DEVELOPMENT &ANALYSIS OF READY TO EAT BREAKFAST CEREAL

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B.VOC FOOD PROCESSING TECHNOLOGY

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DECLARATION

We NANDANA J GOPAN(VB21FPT010), NITHYA JOSEPH (VB21FPT013), SAFNA JALEEL(VB21FPT017) hereby declare that this project entitled "Development and Analysis of ready to eat breakfast cereal" is a bonafide record of the project work done by us during the course of study and that the report has not previously formed the basis for the award to us for any degree, diploma, fellowship or other title of other title of any other university or society.

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CERTIFICATE

This is to certify that the project report entitled, "Development and Analysis of ready to eat breakfast cereal" submitted in partial fulfilment of the requirements for the award of the degree of B.voc Food Processing Technology to St. Teresa's College, Ernakulam is a record of bonafide research work carried out by Ms. Nandana J Gopan, Ms. Nithya Joseph, Ms. Safna Jaleel under my guidance and supervision and that no part of the project has been submitted for the award of my other degree, diploma, fellowship or other similar titles or prize and that the work has not been published in part or full in any scientific or popular journal or magazine

Signature of Guide

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ABSTRACT

The objective of the study was to develop RTE breakfast cereal using Malted foxtail millet (Setaria Italica). The breakfast cereal was prepared by malted foxtail millet (Setaria Italica), Carob powder and dates as primary constituents. The development process involves optimising the ingredient proportions to achieve desired sensory attributes, nutritional profile and shelf stability. Various analytical techniques such as Sensory evaluation and chemical analysis are employed to assess the nutritional quality, acceptability and safety of the cereal product. The main aim to contribute to the diversification of cereal based products with enhanced nutritional value, appeal and the growing demand for healthier breakfast options.

Keywords: breakfast cereal, malted foxtail millet, dates, carob powder, extrusion.

CHAPTER 1

INTRODUCTION

Breakfast marks the initial meal of the day, ending the overnight fast within 2 to 3 hours of waking up. It includes food or drink from at least one food group and can be enjoyed at any place. For numerous years, the significance of breakfast cereals in maintaining a well-rounded diet has been acknowledged. Dietary recommendations emphasize that breakfast cereals, particularly those rich in whole grains or high in cereal fibre, play a crucial role due to their high nutrient content. Beyond delivering essential vitamins and minerals, breakfast cereals may also serve as significant contributors to antioxidants and phytoestrogens, establishing them as a primary source of whole grains.

Breakfast cereal consuming has been coupled to better food quality, and through fortification techniques, cereals can considerably increase the daily vitamin intake. In order to follow nutritional guidelines and healthy eating habits associated to better health outcomes—such as a lower body mass index (BMI), a lower risk of cardiovascular disease, and improved cognitive function—it is important to have breakfast on a regular basis. (Croisier et al., 2021) In the findings of a study on breakfast cereal intake, indicated that individuals who ate the cereal daily had a higher physical and mental health than those who consumed it less frequently. Even after controlling for demographics, lifestyle markers (such as smoking), and other dietary characteristics, this connection persisted. (Smith, 1999)

1.1 FOXTAIL MILLET

Foxtail millet (*Setaria italica*) is one of the oldest cultivated millets and native to China, ranks second in world production, provides six million tons of food for the poorer section of the population. Foxtail millet is used for both human and animal consumption. Foxtail millet grains range in colour from pale yellow to orange, red, brown, or black, and measure around 2 mm in length. The grain must be dehulled before it can be used as food since it is covered with thin hulls.

In terms of nutrition, it is low in fat (4%), high in protein (11–12%), and rich in dietary fibre (6.7%). Foxtail millet is a rich source of fibre, protein, zinc and magnesium. Consumption of foxtail millet results in slow release of sugar to blood. Consumption foxtail millet lowers blood sugar levels while fasting, lowers body weight, and improves lipid profile. Foxtail millet's high fibre content reduces the risk of heart disease, hypertension, and stroke while also easing constipation and improving digestion. It has a good supply of B vitamins, including folate (B9), Thiamine (B1), riboflavin (B2), and niacin (B3). The nervous system and the brain depend on these B vitamins for proper operation. Additionally, it is also high in antioxidants like flavonoids. (Hariprasanna K, n.d.)

1.2 DATES

One of the earliest tree crops to be planted is date fruit (*Phoenix dactylifera*), which has been farmed for thousands of years. In addition to its high nutritional content, dates can be used as a sweetener and as a source of vitamins and minerals when added to cuisine. All the essential amino acids are present in dates, which also aid with digestion, support a healthy mental system, ward off night blindness, increase vitality, and ease constipation. Dates are a food with a high nutritional content, bioactive substances, and health benefits for humans. Because it is available to eat right away, it is far better than cane sugar. The manufacturing of nutritive sweetener from date palm has become more important as a replacement for table sugar and artificial sweeteners in meals, given the nutritional value and health benefits of date fruits. Increased risk of cardiovascular disease, tooth decay, weight gain as a risk factor, obesity, and diabetes has all been linked to high table sugar consumption. Date sweetener production will expand its potential, broaden its applications, and lessen the issue surrounding the usage of artificial sweeteners.(Babarinde & Adegbola, 2016a)

1.3 CAROB POWDER

The carob tree, scientifically known as *Ceratonia siliqua L*., is a member of the Leguminosae family, primarily found in the Mediterranean region. Its fruit, a pod, contains seeds constituting 10% to 20% of the pod's composition. Carob pods are rich in sugars (50% to 65%), proteins (1% to 5%), lipids (0.2% to 0.8%), crude fibres (11% to 16%), minerals (1% to 6%), and

vitamins (E, D, C, Niacin, B6, and folic acid). They also contain dietary fibres and polyphenols like condensed tannins and proanthocyanidins.(Ibrahim et al., 2020a)

Carob powder, a valuable product derived from carob pods, is a source of sucrose, simple sugars, unsaturated fatty acids, and minerals such as calcium, potassium, and iron. The high dietary fibre content, both soluble and insoluble, makes carob powder suitable for various food products. (Červenka et al., 2019)

Due to its sweet taste (with a sugar content of 75% or more sucrose), carob is used as a natural sweetener, raw material for syrup and crystallized sucrose production, in wine manufacturing, pharmaceuticals, carob honey for cakes and pastries, and as a sweetener for compote and jam. In the Mediterranean region, seedless carob pod powder is widely utilized as a cocoa substitute in sweets, biscuits, confectionery items, bakery goods, and beverages. An advantage of carob powder is its lack of caffeine and theobromine, making it a preferred choice.(Ibrahim et al., 2020a)

In conclusion, the utilisation of unconventional yet nutritionally rich ingredients in creation of breakfast cereals represents a promising avenue for addressing contemporary dietary challenges. Foxtail millet, known for its gluten free nature and remarkable nutritional profile, complied with carob powder, a lesser explored ingredient possessing inherent health benefits and sensory appeal, offers a unique opportunity to revolize the breakfast cereal landscape.

As global concerns about health and sustainable food products intensify, the investigation into these ingredients for cereal formulation becomes not only pertinent but imperative.

This dissertation aims to bridge the existing knowledge gap by symmetrically exploring the utilization of foxtail millet and carob powder in breakfast cereal production

1.4 OBJECTIVES

1. Utilization of foxtail millet and carob powder in the development of breakfast cereal.
2. Standardisation of the recipe from three different processing methods.
3. Proximate Analysis of the standardised breakfast cereal.
4. Sensory evaluation of the product- including taste, texture, aroma and overall acceptability of the standardised breakfast cereal.

CHAPTER 2

REVIEW OF LITERATURE

2.1 CONVENIENCE FOOD

Food is one of a person's essential necessities. It is necessary for both healthy growth and the proper operation of all bodily parts. The convenience, affordability, appealing look, flavour, and texture of ready-to-eat (RTE) snacks and ready-to-serve (RTS) food are driving growing consumer interest in these products. Convenience foods are prepared, semi-processed, and ready-to-eat foods. In terms of customer needs for taste and nutrition, technological advancements in food processing equipment, procedures, and packaging materials have revolutionized the convenience food industry. (Pardeshi Panjabrao Deshmukh Krishi Vidyapeeth et al.,2014.)

Any food kind that has been commercially pre-prepared and requires little to no preparation or cooking on the part of the consumer is referred to as convenience food. Ready to Eat (RTE), Ready to Use (RTU), and Ready to Drink/Serve (RTS) are the three categories under which convenient foods fall. Ready to Eat (RTE) meals don't require any preparation and can be eaten right out of the packaging. like bread, biscuits, and munchies, etc. In India, the market for convenience foods is growing daily. The need for convenience, the increase in the working population, the advancement of food technology, and health consciousness and wellness are the main factors that have shaped consumer attitudes toward convenience food products, leading to a notable rise in the ready-to-eat market. Convenience food has become more appealing to customers due to lifestyle changes, increased spending power, and cultural assimilation to the West. Convenient breakfast options are in high demand, and this is one of the main factors propelling the growth of the breakfast cereal market. Cereals for breakfast are a convenient and quick way to start the day, and they're portable. Customers who are busy and want a filling breakfast without having to spend a lot of time preparing it will find this to be especially enticing. (Dhir & Singla, 2020)

2.2 BREAKFAST CEREALS CONSUMPTION GLOBALLY AND IN INDIAN CONTEXT

Breakfast cereal is a processed grain-based dish that is consumed as a morning main course and is served with either hot or cold milk. They are a popular choice for breakfast worldwide due to their convenience and nutritional value (Grand View Research, 2021). They are lightweight, easily shipped, and reasonably shelf-stable. The global breakfast cereal market size was valued at USD 52.6 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 4.8% from 2021 to 2028. The growth is attributed to the increasing preference for healthy breakfast options, rising health awareness among consumers, and busy lifestyles driving the demand for convenient food choices. Their main constituents are corn, wheat, oats, or rice, generally combined with flavourings and strengthening agents. Conversely, the main ingredients of hot morning cereals are wheat or oats. North America dominates the global breakfast cereal market, followed by Europe and the Asia Pacific. The United States is the largest consumer of breakfast cereals, with a wide variety of products available, including flakes, oats, granola, and muesli. In Europe, countries like the United Kingdom, Germany, and France are significant consumers of breakfast cereals.

Breakfast cereal selections have grown throughout time in response to consumer demand and are frequently promoted as an easy way to get nutrient-dense grain meals. 36% of Australians (aged 2 and over) reported eating breakfast cereals in the 2011–2012 National Nutrition and Physical Activity Survey (NNPAS). The data indicates that a larger percentage of consumers are in the younger (2–8 years) and older (71 years and over) population categories. Recent data (2020) indicates that the majority of Australian adults reportedly eat cereal items, milk, and fruit for breakfast. According to recent data (2020), however, it may have increased over the past 20 years for Australian males (<45 years) who consume breakfast cereal (50%) with a median daily amount of 51 g for males and 35 g for females.(Croisier et al., 2021)

There are two categories for breakfast cereals: Ready-to-eat (RTE) cereals and hot cereals. The RTE cereals are ready for eating without any preparation, in contrast to the hot cereals, which require preparation before consumption. The majority of breakfast cereals that are ready to eat (RTE) can be divided into many categories: Corn, wheat, and rice flakes; extruded flakes; gun-puffed whole grains; granola cereals; compressed flake biscuits; oven-puffed cereals; extruded expanded cereals; baked cereals; compressed flake biscuits; muesli-type products; and filled bite-size shredded wheat are examples of flaked cereals. (Kapoor et al., 2020)

Having breakfast physically “breaks the fast” after several hours of fasting during the night, making it one of the most significant meals of the day. The maintenance of cardiovascular health enhancement of cognitive functioning and favourable impact on satiety-related hormones have all been demonstrated by a number of epidemiological and intervention studies. Because there is no universal breakfast due to cultural differences in dietary preferences and behaviour, there is disagreement in the scientific community on its definition despite its significant importance. (Angelino et al., 2019)

One of the most significant meals of the day is traditionally advised to be breakfast. A number of health outcomes, including reduced risk of diabetes, improved weight, and improved cardiovascular health, are inversely correlated with breakfast eating. According to UK dietary guidelines, breakfast should make up between 20 and 25 percent of total energy intake. Fruits and vegetables, dairy products, low-fat spreads and oils, protein sources, and starchy foods (such as cereals, pasta, and bread) are the five main food groups that make up breakfast. For many people in the UK, grain fortification is a significant source of micronutrients. (Lewis et al., 2021)

Consumption of Breakfast Cereals in India: In India, the consumption of breakfast cereals has been increasing steadily, driven by factors such as urbanization, changing lifestyles, and growing health consciousness among consumers (Statista, 2021). The revenue in the breakfast cereals segment in India is projected to reach USD 1,372 million in 2024, with a CAGR of 10.6% from 2020 to 2024.

The Indian breakfast cereal market is dominated by products such as cornflakes, oats, and muesli, with major players like Kellogg’s, Bagrry’s, and Nestle competing in the market. While traditional Indian breakfast options like idli, dosa, and poha remain popular, there is a growing trend of incorporating breakfast cereals into the diet, especially among urban consumers

2.2.1 Advantages of Breakfast Cereals

Regular breakfast cereal consumers have lower serum cholesterol concentrations, improved nutritional status, increased intakes of carbohydrates, total sugars, fat, and cholesterol, enhanced intakes of micronutrients, higher intakes of milk, and a greater likelihood of meeting recommended intakes of micronutrients. These findings are in comparison to those who consume less breakfast cereal or who do not consume it. (Williams, 2014)

The "high fibre content" of the breakfast cereal is regarded. The prepared breakfast cereal was determined to be rich in fibre in the current experiment, with 83.19% of the fibre being soluble and 16.80% being insoluble. The insoluble fraction is linked to an increase in faecal matter, which ensures intestinal peristalsis, prevents constipation, and lowers the risk of diverticulitis and haemorrhoids. Due to its ability to exert a hyperglycaemic impact by delaying gastric emptying, which reduces intestinal transit and glucose absorption, the soluble fraction can be ingested by diabetics and has positive effects on cholesterol and insulin metabolism. Breakfast cereal is categorized as a functional food since it contains a significant amount of soluble dietary fibre (Kumari et al., 2019)

2.2.2 Types of Breakfast Cereals

2.2.2.1 Flaked cereals:

Cereals with flakes include those that are extruded and manufactured from entire grain kernels or portions of corn, wheat, or rice kernels. When creating a flaked cereal, the main goal is to first process the grain to produce particles that are able to form individual flakes. There isn't a method that we are aware of for creating flaked cereal from a thicker, thinner sheet that toasts to separate flakes. Therefore, the final character of flaked cereals greatly depends on the grain choice. To produce flake sized particles, or flaking grits, one or more intermediate size reductions as well as sizing or screening activities may be required. Kernels from whole grains, or portions of them, are usually used to make corn and wheat flakes. (Fast, 1990.)

2.2.2.2 Extruded shredded cereal:

Breakfast cereals that are shredded are mainly composed of wheat and other whole cereal grains. Alternative cereals like rice or corn are being used in the development of new shredded products, some of which now come with soft centre, fruit flavoured confections. After being washed, cereal grains are cooked in water until soft. Before using steel rollers to shred the cooked big grains, the moisture content is allowed to equalize over a few hours in a tempering process. Shredded items are also made using extrusion. Since it is more flexible and allows for the addition of additional cereal products, ingredients, and additives, this method has been employed more frequently to produce shreds from flinty corn and rice cereal. Some of these formulations contain small amounts of substances like sugar and salt. (Lorenz & Kulp, 1991)

2.2.2.3 Extruded flake cereals:

Extruded flakes are cereal flakes produced from finer materials through extrusion or agglomeration processes. Unlike traditional flake production, where cooking and de-lumping are involved, extruded flakes utilize extrusion as the primary method. The dry ingredients, such as whole grain flour or ground whole wheat, combined with flavourings, are continuously fed into a cooking extruder. Initially, in the screw section, they mix with a liquid solution of water and flavour materials like sugar, salt, and malt. Heat input near the feed point is kept low to ensure proper mixing before any cooking or gelatinization occurs. The material is then conveyed through the central section of the barrel for cooking. After cooking, the material is discharged through a perforated disc plate, cut into pellets of suitable size for cereal flakes. These extruded cooked pellets undergo further processing, including drying, tempering, flaking, and toasting, similar to the process for corn or wheat flakes. (Rehal et al., 2012.)

2.2.2.4 Gun-puffed whole grain cereals:

Gun-puffed whole grains are produced by cooking grains and subjecting them to a sudden pressure drop, causing rapid expansion or "puffing" as steam inside the grain seeks equilibrium with the lower-pressure atmosphere. Rice and wheat are the grains used, with wheat requiring pretreatment to prevent bran loosening, achieved through methods like brine solution addition or pearling. Rice undergoes normal milling. Puffing methods include manual single-shot guns, automatic single-shot guns, automatic multiple-shot guns, or continuous guns. After puffing, grains are screened, dried, and packaged due to their porous nature, requiring moisture-resistant packaging. (Rosentrater et al., 2018.)

2.3 MILLETS

A group of extremely diverse, small-seeded plant species that are native to many parts of the world are collectively referred to as millets. The short growing season and higher yield of millets in hot and dry circumstances make them valuable, particularly in semiarid locations. Growing to be the most common millet, pearl millet is a major crop in portions of Africa and India. East Africa and India are big users of finger millet. Near East and China are the main growing regions for foxtail and proso millets. The Russian Federation is also a major producer of proso millet. In Ethiopia and West Africa, respectively, teff and fonio are farmed. The millets that are most frequently grown are Japanese millet, pearl millet, finger millet, foxtail millet, fonio, small millet, teff, and kodo millet. Primarily derived from wild seed stock, millets

originated in East and West Africa, Eurasia, India, and China. Carbonized grains of pear millet have been discovered in sub-Saharan and West African sites that were inhabited about 4000-5000 years ago, making it one of the earliest domesticated millets. (www.AgriMoon.com)

In dry and semi-arid regions of the world, millets are a staple grain. Millets make healthy energy sources. They offer dietary fibre, polyphenols, minerals, vitamins, fatty acids, and protein. A significant amount of necessary amino acids, particularly those that include sulphur (methionine and cysteine), are present in typical millet protein. Milling millet results in a large loss of its fibre- and phytochemical-rich bran and germ layers. Antioxidants including phenolic acids and glycated flavonoids can be found in millets. Foods made with millet have the potential to be prebiotics and can improve the viability or functionality of probiotics with important health advantages. (Amadou et al., 2013)

2.3.1 Foxtail Millet- Introduction

Several factors, including the adoption of modern crop varieties, shifts in land use, labour shortages due to rural-to-urban migration, limited access to quality seeds, labour-intensive post-harvest processing, decreased market opportunities, and insufficient research and extension programs, have contributed to the significant decline in foxtail millet cultivation and utilization. Despite containing beneficial nutrients like zinc, iron, essential carbohydrates for blood sugar control, and being gluten-free with high levels of calcium, dietary fibre, polyphenols, and protein, foxtail millet has suffered a decline in popularity. Its ability to thrive in low-input environments and resistance to abiotic stresses such as drought and hailstorms make it valuable. Studies have highlighted that processing methods like fermentation can reduce antinutrient levels and enhance the bioavailability of micronutrients. Fermentation also improves foxtail millet's edibility and prebiotic qualities by breaking down polysaccharides in the bran layers, resulting in more permeable and loose structures.(Gautam & Pudasaini, 2024)

2.3.2 Production

Foxtail millet*, Setaria italica* (L.) P. Beauv., is one of the earliest cereals to be domesticated in the Old World. Foxtail millet is thought to have originated in China, ranks second in world production, according to recent archaeological research. It provides six million tons of food for the poorer section of the population. Foxtail millet has been used in many different ways, some unique to different parts of Eurasia, and it is believed to have been a major component of early

Old-World agriculture. There is ongoing debate on the foxtail millet's origins. According to cytological research, the green foxtail (S. italica ssp. viridis, syn. S. viridis) is the wild ancestor of foxtail millet. (Fukunaga & Kawase, 2024)

Because it tolerates drought conditions well, foxtail millet is mostly grown as a rainfed crop in dry regions of India. The southern states of India—Andhra Pradesh, Karnataka, Tamil Nadu, and Telangana—as well as Bihar, Uttar Pradesh, and Uttarakhand—are the only places where foxtail millet is cultivated. While foxtail millets and other small millets have lower average productivity, newer, more promising types are now being produced. Both temperate and tropical climates are suitable for growing foxtail millet. However, because of its resistance to moisture stress, it is grown in India's marginal, arid tropical drylands, mostly in rainfed environments.(Maitra, 2020)

2.3.3 Nutritional Composition and Benefits

For consumers to evaluate the quality of foxtail millet, millet colour is an important indicator. The number of carotenoids, which are vital for human nutrition, is the primary cause of millet's yellow colour. However, the nutritional content and marketability of millet products are significantly diminished by the colouring of millet caused by carotenoid breakdown during storage.(Ma et al., 2022)

(Arora et al., 2023) compared the products made from wheat, rice, or barley, those made from foxtail millet had lower glycaemic indexes, lower levels of resistant starch, and higher levels of protein and dietary fibre. The developed Foxtail millet products are suitable for use as therapeutic foods for diabetics, falling into the category of foods with a medium glycaemic index. Because Foxtail millet has a reduced glycaemic index, resistant starch, and high fibre content, its prepared products can help prevent non-communicable disorders including diabetes and obesity.

2.3.4 Foxtail Millets as Functional Foods

Foxtail millet stands out among sorghum, corn, and rice due to its rich functional components such as fibre, minerals like iron and calcium, fats, and proteins, with nutrient levels comparable to or slightly exceeding those of other cereals. Its positive impact on health, potentially preventing various diseases, qualifies it as a functional food. Additionally, its low-calorie nature makes it particularly appealing for individuals aiming for low-calorie diets due to conditions like degenerative diseases and adolescent obesity. Foxtail millet has the potential to be

developed into a functional food product, providing affordable protein for the treatment and prevention of various chronic diseases resulting from lifestyle factors. Its benefits, including high protein content, antioxidant properties, fibre, and its potential in managing type-2 diabetes through supplements and minerals, highlight its promise as a crop with potential for future expansion. Functional foods offer a valuable option for individuals striving to uphold their fitness and well-being.("Research Trends in Medicinal Plant Sciences," 2022)

2.3.5 Functional Properties

In contrast to other types of millets, foxtail millet exhibits narrower temperature ranges for melting, indicating a more consistent and uniform quality of amylopectin crystals within its starch granules. Moreover, foxtail millet flour demonstrates greater structural integrity and resistance to gelatinization compared to other millet flours. Various processing techniques including drying, roasting, germination, and fermentation can enhance the nutritional value of whole grains over refined grains. By utilizing processed whole grain flours, a diverse range of food products like breads, cookies, and porridge can be created.(Sharma & Niranjan, 2018)

The functional qualities of flour are significantly altered by pre-treating foxtail millets in a microwave before milling them. Millet flours can be effectively pre-treated with microwave heating to improve their functional qualities without compromising their physical characteristics. The underutilized foxtail millet can be valued added by using the flour from microwave-treated millet, which has various uses in food processing.(Rao et al., 2021)

A project was done to develop and assess the nutritional value of eight different foxtail millet-based food products, which would have replaced popular cereals like wheat and rice: rusk, kheer, pinni, sattu, vegetable dalia, biscuits, bar, and papad. High acceptance was observed for the items made from Foxtail millet. These dietary items with a wider variety displayed a higher protein content. Products made from foxtail millet appear to have low PGI and high resistant starch content, making them a good option for diabetics. The acquired data imply that all value-added Foxtail millet products have better nutritious profiles and are much more liked than conventional products. Consuming these foods may help avoid type 2 diabetes and malnutrition in the general population.(Arora et al., 2023)

A study examined the sensory attributes of formulated items made from foxtail millet, barnyard millet, and rice (control) such as laddu, halwa, and biryani. When comparing the prepared foxtail and barnyard millet laddu and halwa to the control, there was no discernible change in

terms of colour, flavour, texture, appearance, or overall acceptability. In contrast to barnyard millet and control biryani, foxtail millet biryani was the most appreciated. The formulated goods' nutritional content was computed and compared with that of rice. Compared to rice goods, the designed products made from foxtail and barnyard millet had higher levels of protein, fat, and fibre. Based on the results of this study, it can be inferred that foxtail millet and barnyard millet have more nutritional content than rice and can be used in traditional food products. (Verma et al., 2015)

A study was carried out to create a nutrient-rich millet idli mix and compare its biochemical makeup and sensory attributes to that of the conventional rice-based idli mix. The aim of this study was to create a healthy millet idli mix and compare its sensory qualities and biochemical composition to a typical rice-based idli mix. The study focused on adding value to millets. The study found that the idli prepared by adding millets was more nutrient-dense than the traditional idli and that the processing methods employed were able to eliminate anti-nutritional factors. Fermentation was clearly able to reduce the tannin content when adding millets to the idli mix. Overall acceptability in sensory evaluation stated that millet-based products were liked moderately.(Mounika et al., 2022)

2.4 CAROB POWDER

Belonging to the family Leguminosae, the Carob (*Ceratonia siliqua L.*) tree has been extensively cultivated in the Mediterranean region.(Ibrahim et al., 2020b) It’s significance in the food industry stems from its incorporation into a variety of food products, primarily in confectionery, bakery, and beverages. Both raw and roasted carob powders are valued in food applications for their abundant sweet components, as well as their ability to enhance the flavour and colour of dishes.(Baston, 2016)

2.4.1 Production

Carob, a native tree of Cyprus, has been cultivated on the island for centuries, demonstrating resilience to drought and varying temperatures. Historically, it played a pivotal role in bolstering the agricultural economy of Cyprus, earning it the nickname "black gold." (Papaefstathiou et al., 2018)

Turkey stands out as a significant global producer of carob, contributing approximately 5% to the total world export and production annually. Carob fruits find extensive utilization across various industries including pharmaceuticals, food, textiles, and cosmetics. (Aydın & Özdemir, 2017)

In many Arab countries, carob is popularly consumed as a beverage during Ramadan and is also used in the preparation of traditional Arabic confectionery. In Western nations, carob powder is produced by removing seeds from carob pods, crushing them into small pieces, roasting, and then grinding. In the Mediterranean region, including Turkey, carob pods are finely milled to create a cocoa-like flour known as "carob cocoa," which is sold in large stores and local markets. This flour is often mixed with hot or cold milk for consumption.(Bulca, 2016)

2.4.2 Nutrition

Carob, widely accessible and cost-effective, is primarily utilized in the food industry as flour. Studies have confirmed the presence of carbohydrates (76%), proteins (6%), fats (2%), minerals, and bioactive compounds in carob flour. Additionally, carob pods yield seeds used in the production of carob bean gum, a common thickening agent (E410) widely employed in dairy and confectionery products, as well as low-fat alternatives, serving as a stabilizer. (Benković et al., 2018)

Carob is known for its abundance of phenolic compounds, including gallic acid, Gallo tannins, cinnamic acid, myricetin, and flavonoids. Studies have identified 11 phenolic compounds in carob powder, with pyrogallol, catechol, chlorogenic, and protocatechuic acids being the most prevalent among them. (Vaislean et al., 2022)

Carob powder serves as a rich source of various vitamins, including vitamins E, D, C, niacin, B6, and folic acid, albeit in lower quantities for vitamins A, B2, and B12. Its oil comprises 17 fatty acids, predominantly oleic, linoleic, palmitic, and stearic acids. Carob beans also contain numerous cyclitols, with D-pinitol being the major cyclitol, offering multiple health benefits.(Papaefstathiou et al., 2018)

Various compounds are extracted from carob pods, including fructose, ethanol, C-glycosyl flavones, α-galactosidase, endo β-mannase, sugar syrup, citric acid, and others.(Youssef et al., 2009)

Findings by (Pazir & Alper, 2018) suggest that carob may have favourable effects on cardiovascular health. In numerous developed nations, there has been a rise in fatalities related to cardiovascular diseases. It is recommended to adopt dietary habits that are high in fibre to lower cholesterol levels, a significant contributor to cardiovascular diseases. Additionally, a diet rich in fibre has beneficial effects on colon health. Research has investigated the impact of carob powder on the lipid profile of rats, revealing that it improved parameters such as total cholesterol and LDL cholesterol.

Carob is beneficial in treating infant diarrhoea and possesses tannins that can bind to toxins and hinder bacterial growth. Moreover, the dietary fibre and sugars found in carob pods may increase the viscosity of food in the stomach, potentially reducing reflux and acid backflow into the oesophagus. (Youssef et al., 2009)

2.4.3 Application in Food Industry

Carob pods find application in the food sector as a replacement for cocoa powder in the making of chocolate, as well as in baked goods like cookies and cakes owing to their naturally sweet taste. Subjecting carob legumes to heat during processing improves their colour, rendering them more appealing for a range of uses. Carob is frequently favoured as an alternative to chocolate due to its absence of caffeine and theobromine. Furthermore, carob provides several health advantages, such as the potential to lower the risk of coronary heart diseases and cancer, support anti-allergic effects, and promote vasorelaxation.(Bulca, 2016)

Carob powder is created through a process of crushing, roasting, and grinding deseeded carob. It is often referred to as a "functional ingredient" due to its ability to enhance the nutritional content of foods it is used in.(Pazir & Alper, 2018)

Past research suggests that the cocoa-like scent may arise from the breakdown of sugar during heating and the creation of certain aromatic compounds through the Maillard reaction. (Aydın & Özdemir, 2017)

(Yousif & Alghzawi, 2000)showed that variations in processing conditions and product parameters, such as time, temperature, moisture level, and particle size, yield different types of carob powder. Roasting temperatures below 80°C were ineffective in producing satisfactory carob powder, while temperatures exceeding 400°C were challenging to manage. Based on sensory evaluations, the optimal roasting temperature and time for kibbled carob were

determined to be 150°C for 60 minutes. The resulting carob powder exhibited high sugar content, moderate protein content, and low-fat content compared to cocoa powder. Moreover, carob is devoid of the two anti-nutrients present in cocoa, namely caffeine and theobromine. Therefore, these attributes position carob powder as a natural and healthy alternative to cocoa powder, suitable for replacing or extending its use in various food applications.

In recent times, carob powder has become increasingly popular as a replacement ingredient in a range of products, such as chocolate, with a fat content ranging between 0.4% and 1.3%. Renowned for its natural sweetness and chocolate-like appearance and aroma, carob powder sees widespread use in the food industry as a substitute for cocoa in beverages, ice cream, cakes, and confectionery items. Its notable dietary fibre content classifies carob powder as a fibre-rich product, accompanied by substantial sugar levels (ranging from 40.69% to 57.74%), beneficial protein content (ranging from 3.07% to 4.42%), and minimal fat content (ranging from 0.45% to 0.86%). As a cocoa replacement in chocolate, carob brings forth several advantages, such as higher calcium levels and the absence of addictive substances like caffeine, making it a valuable alternative across various formulations. An investigation explored the substitution of cacao powder with carob flour in different ratios to produce gluten-free cakes. The resultant product received acclaim for its elevated protein content, low calorie count, pleasing sensory attributes, and suitability for individuals with celiac disease. (Pazir & Alper, 2018)

According to research carried out by (Radia et al., 2018)the process of making a natural candy using dates (Phoenix dactylifera L.), olives (Olea europaea L.), and carob (*Ceratonia siliqua L.*) fruits shows that higher proportions of carob powder led to a significant increase in hardness. Therefore, beyond its nutritional benefits, carob powder can also be viewed as an effective thickening and plasticizing agent in the candy preparation.

Recently, there has been an evaluation of using carob flour as a substitute for cocoa in milk chocolate production. The findings revealed that as the levels of carob flour increased, there were no significant differences observed in the aroma of the milk chocolate. Additionally, a study investigated the impact of incorporating carob flour in the production of gluten-free cakes. Results showed that substituting up to 75% of cocoa powder with carob flour did not lead to noticeable differences in sensory properties. Furthermore, carob powder was utilized in milk beverage manufacturing as a chocolate substitute, resulting in samples with higher

polyphenolic content and antioxidant activity. Notably, the samples containing carob powder received higher sensory scores from the panellists. (Akdeniz et al., 2021)

Bakery products are one of the most important dietary components for people all over the world. Hence, a study conducted by (Pawłowska et al., 2018) investigated the substitution of cocoa powder with carob powder in muffins to enhance their nutritional profile. The study evaluated the sensory and physicochemical properties of muffins with either cocoa or carob powder added. Both types of muffins exhibited a predominant cocoa aroma and a light, fluffy texture, but the carob muffins were noted for their increased sweetness. Additionally, the carob muffins showed higher levels of antiradical activity, genistein, and phytosterols compared to the cocoa muffins. Moreover, the inclusion of carob in the muffins led to favourable sensory attributes. These findings suggest that carob can be effectively utilized in bakery products as a cost-effective substitute for cocoa. Substituting cocoa powder with carob powder in soy muffins presents a technological solution that could reduce the use of refined sugar in bakery items and facilitate the production of innovative functional products. Carob emerges as valuable additive rich in bioactive compounds, offering the potential to create healthier confectionery options.

2.5 DATES

One of the earliest tree crops to be planted is date fruit (Phoenix dactylifera), which has been farmed for thousands of years. In addition to its high nutritional content, dates can be used as a sweetener and as a source of vitamins and minerals when added to cuisine. All the essential amino acids are present in dates, which also aid with digestion, support a healthy mental system, ward off night blindness, increase vitality, and ease constipation. Dates are a food with a high nutritional content, bioactive substances, and health benefits for humans. Because it is available to eat right away, it is far better than cane sugar. It is taken in several the manufacturing of nutritive sweetener from date palm has become more important as a replacement for table sugar and artificial sweeteners in meals, given the nutritional value and health benefits of date fruits. Increased risk of cardiovascular disease, tooth decay, weight gain as a risk factor, obesity, and diabetes has all been linked to high table sugar consumption. Date sweetener production will expand its potential, broaden its applications, and lessen the issue surrounding the usage of artificial sweeteners. (Babarinde & Adegbola, 2016b)

2.5.1 Production and Harvest

Throughout Asia, the Middle East, Africa, and the Arabian Peninsula, date palms (Phoenix dactylifera L., Arecaceae) are among the oldest plants still in cultivation. It is a vital source of food for the residents of these areas and is essential to their daily existence. The date skin, date flesh, and date pit are the three main components of date palm fruit. All year long, dates are easily found in the grocery store. However, there are several fresh, soft, high-quality fruit kinds that are only available from September to December. Dates harvested before they reach maturity and let to ripen inside the jars are found in some arid regions of Africa. (Akinola et al., 2019)

Over the past three decades, date palms have been brought to Australia, India, Mexico, South Africa, South America, Pakistan, and the United States, despite the Middle East and North Africa accounting for the majority of the world's date palm production. In many nations, dates are not only a staple diet for the native populace, but their production also has a major positive impact on the environment, society, and economy of those nations. Because of widespread outbreeding, date palms have a high degree of genetic variation. Approximately 3000 date palm cultivars exist globally, yet some of the variants may be synonymous. The majority of the current, well-established cultivars in numerous nations originated from seedling date palms, despite the fact that they are primarily propagated by offshoots. (Wakil et al., 2015)

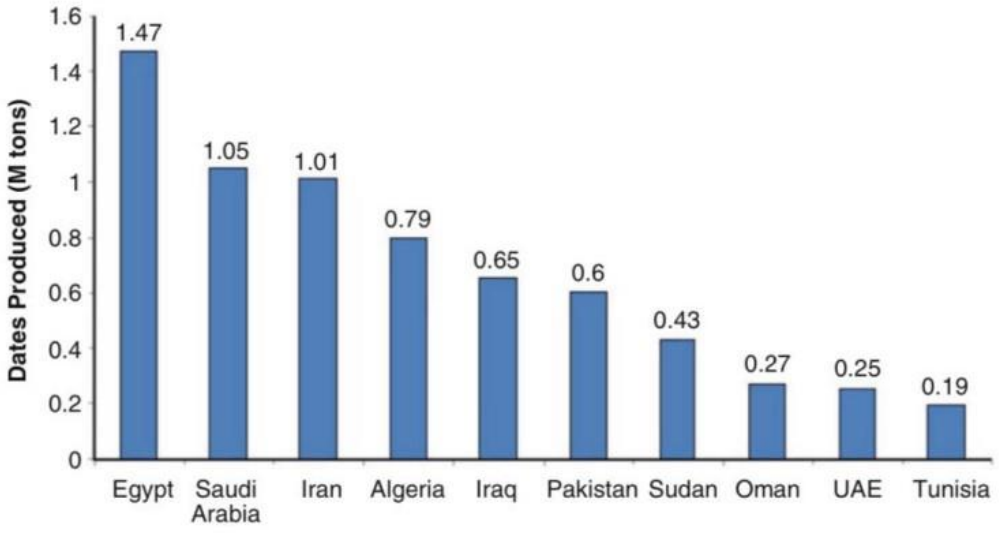

Fig 1: Production of dates in top ten producing countries during 2012 (source: FAOSTAT 2012)

Dates are a great source of carbohydrates, primarily fructose and glucose. Pakistan produced the sixth most dates in 2011 out of all the countries that produced dates. In Pakistan, 150 kinds of dates are grown, including Begum Jangi, Dhakki, Aseel, and Halavi. These are widely grown in several parts of Punjab, Balochistan, and Sindh. Aseel and Dhakki are the most popular kinds. Large amounts of sap are filtered and then cooked in a vessel over a few hours over a wood fire to about 100 C in order to produce palm sugar. When it gets concentrated and thick, it's removed. The liquid from palm sap is heated and then put into bamboo molds to create a pure solid palm that can be used to make sugar. A growing trend is the substitution of dates for refined sugar. The production of date fruit syrup holds significant promise for use in culinary items as a sucrose substitute. Studies have indicated that dates have a significant positive impact on human health. Dates contain 10–20% moisture, 60–75% total sugars, almost 2% protein, 5–8% fibre, and less than 1% fat, based on their dry weight(Arshad et al., 2022)

2.5.2 Types of Dates

Dates are categorized based on the amount of invertase they contain or the type of sugar they contain. Dates were categorized into the following categories thanks to invertase: Dates with high invertase content and high reducing sugar content (roughly 77%) are referred to as soft dates. On the other hand, dates with low invertase content that contain 39% reducing sugars and 38% sucrose are referred to as semi-dry or half-soft dates. Finally, dates devoid of invertase are called dry dates. These have a low percentage of reducing sugars (17%) and are high in sucrose (59%). Based on their amount of sugar, dates are divided into four classes. Dates in the first class have a high sugar content (40–65%). They have 10–25% water content and 20–40% glucose and fructose. The dates in the second class have comparatively little sucrose (10–35%) and are high in glucose and fructose (40–75%). Third-class dates contain 10–35% water, 65–90% glucose and fructose, and 0–10% sucrose. The water content of the fourth-class dates is significant (35–65%). These have a 35–37 percent glucose and fructose content and no sucrose. (Umar Nasir et al., 2015)

2.5.3 Nutrition and Health Benefits

One of the most well-liked fruits, dates are incredibly rich in vitamins, minerals, and phytonutrients that are necessary for healthy growth, development, and general wellbeing. In addition to offering a wealth of vital nutrients, dates are an excellent dietary source of potassium. Ripe dates have approximately 80% sugar content. The remainder is made up of protein, fibre, and trace elements such as zinc, selenium, boron, cobalt, copper, fluorine, and manganese. It has an abnormally high supplement thickness, essential vitamins, and sugar content. Date palm natural products may be more beneficial in some definitions of sustenance than for direct use after boiling or simmering, especially in light of the current rate of population development in developing nations. (Akinola et al., 2019)

Dates have been used more often in recent years to prepare a variety of culinary products, including honey, date bars, jams, fruit paste, cookies, squares, wafers, and date powder, to make them more functional. Fibre and phytochemicals, such as flavonoids, carotenoids, polyphenols, and antioxidants, are abundant in them. Recent research has indicated that these phytochemicals have numerous medicinal and health benefits. In addition, dates are a rich source of minerals like calcium, iron, magnesium, potassium, and copper. They are also a modest source of vitamin B2 and vitamin A (retinol). Due to their ability to provide a multitude of essential nutrients and possible health benefits, dates are almost a diet in and of themselves. (Tahir et al., 2023)

CHAPTER 3

METHODS AND METHODOLOGY

3.1 INTRODUCTION

This chapter deals with material and methods used for the development of breakfast cereal made from foxtail millet. This study was carried out at the Department of B.voc Food Processing Technology, St. Teresa's College Ernakulam during the year 2023 – 2024.

3.2 DOCUMENTATION

Study conducted about the breakfast cereals made from malted foxtail millet, carob powder and dates.

3.3 MATERIALS REQUIRED

1. Foxtail millet - purchased from supermarket
2. Carob powder - purchased online
3. Dates - purchased from supermarket
4. Refined flour -purchased from supermarket
5. Milk - purchased from supermarket
6. Baking powder - purchased from supermarket

Fig 2: malted foxtail millet powder

Fig 3: carob powder

Fig 4: dates

Fig 5: refined flour

Fig 6: milk

Fig 7: water

3.4 EQUIPMENT USED

1. Oven - used to bake prepared cereals (which was already available in the lab)
2. Baking tray - Used to arrange the cut cereals (which was already available in the lab)
3. Weighing machine - Used to weigh the ingredients for the preparation of the product (which was already in the lab)
4. Bowl - used to knead the dough (which was already available in lab)
5. Mixer - used to grind the dates (which was already available in the lab)
6. Wooden chapatti roller - Used to make sheets of the dough (which was already available in the lab)
7. Knife – used to cut the dough (which was already available in the lab)
8. Measuring spoon – used to measure the ingredients (which was already available in the lab)
9. Extruder – used to extrude the dough (which was already available in the lab)

Fig 8: oven

Fig 9: mixer

Fig 10: extruder

Fig 11: Wooden chapatti roller

Fig 12: baking tray

Fig 13: mixing bowl

Fig 14: weighing machine

Fig 15: knife

Fig 16: measuring spoon

3.5 PROCESSING

PROCESISNG METHOD	TEST
Breakfast cereal prepared from malted foxtail millet and baked	T1
Breakfast cereal prepared from malted foxtail millet, cooked and then baked	T2
Breakfast cereal prepared from malted foxtail millet, extruded and baked	T3

Table 1: Processing method

3.6 PROCEDURE

3.6.1 Malted foxtail millet powder:

- Foxtail millet was soaked in water for 8 hours, drained, and then left to germinate by being tied with a muslin cloth for two days.
- Following germination, the millet was dry roasted and ground into powder.
- This whole process is known as malting.

3.6.2 Test: T1

Ingredients:

Malted foxtail millet = 75g

All-purpose flour = 25g

Dates = 40g

Carob powder = 15g

Baking powder = 1 teaspoon

Milk = 4 tablespoon

Method of preparation:

1. Deseeded dates are soaked in warm milk in a small bowl for 15 minutes.
2. The soaked dates and milk are blended into a paste.
3. Combine malted foxtail millet powder and all-purpose flour in a bowl.
4. Add carob powder and baking powder to the dry ingredients and mix thoroughly.
5. The pureed dates are incorporated into the dry ingredients.
6. The mixture is kneaded until a dough forms.
7. The dough is rolled out into a thin sheet using a roller.
8. The sheet is then cut into desired shapes.
9. The shaped pieces are dried in a preheated oven at 180 degrees Celsius for 10 minutes.

3.6.3 Test: T2

Ingredients:

Malted foxtail millet = 75g

All-purpose flour = 25g

Dates = 40g

Carob powder = 15g

Baking powder = 1 teaspoon

Milk = 4 tablespoon

Method of preparation:

1. Deseeded dates are soaked in warm milk in a small bowl for 15 minutes.
2. The soaked dates and milk are blended into a paste.
3. Combine malted foxtail millet powder and all-purpose flour in a bowl.

4. Add carob powder and baking powder to the dry ingredients and mix thoroughly.
5. The pureed dates are incorporated into the dry ingredients.
6. The mixture is kneaded until a dough forms.
7. The dough is rolled out into a thin sheet using a roller.
8. The sheet is then cut into desired shapes.
9. Cook the cut dough in boiling water for 1-2 minutes.
10. Place the boiled dough on a baking tray and dry it in a preheated oven at 180 degrees Celsius for 20 minutes.

3.6.4 Test: T3

Ingredients:

Malted foxtail millet	=	75g
All-purpose flour	=	25g
Dates	=	40g
Carob powder	=	15g
Baking powder	=	1 teaspoon
Milk	=	4 tablespoon

Method of preparation:

1. Deseeded dates are soaked in warm milk in a small bowl for 15 minutes.
2. The soaked dates and milk are blended into a paste.
3. Combine malted foxtail millet powder and all-purpose flour in a bowl.
4. Add carob powder and baking powder to the dry ingredients and mix thoroughly.
5. The pureed dates are incorporated into the dry ingredients.
6. The mixture is kneaded until a dough forms.
7. Pass the dough through an extruder to achieve the desired shape.
8. Dry the extruded product in a preheated oven at 180 degrees Celsius for 5 minutes.

Fig 17: Soaking and germination of foxtail millet

Fig 18: Dry roasting of germinated foxtail millet

Fig 19: Grinding of malted foxtail millet

Fig 20: Mixing of all dry ingredients

Fig 21: Preparation of dough by mixing wet and dry ingredients

Fig 22: The dough is flattened and cut into shape.

Fig 23: The cut dough is boiled in water for 2 minutes.

Fig 24: The dough is extruded through an extruder.

Fig 25: The cut dough is baked at 180^0C for 10 minutes.

Fig 26: The boiled dough is baked at 180^0C for 20 minutes.

Fig 27: The extruded dough is baked at 180^0C for 5 minutes.

3.7 SENSORY ANALYSIS

Sensory analysis was done using hedonic scale, where test1, test2, test3 were done by 10 panellists.

The hedonic scale approach rates stimuli, such as food samples or names, on a 9-category scale from "dislike extremely" to "like extremely." The article discusses the history, laboratory and field methodologies, data analysis, reliability, essential characteristics, applications, specific effects to control, and findings interpretation. Evidence is presented to support the method's validity in predicting food behaviour. The method has several advantages, including its applicability to diverse populations, its ability to handle data through variable statistics, and its ability to provide relevant results for determining general preferences.

After doing sensory analysis, it was discovered that 'test 3' was more widely accepted, thus a chemical analysis was performed on the 'test 3' product.

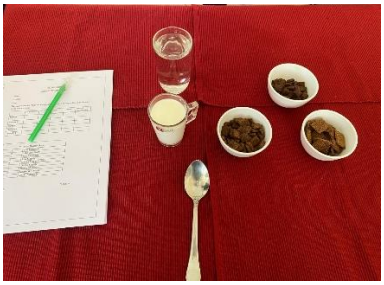


Fig 28: sensory analysis

HEDONIC SCALE

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

Table 2: Hedonic scale

3.8 CHEMICAL ANALYSIS

3.8.1 Determination of fat content:

Transfer 5g of finely ground moisture free sample into an extraction thimble and plug the top with cotton place the thimble into the fat extraction tube of Soxhlet apparatus. Attach the bottom of the extraction tube to a pre weighted Soxhlet flask. Pour approximately 75ml of anhydrous ether through the sample in the tube into the flask. Attach top of fat extraction tube to condenser. Extract sample for 16 hr on heating mantle. Control heating so that etger which volatilized condense and drop continuously upon the sample without any appreciable loss. At the end of extraction period, remove Soxhlet flask and evaporate ether in Soxhlet flask on a steam bath at low heat. Then, dry at 3°c for 1hr cool and weigh. The difference in the weight of flask before and after extraction gives ether soluble material in sample.

Fat (g/100g) = weight of ether soluble material in g x 100

Weight of sample in gram

3.8.2 Determination of protein content:

Weigh 2g of the sample and transfer to a 500ml kjeldahl flask taking care of to see that no portion of the sample clings to the neck of the flask add 0.7g of Cuso4,15 gm of potassium sulphate and 40ml of concentrated sulphuric acid. Add two to three glass beads, place the moderate rate. During heating, rotate the flask several times. Continue heating for about an hour or more until the colour of the digest is plate blue. Cool the digest and slowly add 200ml of water. Add a piece of granulated zinc or anti bump granules, carefully pour down the side of the flask sufficient NaOH solution (about 10ml of a450g/l solution) to make the contents strongly alkaline by mixing the acid and alkaline layer. Connect the flask to a distillation apparatus incorporating an efficient flask head and condenser. To the condenser fit a delivery tube which dips just below the surface of the which dips just below the surface of the pipetted vol of standard acid contained in a conical flask receiver. mix the content of the digestion flask and boil until 150 ml have distilled into the receiver. add 5 drops of methyl red indicator and titrate with 0.1 NaOH solution. Carry out a blank titration.

Protein (g/100g) = 1.4007x(ml NaOH for blank sample - ml NaOH for sample) normality of

NaOH x6.25/wt.(g)

3.8.3 Determination of dietary fibre:

Weigh accurately 3g of the Sample into a round bottom flask of 500 ml capacity. Moreover, 200ml of 1.25% solution of sulphuric acid at room temperature, bring it to a temperature of 95 to 100 degree Celsius and add it to the contents of the flask fit a reflux condensers and bring rapidly to the boil using a heating device and continue boiling gently for 30min.after the specified boiling periods ,add about 50 ml of cold water and separate rapidly the insoluble residue using a fine filter cloth wash the flask with 50 ml portion of hot water and pour the washing over the insoluble residue remaining in the filter cloth repeat the washing of the insoluble residue until the filtrate is substantially neutral to litmus paper. The separation and washing of the insoluble residue shall be completed in less than 30 min.

Return the washed insoluble residue to the flask measure 200ml of 1.25% solution of sodium hydroxide at room temperature, bring it to a temperature of 95 to 100 degree Celsius and add is to the content of the flask fit a reflux condenser and bring rapidly to the boil using a heating device and continue boiling gently for 30 min after the specified boiling period, add about 50 ml of cold water and separate rapidly the insoluble residue the using a for filter cloth. Wash the residue with25 ml of 1.25 % solution of sulphuric acid measured at room temperature and then raised to a temperature of 95 to 100 degrees Celsius. Wash the flask with 50 ml portions of hot water and pour the washing over the insoluble residue remaining in the filter cloth repeat the washing of the insoluble residue until the filtrate is substantially neutral to litmus paper then wash the residue with 95% ethanol separate the residue from the filter cloth and transfer the whole to an incineration dish.

Dry the dish with its contents in a hot -air oven 130 degree Celsius. Allow to cool to room temperature a desiccator and quickly weigh repeat this operation until the difference between two successive weighing, following drying in the oven and cooling in the desiccator, does not exceed 1 mg after drying incinerate the dry residue in a muffle furnace at 550 degrees Celsius to constant mass. Allow to cool to room temperature in the desiccator and weigh again

The crude fibre content, expressed as a percentage by mass relative to the product to a received, is given by the formula

Crude fibre (g/100g) = 100(M1-M2) ÷M

3.8.4 Determination of iron:

The iron content of the sample is determined by atomic absorption spectrophotometry developed by Alan Walsh in 1960. For dissolved iron, the filtered sample is directly aspirated to the atomiser. For total recoverable iron, HNO-H2SO digestion is to be carried out prior to aspiration of the sample. This method is applicable in the 0.1 to 10 mg/l range. However, the concentration range will vary with the sensitivity of the instrument used.

3.8.5 Determination of vitamin C:

Weigh exactly 10 grams of the breakfast cereal sample. Grind the sample into a fine powder using a mortar and pestle. Transfer the powdered sample into a 250 mL Erlenmeyer flask. Add 50 mL of 2% oxalic acid solution (prepared by dissolving 2 g of oxalic acid in 100 mL of distilled water) to the flask. Swirl the flask to mix the contents thoroughly. Allow the mixture to stand for 30 minutes, with occasional swirling. After 30 minutes, filter the mixture using a filter paper and a filtration setup. Collect the filtrate (extract) in a clean 100 mL volumetric flask. Prepare a standard solution of ascorbic acid (vitamin C) with a known concentration, preferably around 0.2 mg/mL.

Use this standard solution to calibrate your instrument or to create a standard curve for vitamin C quantification. Measure the absorbance of the filtrate (extract) at the appropriate wavelength for vitamin C, typically around 520 nm.

Use a spectrophotometer calibrated to measure absorbance accurately. Calculate the concentration of vitamin C in the sample using the absorbance values and the standard curve or calibration equation obtained from the standard solution. Convert the concentration to the amount of vitamin C per 100 grams of the breakfast cereal sample.

Report the results in milligrams (mg) of vitamin C per 100 grams of the cereal sample.

CHAPTER 4

RESULT AND DISCUSSION

4.1 PROCESSING METHOD

The breakfast cereal was made using malted foxtail millet, dates, and carob powder. Malted foxtail millet was the primary ingredient, chosen for its enhanced flavour and nutritional benefits such as high carbohydrates, protein, fibre, magnesium, and iron content. Dates were included as a natural sweetener, while carob powder served as a healthier substitute for cocoa.

PROCESISNG METHOD	TEST
Breakfast cereal prepared from malted foxtail millet and baked	T1
Breakfast cereal prepared from malted foxtail millet, cooked and then baked	T2
Breakfast cereal prepared from malted foxtail millet, extruded and baked	T3

Table 1: Processing method

4.2 SENSORY ANALYSIS OF THE READY TO EAT BREAKFAST CEREAL

Sensory evaluation of the breakfast cereal was carried by 10 members where the appearance, taste, aroma and concept of developed product was evaluated. The samples were arranged in tables with specified codes. Scale was easily understood by each panellist and were a group of 18-25 age and their response were converted into numerical value for computation purpose.

Out of the three tests, test 3 was more widely accepted. Out of the three tests, test 3 was given for proximate analysis.

4.3 PROXIMATE ANALYSIS OF THE READY TO EAT BREAKFAST CEREAL

4.3.1 Protein

The value of protein in T3 was 7.75%. Consuming high-quality protein from animal foods, such as lean meat and dairy, is vital for children's optimal growth and well-being. It also supports and promotes health in various tissues, including muscles, brain, heart, kidneys, liver, and gut. (Wu, 2016)

4.3.2 Fibre

The value of fibre in T3 was 6.34%. fibre content can normalise the bowel movement. It also lowers cholesterol level. According to study conducted by (citation) fibre to improve health impacts, including reducing the glycaemic response and improving fermentation in the colon. (R. Shewry, 2020)

4.3.3 Iron

The value of iron in T3 was 3.50 mg/100g. Iron helps to preserve many vital functions in the body, including general energy and focus at gastro-intestinal processes, the immune system, and the regulation of body temperature. (Naghii et al., 2011)

4.3.4 Fat

The value of fat in T3 was 2.76%. To maintain weight, it's crucial to limit fat intake as high-fat diets contribute to obesity. High dietary fat consumption has been associated to negative health effects such as cardiovascular disease, some cancers, and obesity.(Rolls & Shide, 1992)

4.3.5 Vitamin C

The value of vitamin C in T3 was found to be 4.89mg/100g. Ascorbic acid offers numerous health benefits, including antioxidant, anti-atherogenic, and anti-carcinogenic properties.(Naidu, 2003)

SL.NO	QUALITY PARAMETER	RESULT	UNITS
1	Protein	7.75	%
2	Dietary fibre	6.34	%
3	Vitamin C	4.89	mg/100g
4	Iron	3.50	mg/100g
5	Total fat	2.76	%

Table 3: Proximate analysis

CHAPTER 5

SUMMARY AND CONCLUSION

The present study entitled “development of ready to eat breakfast cereal “, it’s evident that ready to eat breakfast cereal offers a convenient and nutritious option for consumers. The breakfast cereal developed in this project combines the nutritional benefits of Foxtail millet, Carob powder, and dates, produced using the extrusion method. Foxtail millet is rich in fibre, protein, and minerals, providing sustained energy and promoting digestive health. Carob powder, a natural sweetener, adds a chocolate-like flavour without the caffeine and theobromine found in cocoa, making it suitable for individuals sensitive to these compounds. Dates, packed with vitamins, minerals, and fibre, enhance the cereal’s natural sweetness and contribute to its chewy texture. The extrusion process ensures uniformity in shape and texture, enhancing the cereal’s appeal and shelf life. Overall, this cereal offers a nutritious and delicious breakfast option, suitable for a wide range of dietary needs. Our research revealed the importance of balancing taste, texture, and nutritional content to meet consumer preferences. Furthermore, insights into market trends and consumer behaviour can inform future product innovations and marketing strategies. Overall, the development and analysis process underscored the significance of continuous improvement and adaptation in the competitive breakfast cereal industry.

In conclusion, the development of a breakfast cereal made from Foxtail millet, Carob powder, and dates using extrusion has been successful. The combination of these ingredients not only offers a delicious flavour but also provides a range of health benefits. Foxtail millet contributes fibre and protein, Carob powder adds sweetness and flavour without the drawbacks of cocoa, and dates enhance the cereal’s texture and natural sweetness. The extrusion method ensures a consistent product with a pleasing texture. The development and analysis of ready-to-eat breakfast cereals, with a focus on proximate analysis including protein, dietary fibre, vitamin C, iron, and total fat, reveal a product with commendable nutritional attributes. With significant levels of protein and dietary fibre, the cereal offers a satisfying and nutritious breakfast option, promoting satiety and digestive health. Additionally, the inclusion of vitamin C and iron contributes to overall well-being and energy metabolism. The moderate total fat content ensures a balanced nutritional profile, aligning with dietary guidelines. This cereal has the potential to be a popular and nutritious breakfast option, appealing to health-conscious

consumers. Further research could explore variations in ingredient ratios or the addition of other nutritious ingredients to enhance its nutritional profile.

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APPENDICES

SENSORY EVALUATION SHEET

Name: Nandana Rajan Date: 19/03/2024

Product: Ready to eat Breakfast Cereal. Time: 10:15 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	5	5	4	5	6
Test 2	4	4	4	5	4
Test 3	7	6	8	8	8

COMMMENTS (if any):

SIGNATURE: 

SENSORY EVALUATION SHEET

Name: Ufga Ifrath Date: 19/03/2024

Product: Ready to eat Breakfast Cereal. Time: 10 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	7	6	3	3	4
Test 2	7	4	4	3	5
Test 3	8	6	6	7	9

COMMMENTS (if any):

SIGNATURE:

SENSORY EVALUATION SHEET

Name: Alwina Date: 19/03/2024

Product: Ready to eat Breakfast Cereal Time: 11:30 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	3	6	3	2	4
Test 2	4	5	4	5	5
Test 3	6	6	9	8	9

COMMMENTS (if any):

SIGNATURE:

SENSORY EVALUATION SHEET

Name: Saumya Saj Date: 19/03/2024

Product: Ready to eat Breakfast Cereal Time: 11:45 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	7	5	6	6	6
Test 2	6	6	4	5	5
Test 3	7	7	9	9	9

COMMMENTS (if any):

SIGNATURE:

SENSORY EVALUATION SHEET

Name: Sneha S

Date: 19/03/2024

Product: Ready to eat Breakfast cereal

Time: 10:30am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	6	5	2	5	6
Test 2	3	4	3	6	5
Test 3	7	6	8	9	9

COMMMENTS (if any):

SIGNATURE:

SENSORY EVALUATION SHEET

Name: Anju T R

Date: 19/03/2024

Product: Ready to eat breakfast cereal

Time: 11 am .

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	5	5	4	6	4
Test 2	4	5	6	7	6
Test 3	8	7	9	7	8

COMMMENTS (if any):

SIGNATURE: 

SENSORY EVALUATION SHEET

Name: Gouri Gopinath Date: 19/03/2024

Product: Ready to eat Breakfast Cereal Time: 11:25 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	5	5	3	6	5
Test 2	6	5	4	5	6
Test 3	8	5	7	8	8

COMMMENTS (if any):

SIGNATURE: Gopi.

SENSORY EVALUATION SHEET

Name: Rimna Riyas Date: 19/03/2024

Product: Ready to eat Breakfast cereal Time: 10:45 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	4	3	3	5	5
Test 2	6	5	5	5	5
Test 3	8	5	7	7	7

COMMMENTS (if any):

SIGNATURE: Rimna Riyas

SENSORY EVALUATION SHEET

Name: Muina Maria Date: 19/03/2024

Product: Ready to eat Breakfast cereal Time: 11:10 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	7	6	3	7	5
Test 2	7	3	3	4	4
Test 3	8	5	7	8	8

COMMMENTS (if any):

SIGNATURE:

SENSORY EVALUATION SHEET

Name: Niza suman Date: 19/03/2024

Product: Ready to eat Breakfast Cereal Time: 10 am

You are provided with 3 tests. Please evaluate the tests for acceptability and allot a score from the Hedonic scale as below:

Liked Extremely	-9
Liked Very Much	-8
Liked Moderately	-7
Liked Slightly	-6
Neither Like nor Dislike	-5
Dislike slightly	-4
Dislike Moderately	-3
Dislike Very Much	-2
Dislike Extremely	-1

Test	Appearance	Aroma	Texture	Taste	Overall Acceptability
Test 1	3	5	5	5	5
Test 2	4	5	6	5	5
Test 3	7	5	7	7	7

COMMMENTS (if any):

SIGNATURE:

F Q LAB
AND RESEARCH CENTRE
(P) LIMITED

Food Testing • Training • Food Safety Systems

♦ ISO 9001 QMS CERTIFIED ♦ APPROVED BY KERALA STATE POLLUTION CONTROL BOARD ('A' GRADE LAB) ♦
♦ MEMBER : AFI (USA), IFOAM (GERMANY), NIQR (INDIA) ♦ RECOGNISED BY BUYERS IN USA, EU, JAPAN & OTHER COUNTRIES ♦

B 7578

Doc.No: FQLAB/F/7801A

TEST CERTIFICATE

Date of Issue : 27.03.2024

Issued To:
Ms. Safna Jaleel
Dept. of Food Processing Technology
St. Teresa's College
Ernakulam

Sample Code	: FQLAB/23-24/1426/C2645
Sample Receipt	: 21.03.2024
Date of Analysis	: 22.03.2024 - 27.03.2024
Reported Date	: 27.03.2024

Particulars of sample	: Ready to eat breakfast cereal
Condition of Sample	: Received in good condition
Customer Sample ID	: Nil
Sample Quantity	: 100g
Sample Drawn by	: Customer
Sample Description	: Dark brown colour biscuit

TEST RESULTS

SL NO.	PARAMETERS	UNIT	TEST METHOD	RESULT
1	Protein	%	AOAC 22nd Edn. 2023; 920.87, Ch.32.1.22	7.75
2	Dietary Fibre	%	IS 11062 : 2019	6.34
3	Vitamin C	mg/100g	AOAC 22nd Edn. 2023; 967.21, Ch.45.1.14	4.89
4	Iron	mg/100g	AOAC 22nd Edn. 2023; 944.02, Ch.32.1.09	3.50
5	Total Fat	%	IS 12711 : 1989; RA 2020, M.10	2.76

No.of parameters tested: 5

********** End of the Report **********

For FQLAB AND RESEARCH CENTRE (P) LIMITED

Authorised Signatory
MANOJ P
Sr. Technologist
(Chemistry)
FQL & RC

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