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Full Length Research Article

Nutritional, Sensory and Storage Studies of Pregelatinized Porridge Mix

Subasshini V[1] and Midhulashini S*[2]

[1-2] P. G. Department of Home Science – Food Science, Nutrition and Dietetics, Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women, Affiliated to University of Madras, Chromepet, Chennai- 44, Tamil Nadu, India

Correspondence to: Midhulashini S, P. G. Department of Home Science - Food Science, Nutrition and Dietetics, Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women, Affiliated to University of Madras, Chromepet, Chennai- 44, Tamil Nadu, India, Tel: +91 9384616601; E-mail: midhulashini3@gmail.com

Abstract

Breakfast consumption of ready-to-eat (RTE) rice porridge has grown in popularity. The aim of this study was to formulate pregelatinized porridge mix with karungkuruvai rice, chickpea, and chia seeds in various proportions such as PPM_1 (60:30:10), PPM_2 (55:35:10), PPM_3 (50:40:10), PPM_4 (45:45:10), PPM_5 (40:50:10) and compared with control. For the pregelatinization process, the flour has been mixed with water and steamed, cooled, and dried at 40°C in a tray dryer. The microbial analysis revealed the total plate count (80 cfu/gm) and the absence of the total yeast and mould count. Sample PPM_1 was found to be the most variant by evaluating in terms of a nine-point hedonic scale with respect to sensory qualities such as appearance, colour, taste, texture, flavour, and overall acceptability. Hence sample PPM_1 was evaluated for physical properties, a nutritional composition such as ash (2.4 g), moisture (7.09 g), energy (175 Kcal), protein (28.2 g), carbohydrates (7.08 g), fat (3.8 g), dietary fibre (3.7 g), and storage studies including moisture content, peroxide value, and free fatty acids, and the microbial load was analyzed for about 30 days. The overall results of this study demonstrated that pregelatinized porridge mix could be used as a nutritious breakfast porridge.

Key words: Traditional rice, Karungkuruvai rice, Porridge, Rice Porridge, Mix, Storage studies

In recent years, several significant modifications have been made to the modern diet. Obesity, food poisoning, dehydration, heart issues, diabetes, and arthritis have all been significantly more common in younger generations due to the country's rapid changes in food consumption patterns as it becomes more urbanized and industrialized. The state of one's physical, mental, and social characteristics all indicate their level of health. To provide the body with essential nutrients, traditional nutrition is a science (Rajpiraveen *et al.*, 2019). In the current market, customers have access to a wide range of convenience products, but there is resistance to the usage of newer products because food is closely linked to culture and it is difficult to change eating habits. Consequently, a consumer always prefers traditional food with a few modifications to a newly developed product (Pattan *et al.*, 2001). Instant porridge is currently one of Asia's most popular breakfast foods. In several Asian nations, it is widely consumed. With increasing interest in healthy eating, a variety of processed foods in ready-to-eat form have been sold recently. Additionally, consumers now consider nutrition or health advantages as desirable aspects of food (Hussain and Kaul, 2019).

Porridge is predominantly a cereal-based breakfast dish that is enjoyed by people of all ages and it has been utilized extensively in the development of therapeutic diets due to its soft texture, easy digestibility, and suitability as a nutrient-substituted meal for patients (Alyami *et al.*, 2019). Due to its ease of digestion, rice porridge is typically a convenient food for old people and patients. It can also be used as a main course, an appetizer, or diet food (Rhim *et al.*, 2011).Additionally, consuming ready-to-eat (RTE) rice porridge for breakfast has gained popularity (Chysirichote and Phongpipatpong, 2015).

Pregelatinized starch is a type of physically modified starch that has the ability to swell in cold water and has desirable pasting and texturizing properties (Miyazaki *et al.*, 2006). Pregelatinized starch is made by gelatinizing and drying starch suspension. Gelatinization is the transformation of an aqueous starch suspension into a starch paste(Anastasiades *et al.*, 2002). For many years, pregelatinized starch and flour have been utilized in baked goods, pastry flour, instant puddings, and other products (Abbas Butt *et al.*, 2018).

Traditional rice varieties combine a number of desirable qualities, including large yields, resistance to great stress, and a wealth of medicinal and nutritional benefits. They have a lower sugar content and are favoured by those who are trying to control their sugar intake, have diabetes, or are obese. They have more fibre, vitamins, and glutamic acid (Rajpiraveen *et al.*, 2019). A dark-colored rice variety such as "Karungkuruvai" is used to treat elephantiasis arthritis, chickenpox, Hansen's disease (leprosy), anaemia, weakness, cholera, skin conditions, urinary tract infections, and lowering bad cholesterol, and Siddha physicians revered "karungkuruvai" as it is rich in protein, fat, and phosphorus (Rajpiraveen *et al.*, 2019) and its glycemic index was 53.81 GI (Balasubramanian *et al.*, 2019).

The chickpea (*Cicer arietinum* L.), often known as garbanzo bean or Bengal gram, is a traditional Old-World pulse (Lev-Yadun*et al.*, 2000). Chickpea is typically consumed for their dry seeds due to their high nutritional value, especially their protein content. It is also a good source of carbohydrates dietary fibre, minerals, vitamins, and a variety of bioactive components, and is referred to as "poor man's meat"(Ghadge *et al*., 2014). Chia seeds (*Salvia hispanica* L.) originated in Mexico and Guatemala and have been used in human cuisine for around 5500 years. Chia is derived from the spanish word “chian”, which means oily; it is an oilseed with a high concentration of omega-3 fatty acids, superior quality protein, a higher level of dietary fibre, vitamins, minerals, and a diverse range of polyphenolic antioxidants that act as antioxidants and protects the seeds from the chemical and microbial breakdown (Cahill, 2003). Low glycemic response food is regarded to be favorable to certain consumer groups, particularly those at risk for type II diabetes, overweight, and other metabolic diseases (Loypimai and Moongngarm, 2015).Thus, this research is an attempt to formulate and standardize a low-glycemic porridge mix with constituents such askarungkuruvai rice, chickpea, and chia seeds are rich in many nutrients and medicinal value that have healthy food for people and the porridge mix has been pregelatinized and it was examined for the physical properties, microbial analysis, sensory evaluation, nutritional composition and storage studies of the product.

MATERIALS AND METHODS

The study entitled “Nutritional, sensory and storage studies of pregelatinized porridge mix” has been approved by the independent human ethics committee (IHEC) dated: 12/10/2022 (Protocol No. SDNBVC/HSC/IHEC/2022/13), conducted by the department of home science, Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women, Chromepet, Chennai-44, India.

Table 1 Toxicity study

Name	Study	Reference
Chia (*Salvia hispanica*)	Chia does not have an anti-allergic, anti-nutritional,or toxic effect on human health Extension of use in cereal and cereal products at a maximum level of 10%.	(Borneo *et al.* 2010) (NF 2018/0519)

Formulation of pregelatinized porridge mix

All the ingredients like karungkuruvai rice, chickpea, and chia seeds were purchased from organic stores and it was cleaned, weighed, and ground into flour individually. According to a study (Goyat *et al.*, 2019) 100 grams of dry flour mix were mixed with 400 ml of water and steamed at 100^0 C for 5 minutes. After that, the gelatinized paste was cooled at 4^0 C for about 24 hours. The semisolid gel deposited at the bottom was collected by decanting the excess water, leveled for about 5 mm bed thickness, and dried at 40 °C in a tray dryer to obtain 12% moisture (wb), and pulverized to obtain particle sizes of about 100 – 240µm.

Table 2 Different formulations of pregelatinized porridge mix

Variations	Ponni rice flour (g)	Karungkuruvai rice flour (g)	Chickpea flour (g)	Chia seeds flour (g)
Control (PPM_0)	60	-	30	10
PPM_1	-	60	30	10
PPM_2	-	55	35	10
PPM_3	-	50	40	10
PPM_4	-	45	45	10
PPM_5	-	40	50	10

Among all the variations, PPM_1 has a significantly higher overall acceptability of the pregelatinized porridge mix which was based on the organoleptic evaluation and was discussed detailed in (Table 5). Then PPM_1 investigated the physical properties, microbial evaluation, sensory analysis, shelf-life studies, and cost calculation of the product.

Figure 1 Pregelatinized porridge mix

Preparation of porridge from the pregelatinized porridge mix

In the study described by Loypimai and Moongngarm, 2015, the ratio of the sample to hot water was 1:8, and all instant porridges were rehydrated using hot water at 100^0 C. After 3 minutes, the rehydrated samples were tested to assess the characteristics likecolour, appearance, texture, flavor, taste, and overall acceptability of the product.

Physical properties

Rehydration ratio

According to the method described by Loypimai and Moongngarm, 2015,100mlof distilled water and 10 grams of pregelatinized porridge mix were mixed, and then heated in the microwave for five minutes. The extra water was drained for five minutes before weighing. The rehydration ratio was determined by using the formula:

$$\text{Rehydration ratio} = \frac{\text{Weight of instant porridge after cooking (g)}}{\text{Weight of instant porridge before cooking (g)}}$$

Water activity

Pregelatinized porridge mix was subjected to 80% relative humidity at room temperature for about 30 minutes before subjecting to water activity (a_w) analysis using a water activity meter (Goyat*et al.*, 2019).

Microbial analysis

The total plate count was assessed for the pregelatinized porridge mix by using nutrient agar and the total yeast and mould count was examined by using Potato Dextrose Agar (PDA), the streak plate technique was used for isolation as per the procedure which is laid down in the method of (Vidyapeeth *et al.*, 2017).

Sensory evaluation

The sensory evaluation was carried out for the developed porridge from the pregelatinized porridge mix by using a nine-point hedonic scale (9 = like extremely, 1 = dislike extremely) (Peryam& Pilgrim, 1957).

Nutritional composition

The proximate composition of the pregelatinized porridge mix was examined by ash (AOAC, 2012),moisture (AOAC, 2012), energy (AOAC, 2006), protein (AOAC, 2000), carbohydrates (AOAC, 2006), fat (AOAC, 2000) and dietary fibre(AOAC, 2012).

Storage study

According to the study by Geetha *et al.*, 2020, to test the shelf life of the developed pregelatinized porridge mix, 100 grams of it were kept at room temperature (25–30ºC) for 30 days under a low-density polythene cover (350 gauge) and the samples were assessed for factors that affect storage parameters, such as moisture (AOAC, 2012), free fatty acid (AOAC, 2003), peroxide value (AOAC,2000)and microbial load such as total plate count, total yeast and total mould count (Vidyapeeth *et al.*, 2017).

Cost calculation

According to the method described by Kumar Jain *et al.*, 2018,the cost of the raw materials and the cost of processing were used to determine the production costs for the pregelatinized porridge mix. The following formula was used to estimate the amount of pregelatinized porridge per kilogram,

$$\text{Cost of production per kilogram} = \frac{Cost\ A + Cost\ B}{Q}$$

Where, Cost A represents the cost of raw materials

Cost B represents the cost of processing and

Q represents the quantity of pregelatinized porridge mix per kg

RESULTS AND DISCUSSION

Physical properties

Water activity and rehydration ratio

Water activity (aw) is the most useful when predicting the growth of bacteria, yeasts, and moulds (Leistner and Gould, 2002). The pregelatinized porridge mix was found to be (0.34 ± 0.11), it was lower when compared to the study by Mahgoub *et al.*, 2020, developed an instant porridge supplemented with mung bean with the water activity of about (0.42 - 0.44). Depending on the type of food, water activity must be kept (0.60-0.65) to prevent microbial growth(Mercer and Peng, 2008). Hence, the pregelatinized porridge mix has low water activity than the above limits and it can prevent microbial growth and increases the shelf life of the product.

Table 3 Water activity and rehydration ratio of pregelatinized porridge mix

Name of the sample	Water activity (a_w)	Rehydration ratio
Control	0.58 ± 0.10	1.7 ± 0.05
Pregelatinized porridge mix	0.34 ± 0.11	2.10 ± 0.12

Values are expressed as mean ± standard deviation

According to the rehydration ratio, dried materials have the capacity to hold soluble solids and absorb water. Additionally, it is regarded as a crucial aspect of many products that require later preparation for consumption (Jokić *et al.*, 2009). The rehydration ratio of pregelatinized porridge mix was found to be (2.10 ± 0.12) and the control was (1.7 ± 0.05). Loypimai and Moongngarm, 2015, reported the rehydration ratio for the pregelatinized banana flour-based instant porridge mix was found to be 2.02 ± 0.03, and the values are higher than the pregelatinized porridge mix. A high rehydration ratio indicates that the dried product is of good quality since the pores allow water to re-enter the cells (Noomhorm, 2007). Since the rehydration ratio of developed porridge from the pregelatinized porridge mix was higher and it determines the dried product is of good quality.

Table 4 Microbial analysis for pregelatinized porridge mix

Name of the sample	Total plate count (cfu/gm)	Total mould count (cfu/gm)	Total yeast count (cfu/gm)
Control	1×10^3(cfu/gm)	Nil	nil
Pregelatinized porridge mix	80 (cfu/gm)	Nil	Nil

Microbial analysis for pregelatinized porridge mix

Food quality and human health are always negatively impacted by potential microbial contamination (Abadias *et al.*, 2008; Concina *et al.*, 2009). The total plate count was found to be 80 cfu/gm and there is an absence of mould and yeast growth in the pregelatinized porridge mix. Bolton *et al.*, 2009, stated that the total plate count for the reconstituted powdered foods ready to eat after reconstitution or warming was less than 10^4 ($< 10^4$), which is considered to be a satisfactory level. Hence, the total plate count of the pregelatinized porridge mix was within safer limits. However, it has been prepared in hygienic conditions and completely dried. So, the total plate count was low, and absence of yeast and mould growth. Therefore, the pregelatinized porridge mix has safe for consumption.

Table 5 Sensory evaluation for pregelatinized porridge mix

	Appearance	Colour	Taste	Flavour	Texture	Overall acceptability
Control (PPM_0)	7.35 ± 0.67	7.6 ± 0.88	6.6±0.48	6.4 ±0.51	7.5 ± 0.51	6.5 ± 0.51
PPM_1	8.45 ± 0.51	8.3 ± 0.47	8.5 ± 0.51	8.3 ± 0.48	8.5 ± 0.51	8.6 ± 0.50
PPM_2	7.9 ± 0.71	7.65 ± 0.48	8.4 ± 0.59	7.7 ± 0.57	8.3 ± 0.67	7.3 ± 0.47
PPM_3	7.95 ± 0.68	7.65 ± 0.48	7.6 ± 0.59	7.8 ± 0.61	7.4 ± 0.68	7.5 ± 0.60
PPM_4	7.75 ± 0.65	7.7 ± 0.57	7.6 ± 0.67	7.8 ± 0.52	7.3 ± 0.47	7.55 ± 0.68
PPM_5	7.55 ± 0.60	7.65 ± 0.67	7.7 ± 0.73	7.7 ± 0.80	7.5 ± 0.68	7.75 ± 0.85

Values are expressed as mean ± standard deviation

Sensory evaluation for pregelatinized porridge mix

Sensory analysis is regarded as a useful tool for addressing issues with food acceptability. It is helpful for maintaining product quality, enhancing existing products, and developing new products (Singh-Ackbarali and Maharaj, 2014). For the sensory evaluation, the semi-trained or un-trained panelist of 20 members constituted to evaluate the developed porridge from the pregelatinized porridge mix, and all the panel members was associated with the "Srimathi Devkunvar Nanalal Bhatt Vaishnav College for Women", Chromepet, Chennai-44. Samples and a nine-point hedonic scale were provided to each panelist and sufficient time was given to consume the porridge and note down the values in the scorecard.

Figure 2 Preparation of porridge from the mix

Appearance

The first impression of food is usually visual, and the appearance of food influences our inclination to accept it. "Appearance" is a composite of all the information about the product and its environment that reaches the eye(Hutchings, 1977).Among all the five variations and control (PPM), the highest score obtained in the PPM_1 was (8.45 ± 0.51) and it was highly acceptable by the panelists due to the attractive colour of the porridge when compared to the other variations it has dull in colour.

Colour

One of the most crucial visual characteristics of a food product is "colour" (Spence *et al.*, 2010).Colors were stated to provide information and evoke expectations about taste, quality, safety, familiarity, and freshness in food (Paakki *et al.*, 2019).The colour of PPM_1 (8.3 ± 0.47) gained superior acceptability when compared to all the variations because it has light brown in colour due to the proportions of karungkuruvai rice.

Taste

The taste buds in the epithelia of the oral cavity and pharynx are stimulated by molecules, which cause the perception of taste(Breslin and Spector, 2008).The taste of the pregelatinized porridge mix (PPM_1) was8.5 ± 0.51 and it was found to be greater acceptability than other variations. The study by Srivastava *et al.*, 2015, revealed that the taste of the malted cereal and pulse flour mix was found to be 8.32 and which was lower than the above study.

Flavour

The flavour is a key component of sensory qualities and is sometimes referred to as "the feel-good factor" that influences consumer acceptance or rejection of any food product (Song *et al.*, 2019). The flavour of PPM_1 (8.3 ± 0.48) has gained higher acceptability among the panelists when compared to all variations respectively. The control (PPM) has (6.4 ±0.51) which was lower than the PPM_1.

Texture

Texture is the sensory and functional manifestation of the structural, mechanical, and surface properties of foods that are detected through the senses of sight, hearing, touch, and kinesthetics (Szczesniak, 2002). The texture of PPM_1 (8.5 ± 0.51) has gained superior acceptability when compared to all the variations because it has a soft consistency observed.

Overall acceptability

The overall acceptability of PPM_1 (8.6 ± 0.50) has the superlative accepted one among other variations due to the higher addition of karungkuruvai rice. The variation PPM_1 has been highly accepted by the panelists. A study by Mahgoub *et al.*, 2020, revealed that the overall acceptability of the instant porridge supplemented with mung bean was (8.2 ± 0.42) and it was slightly low when compared to the pregelatinized porridge mix.

Nutritional composition for pregelatinized porridge mix

Table 6 Nutritional composition for pregelatinized porridge mix

Nutrient	Control	Pregelatinized porridge mix
Ash (g/100g)	1.33± 0.60	2.4 ± 1.43
Moisture (g/100g)	12.40± 0.83	7.09 ± 0.01
Energy (Kcal/100g)	376. 33± 10.2	175 ± 2.25
Protein (g/100g)	8.6± 1.01	28.2 ± 1.04
Fat (g/100g)	22.56± 3.8	3.8 ± 0.15
Carbohydrates (g/100g)	45.39± 1.3	7.08 ± 0.03
Dietary fibre(g/100g)	0.55± 0.59	3.7 ± 0.57

Values are expressed as mean ± standard deviation

Ash content

Marshall, 2010, stated that the inorganic residue left after the ignition or complete oxidation of organic materials in food is referred to as "ash". The ash content of the control (1.33 ± 0.60) and pregelatinized porridge mix was found to be (2.4 ± 1.43). According to a study by Goyat *et al.*, 2019, the ash content of ready-to-rat chia and quinoa mix enriched low amylose rice-basedporridge mixes was found to be (1.10 ± 0.06). Hence, the pregelatinized porridge mix was higher ash content than the low amylose rice-based porridge mixes.

Moisture content

Moisture content is a measure of the yield and quantity of food solids, and it is commonly used as an indicator of economic value, stability, and quality of food products (Park and Bell, 2004). The moisture content of the control (12.40 ± 0.83) and pregelatinized porridge mix was found to be (7.09 ± 0.01), which was compared to the study by Ade-Omowaye *et al.*, 2003, developed a pregelatinized sorghum-cassava flour porridge mixes with a moisture content of (10.5 ± 0.53). Hence, the moisture content of the pregelatinized porridge mix was lower than in the above study. However, the lower moisture content observed in the pregelatinized porridge mix is a good indicator of their longer shelf life.

Energy content

The energy content of the control (376. 33 ± 10.2) and pregelatinized porridge mix was found to be (175 ± 2.25) lower, when compared to the study by Obinna-Echem *et al.,* 2018,developed a pregelatinized maize flour, carrot, and soybean blend with an energy content was 405 ± 7.76. Sandrou and Arvanitoyannis, 2000, stated that Low-calorie/fat foods were first made available on the market to meet specific dietary and slimming needs, and this food category was initially created for diabetics and people with particular health issues, like obesity and heart disease. Hence the pregelatinized porridge mix was lower and it was considered a "low-calorie food" and intended for people with diabetes, obesity, and heart diseases.

Protein content

Proteins, together with carbohydrates and fats, are the energy-giving components in the diet and play an important role in human growth and maintenance. Furthermore, proteins perform a variety of other tasks in the body, including enzymatic activity and the transport of nutrients and other biochemical compounds across cellular membranes (Wu *et al.,* 2014)**.** It is essential to provide the body with high-quality proteins through diet in order to maintain these vital activities (Wolfe, 2006).

The protein content of the control (8.6± 1.01) and pregelatinized porridge mix was found to be (28.2 ± 1.04). Obinna-Echem *et al.,* 2018, developed a pregelatinized maize flour, carrot, and soybean blend, the protein content was found to be (21.53 ± 00), when compared to the pregelatinized porridge mix was higher protein content. This is due to the addition of karungkuruvai rice was rich in protein content of 8.22g/100g (Balasubramanian *et al.,* 2019), the Kabuli variety of chickpeas was higher in protein content25.3–28.9% (Jukanti *et al*., 2012), as the pulse grains are an excellent source of protein(Singh, 2017) and also chia seeds are said to be rich in protein content 24.2g/100g (Jin *et al.,* 2012). Hence the pregelatinized porridge mix was rich in protein content and could aid in the prevention of protein energy malnutrition.

Fat content

Fat is essential to a healthy and balanced diet. Fats aid in the absorption of some vitamins and provide some fatty acids that the body cannot produce. The following are most common forms of fat found in foods are saturated and unsaturated fats (Lhachimi *et al.*, 2020).

Hence the control (22.56± 3.8) and the pregelatinized porridge mix were found to be a low-fat content (3.8 ± 0.15). Loypimai and Moongngarm, 2015, devised a pregelatinized banana flour-based instant porridge mix, and the fat content was (5.20 ± 0.01), then the fat content in the pregelatinized porridge mix was lower than in the above study. Chao *et al.,* 1991, stated that consumers are concerned about reducing their diets of total fat, saturated fat, and cholesterol in order to improve their health. Fat control is essential for food processors who must attempt to meet consumer demand for products containing low fats ("fat-free" or "low-fat" foods) (Eller and King, 1996). However, the pregelatinized porridge mix product was considered to be a "low-fat food".

Carbohydrate content

The carbohydrate content of the control (45.39 ± 1.3) and pregelatinized porridge mix was found to be (7.08 ± 0.03) significantly lower than the study by Iwansyah *et al.,* 2022, developed Indonesian instant cassava leaves porridge- Rowe luwa with a carbohydrate content of 56.58g. Hence it was observed that the carbohydrate content of the pregelatinized porridge mix was lower due to the addition of karungkuruvai rice which was a low glycemic index (53.81 GI) (Balasubramanian *et al.,* 2019). Kaur *et al.*, 2022, described that the consumption of low GI foods is undeniably associated with a decrease in modern lifestyle diseases such as obesity, diabetes, some forms of cancer, and heart disease. Hence it was observed low carbohydrate content in the pregelatinized porridge mix was suggested for the diseases such as diabetes, obesity, cancer, and heart disease.

Dietary fibre

The functions of dietary fibre are to add bulk to the diet, making feel full faster and thus may reduce appetite, lowers total and LDL cholesterol and thus reducing the risk of heart disease and regulate blood pressure, and thus may reduce the onset risk or symptoms of metabolic syndrome and diabetes (Dhingra *et al.,* 2012). The dietary fibre content of the control (0.55± 0.59) and pregelatinized porridge mixwas found to be (3.7 ± 0.57) which was comparatively higher than the study by Goyat *et al.*, 2019, developed a ready-to-eat chia and quinoa mix enriched low amylose rice-based porridge mixes (2.33 ± 0.33). The increase in dietary fibre in the pregelatinized porridge mix was due to the higher dietary fibre content of chickpeas and chia seeds. As a result, the developed pregelatinized porridge mix could aid in the prevention of certain disorders.

Storage studies for pregelatinized porridge mix

Consumers have become more health conscious and have demanded minimally processed foods with long shelf life and safety guarantees of the food product (Das *et al.,* 2020). Food products typically deteriorate and decay during storage as a result of microbial growth, food enzyme activity, and chemical reactions within the food. One of the most significant processes in food production is determining the shelf life and the term "shelf life" refers to the time period during which a product maintains a satisfactory level of sensory and safety-related eating quality (Prchalová *et al.,* 2016). After the 0^{th}, 1^{st}, 15^{th}, and 30^{th}day, the pregelatinized porridge mix was taken and evaluated for moisture content, free fatty acid content, peroxide value, and microbial load.

Moisture content

Table 7 Changes in moisture content during storage

Storage day	Control	Pregelatinized porridge mix
0^{th} day	6.57 ± 0.15	6.33 ± 0.11
1^{st} day	6.83 ± 0.06	6.55 ± 0.02
15^{th} day	7.00 ± 0.17	6.67 ± 0.03
30^{th} day	7.13 ± 0.22	7.09 ± 0.10

Values are expressed as mean ± standard deviation

Moisture has a significant impact on food quality, value, and freshness, and the drying rate of a food sample has a direct impact on moisture content quantification (Park and Bell, 2004). During storage, the moisture content of the pregelatinized porridge mix ranged from the 0^{th} day (6.33) to the 30^{th} day (7.09) and it was slightly increased from the 0^{th} day to the 30^{th} day of storage, the control increased from 6.57,6.83,7.00 and 7.13 to the 0^{th}, 1^{st}, 15^{th} and 30^{th} of storage. When compared to the control, the pregelatinized porridge mix has a lower moisture content. The increase in moisture content of the pregelatinized porridge mix is due to the hygroscopic nature of the flour and the change in the relative humidity during storage (Shahzadi *et al.,* 2005). The study by Geetha *et al.,* 2019, revealed the millet based high fibre food mix was stored in the low-density polythene cover a room temperature, and the moisture content was found on the initial days (9.10 ±

0.07) as it is increases slightly to the 90th day (11.03 ± 0.14) of, comparatively higher moisture content than the pregelatinized porridge mix. Narayanan and Ravikumar, 2017, reported the moisture content of the biofortified pearl millet flour mix was found to be at the 0th day (6.11±0.01), 15th day (6.88±0.02), 30th day (7.89±0.025), 45th day (8.12±0.02) and 60th day (9.40 ± .025) which was stored under an HDPE covers in a room temperature. The moisture content of the biofortified pearl millet flour mix was increased gradually from the 0th day to the 60th day of storage, and it was well in accordance with the results when compared to the pregelatinized porridge mix. The moisture content needs to be kept under 10% to prevent microbial growth of the product (Mercer and Peng, 2008). Hence the pregelatinized porridge mix has been found to be lower moisture content within the range of 10% because it has been well dried in a tray dryer at a temperature of about 40^0 C to obtain a 12% (wb) and proper storage at a room temperature between 25^0 C to 30^0 C under a low-density polythene cover.

Free fatty acids

Table 7 Changes in free fatty acids during storage

Storage day	Control (% oleic acid)	Pregelatinized porridge mix (% oleic acid)
0th day	0.34 ± 0.09	0.30 ± 0.24
1st day	0.42 ± 0.10	0.35 ± 0.27
15th day	0.47 ± 0.08	0.41 ± 0.32
30th day	0.56 ± 0.05	0.51 ± 0.39

Values are expressed as mean ± standard deviation

The level of free fatty acid (FFA) is a good indicator of the storage conditions of either the grain or the flour (Narayanan and Ravikumar, 2017). Ibeanu *et al.*, 2015, described that the amount of free fatty acid in stored foods is used to determine rancidity. During storage, enzymes inherent in foods hydrolyze fat in the food, converting it to free fatty acid and glycerol. Lipid in food products is easily hydrolyzed by enzymes like lipases during storage (Clayton and Morrison, 1972). In the storage of 30th days, the free fatty acid content value found in fresh pregelatinized porridge mix was 0.30 ± 0.24 % oleic acid, which was increased to 0.35 ± 0.27, 0.41 ± 0.32, 0.51 ± 0.39 % oleic acid at 1st, 15th and 30th day was slightly lower than the control from the 0th, 1st, 15th and 30th of free fatty acid were found to be 0.34 ± 0.09, 0.42 ± 0.10, 0.47 ± 0.08 and 0.56 ± 0.05 % oleic acid respectively. It is speculated that the increase in free fatty acid content in stored products may be due to the breakdown of hydroperoxide because thermal processing denatures lipases (Thakur and Arya 1990; Khan *et al*., 2012). Geetha, 2020, reported that the free fatty acid content of the 0th day (1.31 ± 0.10) significantly increased to the 90th day (3.83± 0.08) for the millet-based diabetic mix was comparatively higher than the pregelatinized porridge mix. The study by Ibeanu *et al.*, 2015, revealed that the free fatty acid content of the seed flour mix made with digitaria exilis seed, *Sesamum indicum,* and Glycine max seed, soybean and oilseed (benne seed) with 60 days of storage. The free fatty acid from the 0th, 14th, 28th, 42th and 60th day was gradually increased to (0.16±0.01), (0.36±0.01), (0.46±0.02), (0.47±0.05), (0.58±0.01) % oleic acid. As it was close to the value obtained from the pregelatinized porridge mix. Hence the free fatty acid values were within acceptable limits.

Peroxide value

Lipid peroxidation and enzymatic hydrolysis are the major factors that affect the shelf life of food (Balasubramanian *et al.*, 2014). Peroxide value is typically used as an indicator of the deterioration of fats. The double bonds in unsaturated fatty acids break down during peroxidation to produce secondary oxidation products, which signifies rancidity (Shobha *et al.*, 2011). During storage, there was no peroxide value of the pregelatinized porridge mix was observed on the 0th day and it gradually increased from the 1st (0.16 ± 0.07meq/kg), 15th day (0.36 ± 0.11meq/kg) to the 30th day (0.53 ± 0.14meq/kg). On the 0th day, the peroxide value of the control was found to be nil and it was slightly increased from the 1st day, 15th day and the 30th day was found to be (0.17 ± 0.06meq/kg), (0.29 ± 0.08meq/kg), (0.29 ± 0.08meq/kg) and (0.57 ± 0.13meq/kg). Therefore, the increase in peroxide value could be attributed to the oxidation of unsaturated fatty acids in the pregelatinized porridge mix (Geetha*et al.,* 2019). Ayub Khan *et al.*, 2014, developed an instant wheat porridge (dalia) mix, the peroxide value from 0th day (7.12 meq/kg), 3 months (11.43meq/kg), 6 months (19.32meq/kg), 9 months (24.45meq/kg) 12 months (29.16meq/kg), as it was stored in a polypropylene pouch and it was comparatively higher peroxide value than the pregelatinized porridge mix.

A study by Geetha et al., 2021, deviseda millet-based composite mix, the peroxide value of 0th day (7.46 meq/kg) to 30th days (8.12 meq/kg) as it stored in the low-density polythene pouches and it was higher peroxide value than the pregelatinized porridge mix. The peroxide value of food freshness as considered rancidity with acceptable limits was 10 meq/kg (Pearson, 1978). Hence the peroxide value of the pregelatinized porridge mix was within acceptable limits and it has a longer shelf life and delays rancidity.

Table 9 Changes in peroxide value during storage

Storage day	Control (meq/kg)	Pregelatinized porridge mix (meq/kg)
0th day	Nil	Nil
1st day	0.17 ± 0.06	0.16 ± 0.07
15th day	0.29 ± 0.08	0.36 ± 0.11
30th day	0.57 ± 0.13	0.53 ± 0.14

Values are expressed as mean ± standard deviation

Microbial activity

The shelf life of food products is significantly influenced by microorganisms. Most often, they are suspected of food spoilage in general (Noah, 2017). Microbial proliferation in foods requires specific conditions, including available water (water activity), proper pH, temperature, nutrients, and time. Controlling these conditions can help to prevent microbial growth and extend food shelf life of food (Geetha *et al.,* 2020). Hence evaluating the microbial quality of the foods during the storage period is crucial. At the initial stage, the total plate count of the pregelatinized porridge mix was found to be 80 cfu/gm, which was increased significantly as the storage period of time increased to 160 cfu/gms on the 30th day. According to (Bolton *et al.*, 2009), the total plate count for the reconstituted powdered foods ready to eat after reconstitution or warming was less than 10^4 (< 10^4), which is considered to be a satisfactory level. As a result, the total plate count of the pregelatinized porridge mix was at a satisfactory level and it was safe for consumption.

Total yeast count was not observed on the 0th and 1st day, and it was gradually increased to 20 cfu/gm, and 25 cfu/gm on the 15th and 30th day of storage. Total mould count has not occurred on the 0th and 1st day, and it has increased to 10 cfu/gm, and 15 cfu/gm on the 15th and 30th day. Therefore, the total yeast, and total mould count of the pregelatinized porridge mix were all within permissible limits. The total plate count of the control was 1×10^3 in the initial days and increases to 2×10^3at the 30th day it was close to the borderline (10^4 - < 10^6) for the reconstituted powdered foods ready to eat after reconstitution or warming (Bolton *et al.*, 2009) and there is an absence of total yeast and total mould count from the 0th day to the 30th day.

Table 10 Changes in microbial activity during storage

Storage day	Control			Pregelatinized porridge mix		
	Total plate count (cfu/g)	Total yeast count (cfu/g)	Total mould count (cfu/g)	Total plate count (cfu/g)	Total yeast count (cfu/g)	Total mould count (cfu/g)
0th day	1×10^3	Nil	Nil	80	Nil	Nil
1st day	1×10^3	Nil	Nil	80	Nil	Nil
15th day	1×10^3	Nil	Nil	110	20	10
30th day	2×10^3	Nil	Nil	160	25	15

Microorganisms, like all living things, require nutrients for growth and maintenance. These nutrients provide energy, carbon, nitrogen, minerals, vitamins, and other growth factors. The ability of a food item to support microbial growth is determined by its nutrient content. Carbohydrates, proteins, and lipids are the most important nutrients used by microorganisms as sources of energy, carbon, and nitrogen (Hamad, 2012). Hence the increase in microorganisms during storage is due to the nutrients such as carbohydrates, proteins and lipids in the pregelatinized porridge mix. The study by Geetha *et al*., 2019, reported the total plate count of the millet based high fibre food mix with the count of 3.55×10^3 increased to 5.12×10^3 from the initial to 30th day of storage and it was comparatively higher than the pregelatinized porridge mix. Hence, the microbial count was low due to the low moisture content, and water activity was observed in the pregelatinized porridge mix, as it does not support the growth of the microorganisms throughout the storage period.

Cost calculation

Increased prices for healthy food can have an impact on food security, especially for those members of society who are most at risk, and they can also contribute to the onset of diseases linked to diet (Wilkinson *et al.,* 2003). The cost for the pregelatinized porridge mix was found to be per kg (Rs 208.1) and per 100 grams (Rs 20.81). Therefore, when compared to the commercial porridge mix in the market, the pregelatinized porridge mix was found to be cost-efficient.

CONCLUSION

The present investigation of the pregelatinized porridge mix was found to be nutritious and microbially safe for consumption and it can be stored for one month. Porridge is a convenient and ready-to-eat product. Hence the karungkuruvai rice used in the formulation of pregelatinized porridge mix has an excellent nutritional profile and also has a very low glycemic index. Therefore, producing low-glycemic porridge could present another healthy food choice for consumers looking for low-glycemic food and it is also beneficial for obesity. The pregelatinized porridge mix has rich in protein and it would prevent protein-energy malnutrition and can be consumed by all age groups. However, it is more nutritionally dense and cost-effective than commercial porridge mix.

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