR 981	9.56	9.28
6.	JNR 1008	8.91	8.32
	C.D. at 5%	0.122	0.274
	SEm ±	0.035	0.078

4.2.2 Protein content in different cultivars of ragi grain and malt

The Protein content in different cultivars of ragi is given in Table 4.2.2. It varies from 5.90 to 7.53 percent. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Variety AVT 5 had the highest protein content of all other which was at par with varieties AVT 1, VL 352 (NC) and JNR 852. Findings presented through table 4.2.2 reveals that protein content in ragi malt flour of six varieties varies from 4.57 to 8.34 per cent. Again variety AVT 5 has shown highest protein content and is found to be superior to all, except AVT 1.

Table 4.2.2 Protein content of ragi grain and malt

S. No.	Moisture content (%)		
	Varieties	**Ragi Grain**	**Ragi Malt**
1.	AVT 1	7.40	7.79
2.	AVT 5	7.53	8.34
3.	VL 352 (NC)	7.26	6.85
4.	JNR 852	7.09	5.70
5.	JNR 981	5.90	4.99
6.	JNR 1008	6.78	4.57
	C.D. at 5%	0.149	0.144
	SEm ±	0.042	0.041

4.2.3 Fat content in different cultivars of ragi grain and malt

The fat content of different ragi varieties are given in Table 4.2.3. An appraisal of the table indicates that the total fat content varies from 1.16 to 2.49 percent. A ragi cultivar VL 352 (NC) has got the highest, whereas JNR 981and AVT 5 have got the lowest. The variety VL 352 (NC) has got the highest fat content and is significantly superior to AVT 1, AVT 5 and JNR 981, however, it is at par with JNR 1008 and JNR 852.

Ragi malts developed from the six varieties of ragi are found to contain total fat content ranging from 1.13 to 2.25 percent as shown through the same table. The ragi variety JNR 1008 has got the significantly higher content of total fat over all the other varieties except VL 352 (NC) which it is at par with, while variety JNR 981 recorded the lowest fat content.

Table 4.2.3 Fat content in ragi grain and malt

S. No.	Varieties Ragi Malt	Fat (%)	
		Ragi Grain	Ragi Malt
1.	AVT 1	1.40	1.32
2.	AVT 5	1.40	1.28
3.	VL 352 (NC)	2.49	2.17
4.	JNR 852	2.18	1.30
5.	JNR 981	1.16	1.13
6.	JNR 1008	2.34	2.25
	C.D. at 5%	0.078	0.074
	SEm ±	0.022	0.021

4.2.4 Carbohydrate content in different cultivars of ragi grain and malt

The mean values of total carbohydrate content in ragi grain, as evident from Table 4.2.4, varies from 68.77 to 86.20 percent. The variety JNR 852 has got the highest quantity of total carbohydrate, whereas AVT 5 has the lowest value. A significant variation was obtained among these varieties and JNR 852 was at par with varieties JNR 1008 and JNR 981.

A cursory review of table 4.2.4 reveals that the total carbohydrate content in ragi malt flour varied from a value of 69.49 to 82.35. The malt flour produced from the ragi variety JNR 852 has got the highest total carbohydrate content (82.35%) which is superior over variety VL 352 (NC) and JNR 1008 while with 69.49% the lowest was found in variety AVT 5.

Table 4.2.4 Carbohydrate content of ragi grain and malt

S. No.	Carbohydrate content (%)		
	Varieties	**Ragi Grain**	**Ragi Malt**
1.	AVT 1	70.92	70.25
2.	AVT 5	68.77	69.49
3.	VL 352 (NC)	77.65	78.32
4.	JNR 852	86.20	82.35
5.	JNR 981	80.20	80.54
6.	JNR 1008	82.70	76.82
	C.D. at 5%	0.101	0.091
	SEm ±	0.029	0.026

4.2.5 Ash content in different cultivars of ragi grain and malt

Table 4.2.5 comprises the results of total ash content in ragi grain of different ragi varieties. As evident from the table, the ash content varies from 4.94 to 6.19. The variety AVT 5 has got the highest content of ash, whereas JNR 852 contained the lowest amount of it. The variety AVT 5 with the highest ash was found to be superior over all the other varieties.

The perusal of the same table also indicates the ash content of malts from all the six varieties of ragi. It varies from 4.73 to 5.80 percent. Variety VL 352 (NC) has got the highest ash content, which is significantly higher than all the varieties. Variety VL 352 (NC) and AVT 5 are having sugar content at par which is significantly higher than all other varieties.

Table 4.2.5 Ash content of ragi grain and malt

S. No.	Varieties	Ash (%)	
		Ragi Grain	Ragi Malt
1.	AVT 1	5.20	4.74
2.	AVT 5	6.19	5.70
3.	VL 352 (NC)	5.02	5.80
4.	JNR 852	4.94	4.73
5.	JNR 981	5.92	5.47
6.	JNR 1008	6.09	4.98
	C.D. at 5%	0.190	0.223
	SEm ±	0.054	0.063

4.2.6 Crude fibre content in different cultivars of ragi grain and malt

The crude fibre content in different cultivars of ragi is given in Table 4.2.6. It varies from 3.17 to 3.60 percent. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Variety VL 352 (NC) had the highest crude fibre content of all other which was at par with varieties AVT 5, and AVT 1.

Findings presented through Table 4.2.6 reveals that crude fibre content in ragi malt flour of six varieties varies from 1.97 to 2.47 percent. Again variety VL 352 (NC) has shown highest fibre content which was at par with AVT 5 and is found to be superior to all.

Table 4.2.6 Crude fibre content in different cultivars of ragi grain and malt

S. No.	Varieties	Crude fibre content	
		Ragi Grain	Ragi Malt
1.	AVT 1	3.46	2.17
2.	AVT 5	3.54	2.33
3.	VL 352 (NC)	3.60	2.47
4.	JNR 852	3.36	2.08
5.	JNR 981	3.41	2.11
6.	JNR 1008	3.17	1.97
	C.D. at 5%	0.159	0.130
	SEm ±	0.045	0.037

4.2.7 Total sugar content in different cultivars of ragi grain and malt

Table 4.2.7 comprises the results of total sugar content in ragi grain of different ragi varieties. As evident from the table, the total sugar content varies from 3.23 to 4.12. The variety VL 352 (NC) has got the highest content of total sugar, whereas JNR 1000 contained the lowest amount of it. The variety VL 352 (NC) with the highest total sugar was found to be superior over all the other varieties.

The perusal of the same table also indicates the total sugar content of malts from all the six varieties of ragi. It varies from 2.80 to 3.46 percent. A variety AVT 5 has got the highest free soluble sugar content (3.46 mg/100 g), which is significantly higher than all the varieties. Variety VL 352 (NC) and AVT 1 are having sugar content at par which is significantly lower all other varieties.

Table 4.2.7 Total sugar content of ragi grain and malt

S. No.	Varieties	Total sugar Content	
		Ragi Grain	Ragi Malt
1.	AVT 1	3.42	3.05
2.	AVT 5	3.91	3.46
3.	VL 352 (NC)	4.12	3.44
4.	JNR 852	3.32	2.90
5.	JNR 981	3.98	3.04
6.	JNR 1008	3.23	2.80
	C.D. at 5%	0.162	0.175
	SEm ±	0.046	0.050

4.2.7.1 Reducing & Non-reducing sugar content in different cultivars of ragi grain and malt

Table 4.2.7.1 comprises the results of reducing and non-reducing sugar contents in different ragi varieties. It indicates that reducing sugar content varies from 0.78 to 2.27 mg/ 100 g. Ragi variety VL 352 (NC) has got significantly higher amount of reducing sugar content In comparison to all other ragi varieties. The non-reducing sugar content of all six varieties of ragi grain ranges from 1.11 to 3.20 mg/100 g (Table 4.2.4). The ragi variety JNR 981 contains the highest amount of non-reducing sugar and it also varies significantly to all other varieties of ragi. The variety JNR 1008 is having the lowest amount of non-reducing sugar content which is significantly lower than all other varieties.

A cursory review of Table 4.2.7.1 reveals the results of reducing and non-reducing sugars present in ragi malt. Reducing sugar content in ragi malt varies from 0.63 to 1.91 mg/100 g. Ragi malt from VL 352 (NC) has got maximum content of reducing sugar (1.91 mg/100 g) which is significantly superior to all other ragi varieties except JNR 1008. The malt from JNR 981 ragi variety has got minimum reducing sugar and it is significantly lower to the malts of all other varieties of ragi. The non-reducing sugar in ragi malt from all the varieties varies from 0.94 to 2.41 mg/100 g. statistically no significant variation has been obtained among all the varieties.

Table 4.2.7.1 Reducing & Non-reducing sugar content of ragi grain and malt

S. No.	Varieties	Reducing sugar		Non-reducing sugar	
		Ragi Grain	Ragi Malt	Ragi Grain	Ragi Malt
1.	AVT 1	1.26	1.12	2.16	1.93
2.	AVT 5	1.93	1.68	1.98	1.77
3.	VL 352 (NC)	2.27	1.91	1.79	1.55
4.	JNR 852	1.10	0.94	2.22	1.96
5.	JNR 981	0.78	0.63	3.20	2.41
6.	JNR 1008	2.12	1.86	1.11	0.94
C.D. at 5%		0.072	0.138	0.088	0.154
SEm ±		0.020	0.039	0.025	0.044

4.2.8 In-vitro Starch Digestibility in different cultivars of ragi grain and malt

A cursory review of Table 4.2.8 reveals the results of In-vitro Starch Digestibility in ragi grain. IVSD content in ragi grain varies from 3.11 to 4.94 mg/100 g. Ragi grain from AVT 5 has got maximum content of IVSD (4.94 mg/100 g) which is significantly superior to all other ragi varieties. The grain from JNR 981 ragi variety has got minimum IVSD and it is significantly lower to the grains of all other varieties of ragi.

The perusal of the same table also indicates the IVSD content of malts from all the six varieties of ragi. It varies from 3.54 to 4.53 percent. Ragi malt from variety JNR 1008 has got the highest IVSD content, which is significantly higher than all the varieties. Variety JNR 852 and AVT 5 are having IVSD content at par which is significantly higher than all other varieties.

Table 4.2.8 In-vitro Starch Digestibility in different cultivars of ragi grain and malt

S. No.	Varieties	IVSD content	
		Ragi Grain	Ragi Malt
1.	AVT 1	3.35	3.61
2.	AVT 5	4.94	4.44
3.	VL 352 (NC)	3.91	4.31
4.	JNR 852	4.17	4.47
5.	JNR 981	3.11	3.54
6.	JNR 1008	4.25	4.53
C.D. at 5%		0.325	0.210
SEm ±		0.092	0.060

4.2.9 Mineral nutrient content in different cultivars of ragi grain and malt

4.2.9.1 Calcium content

The calcium content in different cultivars of ragi is given in Table 4.2.9.1. It varies from 503.49 to 552.06 mg/100g. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Variety VL 352 (NC) had the highest calcium content of all other which was at par with variety JNR 1008.

Findings presented through Table 4.2.9.1 reveals that calcium content in ragi malt flour of six varieties varies from 398.63 to 501.14 mg/100g. Again variety VL 352 (NC) has shown highest fibre content which was at par with JNR 1008 and is found to be superior to all.

Table 4.2.9.1 Calcium content (mg/100g) in ragi grain and malt

S. No.	Varieties	Calcium (mg/100g)	
		Ragi Grain	Ragi Malt
1.	AVT 1	515.34	409.91
2.	AVT 5	503.49	398.63
3.	VL 352 (NC)	552.06	501.14
4.	JNR 852	505.60	447.66
5.	JNR 981	526.66	474.13
6.	JNR 1008	542.46	498.33
C.D. at 5%		1.055	1.263
SEm ±		0.299	0.358

4.2.9.2 Phosphorous content

A cursory review of Table 4.2.9.2 reveals the results of Phosphorous content in ragi grain. Phosphorous content in ragi grain varies from 303.34 to 322.42 mg/100 g. Ragi grain from VL 352 (NC) has got maximum phosphorous content which is at par to JNR 981 and is significantly superior to all other ragi varieties. The grain from AVT 5 ragi variety has got minimum Phosphorous content and it is significantly lower to the grains of all other varieties of ragi.

The perusal of the same table also indicates the Phosphorous content of malts from all the six varieties of ragi. It varies from 291.50 to 315.61 mg/100g. Ragi malt from variety VL 352 (NC) has got the highest Phosphorous content, which is at par with JNR 852 and JNR 1008 and significantly higher than rest of the varieties. Variety AVT 5 have the lowest Phosphorous content which is at par with variety AVT 1 and is significantly lower than rest other varieties.

Table 4.2.9.2 Phosphorous content (mg/100g) in ragi grain and malt

S. No.	Varieties	Phosphorous (mg/100g)	
		Ragi Grain	**Ragi Malt**
1.	AVT 1	311.06	298.24
2.	AVT 5	303.34	291.50
3.	VL 352 (NC)	322.43	315.61
4.	JNR 852	310.30	311.60
5.	JNR 981	319.20	304.10
6.	JNR 1008	316.60	314.26
C.D. at 5%		1.001	0.963
SEm ±		0.284	0.273

4.2.9.3 Copper content (ppm)

The Copper content in different cultivars of ragi grain is given in Table 4.2.9.3. It varies from 0.60 to 0.95 ppm. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Variety VL 352 (NC) had the highest Copper content of all other varieties; it was found at par with variety AVT 1. Variety JNR 1008 had lowest copper content of all.

Findings presented through Table 4.2.9.3 reveals that copper content in ragi malt flour of six varieties varies from 0.73 to 0.90 ppm. Again variety VL 352 (NC) has shown highest copper content which was at par with AVT 1 and was found to be superior to all while variety JNR 852 was found containing least copper content (0.73 ppm) in comparison to rest of the varieties.

Table 4.2.9.3 Copper Content (ppm) in ragi grain and malt

S. No.	Varieties	Copper (ppm)	
		Ragi Grain	Ragi Malt
1.	AVT 1	0.68	0.87
2.	AVT 5	0.90	0.75
3.	VL 352 (NC)	0.95	0.90
4.	JNR 852	0.93	0.73
5.	JNR 981	0.78	0.81
6.	JNR 1008	0.60	0.79
C.D. at 5%		0.118	0.118
SEm ±		0.033	0.033

4.2.9.4 Iron Content (ppm)

A cursory review of Table 4.2.9.4 reveals the results of iron content in ragi grain. Iron content in ragi grain varies from 3.11 to 3.69 ppm. Ragi grain from VL 352 (NC) has got maximum iron content which is significantly superior to all other ragi varieties. The grain from JNR 981 ragi variety has got minimum iron content and it is significantly lower to the grains of all other varieties of ragi.

Findings presented through Table 4.2.9.4 reveals that iron content in ragi malt flour of six varieties ranges from 2.85 to 3.19 ppm. Again variety VL 352 (NC) has shown highest iron content which was at par with AVT 1 and was found to be superior to all while variety JNR 981 was found containing least iron content (2.85 ppm) in comparison to rest of the varieties.

Table 4.2.9.4 Iron Content (ppm) in ragi grain and malt

S. No.	Varieties		Iron (ppm)	
			Ragi Grain	Ragi Malt
1.	AVT 1	3.43	3.11	
2.	AVT 5	3.37	3.04	
3.	VL 352 (NC)	3.69	3.19	
4.	JNR 852	3.16	2.89	
5.	JNR 981	3.11	2.85	
6.	JNR 1008	3.26	2.91	
C.D. at 5%		0.097	0.110	
SEm ±		0.027	0.031	

4.2.9.5 Zinc Content

The zinc content in different cultivars of ragi grain is given in Table 4.2.9.5. It varies from 1.89 to 2.29 ppm. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Variety AVT 5 had the highest zinc content from all other varieties; it was found at par with variety AVT 1. Variety JNR 1008 had lowest zinc content of all.

The perusal of the same table also indicates the zinc content of malts from all the six varieties of ragi. It varies from 1.65 to 1.97 ppm. Ragi malt from variety AVT 5 has got the highest zinc content, which is at par with VL 352 (NC) and significantly higher than rest of the varieties. Ragi malt from variety JNR 1008 has the lowest zinc content which is significantly lower than rest other varieties.

Table 4.2.9.5 Zinc Content (ppm) in ragi grain and malt

S. No.	Varieties	Zinc (ppm)	
		Ragi Grain	Ragi Malt
1.	AVT 1	2.11	1.89
2.	AVT 5	2.29	1.97
3.	VL 352 (NC)	2.16	1.91
4.	JNR 852	2.04	1.87
5.	JNR 981	1.97	1.76
6.	JNR 1008	1.89	1.65
C.D. at 5%		0.225	0.122
SEm ±		0.06	0.035

4.2.9.6 Manganese content

Findings presented through Table 4.2.9.6 reveals that manganese content in ragi malt flour of six varieties varies from 37.74 to 56.61 ppm. Variety AVT 1 shows highest manganese content which was at par with VL 352 (NC) and was found to be superior to all while variety JNR 1008 was found containing least manganese content (38.79 ppm) in comparison to rest of the varieties.

Ragi malts developed from the six varieties of ragi are found to contain manganese content ranging from 37.95 to 52.16 ppm as shown through the table. The ragi variety AVT 1 has got significantly higher manganese content over all the other varieties, while variety JNR 1008 recorded the lowest manganese content which is at par with JNR 981.

Table 4.2.9.6 Manganese Content (ppm) in ragi grain and malt

S. No.	Varieties	Manganese (ppm)	
		Ragi Grain	Ragi Malt
1.	AVT 1	56.61	52.16
2.	AVT 5	48.66	41.81
3.	VL 352 (NC)	55.87	44.40
4.	JNR 852	37.74	41.44
5.	JNR 981	44.77	39.56
6.	JNR 1008	38.79	37.95
C.D. at 5%		0.837	1.045
SEm ±		0.237	0.296

4.3 Spray dried Ragi malt: cow milk powder

4.3.1 Physical and functional properties of spray dried Ragi malt: cow milk powder

4.3.1.1 Bulk Density and Solubility Index

The bulk density (g/ml) and solubility index value of Ragi malt: cow milk powder ranges from 0.23 to 0.28 g/ml and 1.7 to 2.4 respectively (Table 4.3.1.1). The maximum value of bulk density was observed at Exp. No. 09 while it was minimum at Exp. No. 01. The minimum and maximum solubility index of Ragi malt: cow milk powder was obtained at experiment 05 and 09 respectively.

The temperature and pressure have linear significant effect on bulk density and solubility index. The interaction of slurry concentration and pressure of spray drying was also significant for solubility index of beverage powder.

4.3.1.2 Yield and recovery of Ragi malt: cow milk spray dried powder

The finding presented in table 4.3.1.1 shows that the minimum amount of Ragi malt: cow milk spray dried powder (100 gm) was obtained at inlet temperature 190±5^{0}C and out let temperature 85±5^{0}C. i.e., Exp. No. 09 and maximum (180 gm) at inlet temperature 205±5^{0}C i.e., Exp. No. 09 and outlet temperature 75±5^{0}C and the pressure was 3.5kg/cm^2 respectively.

4.3.1.3 Protein, fat, carbohydrate and total ash content in spray dried Ragi malt: cow milk powder

The finding presented in Table 4.3.1.3 reveals that spray dried Ragi malt: cow milk powder contains Protein (4.38 to 5.21%), fat (3.52 to 3.75%) and Carbohydrate (11.6 to 19.9%). The difference in fat, protein, and carbohydrate, in different experimental product were due to variation of different component used for preparation of product. The minimum and maximum Protein, fat, and Carbohydrate of spray dried Ragi malt: cow milk powder was seen in experiment no 1, 3, 1 and 9, 8, 9 respectively.

4.3.1.4 Sensory quality attributes score of spray dried Ragi malt: cow milk powder

The results of hedonic rating test for different sensory attributes are given in Table 4.3.1.4. The minimum and maximum score for color, flavor, taste and overall acceptability varied from 7.1 to 7.9, 4.7 to 7.4, 6.0 to 7.1 and 5.9 to 7.4 respectively. The general perception about the product was an acceptable by consumer.

Table 4.3.1.1 Physical and functional properties of spray dried Ragi malt: cow milk powder

Expt. No.	Treatment Combinations	Bulk density (g/ml)	Solubility index	Yield and recovery
1.	S_1T_1	0.23	2	40
2.	S_1T_2	0.26	2	60
3.	S_1T_3	0.24	2.1	110
4.	S_2T_1	0.25	1.8	40
5.	S_2T_2	0.26	1.7	70
6.	S_2T_3	0.26	1.9	80
7.	S_3T_1	0.27	1.9	160
8.	S_3T_2	0.27	2.3	130
9.	S_3T_3	0.28	2.4	180

Table 4.3.1.2 Chemical composition of spray dried Ragi malt: cow milk powder

Expt. No.	Treatment Combinations	Protein %	Fat %	Carbohydrate %
1	S_1T_1	4.38	3.55	11.6
2	S_1T_2	4.40	3.58	11.8
3	S_1T_3	4.45	3.52	12.1
4	S_2T_1	4.77	3.62	16.3
5	S_2T_2	4.80	3.65	16.8
6	S_2T_3	4.85	3.65	17.3
7	S_3T_1	5.16	3.70	18.8
8	S_3T_2	5.19	3.75	19.4
9	S_3T_3	5.21	3.73	19.9

Table 4.3.1.3 Sensory quality attributes of spray dried Ragi malt: cow milk powder

Expt No.	Treatment Combinations	Color (score)	Flavor (score)	Taste	Overall acceptability (score)
1	S_1T_1	7.1	4.7	6.0	5.9
2	S_1T_2	7.1	4.9	6.0	6.0
3	S_1T_3	7.2	5.3	6.2	6.2
4	S_2T_1	7.2	5.5	6.5	6.4
5	S_2T_2	7.3	5.7	6.5	6.5
6	S_2T_3	7.3	5.9	6.6	6.6
7	S_3T_1	7.6	6.9	6.9	7.1
8	S_3T_2	7.8	7.4	6.9	7.2
9	S_3T_3	7.9	7.3	7.0	7.4

DISCUSSION

Biochemical evaluation new cultivars of ragi and their utilization for development of ready to drink malted milk products is an area of current research interest because of nutritional awareness of consumer and changing demographics. This chapter deals with the justification of the findings obtained in the experiments related to evaluation of varieties for above purpose. The results have been explained with the help of reported values of various parameters given by different researchers and they are discussed as under.

5.1 Physical attributes

A perusal of Table 4.1, indicates that 1000-seed weight in different varieties of ragi ranged from 2.36 g to 3.20 g. The statistical analysis indicated a significant variation is present in the 1000-seed weight between the varieties. No reports are available to corroborate the present findings except the report from Winton and Winton (1932) in their study of structure of various foods. They have reported the seed weight of ragi to be 300 to 450 seeds/g which is similar to the present finding.

Results as summarized in Table 4.1 indicated a range of volume of seeds to be 2.33 to 2.80 cc for 1000-seeds in six varieties of ragi. Ragi variety VL 352 (NC) with maximum 1000-grain weight again ranked highest in 1000-seed volume. No reports are available in the literature to confirm the present finding.

The seed density of various ragi varieties varied from 1.01 to 1.23 as evident from Table 4.1. The variety JNR 1008 with heaviest grain is significantly superior to all other varieties, whereas variety JNR 981 is significantly lighter to all the varieties. For want of published reports, the present finding could not be discussed.

Ragi seeds have excellent malting quality with considerable industrial potential for producing malt-based foods and beverages. The malting capacity of the seeds depends directly on the germination percentage of the seeds. It is in this context, the germination percentage of all the varieties of ragi was investigated.

As given in Table 4.1, the mean values of germination percentage varied from 85.33 to 99.66%. Ragi variety AVT 5 had highest viability, whereas variety JNR 852 recorded the poorest. Incidentally, the varieties which fared well in germination belongs to a group of brown seed coat color and the varieties with lower germination percentage falls in the group of white seed coat color. The results reported by Malleshi and Desikachar (1979) from their study of malting quality of ragi varieties are in conformity with the present findings.

5.2 Biochemical attributes

5.2.1 Moisture content

Moisture content in the different varieties of ragi grain varies from a value of 8.91 to 9.90 percent, whereas that of Ragi malt varied from 8.32 to 9.57 percent (Table 4.2.1). The highest and lowest contents of moisture can be seen in variety AVT 1 and JNR1008 varieties of ragi grain as well as in ragi malt respectively.

5.2.2 Protein content

In the present investigation, the protein content in the different varieties of ragi varied from 5.90 to 7.53 percent (Table 4.2.2). The protein content of ragi grain has been variously reported to range between 7 and 10 per cent (Kadkol and Swaminathan, 1954 and Johnson and Raymond, 1964), which seems to be little higher than the present findings. However, protein content as low as 5.85 per cent (Adrian and Jaquot, 1964) and as high as 14.2 per cent (Iyengar et al., 1945-46) have been reported.

Results given in Table 4.2.2 also indicated the range of protein content in ragi malt from various varieties of ragi. The protein content varied from 4.57 to 8.34 percent and statistically significant variation was also observed to be present between the malt from different varieties. On comparing the protein content in the ragi varieties with the protein content in the respective ragi malt flour, a general decrease was observed as a result of malting processes. This decrease in the malt flour seems to be because of losses of water soluble protein when the grains were subjected to steeping in water for 24 hrs for making malt. The present findings are well corroborated by the study of Malleshi and Desi-kachar (1979).

5.2.3 Fat content

The results of fat content in ragi grain and malt are summarized in Table 4.2.3. The fat content in different varieties of ragi ranged from 1.16 to 2.57 per cent and significant variation existed between the varieties as evident from the C.D. values given at the bottom of the table. The present findings can well be justified with the reported values given by various authors (Kadkol and Swaminathan, 1954 and Mahadevappa and Raina, 1978).

A cursory review of the above table also indicated a wide variation in the fat contents of ragi malt flour developed from different ragi varieties. The fat content ranged from 1.40 to 2.49 per cent and significant variation between the malt from different varieties also existed as evident from the C.D. values. A general decrease in the fat content was observed as a result of malting process. The present findings can well be corroborated by the reported values of fat content in malted weaning food based on ragi (Malleshi and Desikachar, 1981).

5.2.4 Total carbohydrate

An appraisal of the table 4.2.4 indicated the range of carbohydrate in various ragi varieties varied from 70.92 to 86.20 per cent and no significant variation was observed between the varieties with respect to carbohydrate content. The present findings are well corroborated by the reports of various authors (Moruze, 1931; Kadkol and Swaminathan, 1954; Wankhede et al., 1979 and Pore and Nagar, 1979). These authors reported the carbohydrate content of indigenous and hybrid ragi varieties from 63 to 73.8 per cent.

The carbohydrate content in the malt developed from various varieties varied from 70.25 to 82.35 per cent as indicated by the above table. It clearly indicated a significant variation in the malt of various ragi varieties. Malleshi and Desikachar (1981) also reported the same results in their study of formulation of a weaning food with ragi malt.

5.2.5 Ash content

Table 4.2.5 comprises the results of total ash content in ragi grain of different ragi varieties. As evident from the table, the ash content varies from 5.02 to 6.19. The perusal of the same table also indicates the ash content of malts from all the six varieties of ragi. It varies from 4.73 to 5.80 percent.

5.2.6 Crude fibre content

The crude fibre content in different cultivars of ragi is given in Table 4.2.6. It varies from 3.17 to 3.60 percent. A perusal of table shows that significant difference was found among all the six varieties of ragi grain. Findings presented through same table reveals that crude fibre content in ragi malt flour of six varieties varies from 1.97 to 2.47 percent.

5.2.7 Total sugar

The total sugar which is imparts product's sweetness, were analyzed in the ragi grain and malt. The results are summarized in Table 4.2.7, was made to depict the variation present among the varieties.

Ragi grain from various varieties contained the total sugar which ranged from 3.23 to 4.02 mg/100 g, and a significant variation was observed among the varieties. Reports on the total sugars are also available in the literature. Moruzi (1931) reported the soluble sugars similar to the present findings. Wankhede et al. (1979) also analysed the carbohydrate composition and reported around 6 per cent of soluble sugar.

Table 4.2.7 depicts the total sugar content in the ragi malt of different ragi varieties, which varied from 2.80 to 3.46 mg/100 g of malt flour. The table revealed a significant variation among the malt flour of different varieties. The present findings could not get support in absence of the literature values. In general, the malting processes increased the total sugar due to hydrolytic enzymes induced during malting processes. This increase in total sugar in the malt flour is evident by the taste which is comparatively sweeter.

5.2.7.1 Reducing and non-reducing sugars

The total sugars were further fractionated to make the variation present, if any, in different varieties of ragi and their products more evident. The reducing and non-reducing sugars were also analyzed and the results are presented in Table 4.2.7.1

Reducing sugar content in different varieties of ragi grains ranged from 0.78 to 2.27 mg/100 g and the variation among the varieties came up to the level of significance. The results reported by Moruzi (1931) are in agreement with the present findings.

Since the malting process induces the breakdown of the polysaccharides and thereby increases the total reducing and non-reducing sugar, hence, an idea of the free reducing and non-reducing sugars which were present in the grain cannot be ascertained. Therefore, instead of analyzing the free reducing and non-reducing sugars, an assay of the activity of amylase enzyme was undertaken.

The free non-reducing sugar content, as given in the above table ranged from 1.11 to 3.20 mg/100 g of ragi grain. Significant variation among the varieties became evident on statistical analysis.

5.2.8 In-vitro Starch Digestibility

A cursory review of Table 4.2.8 reveals the results of In-vitro Starch Digestibility in ragi grain. IVSD content in ragi grain varies from 3.11 to 4.94 mg/100 g. Ragi grain from AVT 5 has got maximum content of IVSD and is significantly superior to all other ragi varieties. The perusal of the same table also indicates the IVSD content of malts from all the six varieties of ragi. It varies from 3.54 to 4.53 percent. Ragi malt from variety JNR 1008 has got the highest IVSD content.

5.2.9 Mineral content

Mineral composition of the different ragi varieties was worked out to assess the variation present between the different varieties. Mineral content of ragi grain and malt was also analyzed to evaluate the effect of these processes on the mineral composition of the products.

5.2.9.1 Calcium content

The calcium content in the ragi grain of different varieties ranged from 503.49 to 552.06 mg/100 g as evident from Table 4.2.9.1. The C.D. values in the table clearly indicated a significant variation between the varieties. Similar findings have been reported by various workers (Kadkol and Swaminathan, 1954; Girija et al., 1971 and Balakrishnarao and Mithyantha, 1973). However, Kempanna et al. (1968) reported very high calcium content (930 mg/100 g). Pore and Magar (1979) also reported that hybrid varieties are rich source of calcium.

Ragi malt flour from different varieties contained calcium content from 398.63 to 501.14 mg/100 g. A significant variation in the malt from different varieties has been observed. Ragi malting processes reduced the calcium content invariably in the malt from different varieties. The major contribution in the losses of calcium content in malt is made by the removal of husk from the malt, as the husk is known to contain around 49 per cent of the total calcium present in the grain. Some losses of calcium during malting can be assigned to the leaching losses during steeping stage. Malleshi and Desikachar (1981) reported the calcium content in malted weaning food based on ragi to be 240 mg/100 g which is far below to the above.

5.2.9.2 Phosphorus content

The results of the phosphorus content in the ragi grain and malt have been summarized in Table 4.2.9.2.

The phosphorus content in the ragi grain from different varieties ranged from 303.34 to 322.42 mg/100 g as evident from the table 4.2.9.2. The present findings are well documented by the reports of Giri (1940) and Aykroid et al. (1963).

Ragi malt from different varieties is having phosphorus content ranged from 304 to 349.60 mg/100 g. A significant variation was observed between the malts from different varieties as seen from the C.D. values. Again, Malleshi and Desikachar (1981) reported a low value of phosphorus in the malted weaning food based on ragi and the possible reason for this being the inclusion of white-seeded ragi varieties with low phosphorus content for the formulation of above baby food.

Micronutrient composition of the different ragi varieties was worked out to assess the variation present between the different varieties. Micronutrient content of ragi grain and malt was also analyzed to evaluate the effect of these processes on the micronutrient composition of the products.

5.2.9.3 Copper content

The copper content in ragi grain ranged from 0.60 to 0.95 ppm as given in Table 4.2.9.3, which is in agreement with the reported values (Busson, 1965). A significant variation was observed as indicated by the C.D. values.

The copper content in ragi malt ranged from 0.73 to 0.90 ppm in the malts flour of different ragi varieties (table 4.3.9.3). Non-significant variation was observed in copper content between the malts from various varieties.

5.2.9.4 Iron content

Table 4.2.9.4 comprises the results of iron content in ragi grain and malt. An appraisal of the above indicated a range of 3.11 to 3.69 ppm of iron in different varieties of ragi. Statistically significant variation was observed between the varieties as indicated by the C.D. values. Kadkol and Swami-nathan (1954) reported the similar results. However, a wide variation has been reported by various authors (Aykroyd et al., 1963; Deosthale et al., 1970 and Balakrishnarao and Mithyantha, 1973).

The iron content in the malts of different ragi varities varied from 2.85 to 3.19 ppm. The C.D values clearly indicated significant variation between the malts from various varieties. In general, with few exceptions the malting process increased the iron content in the product.

5.2.9.5 Zinc content

The zinc content in ragi grain varied from 1.89 to 2.29 ppm (Table 4.2.9.5). Busson (1965) also reported the zinc content in ragi grain as 15 ppm. A non-significant variation was found between the varieties.

Ragi malt from different varieties contained zinc content from 1.65 to 1.97 ppm (Table 4.2.10.10). A significant variation was observed between the malts from different varieties. The malting process in general reduced the zinc content.

5.2.9.6 Manganese content

The manganese content, as given in Table 4.2.9.6, ranged from 37.74 to 56.61 ppm in the grains of different varieties of ragi, with significant variation, as evident from the C.D. values. Busson (1965) reported 19 ppm of Mn in the ragi grain which is well in agreement with the above results.

The Mn content in ragi malt varied from 37.95 to 52.16 with significant variation (Table 4.2.10.7). No consistent trend was observed in Mn content of ragi malt flour as result of malting process.

5.3 Spray dried Ragi malt: cow milk powder

5.3.1 Physical and functional properties of spray dried Ragi malt: cow milk powder

5.3.1.1Bulk density and Solubility Index

The bulk density (g/ml) and solubility index value of Ragi malt: cow milk powder ranges from 0.23 to 0.28 g/ml and 1.7 to 2.4 respectively (Table

The results of factorial experiment plan conducted for production of spray dried Ragi malt: cow milk powder indicates the possibilities of production of a potential product for community. The mean value of bulk density (g/ml) and solubility index value of powder were found to be 0.23 to 0.28 g/ml and 1.7 to 2.4 respectively (Table 4.2.1.1). The effect of conditioned on quality attributes shows that bulk density (g/ml) and solubility index value of spray dried powder markedly influence by temperature of drying. The increase in temperature during spray drying reduces the moisture content, but the optimum moisture content in the product is desired. The present findings are in conformity with reported value of Sharma, (2000).

4.2.1.2 Yield and recovery of Ragi malt: cow milk spray dried powder

The yield of spray dried powder varies from 100 – 180 g at inlet temperature of 190±5^{0}C and 205±5^{0}C respectively. The pressure of 3.5 kg/cm^2 was maintained in whole experiment. The present findings are in conformity with reported value of Kumar (2006) and Jatav (2009).

4.2.1.3 Protein, fat, carbohydrate and total ash content in spray dried Ragi malt: cow milk powder

The spray dried malted milk powder contains Protein (4.38 to 5.21%), fat (3.52 to 3.75%) and Carbohydrate (11.6 to 19.9%). The difference in fat, protein, and carbohydrate, in different experimental product were due to variation of different component used for preparation of product. The similar findings were also reported by Sharma (2000) and kumar (2006).

4.2.1.4 Sensory quality attributes score of spray dried Ragi malt: cow milk powder

The results of hedonic rating test for different sensory attributes viz color, flavor, taste and overall acceptability varied from 7.1 to 7.9, 4.7 to 7.4, 6.0 to 7.1 and 5.9 to 7.4 respectively. The general perception about the product was observed to be acceptable by consumer. The colour and appearance of powder varies from light creamish with fine particles to yellowish with fine particles. The combination of higher temperature range treatment, exhibit yellowish colour product. The fine particle appearance of is due to increase in pressure during spray drying. This is due to the increase in pressure helps to form the mist which the water molecule removes rapidly and do not allow to form agglomerate of particles. The findings are in conformity with the reported of De (1985) and Sharma (2000).

In a nutshell it is deduced from the findings of present investigation and their justification that Ragi malt can be can be blended with cow milk for production of spray dried ragi malt :cow milk power. The best product upon sensory quality can be utilized for real value added spray dried product for domestic and commercial application.

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

In southern India nutritious ragi grains are germinated at home scale to prepare malted weaning food for infants. Recently many high yielding varieties of ragi have been released for cultivation. The information about their biochemical composition and suitability for new malted product characteristics is not available in literature. The information on proper blending ratio of malted flour of finger millet: cow milk, optimum spray drying conditions for development of malted milk powder are also not available in literature to develop commercially viable technology. Therefore the present investigation on “Development and evaluation of ready to drink malted milk powder from Ragi (*Eleucine coracana)”*has been planned.

The results obtained from different experiments are summarized as under:

1. The physical attributes viz., 1000-seed weight, 1000-seed volume, density and germination percentage varies from 2.78 to 3.20 g, 2.33 to 2.80 cc, 1.01 to 1.23 and 85.33 to 99.66% respectively. On statistical analysis, significant variation was observed between the different varieties with respect to 1000-seed weight, 1000-seed volume, seed density and the germination percentage.
2. The biochemical attributes viz moisture, crude protein fat, Ash content and total carbohydrate among six cultivars of ragi varied from 8.91 to 9.90%, 4.94 to 7.53%, 1.16 to 2.49%, 5.02 to 6.19 and, 68.77 to 86.20% respectively
3. The cultivars were also rich in crude fibre (3.17 to 3.60), total sugar (3.23 to 4.02 mg/100 g), reducing sugar (0.78 to 2.27 mg/100 g), non-reducing sugar (0.63 to 1.91 mg/100 g), IVSD (3.11 to 4.94 mg/100 g) respectively.
4. The mineral content, expressed as mg/100 g in the grain of different varieties of ragi were found to have a range: Ca (503.49 to 552.06 mg/100g), P (303.34 to 322.42 mg/100 g), Mn (37.74 to 56.61 ppm), Cu (0.60 to 0.95 ppm), Zn (1.89 to 2.29 ppm) and Fe (3.11 to 3.69 ppm).

5. The ragi malt flour from different varieties were also analyzed for the different biochemical indices and found to contain moisture (8.32 to 9.57%) protein (4.57 to 8.34%), total carbohydrate (70.25 to 82.35%), Ash (1.13 to 2.25%), Fibre content (1.97 to 2.47%), total sugar (2.80 to 3.46 mg/100 g), reducing sugar (0.63 to 1.91 mg/100 g, non-reducing sugar (0.94 to 2.41 mg/100 g), IVSD (3.54 to 4.53).
6. The mineral contents expressed in mg/100 g, were also investigated in ragi malt flour which ranged: Ca (398.63 to 501.14 mg/100g), P (291.50 to 315.61 mg/100g), Mn (37.74 to 56.61 ppm), Fe (2.85 to 3.19 ppm), Cu (0.73 to 0.90 ppm) and Zn (1.65 to 1.97 ppm).
7. Statistically significant variation between the grains of different varieties has been observed with respect to moisture, total ash, crude protein, total sugar, reducing sugar, non-reducing sugar, fat, IVSD, Ca, P, Mn, Fe, Zn and Cu.
8. The significant variation in the malt from different varieties has been observed with respect to various biochemical attributes like; moisture, total ash, crude protein, total sugar, reducing sugar, non-reducing sugar, fat, IVSD, Ca, P, Mn, Fe, Zn and Cu.
9. In general, malting process was found to reduce few biochemical constituents .
10. Sensory evaluation test conducted to compare the quality of ragi based spray dried malted milk powder from different varieties of ragi shows that malted milk of 20% slurry concentration was liked extremely, while others i.e., with 15% and 10% slurry concentration malted milk were rated as “liked moderately” and “liked slightly” respectively.
11. The spray drying conditions viz Temperature 205 ^{0}C, Ragi malt slurry concentration 20% and spray drying pressure of 3.5 Kg/cm^2 yields 250 g spray dried malted milk powder from 1000 ml cow milk blend.

Conclusions

1 The new selected ragi varieties were found to contain high amount of essential macro-nutrients and other quality traits.

2 Significant variation has also been observed among the varieties with respect to malting qualities parameters and chemical composition.

3 The spray drying conditions viz Temperature 205 ^{0}C, Ragi malt slurry concentration 20% and spray drying pressure of 3.5 Kg/cm^2 yields 250 g spray dried malted milk powder from 1000 ml cow milk blend.

Suggestions For Further Work

1. Further research work is needed to explore the quality traits of other advance breeding line of ragi.
2. The nutritional potential and malting quality information may be used for development of new weaning to over come the problem of malnutrition.

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APPENDIX

Name : ……………….
Designation : ……………….
Address : ……………….

Sir,

Given sample is newly developed product Name: **Ragi based malted milk powder**, of our laboratory. Please give the rating of the food product on the various sensory attributed based on the following 9 point hedonic scale.

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

Sensory attributes	Sample code	Sample code	Sample code	Sample code	Sample code	Sample code
Colour						
Taste						
Texture						

Remark:

Date: Signature

Abstract

To explore the possibility of utilization of new cultivars of ragi for development of malted milk powder. The investigation has been planned during the year 2014-15. Ragi grain and ragi malt of each variety was evaluated for various quality traits findings indicates that: the physical attributes viz., 1000-seed weight, 1000-seed volume, density and germination percentage varies from 2.78 to 3.20 g, 2.33 to 2.80 cc, 1.01 to 1.23 and 85.33 to 99.66% respectively. The biochemical attributes viz moisture, crude protein fat, Ash content and total carbohydrate among six cultivars of ragi varied from 8.91 to 9.90%, 5.90 to 7.53%, 1.40 to 2.49%, 5.02 to 6.19 and, 70.92 to 86.20% respectively. The cultivars were also rich in crude fibre (3.17 to 3.60), total sugar (3.23 to 4.02 mg/100 g), reducing sugar (0.78 to 2.27 mg/100 g), non-reducing sugar (0.63 to 1.91 mg/100 g), IVSD (3.11 to 4.94 mg/100 g) respectively. The mineral content of different varieties of ragi were found to have a range: Ca (503.49 to 552.06 mg/100g), P (303.34 to 322.42 mg/100 g), Mn (37.74 to 56.61 ppm), Cu (0.60 to 0.95 ppm), Zn (1.89 to 2.29 ppm) and Fe (3.11 to 3.69 ppm). The ragi malt flour from different varieties were also analyzed for the different biochemical indices and found to contain moisture (8.32 to 9.57%) protein (4.57 to 8.34%), total carbohydrate (70.25 to 82.35%), Ash (1.13 to 2.25%), Fibre content (1.97 to 2.47%), total sugar (2.80 to 3.46 mg/100 g), reducing sugar (0.63 to 1.91 mg/100 g, non-reducing sugar (0.94 to 2.41 mg/100 g), IVSD (3.54 to 4.53). The mineral contents in ragi malt flour ranged: Ca (398.63 to 501.14 mg/100g), P (291.50 to 315.61 mg/100g), Mn (37.74 to 56.61 ppm), Fe (2.85 to 3.19 ppm), Cu (0.73 to 0.90 ppm) and Zn (1.65 to 1.97 ppm). Statistically significant variation between the grains of different varieties has been observed with respect to various biochemical attributes of ragi grain and malted flour. Sensory evaluation test of spray dried malted milk powder shows that malted milk of 20% slurry concentration was liked extremely, while others i.e., with 15% and 10% slurry concentration malted milk were rated as “liked moderately” and “liked slightly” respectively. The spray drying conditions viz Temperature 205 ^{0}C, Ragi malt slurry concentration 20% and spray drying pressure of 3.5 Kg/cm^2 yields 250 g spray dried malted milk powder from 1000 ml cow milk blend.