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Development and Evaluation of Pearl Millet-Based Papads

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Chapter I Introduction

1.1 Millets

Millets, also known as Nutri-cereals or dry-land cereals, are small-seeded grasses that include Sorghum, Pearl millet, Ragi, Foxtail millet, Proso millet, Barnyard millet, Kodo millet, and small millet, and are noted for their high nutritious content. Millets are one of the oldest foods found in Africa and Asia. Millets are a staple meal in various African and Asian countries due to their short life cycles. Millets are also utilised in the manufacturing of bioethanol and as livestock feed **(Nikhil et al., 2012**). With an increase in health consciousness in people to reduce health problems regarding micronutrients research is also ongoing on millets to make available in everyday life and to replace some traditional cereals. Millet products are now available in the market replacing some quantity cereals like multigrain atta and some instant mixes. Millets are used as functional foods.

1.2 Health benefits of millets

The beneficial properties of millet are they have a low glycemic index, gluten free properties, high fiber and low fat content compared to some major cereals **(S. Singh and ESChauhan,2019**). They also have micronutrients like vitamins and mineral content. Every single millet is superior to rice and wheat in terms of micronutrients and low in fat content. They are added to diet as they are healthy, nutritious and versatile grains. Pearl millet, finger millet, foxtail millet and sorghum are the major millets that are cultivated of all the millets. Millets can grow in harsh and drought conditions. In addition to good nutritive properties, several potential health benefits as anticancer, antidiabetic, antidiarrheal, antiulcer,anti-inflammatory, anti-tumourigenic, atherosclerogenic effects, antimicrobial, and antioxidant properties have been reported from millets and is also known to be drought resistant crop**.(Zhu et al.,2010).** Millets are a solution to global issues like food insecurity as they can grow in adverse agro-climatic conditions and malnutrition.

1.3 Pearl millet

Pearl millet (Pennisetum glaucum), often known as Bajra, is a key millet crop farmed primarily in semi-arid climates around the world. Pearl millet is a gluten free grain and is the only grain that retains its alkaline properties after being cooked which is ideal for

people with gluten allergies **(Ritu Kumari et al., 2018)**. Because pearl millet includes a higher amount of insoluble dietary fibre, which slows the release of sugar, it is utilised in the manufacture of a variety of nutritious foods and food ingredients, including those for diabetics. Pearl millet is a high-energy grain that can be used in place of ordinary cereals. Pearl millet is gluten free and comprises essential amino acids like lysine, threonine, methionine, and cysteine and tryptophan content and it also exhibits higher apparent digestibility in pearl millet of essential amino acids than other grains **(Adeola et. al., 2005 and Kalinova and Moudry, 2006).**

1.3.1 Health benefits

Because of its nutritional properties, pearl millet has potential health benefits and can be used to prevent some diseases. Some of the health benefits are:

Table 1.1 Health benefits of pearl millet (Patni & Agarwal., 2017)

Disease	**Health Benefits**
Anemia	Help in increasing hemoglobin count because it has good iron content.
Cancer	It has anticancer property inhibits tumor development because of its antioxidant property and also has flavonoids.
Celiac	As it is gluten free prevents allergy.
Constipation	Rich in fiber content.
Diabetes	It has low a glycemic index and helps in dealing with diabetes.
Diarrhea	It helps in probiotic treatment (lactic acid bacteria).
Noncardiac diseases	It contains flavonoids, phenolics, and Omega 3 fatty acids, it prevents DNA scission, LDL cholesterol, and liposome oxidation.
Heart diseases	In comparison to cereals, it also has a reduced fat level.

Though pearl millet is rich in nutrients, it also has some anti-nutritional factors like phytates, etc. that decrease the bioavailability of the nutrients. To decrease the anti- nutritional factors certain pre-processing and processing methods are followed like blanching, soaking, parboiling, germination, milling, fermentation with pure and mixed cultures, heat treatments like roasting and microwave treatment, hydrothermal treatments like steaming. These treatments improve the bio-accessibility of minerals.

1.3.2 Products from Pearl millet:

The common traditional food made from pearl millet is porridge (fermented and unfermented). Fermented products like beer, Ontaku, Fura from parboiled grains are manufactured in Nigerian countries **(Embashu & Nantanga, 2019**) is also prepared from pearl millet. The traditional product mostly made in India is flatbread(chapatti) it is prepared for years and is a staple food in many areas. Research is also done by fermenting the flour with yeasts and lactobacilli and weaning food is developed from the flour to increase starch and protein digestibility **(Balasubramanian et.al., 2011**).

Bakery products like bread, biscuits and cookies, pancakes were prepared from millet flour to develop gluten free foods (**A.A.Kulthe et al., 2017**). Extruded chips, pasta (**Jalgoankar&Jha 2016**) are prepared by incorporating the flour with other ingredients. Popping is also done on grains to increase the bio-accessibility of minerals to develop weaning foods and millet bars (**Ritu Kumar, 2018**). Research is also done by processing flour like laddoos, noodles, vermicelli, chips, dhokla, Idli is also prepared with parboiled rice, pearl millet flour, black gram and fenugreek seeds. Upma dry mix is developed by steaming, drying and pulverizing pearl millet grains along with some other dry ingredients as diabetic foods (**Yadav et.al., 2012**). Ready to reconstitute kheer mix is done by mixing pearl millet flour, dairy whitener and powdered sugar **(Durga Shankar et al.,2012**). Research is also done to use pearl millet grains along with rice broken for ethanol production **(Gohel & Duan., 2011).**

1.4 Papads

Papad is ready to cook product it is a processed dried product that is later fried in oil just before consumption. It is a traditional savory product and is widely consumed in India as an adjunct. Papad is a snack having a crunchy wafer-like taste and is mainly made out of black gram flour, rice, green gram, sorghum and other ingredients such as common salt, spices, carbonates and oil are also added (**Gaikwad Pratik, et al.,2010**). Traditionally papads are prepared with black gram, rice flour and in the combination with other flours for variation. The papad industry in India is predominantly a cottage industry and is mainly started for women empowerment and social welfare **(Awalgaonkar et al., 2015*).*** The demand for papads is increasing commercially, the market is also growing at different levels.

Now a days papads are prepared from many composite flours like potato flour, banana flour, beetroot, mint and spinach extracts, masoor dhal, legume flours, lentils, jowar, ragi, soy flour and moringa leaves etc. to increase the value addition of the product.

Generally, pearl millet flour has low storage stability, so the flour is processed into different value-added products. Different products were developed from pearl millet using different methods and research is ongoing to develop value added products by incorporating millet flour with other ingredients. As there is no requirement of high temperature or processing steps for papads, the nutritive loss of papads is low. Papads are dried product so there is less chance for microbial growth, which increases the storage period of the product.

1.5 Objectives

- To develop papads from pearl millet
- To study physico-chemical properties of developed papads

Chapter II Review of literature

This chapter includes the studies that are carried on the millets till present. It includes details of the millets, pearl millet and papads their nutritional properties and the research work had done up to present day. Research was carried done on all types of millets to add some value to the traditional food products. Many studies were done by mixing the millet flour with the cereal-based flours and comparing the nutritional properties. Different types of value-added products are prepared up to now on pearl millet to increase the nutrition and the demand of the millets.

Hou et al., (2021) studied the nutritional and functional changes during processing of millets and how pre-processing is important in millet processing, and how it is advantageous for industries, consumers and research areas. They explained that processing of millets helps to meet the demand of food security with help in get rid-off malnutrition the main problem in the society.

Anitha et al., (2021) reported the systematic review on how millets help in reducing the risk of developing Diabetes Mellitus as they have low Glycemic Index that helps to manage diabetes. They concluded that the millets are to be kept in daily diet to reduce the risk of diabetes and many other diseases.

Hassan et al., (2021) explained the phenolic status and anti-nutritional properties of millets and their impact on human health and livestock. It gave the information on optimum level of inclusion of millets in human diets although it did not provide the information regarding the animal diets.

Kaushik et al., (2021) explained the ways to enhance the nutritional properties of millets for their value addition. They explained the processing methods of germination, fermentation, decortication, milling, parboiling and nutritional profile and value addition in baked and extruded food products.

Singh & Chauhan (2019) explained the role of underutilized millets and their nutraceutical importance in the new era. They explained the methods for reducing the antinutritional factors of millets for developing value added products with millets. They concluded thatmillets can be a great source of ending hunger, poverty, nutritional insecurities among the lower section of the people.

Changmei & Dorothy (2014) described millet as a frugal grain. They explained about fortification of millets helps in developing new products that can enhance nutritive availability of the products. They explained about how different millets help in cure of different diseases as millets are cheapest source for fortification.

Punia &Whiteside (2021) explained about pearl millet grain as a emerging source of starch as it contains 70% starch in the grain. Its functional properties, industrial applications, physico-chemical properties. They isolated the starch from pearl millet and modified it using physical, chemical, and enzymatic modifications to improve properties. Techno functional properties like gelatinization, pasting properties, swelling power, solubility and digestibility are studied and compared with the native starches.

Jideani, & Okudoh (2021) prepared a Non-alcoholic beverage innovation with Own Leuconostoc mesenteroids(0.05%), Pediococcus pentosaceus(0.025%) and Enterococcus gallinarium thereby reducing the production time to 18h from traditional 24h from pearl millet slurry.

Satankar et al., (2020) reported the fundamental review about pearl millet and its underutilization for nutrition. It provided the information about the great potential of the importance of the pearl millet its nutritional profile, processing techniques, health benefits, products and how it useful for producers and consumers.

Abah & Oladejo (2020) reviewed the nutritional composition, functional properties and food applications of millets. They explained the nutrition of millets and how they meet present demand for nutrition. They explained the functional characteristics of millets and how millets can be used in food application to replace cereals. They also explained procedures for production of millet-based foods like fermented beverages, alcoholic and non- alcoholic beverages etc.

Himanshu et al., (2018) reviewed the nutraceutical properties of millets. Millets have bioactive compounds like phenolic compound, flavonoids, phytic acid, phytosterols, carotenoids and tocopherol that help in body functions for some degenerative diseases in their isolated form. These components help in antioxidant and antimicrobial activities.Millets also have potential health benefits that helps in reducing and preventing some chronic diseases.

Pawase et al., (2019) studied about the pearl millet processing and its effect on antinutritional factors. They explained about different methods of pearl millet dehulling, malting, blanching, fermentation, heat treatment and acid treatment. They concluded that the processing methods improved the nutritional profile of millets and altered the storage properties of flours as well as the flours. For commercial utilization of millets it is necessary to use a appropriate processing methods.

Patani & Agrawal (2017) studied about the nutritional properties and health potential benefits about the pearl millet. The article describes how different components present in pearl millet help in cure and prevention of certain diseases like Anaemia, diabetes, weight loss, anti-ageing and also because of its hypo allergic properties it also has anti allergic properties and can be included in diets of infants, lactating mothers and elders etc.

Kulthe et al., (2017) developed cookies with pearl millet flour and wheat Physical properties like color and textural properties like hardness, breaking strength and cutting strength are evaluated using color scanning machine colour flex for color and Instron universal texturometer for measuring textural characteristics. Spread ratio and spread factor were estimated. The nutritional composition of cookies is good compared to control samples. The hardness of cookies also increased with increase in the percent of pear millet flour because of the interaction of the wheat proteins with the pearl millet proteins made cookies compact thus increasing the hardness of cookies.

Krishnan & Meera (2018) reviewed the effect of processing on bio-accessibility of minerals in pearl millet and their anti- nutrition factors responsible for their inhibition and treatments for their enhancement of bio-accessibility. They also described some treatments to increase their bioavailability like soaking, blanching, hydrothermal treatments, decortication, germination and fermentation. The percentage reduction of phytic acid and polyphenols were described in this article along with the processing efficiency of these methods also described. They concluded that by adding enhancers it increased the bioavailability of the minerals.

Dashrath & Acharya (2016) studied the impact of pre-milling processing procedures on pearl millet total iron content and invitro iron availability was investigated. The grains are then pulverised and stored in an airtight container in a polythene bag. Total iron, invitro iron, free fatty acids, and polyphenols were measured in all samples. All the treatments reduced the polyphenols. They observed that total iron is lost in all treatments but maximum iron was lost in acid treatment and the minimum loss is observed in dry heat treatment. The bioavailability of iron is increased in all treatments maximum is observed in dry heat treatments (120 min).

Budiman et al., (2015) performed on absorbable iron in pearl millet in comparison of iron) biofortified (high iron) pearl millet variety to standard variety (low iron). The two varieties are fed to two groups of broilers for about 40 days. After observation the blood samples were collected and hemoglobin content and the total amount of iron absorbed was identified. They concluded the more iron was absorbed in biofortified variety because the phytic acid functionalization was reduced in this variety.

Banumathi et al., (2015) studied the impact of heat treatment on the functional and phytochemical qualities of modified and native flours was investigated. Wheat flour, pearl millet, and proso millet have been taken and samples were submerged them for two hours, autoclaved them for one hour, and let them cool to room temperature. After cooled the samples are frozened followed by cabinet drying. The samples' water absorption capacity, oil absorption capacity, colour, and phytochemical characteristics were investigated. When comparing modified flours to native flours, the water and oil absorption capacities were shown to be higher in changed flours.The phytates also reduced in modified flours compared to native flours but the maximum phytate composition is found in proso millet. Phenolic compounds and antioxidant activity was high almost in all samples.

Ranasalva & Visvanathan (2014) To improve the amino acid profile, bread was made using fermented pearl millet flour. Pearl millet is boiled and fermented with water in 1:2 and 1:3 ratios for 48 hours before being combined with refined wheat flour to make bread. characteristics such as bread volume, texture analysis, composite bread stiffness, colour measurement, and sensory evaluation They came to the conclusion that pearl millet flour can be utilised in bread items, but only in small quantities. The use of cooked flour instead of plain flour lowered the bread's rising volume.

Nambiar et al., (2011) explained the potential implications of pearl millet in health based on the project on “Background nutritional studies on pearl millet”-Gujarat. This article concentrated on the impact of pearl millet as a therapeutic use for diabetic people, celiac disease people and non -communicable diseases.

Kriti et al., (2016) studied the effect of thermal treatments on the storage life of pearl millet flour by keeping it at different temperatures. They evaluated the FFA, phytic acidity, trypsin activity and moisture content and compared the values with the control samples. The treatment is done in twin screw extruder (60 sec) and boiling for 15 minutes and dried. The grains were made into flour and are then packed. The phytic acid and trypsin activity is reduced in both treatments. Even the pretreatments the flour stored only for one month in ambient temperatures for hydrothermally treated flour and 45 days in controlled conditions.

Bhupender et al., (2013) investigated the physicochemical, functional, thermal and pasting properties of starch that is isolated from pearl millet. The starch is isolated from the sample and was analyzed for moisture, ash, crude fat, ph, acidity and amylose content, functional properties like solubility, water binding capacity, viscosity and pasting properties were determined with Rapid visco analyzer. Swelling of starch showed highly restricted are relatively stable during cooking with water. The amylose content is found to be from 15%- 18%. The granular dimensions are important in determining the characteristics of pearl millet.

Adebiyi et al., (2016) developed biscuits prepared from fermented and malted pearl millet flour and studied the effect of fermentation and malting on biscuits. The biscuits are evaluated for functional, physicochemical and microstructural analysis and compared to native biscuits. Malting and fermentation improved the functional properties of the flour and induced desirable changes in the microstructure and physicochemical properties of the flour. They concluded that malting and fermentation degraded the protein and starch polymers to other small constituent structures. The changes resulted in enhanced biscuit hardness and functionalities for potential applications for baked products to obtain gluten free products with desirable characteristics.

Akinola et al., (2017) investigated the effect of preprocessing techniques and technological properties of pearl millet flour in industrial applications. The effect of blanching, fermentation, de-branning and malting are explained. They concluded that pearl millet is fit for making sourdough bread by modifying the starch. Pretreatment of pearl millet grains can be utitilized for making quality flour blends, weaning foods, sausages and other pastry products.

Balasubramanian et al., (2021) studied the shelf-life evaluation of pearl millet-based upma dry mix was produced and tested. The grains of peral millet were hydrothermally treated, dried, and milled. Other components include vanaspathi, Bengal gramme, black gramme, mustard seeds, and green chilies. All of the ingredients were shallow fried, chilled, and then sealed in polythene bags. As a preservative, citric acid is utilised and maintained at room temperature. Both a chemical and a sensory investigation were carried out. According to shelf-life studies, the mix can be stored at room temperature for up to 6 months. They also determined that because it has a high calorie content and a high protein content, it can be used as a source of mid-day meals and other nutritional status.

Ali et al., (2012) studied the qualities of pearl millet flour were investigated in combination with defatted soyabean flour to increase the protein level by 5%, 10%, and 15%, respectively. They looked assessed the flour's functional qualities such absorption of water and fat, bulk density, nitrogen solubility, and dispersibility.

They came to the conclusion that soyabean flour boosted the protein level of the composite flour while having no effect on it's own gelation**.** The emulsifying and foaming properties were improved makes it a useful ingredient for several food products.

Jaspreet Kaur et al., (2011) developed a weaning mix based on malted and extruded pearl millet and barley. Pearl millet were soaked in water for 2hrs and steamed for 15 mins. They were then dried at 60^{o}C. The grains were then pearled and milled. Barley flour was prepared by conditioning the grains to 12% moisture then pearled and milled into flour. Malted flours were made by steeping grains in water for 8 hours, then germinating and drying them. The grins were ground for flour after drying. A twinscrew extruder was used to extrude both raw and malted flours. Peak viscosity, colour, water solubility index, and water absorption index were investigated as functional qualities. They concluded that it has a great potential to eradicate malnutrition in children. Addition of malt improved the functional and nutritional properties of the weaning food.

Arora et al., (2011) studied the effect of germination and fermentation on nutrient profile of pearl millet based food blends. They collected pearl millet samples and germinated the seeds and then fermented with lactobacillus culture. They made two types of flour blends with tomato pulp and whey powder. They concluded that a combination of germination followed by fermentation with probiotic organism is a potential process for developing food products of improved nutritional quality and therapeutic value.

Sharma et al., (2019) investigated the nutritional quality of papads prepared from black gram and rice bean flour of different blending proportions. The chemical and sensory analysis was conducted for all the blends for every 3 months. They concluded that the overall acceptability is found to be more for black gram papads and low for rice bean papads however the nutritional composition is more for rice bean papads and the papads can be stored upto 5 months without any deterioration.

Anil et al., (2018) standardized papads using urad flour, raw banana and sweet potato and the storage stability of papads. The ingredients were blended in different ratios. They concluded that substitution of unripe banana and sweet potato significantly affected that the stickiness and hardness of the papad dough. The sensory analysis showed high for papads that have equal ratios of unripe banana flour and sweet potato flour.

Surve & Madhavareddy (2018) studied the characterization and development of jowar papads. The papads prepared with fermented sorghum flour for improvement in indigenous process. They studied the nutritional, textural, functional and gel properties of the papads and flour. Importantly, the studies were carried on effect os fermentation on phytic acid content, minerals and anti-nutritional factors. They concluded that there is scope for introduction of indigenous fermentation technology as functional diet and they are alternative to black gram dhal papads.

Prabhakar & More (2017) studied the effect of addition of various proportion finger millet on chemical, sensory and microbial properties of sorghum papads. They were then analysed for proximate composition, organoleptic and microbial evaluation. They concluded that calcium and iron content increase with increasing the finger millet concentrations. They stored papads for three months.

Agarwal et al., (2016) developed papad using Buckwheat and Guar gum. Black salt and black pepper were added to enhance the flavour and taste of the papads. The papads were prepared by mixing buckwheat, potato mash, guar gum and water made into a dough by cooking. Then dough is then shaped into small balls and pressed in the papad mould. They are then dried kept for sun drying, packed and stored at ambient temperature. Physico- Chemical, microbial and sensory analysis were done to the papads. They concluded that the papads have high acceptability and consistent quality.

Kodandaramreddy and Waghray (2013) developed papads with mint leaves. Black gram flour and mint leaves are blended at different levels and evaluated for proximate studies.

The fried papads given for sensory evaluation for semi trained panelists. Minerals, flavour, vitamins and fibre contents increased significantly as the level of supplementation of mint leaves increased. All ratios gave good score for overall acceptability of the papads.

Nazani & Pradheepa (2010) developed papads from jowar millet and black gram with different proportions and evaluated the physico-chemical and organoleptic properties of the papads along with the storage studies for 6 months. The papads were prepared by mixing all the ingredients and made them into dough, this dough is made into small balls and then rolled. These rolled papads are then dried at 50^{o} C for 1 hr and packed. The papads do not show any remarkable changes in six months in ambient conditions and the papads are shelf stable for about 6 months.

Kamat et al., (2009) investigated the consumption pattern of papads in household and its availability. They conducted a survey in different places of Karnataka to know consumer preferences for papads. Then collected the data through questionnaires, interviews and in retail shops etc., and they categorized the data into different variables like age, educational level, family size, occupation. Finally,concluded that rice flour papads have more demand followed by black gram and horse gram.

Patil et al., (2004) studied the about the substitution of papadkhar with 2:1 sodium carbonate and sodium bicarbonate. They studied the effect on quality of fried papads and oil. They results concluded that this mixture is effective by 1% and is effective for up to two frying cycles.

Garg & Dahiya (2002) evaluated the nutritional and shelf life of papads prepared from wheat-legume composite flours and developed papads from wheat and legume blends and analysed them for organoleptic, proximate and keeping quality. The papads were prepared with wheat flour, chick pea and pea flour. The level of supplementation of papads was found to be acceptable and they were nutritionally evaluated. They concluded that the protein content significantly increased in the flour. Total carbohydrates, phytic acid and trypsin inhibitor decreased significantly on supplementation. The storage studies showed that papads supplemented with chick pea and pea flour are safe up to 60 days and wheat flour supplemented papads were safe up to 30 days both at room and refrigeration temperatures.

Chapter 3 Materials and methods

3.1 Availability of raw materials

The required raw materials are procured from the local market and super market in Hyderabad. Rice flour, ajwain, cumin, salt from super market and pearl millet grains were purchased from the local market.

3.2 Preparation of sample mix

Pearl millet grains were cleaned and soaked in water for 3 hours and then steamed for 20 minutes. The steamed grains were dried in a tray drier until they were completely dried. The dried grains are then milled in a flour mill finely. The pearl millet flour and rice flour are mixed and cooked in a pan. To this mixture salt, ajwain, cumin and papad khar to this mixture. Sample trials were made by mixing pearl millet flour and rice flour in different ratios with 100 %, 60%,50% and 40% pearl millet flour. The sample trials are given for sensory evaluation. Based on the score of the sensory evaluation with 9-point hedonic scale the final ratio of the product is taken for the preparation of the final product.

Formulation

Along with flours salt, cumin and ajwain and papad khar are mixed. Papad khar is an alkaline salt prepared by mixing sodium bicarbonate and sodium carbonate (1:2) ratio. It is a essential and vital ingredient in making papads. It can be added directly or added by mixing in the water. It gives crispness and expansion to the papads. Salt is added for taste and it also acts as a preservative. Ajowan and cumin are added as seasoning to the papads as they also help in digestion.

Formulation of the product for 1 kg

Table3.1 Final formulation of Papads

Name of the ingredient	Amount (g)
Pearl millet flour	500
Rice flour	500
Salt	20
Ajowan	2
Cumin	3
Papad khar	10

Table 3.2 Trails of papads

S.no	T1	T2	T3	T4
Pearl millet(g)	100	60	50	40
Rice flour(g)	0	40	50	60
Salt (g)	30	30	20	20
Cumin (g)	3	3	3	3
Ajwain (g)	2	2	2	2
Papad khar(g)	10	10	10	10

Fig 3.1 Trials of papads

3.2.1 Preparation of papads

The pearl millet flour and rice flour were weighed in equal quantities using weighing balance. Add water to about 1 ½ times to the flour to the pan and boiled. Flour was added to the boiled water and stir the mixture continuously to avoid lump formation.

The flour was cooked until it become thick and soft. To this add salt, ajowan, cumin and papad khar that are pre-weighed directly into the dough. Allow it to cook for 2-3 minutes and then remove it from the flame. After the mixture is cooled, mix it with a ladle once again. The dough was now made into small balls(6-7g) and pressed in a papad press (1mm). The papads are then dried in tray drier (40°C for 7-8 hr) and packed in polythene covers.

Pearl millet flour and rice flour are weighed and premixed

↓

Boil water for about 5 minutes

↓

Add the flour to the boiled water

↓

Add the other ingredients to the mixture

↓

Cool it for 3-5 minutes

↓

Make it into dough

↓

Make the dough into small balls

↓

Pressing

↓

Drying in tray drier

↓

Packing

Fig 3.2 Processing flow sheet of papads

Fig 3.3 Raw and fried papad

3.3 Physical analysis

3.3.1 Color estimation

Procedure:

- The samples were closely packed in small, transparent poly ethylene packs, making sure much airgaps were not resent.
- This packs with the sample were analysed using hunter lab color evaluation system. Where the color which was determined by CIE (commission internationale de l'eclairage) classification in three dimensions; L^*, brightness, a^*, red to green color and b^*, yellow to blue color was noted.
- The measurements were carried out in triplicates and average was noted.

Fig 3.4 Hunter lab color analyser

3.3.2 Texture analysis

Procedure:

- Texture profiling of papads were carried out using brook field texture analyser.
- The distance between two supports was adjusted to be 20mm the diameter of the product was along with 80% diameter were established using a vernier calipers desired parameters were setting the Brookfield texture analyser along with 80 % cutting.
- The sample was mounted on the supports and probe was allowed to cut through the sample. The highest peak value is noted down as this is measure of hardness of the product. The values for load were noted accordingly.

Fig 3.5 texture analyzer

3.3.3 Expansion ratio of papads

Procedure:

- The percentage expansion was calculated by using the formula (Annapure et al., 1997)

Formula:

Percentage of expansion=Q-P/Px100

P=Diameter of papad before frying Q= Diameter of papad after frying

3.4 Chemical analysis

3.4.1 Moisture content (AOAC method 934.01, 2000) Procedure:

- The moisture percentage in the product was estimated by using oven drying method.
- A flat bottomed pre-washed and dried petri dish was taken and weighed (P).
- To this petri dish sample was added and weight was noted (Q).
- From this the initial weight of the sample was calculated (S).
- These petri dishes were then placed in a hot air oven for 16-18 hours at 100^{o}C.
- After the drying, the petri dish along with the sample was weighed once more (R).
- The moisture content of the product was calculated from the above obtained values.

Formula:

Percent Moisture =[(Q-R)/S] * 100 Weight of petri dish + sample = Q grams

Weight of the sample = (Q-A) =S grams Weight of petri dish +dried sample = R grams

Fig 3.6 hot air oven

3.4.2 Estimation of fat content (AOAC method 963.15,2000)

Procedure:

- A dry thimble was taken and to it 2 grams of sample is weighed in a tissue paper and placed in the thimble and covered with cotton.
- The extraction beaker

- Was taken and its weight was noted down .
- hexane 85-90 ml is added poured into the extraction beaker through the thimbles.
- It takes about 2 hrs to complete the process.
- The extraction beaker is now kept in hot air oven until the solvent dries and kept for cool down. After cooling weights are noted.

Formula:

Percentage of fat= S/P *100 Weight of sample= S (g)

Weight of the extraction beaker with fat after solvent extraction=R (g) Weight of fat=(R-Q) = P (g)

Fig 3.7 Soxhlet apparatus

3.4.3 Estimation of protein content (AOAC method 960.12,2000)

Procedure:

- Two grams of sample was weighed in Kjeldahl flask.
- To this 2 g digestion mixture and 40ml Conc.H_2SO_4 was added.
- the contents were boiled using a burner inside a fume cupboard, until the sample turned clear.
- Volume was made upto 100ml by addition of distilled water in a volumetric flask. 10-20ml aliquot was taken into distillation flask and to this 40% NAOH was added to neutralize the acid.
- 10ml of the distillate was collected by vapor heating into 10ml saturated boric acid solution.
- When titrated in the presence of mixed indicator the solutions color changed from pink to green.
- Boric acid was back titrated with 0.05 N HCL. End point was indicated by the appearance of pink color.

fig 3.8 Protein digester **fig 3.9 Protein distillation unit**

3.4.4 Estimation of crude fiber (AOAC method 945.38,2000)

Procedure:

- Two grams of sample was weighed and transferred into a conical flask.
- To this 200 ml of 1.25% of hot H_2SO_4 was added. The contents of the conical flask were boiled on a hot plate for)30 mins followed by filtration using filter paper.
- The residue on the filter was washed using hot distilled water until the acidity was removed (tested with blue litmus paper).
- This residue was boiled in a conical flask along with 1.25% NaOH for 30 mins. It was then filtered through a previously weighed whatmann No.1 paper.
- The residue was washed with hot distilled water until the alkalinity was removed (tested with red litmus paper).
- This filter paper was placed in the hot air overnight at 110^{o}C for removal of moisture.

Formula:

Percentage of crude fiber= (D/A) X 100 Weight of sample=A grams

Weight of whatman No. 1 paper=B grams Weight of filter paper + crude fiber=C grams Weight of crude fiber=C-B=D

3.4.5 Estimation of Ash content (AOAC method 923.03,2000)

Procedure:

- Total ash was estimated by dry ashing method. The sample was ground in a mixer.
- A dry crucible was taken and weighed. Sample was added in the crucible and the weight was noted.

- The contents of the crucible were burnt on a Bunsen burner. The crucible was then transferred to a muffle furnace, maintaining the temperatures between 500-600°C for 6 hours.
- In the furnace water and volatile materials were vaporized, the organic substances were burnt in the presence of CO_2, H_2O and N_2 while minerals were converted to oxides, sulfates, phosphates, chlorides and silicates. After ashing the crucible is left to cool down and is weighed.

Formula:

Percentage of total ash=(T/S) X 100

Weight of the crucible=P
Weight of the crucible+ sample=Q

Weight of crucible+ sample after ashing=R Weight of sample=Q-P=S

Weight of ash=S-P=T

Fig 3.10 Muffle furnace

3.5 Storage studies

Moisture sorption studies

The relation between the moisture content and the water activity at constant temperature is known as the moisture sorption isotherm (Labuza,2002). Known quantity of products were taken in petri-dishes and was exposed to different levels of relative humidity's (RHs) ranging from 11 to 92% built in desiccators using appropriate saturated salt solutions (Lopez et.al.,2000). The samples were periodically weighed till they attained practically constant weight and showed signs of mold growth which ever was earlier. After equilibration the moisture content of the product at different RHs was calculat3d by adding / subtracting % pick up / loss to /from the initial moisture content (brumauer et.al.,2004). The sensory remarks on their quality were taken and critical moisture content were fixed **(Andrade ei.al.,2011**).

Critical moisture content (CMC%): According to **Azanha and Faria 2005**, the critical moisture is the moisture content at which the product lossess it crispness to a level that would be rejected by the consumer.

Initial moisture content (IMC%): This was determined by drying known weight of the product taken in petri dish at 100±5°C till constant weight as per AACC,1983.

3.6 Sensory evaluation

Sensory evaluation was performed using a 9-point hedonic scale. The panelists to scale the different attributes of the product on a broad range. They were provided with sensory sheets to record their observations. The were placed in disposable plates, labelled and provided to them. Scores were based on hedonic scale of 1-9.

Table 3.5 Sensory evaluation

Attributes	Description
Colour& appearance	Poor=0 to extremely acceptable=9
Brown	Poor=0 to extremely acceptable=9
Texture	Poor=0 to extremely acceptable=9
Crispy	Poor=0 to extremely acceptable=9
Taste	Poor=0 to extremely acceptable=9
Overall acceptability	Extremely unacceptable=0 to extremely acceptable =9

3.7 Statistical analysis

Using IBM SPSS statistics software, the data from the proximal analysis, hardness, and sensory evaluation was statistically evaluated (version 28.0.1.0). For each sample, the mean and standard deviation were calculated. The data was evaluated using one-way analysis of variance (ANOVA) using Duncan's method with three replications for moisture content, protein, fat, crude fiber, color, texture, ash, expansion ratio and five replications for sensory evaluation. A 5% level of significance was used to establish the degree of significance.

Chapter IV Results and discussions

Physical and chemical experiments were conducted during the research work and the observations were recorded. Experiments were conducted for every 30 days and the observations were recorded. On the basis of the observations the results are described below:

4.1 Physical properties of papads

The physical properties are observed visually and conducted every month it includes color and texture, diameter before and after frying for expansion and weight of the papads.

4.1.1 Evaluation of the color

Color of the papads for both control papads and pearl millet papads is checked colorimeter every month. The observations were noted as L*, a*, b* in experimental studies the denotes three different specifications L* denotes the brightness of the products, a* and b* denotes the color variants like redness and greenness in the food products. The brightness of papads is stable for two months and increased gradually in third and fourth months. The redness and greenness is also stable up to two months and decreased gradually in third and fourth month. The results were similar to **Ajmal (2015**), where the color of papads increased gradually during storage of papads it may be due to increase in yellowness of papads. The recorded observations of the papads are tabulated in table 4.1.

Table 4.1 color analysis of papads

Month	Control Papads			Pearl Millet Papads		
	L*	**a***	**b***	**L***	**a***	**b***
0	64.01±1.68[a]	3.04±0.02[a]	26.31±1.39[a]	78.82±1.03[b]	1.65±0.04[b]	21.89±0.41[b]
1	64±0.01[c]	3.06±0.12[c]	25.99±1.25[c]	77.65±0.32[d]	1.16±0.03[d]	21.61±0.84[c]
2	67.66±0.23[e]	2.16±0.03[e]	27.80±0.81[d]	73.55±0.94[f]	0.17±0.02[f]	25.58±0.75[e]
3	77.16±0.33[g]	0.57±0.04[g]	24.2±0.26[*]	67.63±0.72[h]	1.37±0.06[h]	28.61±0.13[*]
4	78.2±0.42[i]	0.48±0.12[i]	22.6±0.16[*]	65.5±0.51[j]	1.07±0.08[j]	22.45±0.32[*]

All the values are represented as mean ± standard deviation (n=3). Different superscripts represent significant difference is between the rows L, a*, b*.

4.1.2 Evaluation of texture

Texture is one of the important factor and it plays an important role in the food products because it determines the hardness, softness and chewiness of the food products. Texture is important to papads as it determines the crispiness and hardness which is important for papads. The hardness of the product varies with increase and decrease of the moisture content. The peak load indicates the hardness of the product. Texture of papads were determined every month and the observations were recorded. The hardness of papads increased as the storage period increases it may be due to increase in moisture content of the papads. The hardness of papads is directly dependent on the moisture level of papads and also the atmospheric relative humidity also influences the hardness level.

The results are same as **Pratik et. al., (2016)** where the hardness of papads increased as the shelf life of the papads increased.

Table 4.2 Texture analysis

S.no	Textural analysis				
	0^{th} month	1^{st} month	2^{nd} month	3^{rd} month	4^{th} month
Control papad	243.33±7.63[a]	255±15[c]	561±53[e]	640±36[g]	733±24[i]
Pearl papad	750±50[b]	810±20[d]	826±25[f]	1253±45[h]	1716±30[j]

All the values are represented as mean ± standard deviation (n=3). Different superscripts represent significant difference is between the columns.

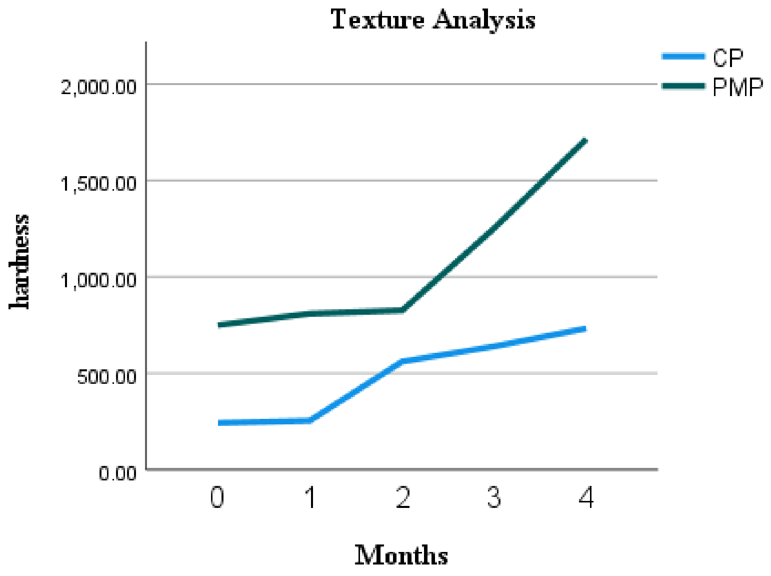


Fig 4.1 Graphical representation of texture analysis

4.1.3 Expansion ratio of Papads

The ratios are calculated by using diameter of the papads before and after frying. The diameters of the papads before and after frying did not show any difference in expansion ratios for pearl millet papads. All the papads showed similar expansion. There is a difference between in expansion ratio for control papads and pearl millet papads. The expansion of control papads is more compared to pearl millet papads. It is may be due to the thickness of papads as the dried pearl millet papads have more thickness than the control papads.

Table 4.3 Expansion ratios of papads

S.no	**Expansion ratio**		
	0^{th} month	2^{nd} month	4^{th} month
CP	$11.1±0.45^{a}$	$9.6±0.64^{c}$	$10.7±0.45^{d}$
PMP	$7.3±0.30^{b}$	$7.4±0.34^{d}$	$7.5±0.51^{e}$

CP=Control Papad PMP=Pearl Millet Papad

All the values are represented as mean ± standard deviation (n=3). Same superscripts in a column represent no significance difference between the reported values.

4.2 Chemical analysis

Proximate analysis to both control papads and pearl millet papads. It includes moisture content, protein, fat and crude fiber. The chemical analysis were evaluated and recorded.

4.2.1 Evaluation of moisture content

. The moisture content of papads increased gradually as the storage period increased. It may be due to the hygroscopic nature of papads and atmospheric relative humidity. The moisture content is high in pearl millet papads than in control papads.

The results were similar to the study conducted by **Garg & Sabharwal (2013).** The moisture content for papads increased as the storage period increased.

Table 4.4 Moisture content analysis

S.no	Moisture content				
	0th month	1st month	2nd month	3rd month	4th month
CP	7.3±0.14[a]	8.25±0.21[c]	8.5±0.5[e]	9.5±0.07[*]	8.5±0.28[g]
PMP	9.1±0.28[b]	9.5±0.35[d]	9.7±0.42[f]	10.1±0.28[*]	10.3±0.21[h]

All the values are represented as mean ± standard deviation (n=3). Same superscripts in a column represent no significance difference between the reported values.

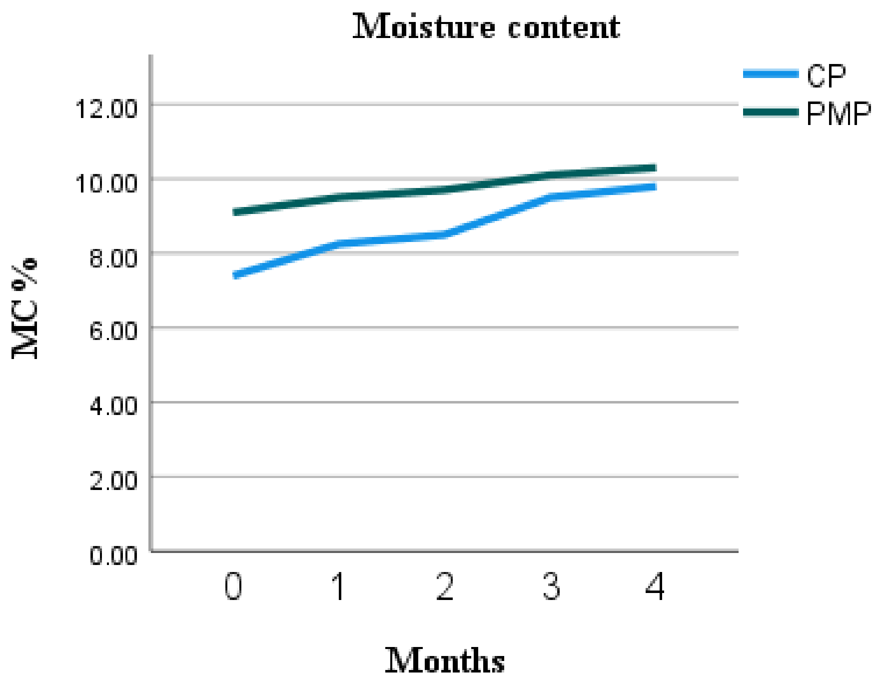


Fig 4.2 Graphical representation of moisture content

4.2.2 Evaluation of protein content

Pearl millet has higher protein content compared to control papads. No change in protein content is observed during storage period it may be due to no protein denaturation and the protein denaturation is independent of the storage conditions Proteins also improve the functional properties of the foods as they can change the molecular structure in the foods. The results of protein are similar to the research paper **Chowdary et al., (2009)** and the protein content of the product did not vary in the shelf-life studies of the product

Table 4.5 Protein content analysis

S.no	Protein content		
	0th month	2nd month	4th month
Control papad	12.29±0.55[a]	12.6±0.28[c]	12.45±0.35[e]
Pearl papad	16.95±0.07[b]	17±0.28[d]	17.25±0.21[f]

All the values are represented as mean ± standard deviation (n=3). Different superscripts in the columns represent significant difference between the values.

4.2.3 Evaluation of fat content

Fat content does not show any change in storage period before frying. The values of fat content remained same throughout the storage period. No change in fat content, it may due to no rancidity occurred during storage period. The results were similar to the studies conducted by **Kodandaramreddy (2013**), where the papads were good up to three months, after three months the papads are prone to rancidity, which in result there is a change in overall fat content.

Table 4.6. Fat content of papads

S.no	Fat content		
	0th month	2nd month	4th month
Control papad	0.87±0.04[a]	0.86±0.06[c]	0.8±0.01[e]
Pearl papad	4.1±0.14[b]	4.2±0.14[d]	4.4±0.42[f]

All the values are represented as mean ± standard deviation (n=3). Different superscripts in the columns represent significant difference between the column values.

4.2.4 Evaluation of crude fiber

Crude fiber is present in very low composition it helps to maintain good health. No change is observed in crude fiber, it may be due to it is independent of storage conditions and remained same during storage months. The results are similar to the study of **Sabharwal (2015)**, where there is no change in the amount of crude fiber in the shelf-life studies of the pea flour supplemented papads.

Table 4.7. Crude fiber in papads

S.no	Crude fibre content		
	0^{th} month	2^{nd} month	4^{th} month
Control papad	$0.5±0.14^{a}$	$0.56±0.06^{c}$	$0.47±0.02^{e}$
Pearl papad	$0.8±0.14^{b}$	$0.8±0.01^{d}$	$0.74±0.03^{f}$

All the values are represented as mean ± standard deviation (n=3). Different superscripts in the column represent significant difference between the column values.

4.2.5 Evaluation of ash content

It is very essential to determine the total ash as it composes of minerals, which is very essential for almost all physiological functions. Pearl millet is rich in minerals like zinc, iron, calcium, phosphorous **(Seetharaman et al., 2008**). Minerals are the inorganic that is in the ash content, so mineral content do not change during storage they remain same throughout the storage period. The results are similar to **Chavan et al., (2015**), where the crude fiber content did not change up to seven months of storage.

Table 4.8 Ash content of papads

S.no	Ash content		
	0^{th} month	2^{nd} month	4^{th} month
Control papad	$0.94±0.05^{a}$	$0.74±0.05^{c}$	$0.99±0.01^{e}$
Pearl papad	$1.49±0.01^{b}$	$1.58±0.03^{d}$	$1.57±0.04^{f}$

All the values are represented as mean ± standard deviation (n=3). Different superscripts in the column represent significant difference between the column values.

4.3 Sensory analysis

The sensory evaluation is performed using a 9-hedonic scale. Trained panelists were selected to discriminate and scale the different attributes of the product. It was observed that product was good at storage period. It was observed that sensory evaluation was good up to fourth month. The product did not loose its crispiness at room temperature and has good sensory properties. The parameters of the sensory evaluation are tabulated below:

Table 4.11 Sensory evaluation of papads

Parameters		**Storage Period (Months)**				
		0	**1**	**2**	**3**	**4**
Color &appearance	C	8.4 ± 0.54^{a}	8.4 ± 0.54^{c}	8.4 ± 0.54^{e}	8.2 ± 0.44^{f}	8.4 ± 0.54^{h}
	P	7.2 ± 0.83^{b}	7.4 ± 0.54^{d}	7.8 ± 0.83^{e}	7.4 ± 0.54^{g}	7.4 ± 0.54^{i}
Texture	C	$7.6\pm0.54^{*}$	8.8 ± 0.44^{a}	$8.8\pm0.44^{*}$	8.8 ± 0.44^{c}	$8.6\pm0.54^{*}$
	P	$7\pm0.81^{*}$	7.8 ± 0.83^{b}	$8\pm0.70^{*}$	7.8 ± 0.4^{d}	$8\pm0.70^{*}$
Flavor	C	$8.2\pm0.83^{*}$	$8\pm0.70^{*}$	$8\pm0.01^{*}$	$9\pm0.02^{*}$	$8.2\pm0.44^{*}$
	P	$7.4\pm0.54^{*}$	7.8±0.83*	$7.6\pm0.54^{*}$	$7.8\pm0.83^{*}$	$8\pm0.70^{*}$
Taste	C	$8\pm0.70^{*}$	9 ± 0.20^{a}	8.4 ± 0.54^{c}	$8.2\pm0.44^{*}$	8.4 ± 0.54^{e}
	P	$7.8\pm0.44^{*}$	7.4 ± 0.54^{b}	7.4 ± 0.54^{d}	$7.8\pm0.44^{*}$	7.6 ± 0.54^{f}
Overall acceptability	C	$8.4\pm0.54^{*}$	$8.6\pm0.54^{*}$	$8.8\pm0.44^{*}$	$8.6\pm0.54^{*}$	8.6 ± 0.54^{a}
	P	$8.4\pm0.89^{*}$	$8.6\pm0.54^{*}$	$8.2\pm0.44^{*}$	$8.4\pm0.54^{*}$	7.6 ± 0.54^{b}

C= Control papads P=Pearl millet papads

All the values are represented as mean ± standard deviation (n=5). Different superscripts in a rows represent significant difference between the values.

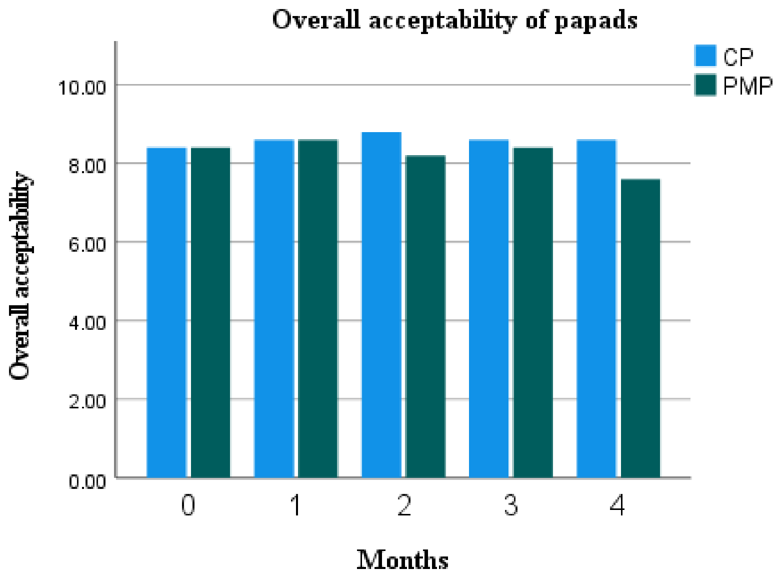


Fig 4.7 Overall acceptability of papads

4.3.1 Color & Appearance: The product color and appearance is good in the storage period. The papads color is dependent on the frying temperature and time. No significant change is observed in the results. The color of papads is desirable up to four months storage.

4.3.2 Flavour: The flavour of papads is good during storage period. Slight change in flavor is observed in the fourth month of storage. The papads flavour is also dependent on the frying temperature and time.

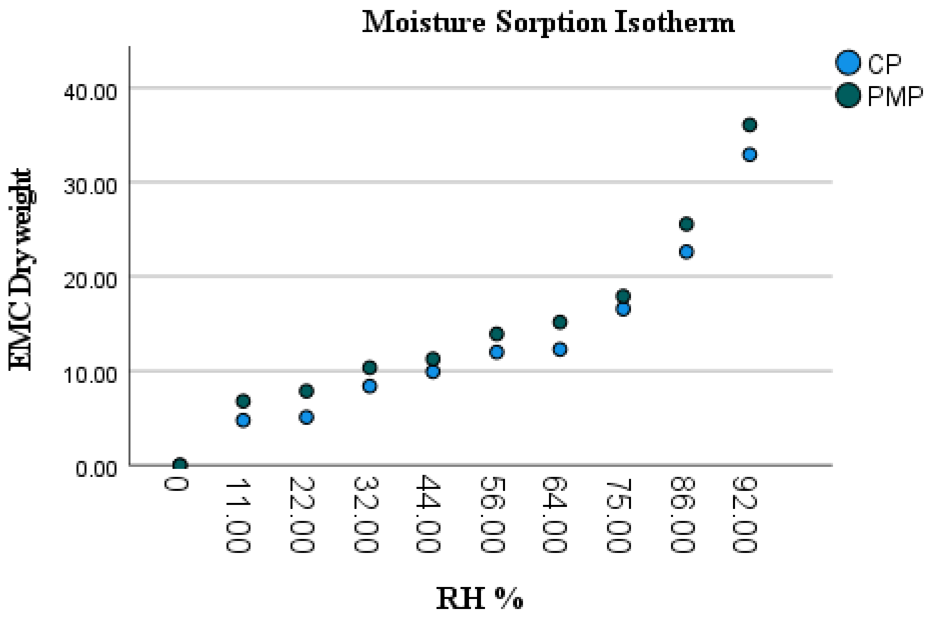
4.3.3 Texture: The hardness of papads is increased in the final months of storage it is due to moisture content of papads. But no remarkable changes were observed in fried papads. The papads after frying didn't loose the crispiness and they are good.

4.3.4 Taste: The taste of papads was good during the storage period at room temperature. The taste of papads didn't change and remained same.

4.3.5 Overall acceptability: The overall acceptability for papads is good throughout the storage period. Only marginal changes were observed between control and pearl millet papads from the results. Pearl millet papads can be consumed as traditional papads.

4.4 Moisture sorption studies

Moisture sorption isotherm is to design functional economic package of the sample, moisture sorption characteristics were studied. The moisture isotherm is presented in fig.



4.8 Graphical representation of moisture sorption isotherm

The curve starts rising high above 50% RH for control and sample indicating the product deteriorates faster above 50% RH. The product with initial moisture content 8.39% & 10.36% on as is basis equilibrates to 32% RH. The product equilibrating to 11% and 22% RH with the moisture content 4.77% & 5.1% ,6.80%, 7.87% are good and crispy. The product equilibrated to 56% RH with moisture content of 12.01% & 13.94% had become hard and above RH, they became soft and developed mold growth at 92 and 86 % RH in 4 & 3 weeks.

The CMC of the sample and control are 12.01 &13.94% beyond this moisture content the product is not acceptable.

Hence the moisture equilibrating to 50% RH is taken as critical for the sample and control papads. The moisture tolerance of the product is 12.01-8.39=3.62% &13.94- 10.395=3.54% (difference between initial and critical moisture contents). The critical RH being high, it requires a moisture barrier like LDPE, PE/PET for a required shelf-life.

To prevent fungal growth in papads the moisture content of the papads should not exceed the CMC. Common salt and papad khar contributes to increased moisture sorption.

Chapter v Summary and conclusion

The present study was conducted to develop value added product from millets. Millets are a good source of nutrients, which can meet the daily nutritional requirements people of different age group. Pearl millet is selected as a base millet for papads. Rice flour papads were kept as control samples and pearl millet flour is supplemented with rice flour papads. Rice flour and pearl millet flour are blended in four ratios with 40%, 50%,60% and 100%. The samples are given for sensory evaluation. Based on the sensory analysis 50% pearl millet papads scored good and it was selected as final product.

The final product composition papads were prepared and packed in LDPE packs and performed the shelf-life studies, proximate analysis and microbial analysis. The fries papads were given for sensory analysis to panellists and scores were given in 9-point hedonic scale. Shelf-life studies are evaluated during every month of storage period up to four months. Moisture sorption studies were studied by keeping samples in desiccators having alkaline salts.

Moisture content, hardness and sensory analysis were evaluated during storage period. Fat, protein and crude fibre were evaluated in alternate months. However, the results showed there is no significance difference in fat, protein and crude fibre content. Hardness of papads increased as the storage period increased. There is a remarkable increase in moisture content as the storage period increased. The papads maintains the crispiness up to four months. The overall acceptability of papads was good during the storage period.

Based on the above study it was concluded that the papads have good storage stability up to four months. The nutritional quality of the papads are good and the papads can be compared with rice flour in texture. The papads can be consumed as an adjunct like traditional rice flour and black gram flour.

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