Original Research Article

EFFECT OF HYDROTHERMAL AND NON-THERMAL TREATMENTS ON FUNCTIONAL AND NUTRITIONAL PROPERTIES OF PEARL MILLET GRAIN AND FLOUR

ABSTRACT

Aim: To investigate the effect of hydrothermal and non-thermal treatments on functional and nutritional properties of pearl millet grain and flour. Storage of produced grains and flour is one of the most crucial parts. Therefore, the development of innovative methods is required for the storage of millets, particularly pearl millet. This study concentrated on appropriate shelf life improving methods to raise the quality of its preservation. Consequently, to extend the pearl millet's shelf life, hydrothermal treatments as parboiling and non-thermal treatments like cold plasma and gamma radiation were used.

Study Design: Experimental design

Methodology: Pearl millet (*Pennisetum glaucum*) PBH1625 variety (whole grain, dehulled grain and dehulled flour) was subjected to hydrothermal (parboiling) and non-thermal treatments (cold plasma and gamma radiation). Subsequently the samples were packed in low density polyethylene (LDPE) pouches and metalized polypropylene (MPP) stored for 90 days and analyzed for functional parameters viz. water absorption capacity, oil absorption capacity, foaming capacity and emulsifying capacity. Nutritional properties like moisture, fat, ash, protein and crude fiber.

Results: It was found that moisture content increases in all the control and treated samples among both type of packaging and the lowest was observed in whole grain exposed to gamma radiation at 0.75 kGy (10.263-12.223 %) packed in MPP. The lowest Fat content ranges was observed in gamma radiated (0.75 kGy) whole grain (5.153-5.304 %) packed in MPP. Highest ash content was seen in the gamma radiated (1.0 kGy) whole grain (2.004-2.017 %) packed in

LDPE. Similarly, highest protein content was noticed in gamma radiated (0.75 kGy) whole grain range (13.187-13.213 %) packed in MPP. Crude fiber content drastically reduced in treated samples than control samples and highest was seen in the gamma radiated (0.75 kGy) whole grain (2.571-2.645 %) packed in LDPE. During storage there was no significant increase in fat, ash, protein and crude fiber contents. The highest WAC was noticed in parboiled dehulled grain (1.322-1.511 g/g) packed in LDPE. Highest FC was seen in parboiled whole grain (14.790-14.903 %) packed in LDPE. The highest EC was observed in the cold plasma treated (25kv for 10 mins) whole grain (45.720-45.916 %) packed in LDPE. The highest OAC was noticed in the cold plasma treated (30kv for 10 mins) whole grain (1.377-1.446 g/g) packed in LDPE.

Key words: Parboiling method, Cold plasma treatment, Gamma radiation, Low density polyethylene (LDPE), Metalized polypropylene (MPP).

1. INTRODUCTION

Millets have many health benefits and among all of them the major one is pearl millet. The Poaceae family includes the versatile cereal crop known as pearl millet (*Pennisetum glaucum*) is a traditional and nutrient-dense crop (Jukanti *et al*., 2016). It is resistant to insects, diseases high temperatures and droughts and does not readily succumb to poor soils (Dayakar *et al*., 2004). After rice, wheat, maize, and sorghum, pearl millet is the fifth most important cereal crop planted worldwide. It is grown in dry and semi-arid locations (Ojediran *et al*., 2010). In terms of cultivated area, it is the most important variety of millet and helps ensure food security in arid regions of Asia and Africa.

India is the world's largest producer of pearl millet, with 9.8 million hectares of land, accounting for more than 95% of the crop. Because of this, 46% of the grain produced from pearl millet is consumed by humans and the remaining is utilized for feed and fodder (Basavaraj *et al*., 2010). It has higher carbohydrate (67.5%), protein (14.0%), fat (5.7%), fiber (2.0%) and ash (2.1%) content (Jukanti *et al.*, 2016).

Look for another author's information on nutrients present in pearl millet.

***the nutritional components from one author is not the best ***

*****One author, one paragraph is unacceptable *****

Knowledge from one author is no research, get extra one or two

Despite nutritional superiority, the utilization of pearl millet flour is limited to few specific pockets and regions all-round the world due to the poor keeping quality of the flour and development of off odour during storage. The poor keeping quality of pearl millet flour is due to the oxidative / hydrolytic rancidity (Rani *et al.,* 2018). The pearl millet has high fat content when compared with other millets. Whole grain when stored for 3 months and dehulled grain on storage for 2 months, leads to the development of off-odours. Hence, proper shelf life enhancing treatments are necessary for pearl millet to improve its keeping quality.

Parboiling (hydrothermal treatment) also is one of the technological treatments including hot water soaking, steaming and drying before dehulling. This is the major important operation with the potential to improve dehulling efficiency as well as the nutritional quality of the finished product. Cold plasma technology represents diverse applications such as surface decontamination, pest control, improvement of enzymatic action, antioxidant properties and alteration of functional properties of grains. Food irradiation is a physical means of food processing that involves exposing the pre-packaged or bulk foodstuffs to gamma rays, X-rays or electron beams. Irradiation protects foods by reducing parasites, food-borne pathogens and spoilage microorganisms, and eliminating pests and insects (Dikkala *et al.,* 2018).

Bora (2013) reported that the impact of parboiling on millets nutritional value and decortication of selected millets. The *in vitro* protein digestibility was decreased by 13-16% by parboiling. The nutritional composition and *in vitro* protein digestibility of the couscous (pasta) and millet porridge were mostly influenced by the type of millet and the product itself. Parboiling altered the products nutritional composition and *in vitro* protein digestibility and increased the yield of decorticated millets. However, the variety of millet and the parboiling conditions used may affect the product's nutritional composition.

Cold plasma technique has a wide range of uses including surface cleaning, insect control, enhancing enzyme activity, modifying the functional characteristics of grains and antioxidant qualities. Cold plasma has several advantages over its comparable gas including greater electron temperatures (macroscopic temperature), lower power requirements and the ability to manufacture plasma at 30-60°C in atmospheric or reduced pressure (vacuum). Additionally, cold plasma lacks a local thermodynamic equilibrium (Tavakovli *et al.,* 2022).

Food irradiation is a physical food processing method that entails subjecting bulk or pre-packaged goods to ionizing radiations such as gamma rays, X-rays or electron beams. This radiation originates from the radioactive isotopes Cs-137 and Co-60. Food technologists and manufactures that use ionizing radiation in culinary applications. Foods are protected from spoiling microbes, parasites and food-borne pathogens by means of radiation, which also helps to extend the shelf life and safety of various foods and get rid of pests and insects (Dikkala *et al.*, 2018).

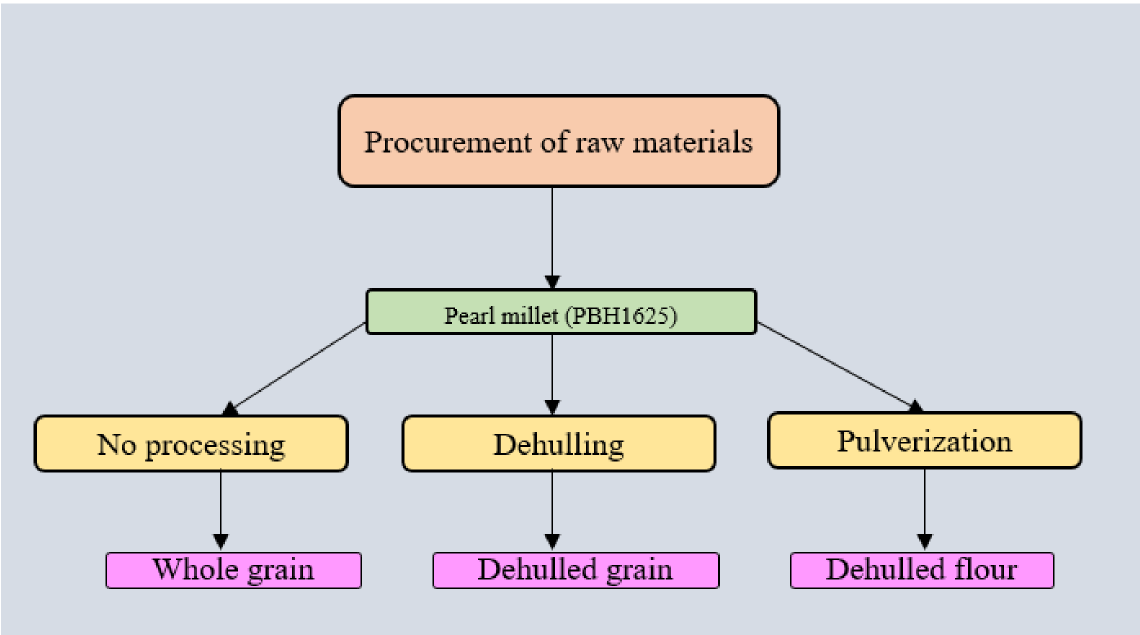
2. MATERIALS AND METHODS

2.1 Raw materials

The Pearl millet (PBH1625) was procured from Regional Agricultural Research Station (RARS), Palem, Nagarkurnool district and packaging materials i.e., low density polyethylene (LDPE) and metalized polypropylene (MPP) from commercial outlets in Hyderabad, Telangana State, India.

2.2 Preparation of sample for treatments

From a 50kg sample of pearl millet (PBH 1625) variety, a homogenised sub sample of 3 kgs (2 sets) was subjected to dehulling and pulverizing. After dehulling 3kgs of pearl millet grains, 1.5 kgs of dehulled pearl millet grains was obtained which were used for pulverization. Whole grain, dehulled grain and dehulled flour of pearl millet (PBH 1625) variety was used for parboiling, cold



plasma and gamma radiation treatments as shown in Figure 1.

Figure 1 Preparation of sample

2.3 Parboiling process

There are three major steps in the parboiling process namely soaking, steaming and drying which are described below (Sene *et al.*, 2018).

1. Soaking: Soaking is a slow process which involves diffusion of water into the grain. (Clegg *et al.* 1991). 500 g of whole grains and dehulled pearl millet grains were initially soaked in 750 ml of water using a kettle for 4 hours with increasing temperatures of 60-70°C. After soaking, the grains were cooled to room temperature in covered kettle.

2. Steaming: Steaming was done using an autoclave at 100°C (14.698 lbf/in2) for 15 mins.

3. Drying: Drying lowers the moisture content of the grains for safe storage and milling of the grains. A safe storage level for cereals and millets would be 10-12% moisture (Young *et al*. 1991). There are different methods of drying: air-drying, sun-drying and oven-drying.

2.4 Cold plasma treatment and storage of pearl millet

The cold plasma exposures (25 kv for 10 mins and 30 kv for 10 mins) were given to whole grain, dehulled grain and dehulled flour of pearl millet, followed by packing in low density polyethylene (LDPE) pouches and metalized polypropylene (MPP) for storage upto 90 days. The nutritional analysis during storage were carried out at regular intervals i.e., 0, 30, 60 and 90 days (Tavakovli *et al.*, 2022).

2.5 Gamma radiation and storage of pearl millet

The gamma radiation exposures (0.75 kGy for 1 hour, 19 minutes and 12 seconds and 1.0 kGy for 1 hour, 46 minutes and 10 seconds) were given to whole grain, dehulled grain and dehulled flour of pearl millet followed by packing in low density polyethylene (LDPE) pouches and metalized polypropylene (MPP) for storage up to 90 days. The nutritional analysis were carried out at regular intervals i.e., 0 and 90 days (Dikkala *et al*., 2018).

2.6 Estimation of nutritional parameters

As per AOAC (2005) the moisture, Ash and Crude fiber contents of the samples was estimated. Fat content of the samples was determined using AOAC (1997). Protein was estimated by Lowry method (Waterborg, 2009).

2.7 Estimation of functional properties

Water absorption capacity and oil absorption capacity was determined using Dwivedi *et al*. (2023). Foaming capacity was estimated using Booma and Prakash (1990). Emulsification capacity was estimated by Soo *et al*. (2021).

3. RESULTS AND DISCUSSION

3.1 Nutritional composition of control and treated pearl millet grain and flour during storage

The proximate analysis such as moisture, ash, protein, fat, crude fiber of control whole grain, dehulled grain and control dehulled flour and parboiled, cold plasma and gamma radiation treated pearl millet whole grain, dehulled and dehulled flour were reported.

Control whole grain, dehulled grain and control dehulled flour and parboiled, cold plasma and gamma radiation treated pearl millet whole grain, dehulled grain and dehulled flour were packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) at ambient temperature and stored for 90 days.

3.1.1 Moisture content during storage

The moisture content of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at the intervals of 0, 30, 60 and 90 days and shown in figure 2.

The whole grain exposed to gamma radiation at 0.75 kGy packed in MPP had a lower moisture content range (10.263-12.223 %) than gamma radiated (0.75 kGy) dehulled grain (10.093-13.142 %) and dehulled flour (10.154-13.938 %) packed in MPP. Similarly gamma radiated (0.75 kGy) whole grain packed in LDPE had a lower moisture content range (10.263-13.767 %) than gamma radiated (0.75 kGy) dehulled grain (10.093-14.557 %) and dehulled flour (10.154-14.951 %) packed in LDPE during the 90 day s storage period. Gamma radiation was more effective than parboiling and cold plasma in controlling moisture content during storage. So, gamma radiation could be a non-thermal technology that aids at ensuring the shelf life of the pearl millet grains and flour during storage.

There was an increase in moisture content in all the control and treated samples among both type of packaging. But the increase was less observed in treated samples than control samples. But when compared among treated samples, the samples exposed to gamma radiation at 0.75 kGy packed in MPP and LDPE showed less increase in moisture content than other treated samples. The radiolysis of water caused by radiation may be the cause of the reduction in moisture content after irradiation. So, when observed in packaging material on storage MPP outperformed than LDPE in controlling moisture content ranges in samples. MPP packaging material will not come into contact with oxygen (air) easily and hence could be primarily responsible for the lower increase in moisture content during storage.

Mala *et al*. (2019) found that prior to radiation, the beginning moisture content was 10.60 percent. During the first month of storage, the moisture percentage of the irradiation foxtail millets ranged from 10.48 to 10.34 percent, while the control group had the maximum moisture content (10.50%). After six months of storage, the control group's maximum moisture content was 9.83%, while treatment T8's least was 9.68%, which was statistically comparable to treatment T7's 9.70% and treatment T6's 9.71%.

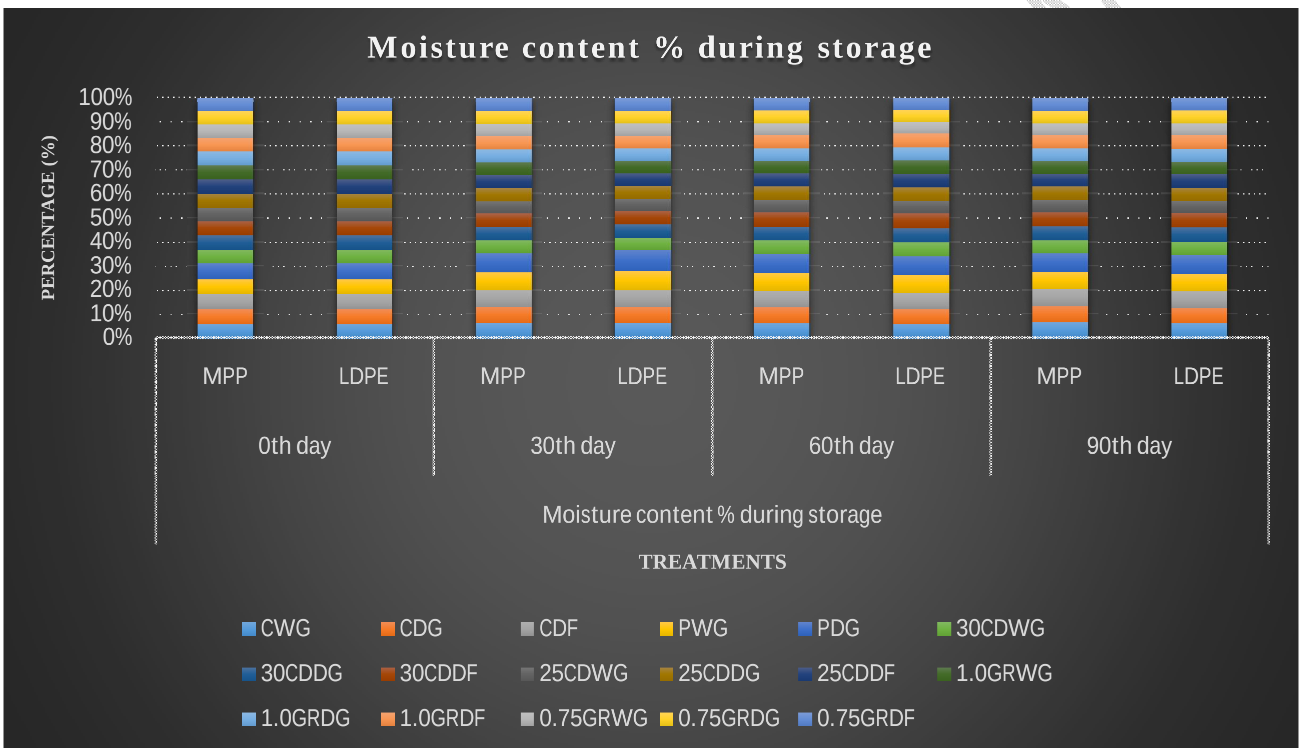


Figure 2 Moisture content during storage

3.1.2 Fat content during storage

The Fat content of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at the intervals of 0, 30, 60, 90 days and shown in figure 3.

The whole grain exposed to gamma radiation at 0.75 kGy packed in MPP had a higher fat content range (5.153-5.304 %) than dehulled grain (4.407-5.025 %) and dehulled flour (4.610-4.973 %) exposed to gamma radiation at 0.75 kGy packed in MPP. Similarly, whole grain exposed to gamma radiation at 0.75 kGy packed in LDPE had a higher fat content range (5.153-5.686 %) than dehulled grain (4.407-5.329 %) and dehulled flour (4.610-5.352 %) exposed to gamma radiation at

0.75 kGy packed in LDPE during the 90 day s storage period. Gamma radiation was more effective than parboiling and cold plasma in controlling moisture content during storage. During storage there was no significant increase in fat content was seen, which is very good observation.

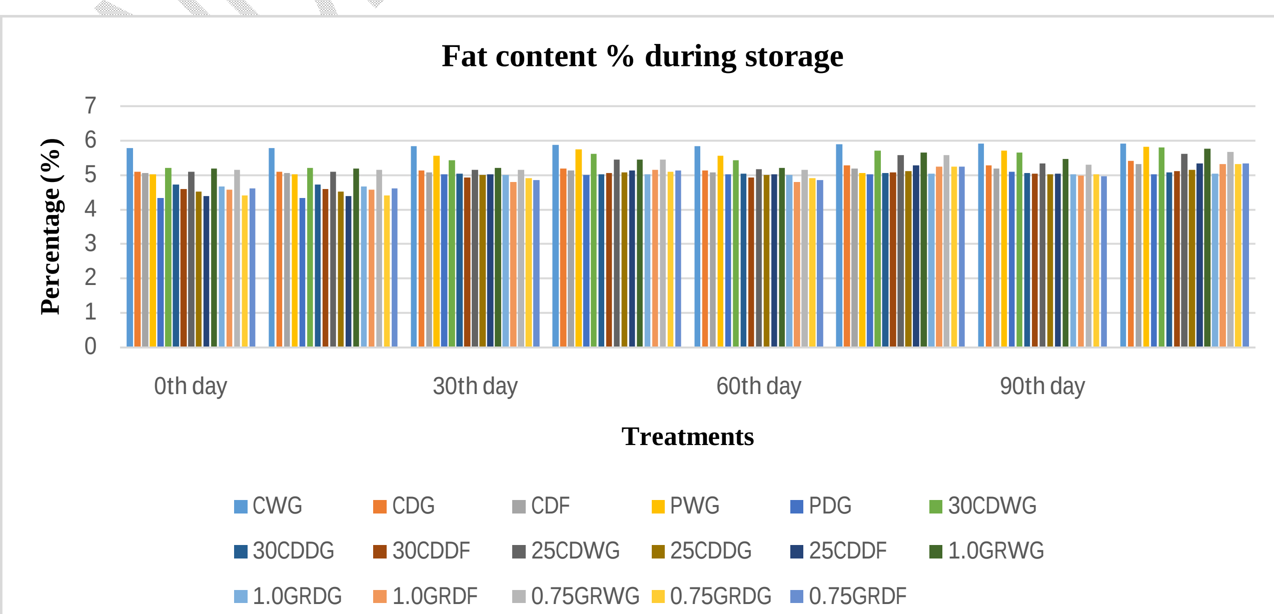
The decrease in fat content can be seen in dehulled grains than whole grains due to decortication, the germ layer i.e., which contains high amount of fat in pearl millet is removed. The fat content reduced in treated samples than control samples. A decrease in lipid content was seen in the early stages of treatment because complex fat aggregates with other components were forming during the early phases of the plasma treatment. The radiolytic breakdown of fat may be the cause of decline in fat. Due to fat's increased sensitivity to radiation, radiolytic lipid breakdown occurs both during and after radiation exposure. So, when observed in packaging material on storage MPP outperformed than LDPE in controlling fat content ranges in samples.

Mala *et al*. (2019) found that the irradiation dehusked foxtail millets had an initial fat level of 4.38%. Following the first month of storage, the fat content varied among 4.20 to 4.11 percent, with the maximum percentage being 4.26 percent (T0) in the control group. Following 6 months of storage, the highest fat content in the control group was 3.48 percent, while Treatment T8 had a minimum percentage of 3.34 percent, which was statistically comparable to treatments T7 (3.35 percent) and T6 (3.37 percent).

Figure 3. Fat content during storage

3.1.3 Ash content during storage

The ash content of control and treated whole grain, dehulled grain and dehulled flour



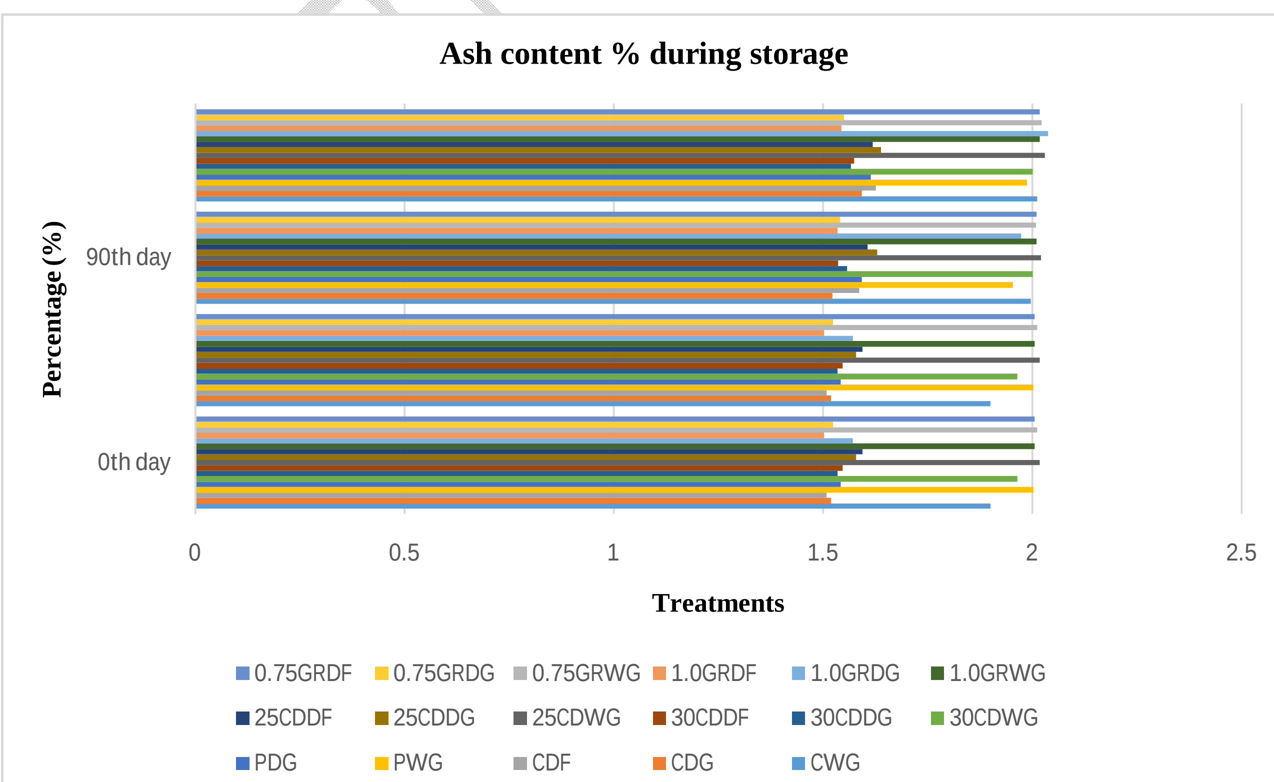
packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in figure 3.

The whole grain exposed to gamma radiation (1.0 kGy) packed in MPP had a higher ash content range (2.004-2.009 %) than dehulled grain (1.570-1.972 %) and dehulled flour (1.501-1.534 %) exposed to gamma radiation (1.0 kGy) packed in MPP. Similarly, whole grain exposed to gamma radiation (1.0 kGy) packed in LDPE had a higher ash content range (2.004-2.017 %) than dehulled grain (1.570-2.036 %) and dehulled flour (1.501-1.543 %) exposed to gamma radiation (1.0 kGy) packed in LDPE during the 90 day s storage period. Gamma radiation was more effective than parboiling and cold plasma in controlling loss of ash content during storage. There was no significant ($p<0.05$) increase in ash content in treated samples and control samples packed in both MPP and LDPE during storage.

Gowthamraj *et al*. (2021) revealed that for CO14 and CO15, the ash content ranged from 2.45% (0 kGy) to 2.91% (10 kGy) and 2.38% (0 kGy) to 2.84% (10 kGy), respectively. Samples of finger millet had an ash content of raising considerably ($P<0.05$), as irradiation doses are increased, regardless of the finger millet kinds (CO14 and CO15).

Figure 4 Ash content during storage

3.1.4 Protein content during storage



The protein content of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in figure 4.

The gamma radiated (0.75 kGy) whole grain packed in MPP had a higher protein content range (13.187-13.213 %) than gamma radiated (0.75 kGy) dehulled grain (13.157-13.173 %) and dehulled flour (13.147-13.153 %) packed in MPP. Similarly gamma radiated (0.75 kGy) whole grain packed in LDPE had a higher protein content range (13.173-13.213 %) than gamma radiated (0.75 kGy) dehulled grain (13.147-13.173 %) and dehulled flour (13.143-13.153 %) packed in LDPE during the 90 day s storage period. There was not much change in the protein content in pearl millet grains as well as flour, indicating that treatment with gamma radiation or cold plasma or parboiling did not alter the protein content in a significant way, which is a good indication that treatment can enhance shelf life but doesn't significantly alter the nutrients. There was no significant ($p<0.05$) change in protein content in treated samples and control samples packed in both MPP and LDPE during storage.

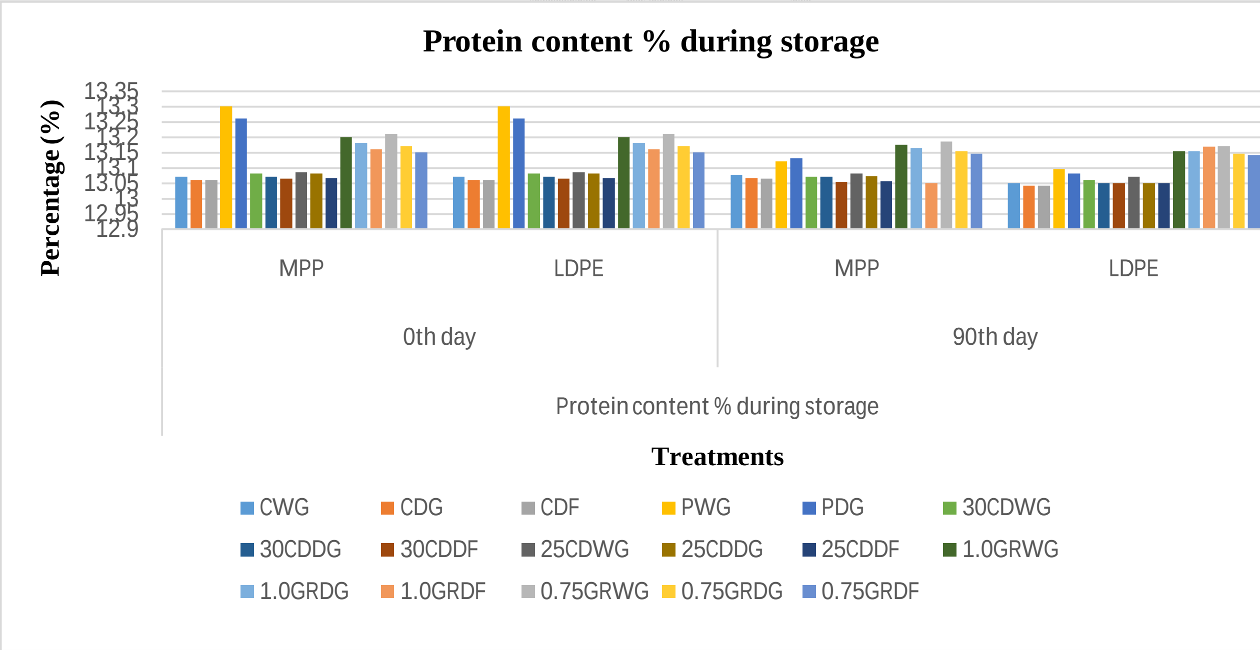
Mala *et al*. (2019) explained that after irradiation, the crude protein content of foxtail millet ranged from 12.04 to 11.93 percent, in comparison to 12.08 percent in the control after the first month of storage. The initial crude protein level of foxtail millets was determined to be 12.23 percent. Following six months of storage, the highest amount of crude protein was 11.35 percent and the minimum for treatment T8 was 11.20 percent, which was statistically comparable to treatments T7 (11.21 percent) and T6 (11.23 percent).

Figure 5 Protein content during storage

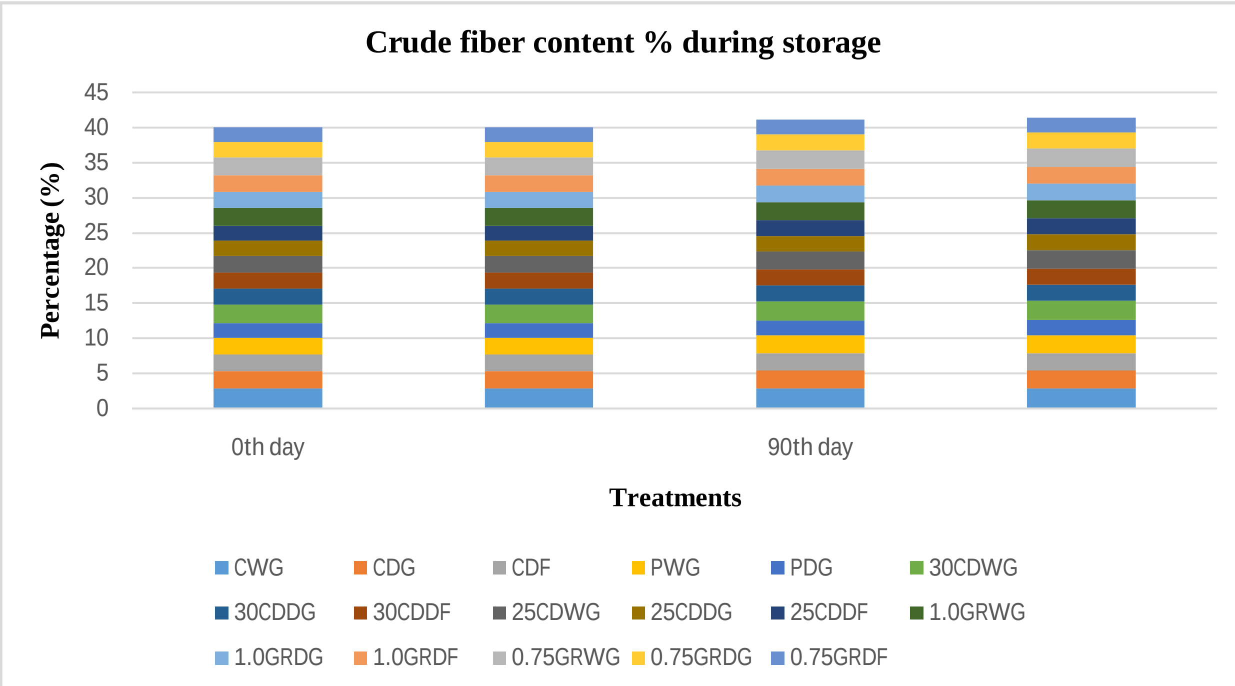
3.1.5 Crude fiber content during storage

The crude fiber of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown.

The whole grain exposed to gamma radiation (0.75 kGy) packed in MPP had a higher crude fiber content range (2.571-2.635 %) than dehulled grain (2.182-2.260 %) and dehulled flour (2.067-2.133 %) exposed to gamma radiation (0.75 kGy) packed in MPP. Similarly, whole grain exposed to gamma radiation (0.75 kGy) packed in LDPE had a higher crude fiber content range (2.571-2.645 %) than dehulled grain (2.182-2.273 %) and dehulled flour (2.067-2.145 %) exposed to gamma radiation (0.75 kGy) packed in LDPE during the 90. day s storage period. There was no significant



($p<0.05$) increase in crude fiber content in treated samples and control samples packed in both MPP and LDPE during storage. Gamma radiation was more effective than parboiling and cold plasma in terms of nutritional profile indicating a non-thermal technology that aids at ensuring the shelf life of the pearl millet grains and flour during storage. During storage there was no significant increase in fat, ash, protein and crude fiber contents which is a very impressive observation and it can be mentioned that by giving parboiling, cold plasma and gamma radiation treatments helps in improving the shelf life, but not changing the nutritional composition to a vast extent.



Shindume *et al*. (2019) presented that there was a statistically significant variation in the amount of crude fiber at $p < 0.05$ compared to the parental lines and the corresponding mutant derivatives. In general, lower crude fiber content was seen in the mutant lines compared to the parental lines, and this could have resulted from the other nearby incremental influence of composition and crude fiber percentage was found that 2.51–4.7%.

Mala *et al*. (2019) concluded that after foxtail millets were exposed to radiation, the initial crude fiber content was discovered to be 6.05 percent. After the first month of storage, the dehusked foxtail millets had a crude fiber content ranging from 5.88 to 5.77 percent, while the control group had the highest percentage at 5.92 percent. After six months of storage, the control's maximum fiber content was 5.19 percent, whereas the lowest was 5.03 percent in treatment T8.

Figure 6 Crude fiber content during storage

3.2 Functional properties of control and treated pearl millet grain and flour during storage

The functional properties was done for control whole grain, dehulled grain and control dehulled flour and parboiled, cold plasma and gamma radiated whole grain, dehulled and dehulled flour of pearl millet were packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) at ambient temperature and stored for 90 days.

3.2.1 Water absorption capacity (WAC) during storage

The water absorption capacity of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in figure 6.

The parboiled dehulled grain packed in MPP had a higher water absorption capacity range (1.322-1.446 g/g) than parboiled whole grain (1.263-1.359 g/g) packed in MPP. Similarly parboiled dehulled grain packed in LDPE had a higher water absorption capacity range (1.322-1.511 g/g) than parboiled whole grain (1.263-1.459 g/g) packed in LDPE during the 90 day s storage period. Parboiling was more effective than cold plasma and gamma radiation in improving water absorption capacity during storage. There was no significant ($p<0.05$) increase in water absorption capacity in treated samples and control samples packed in both MPP and LDPE during storage.

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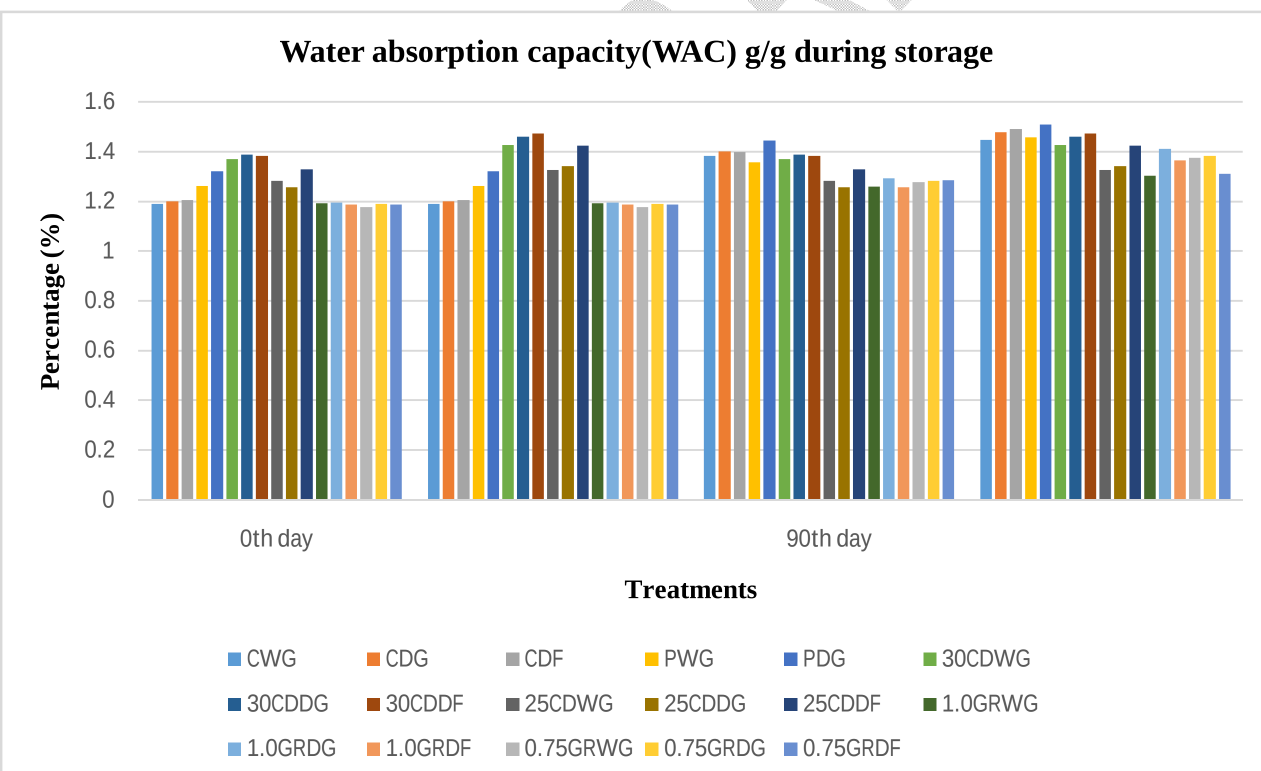

Figure 7 Water absorption capacity during storage

3.2.2 Oil absorption capacity (OAC) during storage

The oil absorption capacity of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in figure 7.

The whole grain treated with cold plasma at 30kv for 10 mins packed in MPP had a higher oil absorption capacity (1.377 g/g) than dehulled flour treated with cold plasma (1.373 g/g) and dehulled grain (1.364 g/g) at 30kv for 10 mins packed in MPP. Similarly, dehulled flour treated with cold plasma at 30kv for 10 mins packed in LDPE had a higher oil absorption capacity range (1.373-1.463 g/g) than cold plasma treated dehulled grain (1.364-1.459 g/g) and whole grain (1.377-1.446 g/g) at 30kv for 10 mins packed in LDPE during the 90 day s storage period. Cold plasma was more effective than parboiling and gamma radiation in improving oil absorption capacity during storage. There was no significant ($p<0.05$) increase in oil absorption capacity in treated samples and control samples packed in both MPP and LDPE during storage.

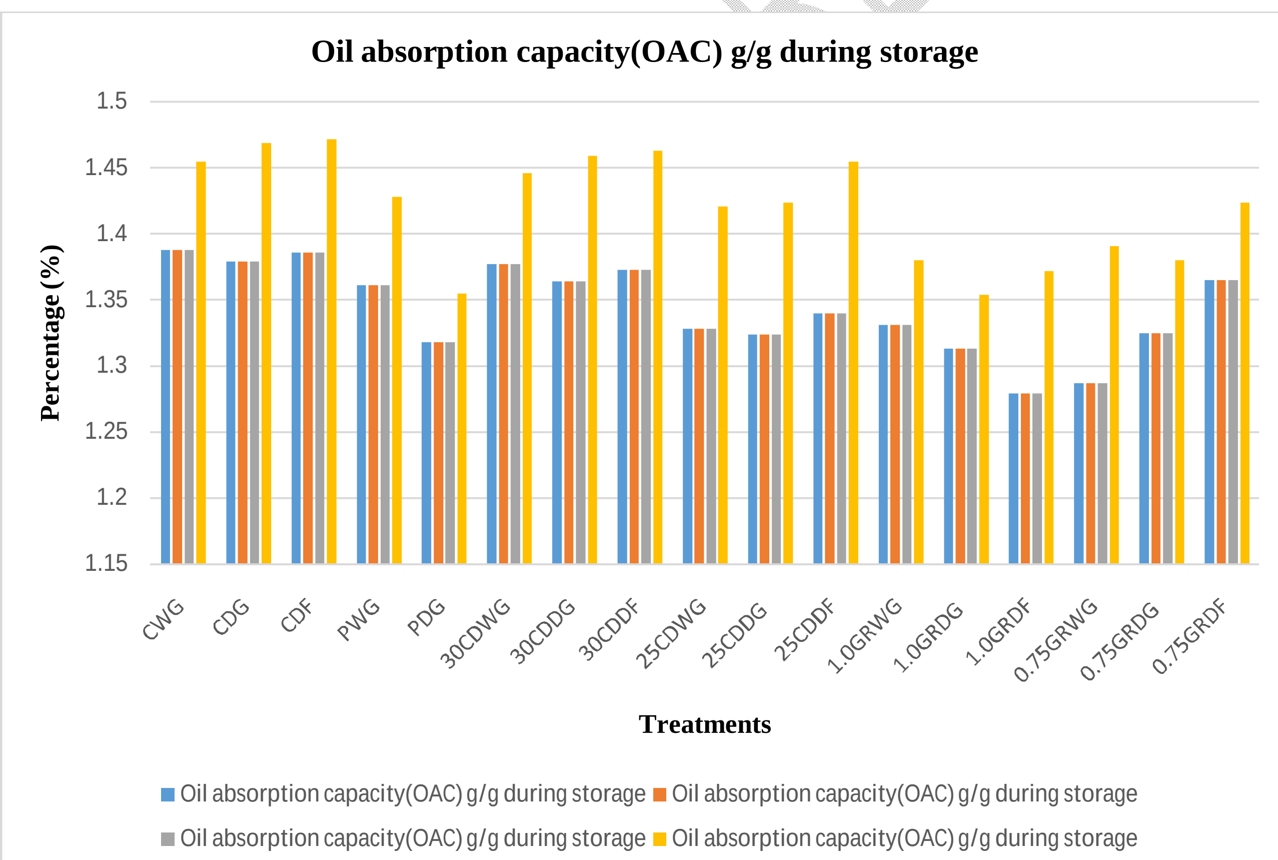

Figure 8 Oil absorption capacity during storage

3.2.3 Foaming capacity (FC) during storage

The foaming capacity of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in 9.

The parboiled whole grain packed in MPP had a higher foaming capacity range (14.790-14.892 %) than parboiled dehulled grain (14.857-14.856 %) packed in MPP. Similarly parboiled whole grain packed in LDPE had a higher foaming capacity range (14.790-14.903 %) than parboiled dehulled grain (14.857-14.864 %) packed in LDPE during the 90 day s storage period. Parboiling was more effective than cold plasma and gamma radiation in improving foaming capacity during storage. There was no significant (p<0.05) increase in foaming capacity in treated samples and control samples packed in both MPP and LDPE during storage.

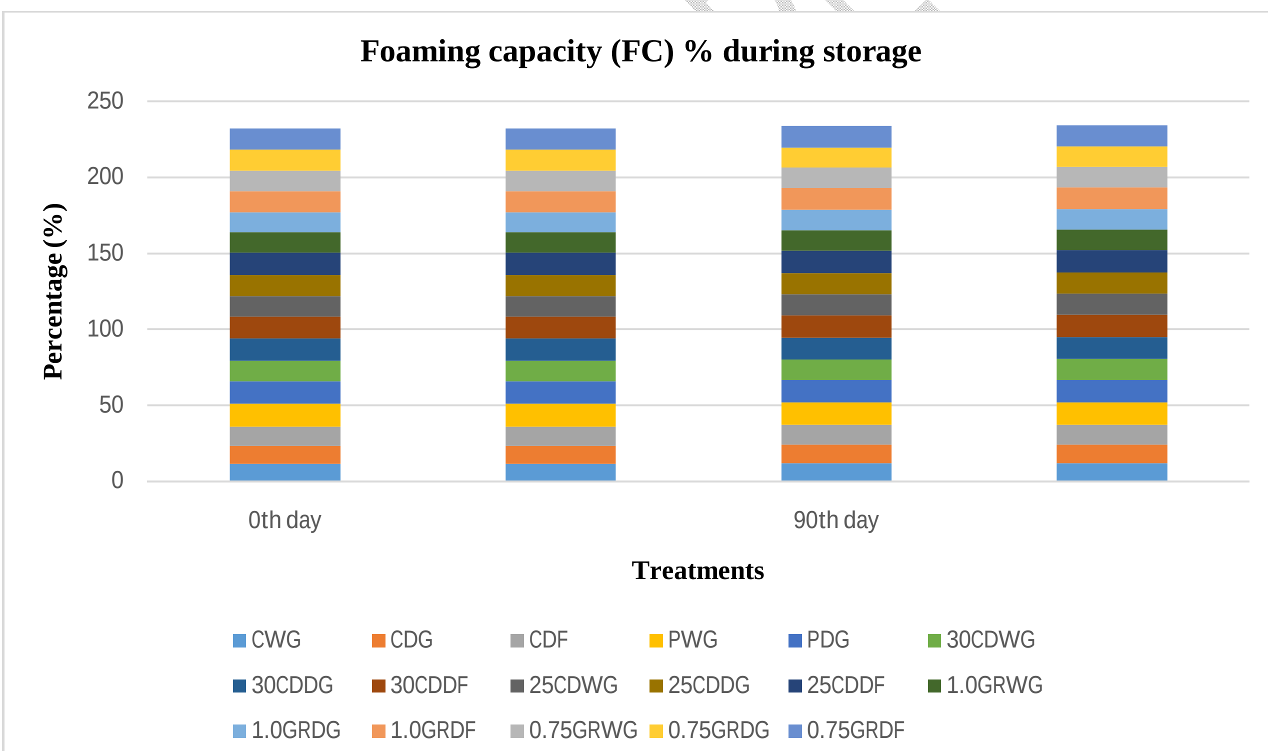

Figure 9 Foaming capacity during storage

3.2.4 Emulsifying capacity (EC) during storage

The emulsifying capacity of control and treated whole grain, dehulled grain and dehulled flour packed in metalized polypropylene (MPP) and low density polyethylene (LDPE) were analysed at 0 and 90 days and shown in figure 10.

The cold plasma treated (25kv for 10 mins) whole grain packed in MPP had a higher emulsifying capacity range (45.720-45.875 %) than cold plasma treated (25kv for 10 mins) dehulled grain (44.777-44.840 %) and dehulled flour (44.077-44.093 %) packed in MPP. Similarly cold plasma treated (25kv for 10 mins) whole grain packed in LDPE had a higher emulsifying capacity range (45.720-45.916 %) than cold plasma treated (25kv for 10 mins) dehulled grain (44.777-44.936 %) and dehulled flour (44.077-44.120 %) packed in LDPE during the 90 day s storage period. There was no significant ($p<0.05$) increase in foaming capacity in treated samples and control samples packed in both MPP and LDPE during storage.

Parboiling was more effective than cold plasma and gamma radiation in terms of water absorption capacity and foaming capacity indicating that parboiling could be better low cost treatment. During storage there was no significant increase in water absorption capacity and foaming capacity. Therefore, Cold plasma was more effective than parboiling and gamma radiation with regard to oil absorption capacity and emulsifying capacity indicating that novel non-thermal technology that aids in improving the functional properties, which are essential for value addition of products. During storage there is no significant increase in oil absorption capacity and emulsifying capacity.

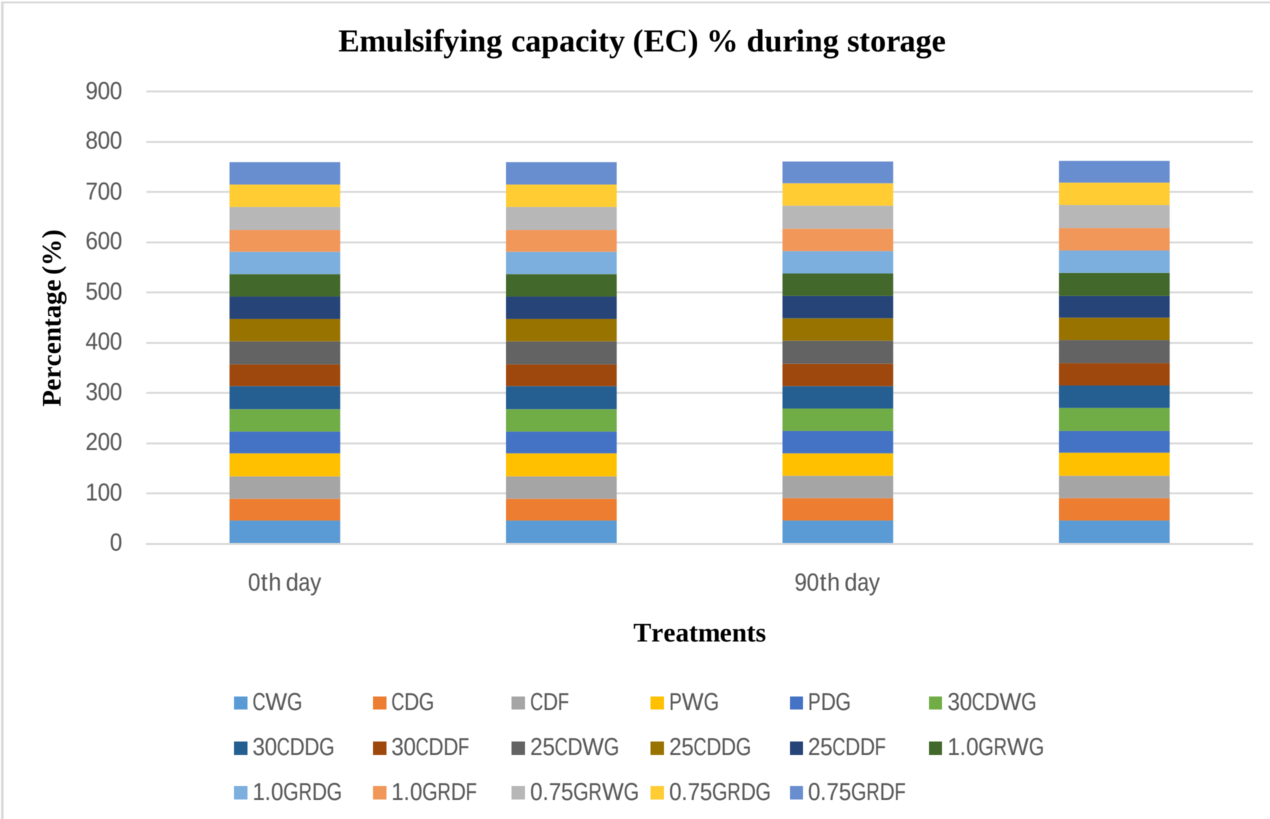

Figure 10Emulsifying capacity during storage

Note: CWG-Control whole grain; CDG-Control dehulled grain; CDF-Control dehulled flour; 30CDWG-Cold plasma treated whole grain at 30kv for 10min; 30CDDG-Cold plasma treated dehulled grain at 30kv for 10min; 30CDDF-Cold plasma treated dehulled flour at 30kv for 10min; 25CDWG-Cold plasma treated whole grain at 25kv for 10min; 25CDDG-Cold plasma treated dehulled grain at 25kv for 10min; 25CDDF-Cold plasma treated dehulled flour at 25kv for 10min; LDPE-Low density polyethylene; MPP-Metalized polypropylene.

4. CONCLUSION

In the present study the effect of hydrothermal and non-thermal treatments on functional and nutritional properties of pearl millet grain and flour was studied. The findings indicated the moisture content increases in all the control and treated samples among both type of packaging and the lowest was observed in whole grain exposed to gamma radiation at 0.75 kGy (10.263-12.223 %) packed in MPP. The lowest Fat content ranges was observed in gamma radiated (0.75 kGy) whole grain (5.153-5.304 %) packed in MPP. Highest ash content was seen in the gamma radiated (1.0 kGy) whole grain (2.004-2.017 %) packed in LDPE. Similarly, highest protein content was noticed in gamma radiated (0.75 kGy) whole grain range (13.187-13.213 %) packed in MPP. Crude fiber content drastically reduced in treated samples than control samples and highest was seen in the gamma radiated (0.75 kGy) whole grain (2.571-2.645 %) packed in LDPE. During storage there was no significant increase in fat, ash, protein and crude fiber contents.

The highest WAC was noticed in parboiled dehulled grain (1.322-1.511 g/g) packed in LDPE. The highest FC was seen in parboiled whole grain (14.790-14.903 %) packed in LDPE. Highest EC was observed in the cold plasma treated (25kv for 10 mins) whole grain (45.720-45.916 %) packed in LDPE. The highest OAC was noticed in the cold plasma treated (30kv for 10 mins) whole grain (1.377-1.446 g/g) packed in LDPE. During storage there was no significant increase in functional properties such as water absorption capacity (WAC), foaming capacity (FC) and emulsifying capacity (EC).

In conclusion, for pearl millet whole grain and dehulled grain, hydrothermal treatment (parboiling) performed far superior to the other two treatments and for dehulled flour, gamma radiation treatment at 0.75 kGy performed superior than the other two treatments. However, gamma radiation at 0.75 kGy better than other non-thermal treatment (cold plasma). MPP performed better than LDPE when it came to packing materials. This could be because MPP packaging materials are less likely to readily come into contact with oxygen (air) and are therefore primarily responsible for the reduced increase in moisture during storage.

****Explain the phrase…. Performed far superior******

DISCLAIMER (ARTIFICIAL INTELLIGENCE): Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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