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Cold plasma treatment on pearl millet grain and flour: Impact on bio actives, physical and functional properties

[1]CJ Gnananethri, [2]Afifa Jahan, [3]Aparna Kuna and [4]MV Nagesh Kumar

[1]Master's Student, Department of Food and Nutrition, College of Community Science, Saifabad, Hyderabad, Telangana, India

[2]Assistant Professor, Department of Food and Nutrition, College of Community Science, Saifabad, Rajendra Nagar, Hyderabad, Telangana, India

[3]Principal Scientist & Head, MFPI - Quality Control Laboratory, PJTSAU, EEI, Hyderabad, Telangana, India

[4]Principal Scientist (Millets), Maize Research Centre - ARI, Department of Genetics and Plant Breeding, PJTSAU, Rajendra Nagar, Hyderabad, Telangana, India

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Corresponding Author: CJ Gnananethri

Abstract

In the present study pearl millet (*Pennisetum glaucum*) PBH1625 variety (whole grain, dehulled grain and dehulled flour) was subjected to cold plasma exposure at 25 kv for 10 mins and 30 kv for 10 mins. Subsequently the samples were packed in low density polyethylene (LDPE) pouches and metalized polypropylene (MPP) stored for 90 days and shelf life studies were conducted. The results revealed that cold plasma exposure at 25 kv for 10 mins outperformed in reducing tannin content. On storage MPP packaging material outperformed LDPE in controlling tannin content. The findings collectively indicate that pearl millet whole grain, dehulled grain and dehulled flour exposed to cold plasma at 25 kv for 10 mins followed by packing in MPP have better shelf life and storability upto 90 days.

Keywords: Cold plasma treatment, low density polyethylene (LDPE), Metalized polypropylene (MPP), pearl millet, shelf life

1. Introduction

The Poaceae family includes the versatile cereal crop known as pearl millet (*Pennisetum glaucum*) is a nutricereal and traditional crop and grown widely in Asian and African countries (Jukanti *et al.*, 2016) [6]. It has the capability to survive under drought and high temperature conditions. Among all the millet varieties, greater than 29-million-hectare area is occupied by pearl millet; however, its distribution is restricted geographically mainly in Africa (15 million) and Asia (11 million), as being the largest producer (Basavaraj *et al.*, 2010) [1]. More than 95 percent pearl millet production comes from developing countries, and India as the largest producer covers an area of 9.8 million hectares out of total world production (Basavaraj *et al.*, 2010) [1]. This Pearl millet commonly used for food, feed, and forage's purpose. It has higher carbohydrate (67.5 percent), protein (14.0 percent), fat (5.7 percent), fiber (2.0 percent) and ash (2.1 percent) content (Jukanti *et al.*, 2016) [6].

Cold Plasma consists ionized gas is formed by relatively low energy (1-10 eV) and gases used in food applications are argon (Ar), helium (He) and air Electrode material are steel, aluminium, brass, iron, and copper (Lokeswari *et al.*, 2021) [7]. Cold plasma is generated at 30-60 °C under atmospheric or reduced pressure (vacuum), requires less power, exhibits electron temperatures much higher than the corresponding gas (macroscopic temperature), and does not present a local thermodynamic equilibrium. This work is aimed to see the impact of cold plasma (CP) treatment on bioactive compounds, physical and functional properties of pearl millet, so that the product quality can be improved.

2. Materials and Methods

2.1 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 bio active compounds, physical and functional properties during storage were carried out at regular intervals i.e., 0 and 90 days.

2.2 Estimation of the bio active compounds, physical and functional properties during storage

Bulk density of the samples was determined using Stojceska *et al.* (2008) [13]. Tapped density was estimated by Narayana and Narasinga (1982) [8]. Emulsifying capacity were measured according to Soo *et al.* (2021) [12]. Water absorption capacity and Oil absorption capacity was estimated according to Dwivedi *et al.* (2023) [4]. Foaming capacity was determined according to Booma and Prakash (1990) [2].

Determination of phenols was performed according to the method described by Slinkard and Slingleton (1997) [11].

Tannin content was estimated according to Deshpande *et al*. (1986) [3]. The data statistically evaluated by one-way analysis of variance procedure (ANOVA).

3. Results and Discussion

3.1 Effect of cold plasma treatment on bio active compounds: The bio active compounds such as phenols and tannins were done for control whole grain, dehulled grain and dehulled flour and cold plasma treated at 30 kv and 25 kv for 10 mins pearl millet whole grain, dehulled 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 Phenolic content during storage: The control whole grain (234.517-278.623mgGAE/100g) packed in LDPE had a higher phenols range than control dehulled grain (224.829-267.950 mgGAE/100 g) and dehulled flour (221.447-262.197 mgGAE/100 g) packed in LDPE. Similarly, the cold plasma treated whole grain at 30 kv for 10 mins packed in LDPE had a higher phenols range (179.929-219.623 mgGAE/100g) than cold plasma treated dehulled grain (173.481-211.950 mgGAE/100 g) and dehulled flour (170.080-204.863 mgGAE/100 g) at 30 kv for 10 mins packed in LDPE. There was a significant decrease in phenolic content in treated samples than control samples shown in figure 3.1.1. During storage the increase was observed in both treated samples and control samples. But when compared among treated samples, the cold plasma treated whole grain, dehulled grain and dehulled flour at 30 kv for 10 mins packed in MPP and LDPE showed more increase in phenolic content than 25 kv for 10 mins packed in MPP and LDPE during storage period. Elevated levels of plasma treatment have the potential to hasten oxidative processes and break down phenolic compounds by aliphatic chains and benzene rings. These results is in close agreement with that reported by Pradeep and Guha (2011) [9] found it to be ~423 mg/100 g in little millet. TPC of plasma treated flour were found to increase from 527.54±8.94 to 575.82±3.58 mg/100 g.

3.1.2 Tannin content during storage: The control whole grain (0.043-0.420 mgTAE/100 g) packed in LDPE had a higher tannins range than control dehulled grain (0.039-0.304 mgTAE/100g) and dehulled flour (0.038-0.329 mgTAE/100 g) packed in LDPE. Similarly, the cold plasma treated whole grain at 30 kv for 10 mins packed in LDPE had a higher tannins range (0.025-0.186 mgTAE/100 g) than cold plasma treated dehulled grain (0.024-0.259 mgTAE/100g) and dehulled flour (0.023-0.261 mgTAE/100 g) at 30 kv for 10 mins packed in LDPE. There was a significant increase in tannin content in treated samples than control samples figure 3.1.2. During storage the increase was observed in both treated samples and control samples. But when compared among treated samples, the cold plasma treated whole grain, dehulled grain and dehulled flour at 30 kv for 10 mins packed in MPP and LDPE than 25 kv for 10 mins packed in MPP and LDPE. These results is in close agreement with that reported by Sarkar *et al*. (2023) [10] control sample had tannin content of 0.98 ± 0.05 (g tannin acid/100 g dm) and CP therapy has dramatically ($p<0.05$) lowered tannin content, with the lowest value recorded in 30 kV–20 min 0.81 g of tannic acid/100 g. Tannic concentration may have decreased as a result of the dissolution of glycosidic linkages brought on by reactive oxygen species.

3.2 Effect of cold plasma treatment on physical properties:

3.2.1 Bulk and tapped density during storage: The control whole grain packed in LDPE had a higher bulk density range (0.504-0.545 g/ml) than control dehulled grain (0.415-0.491 g/ml) and dehulled flour (0.336-0.491 g/ml) packed in LDPE. Similarly, the control whole grain packed in LDPE had a higher tapped density range (0.630-0.688 g/ml) than control dehulled grain (0.619-0.681 g/ml) and dehulled flour (0.460-0.477 g/ml) packed in LDPE. While, the cold plasma treated whole grain at 25 kv and 30 kv for 10 mins packed in LDPE had a higher bulk density range (0.477-0.495 g/ml), (0.490-0.498 g/ml) than cold plasma treated dehulled grain (0.447-0.475 g/ml), (0.476-0.488 g/ml) and dehulled flour (0.384-0.397 g/ml) (0.348-0.366 g/ml) at 25 kv and 30 kv for 10 mins packed in LDPE.

However, the cold plasma treated whole grain at 25 kv and 30 kv for 10 mins packed in MPP had a higher tapped density range (0.651-0.662 g/ml), (0.628-0.651 g/ml) than cold plasma treated dehulled grain (0.628-0.642 g/ml), (0.628-0.648 g/ml) and dehulled flour (0.452-0.460 g/ml), (0.461 g/ml) at 25 kv for 10 mins packed in MPP. There was a significant ($p<0.05$) decrease in bulk density in treated samples than control samples. During storage the increase was observed in both treated samples and control samples figure 3.2.1. But when compared among treated samples, cold plasma exposed at 25 kv for 10 mins packed in MPP and LDPE than 30 kv for 10 mins packed in MPP and LDPE. So, when observed in packaging material on storage LDPE outperformed than MPP in enhancing bulk and tapped density ranges in samples. Bulk and tapped density depends on the polydispersity of particle size and the particle packing of the powder. These results is in close agreement with Gowthamraj *et al.* (2021) [5] reported that the bulk and tapped densities of the control sample flours (CO14 and CO15) were determined to be 0.48 g/mL and 0.46 g/mL, 0.64 and 0.67 g/mL. After being exposed to cold plasma at 25 kv for 5 mins, the finger millet flour samples bulk and tapped densities decreased substantially ($p\leq0.05$) to 0.33 g/mL, 0.60 g/mL (CO14) and 0.34 g/mL, 0.61 g/mL (CO15).

3.3 Effect of cold plasma treatment on functional properties

3.3.1 Water and oil absorption capacity during storage: The control dehulled flour packed in MPP had a higher water absorption capacity range (1.206-1.399 g/g) than control dehulled grain (1.201-1.401 g/g) and whole grain (1.191-1.385 g/g) packed in MPP. Similarly, the control whole grain packed in MPP had a higher oil absorption capacity (1.388 g/g) than control dehulled flour (1.386 g/g) and dehulled grain (1.379 g/g) packed in MPP. Therefore, the cold plasma treated dehulled flour at 30 kv for 10 mins packed in MPP had a higher water absorption capacity range (1.192-1.383 g/g) than cold plasma treated dehulled grain (1.189-1.389 g/g) and whole grain (1.186-1.370 g/g) at 30 kv for 10 mins packed in MPP. However, the cold plasma treated dehulled flour at 25 kv for 10 mins packed in MPP had a higher water absorption capacity range (1.207-1.331 g/g) than cold plasma treated dehulled grain (1.190-1.257 g/g) and whole grain (1.184-1.283 g/g) at 25 kv for 10 mins packed in MPP.

Meanwhile, The cold plasma treated whole grain at 30 kv for 10 mins packed in MPP had a higher oil absorption capacity (1.377 g/g) than cold plasma treated dehulled flour (1.373 g/g) and dehulled grain (1.364 g/g) at 30 kv for 10 mins packed in MPP. Similarly, the cold plasma treated dehulled flour at 25 kv for 10 mins packed in MPP had a higher oil absorption capacity (1.340 g/g) than cold plasma treated whole grain (1.328 g/g) and dehulled grain (1.324 g/g) at 25 kv for 10 mins packed in MPP. There was a significant ($p<0.05$) increase in water absorption capacity in treated samples than control samples figure 3.2.1. During storage the increase was observed in both treated samples and control samples. But when compared among treated samples, cold plasma treated whole grain at 30 kv for 10 mins packed in MPP and LDPE than 25 kv for 10 mins packed in MPP and LDPE. So, when observed in packaging material on storage LDPE outperformed than MPP in enhancing water and oil absorption capacity ranges in samples. These results is in close agreement with Sarkar *et al*. (2023) [10] indicated that the sample that was exposed to 30 kV for 20 minutes had the highest WAC (1.62 g/g), OAC (1.31 g/g) which was considerably ($p<0.05$) greater than the control (1.32 g/g), (1.11 g/g).

3.3.2 Foaming and emulsifying capacity during storage

The control dehulled flour packed in MPP had a higher foaming capacity range (12.733-12.886%) than control dehulled grain (12.033-12.374%) and whole grain (11.600-12.015%) packed in MPP. While, the control whole grain packed in MPP had a higher emulsifying capacity range (45.437-45.736%) than control dehulled grain (44.387-44.920%) and dehulled flour (44.127-44.080%) packed in MPP. Similarly, The cold plasma treated dehulled flour at 30 kv 25 kv for 10 mins packed in MPP had a higher foaming capacity range (14.543-14.811%), (14.590-14.876%) than cold plasma treated dehulled grain (14.520-14.255%), (13.923-13.922%) and whole grain (13.567-13.458%), (13.570-13.670%) at 30 kv for 10 mins packed in MPP. Meanwhile, the cold plasma treated whole grain at 30 kv and 25 kv for 10 mins packed in MPP had a higher emulsifying capacity range (45.493-45.536%), (45.720-45.916%) than cold plasma treated dehulled grain (44.727-44.835%), (44.777-44.936%) and dehulled flour (43.997-44.023%), (44.077-44.120%) at 25 kv for 10 mins packed in MPP figure 3.2.2. Sarkar *et al*. (2023) [10] reported that the 30 kV–20 min sample, the EC and FC of the CP-treated sample were considerably ($p<0.05$) greater than those of the control (86.58 and 10.67%).

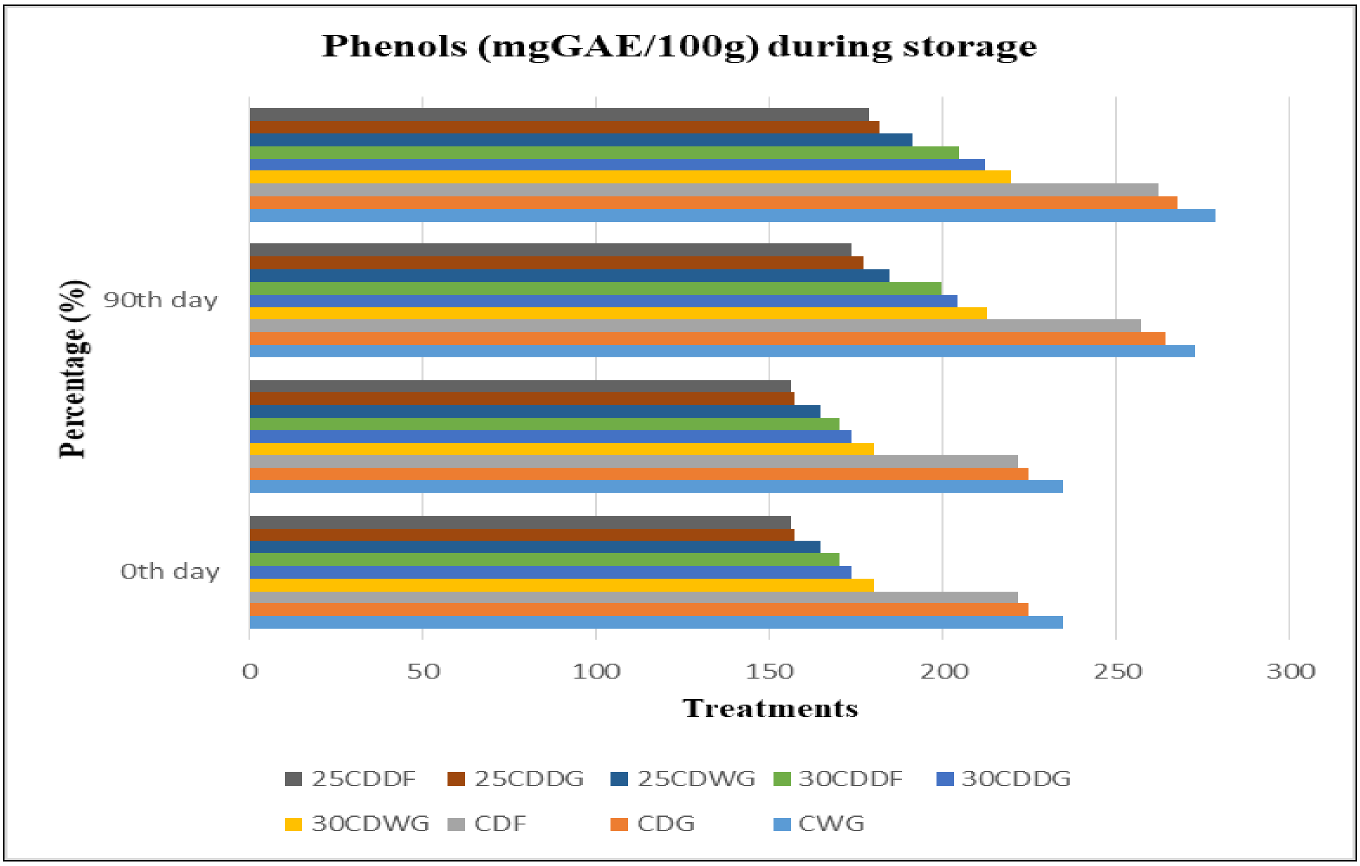

Fig 1: Phenolic content during storage

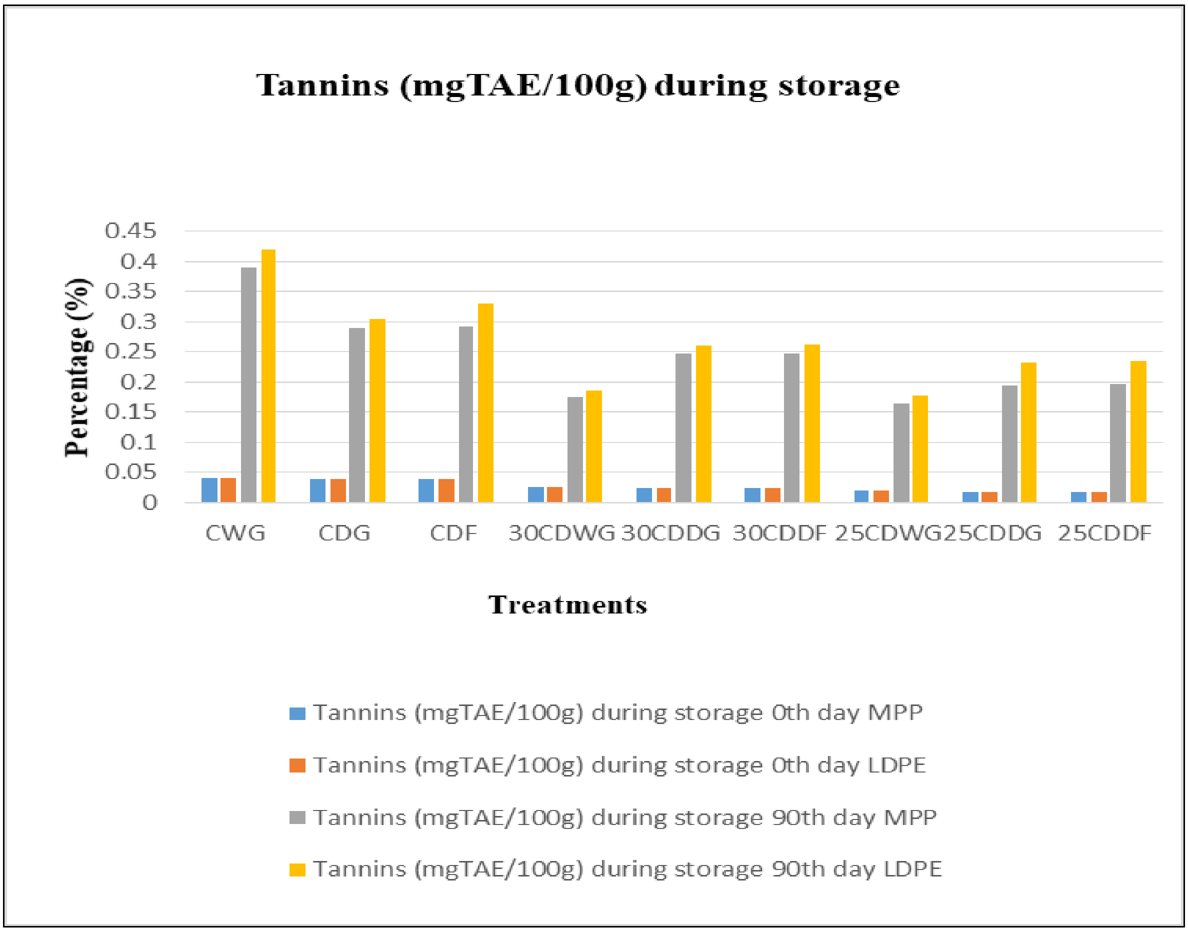

Fig 2: Tannin content during storage

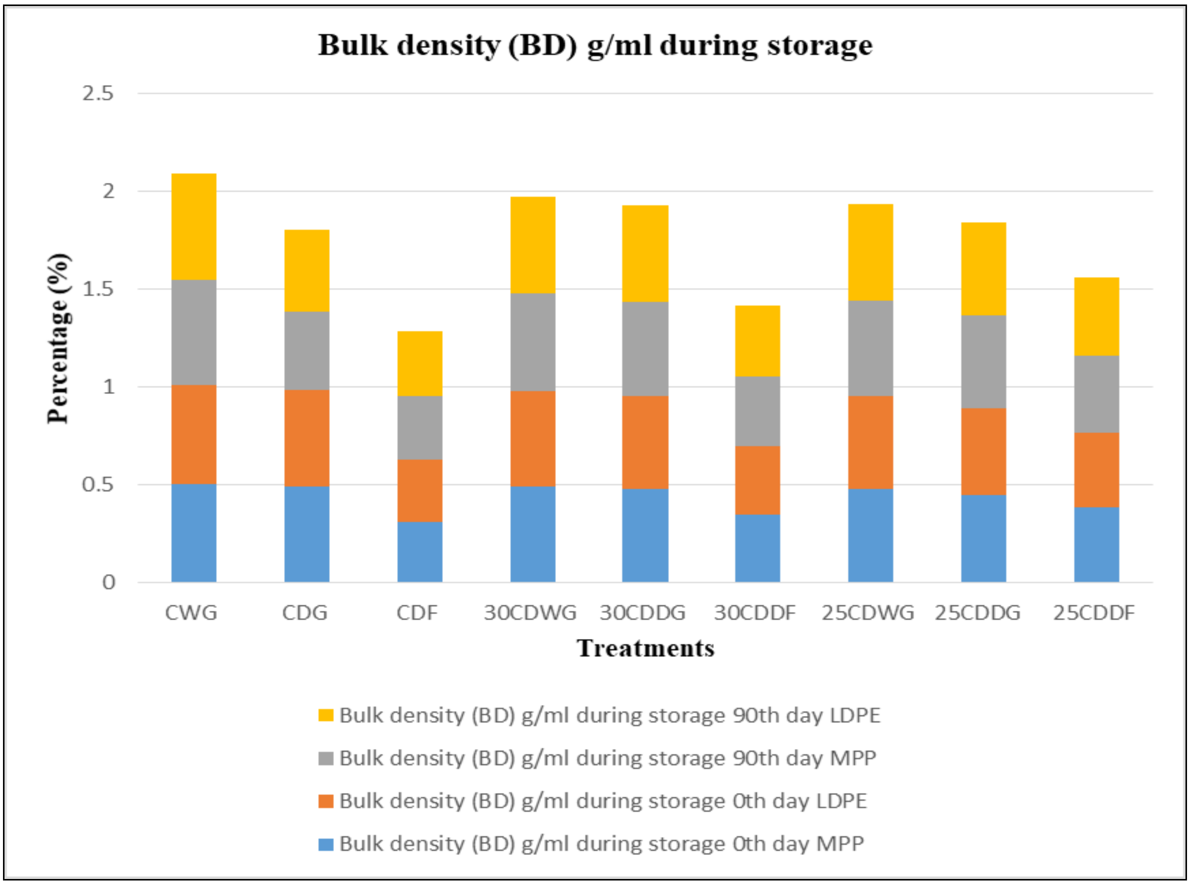

Fig 3: Bulk density during storage

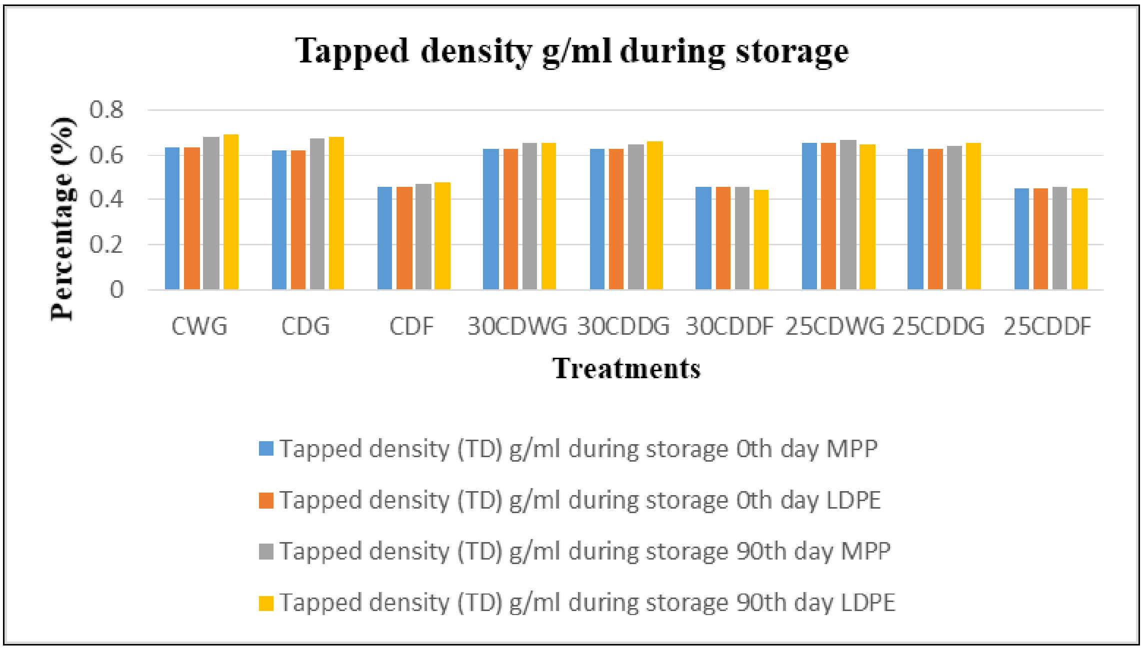

Fig 4: Tapped density during storage

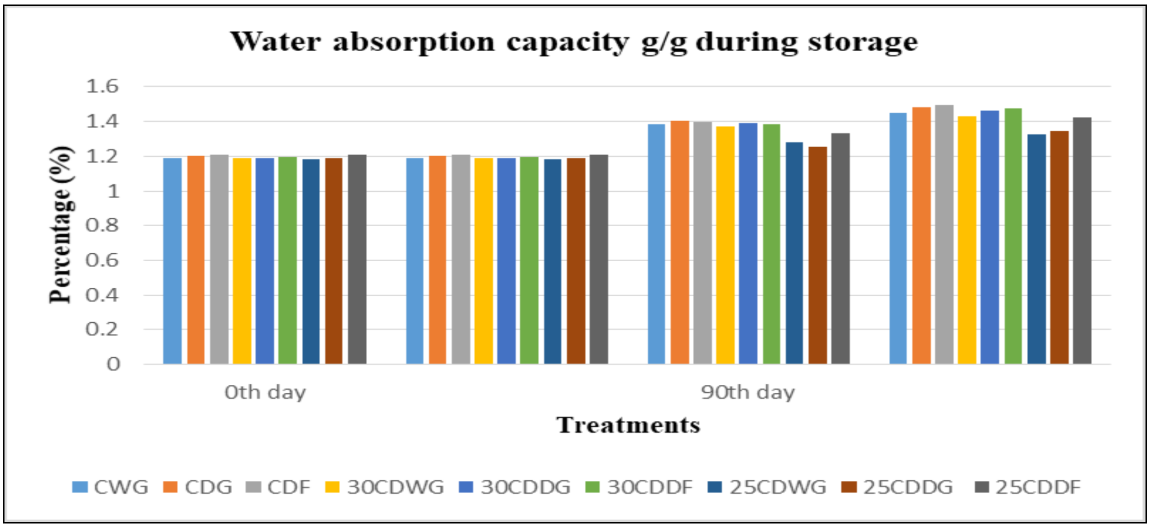

Fig 5: Water absorption capacity during storage

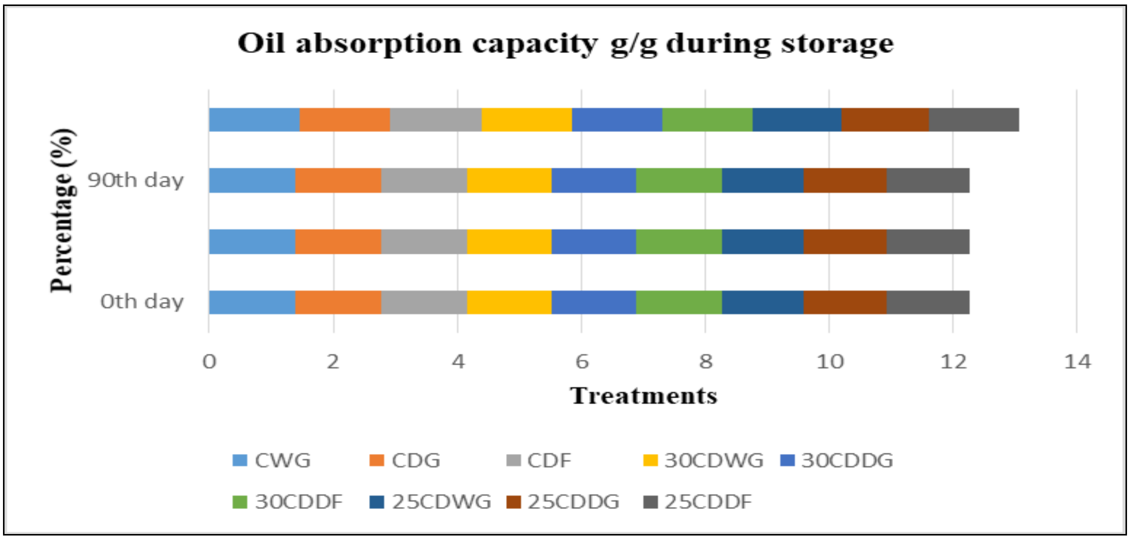

Fig 6: Oil absorption capacity during storage

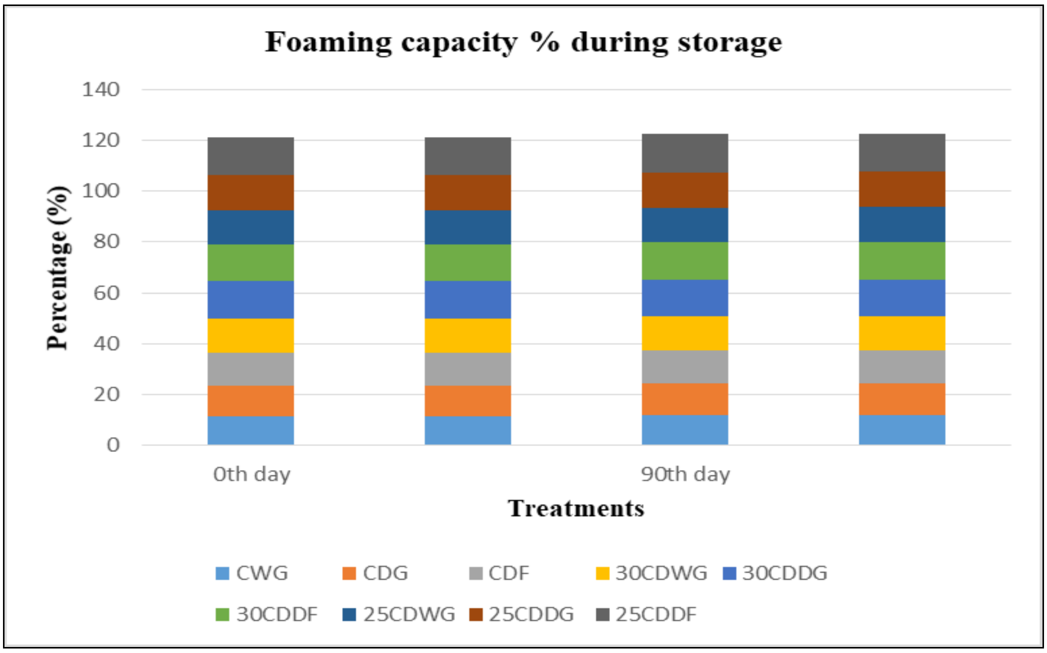

Fig 7: Water absorption capacity during storage

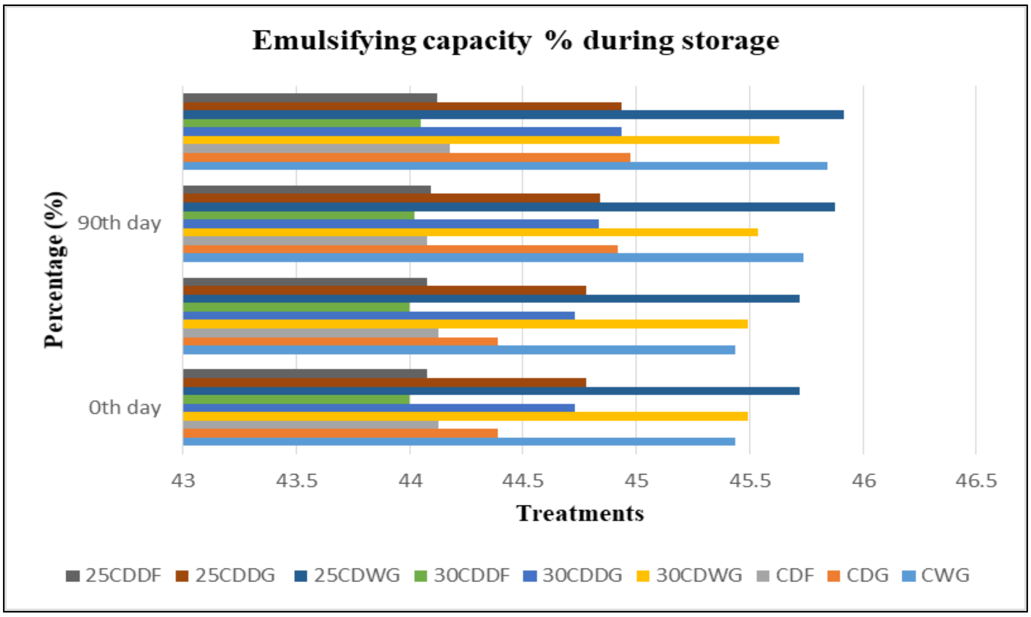

Fig 8: Oil absorption capacity during storage

5. Conclusion

Despite having excellent nutritious qualities, pearl millet isn't utilized much because of its short shelf life. Both functional and bio active compounds have changed significantly ($p<0.05$) in the cold plasma. On the other hand, it significantly affects tannin content. As a result of the cold plasma treatment's plasma reactive species. In particular, cold plasma packed in MPP at 25 kV for 10 minutes demonstrated superior control over tannin content compared to 30 kV for 10 minutes in MPP. After being stored for 90 days, the whole grain, dehulled grain and flour of pearl millet all had significant changes in their nutritional composition, physical and functional properties. It has been determined that treating pearl millet with cold plasma can lower tannin content. This novel non-thermal technique can be applied by the whole grain processing sectors to improve the features, applications and quality of new food products.

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References

1. Basavaraj G, Rao PP, Bhagavatula S, Ahmed W, Rathore G. Availability and utilization of pearl millet in India. SAT e Journal. 2010;8(2):1-6.

2. Booma K, Prakash V. Functional properties of the flour and the major protein fraction from sesame seed, sunflower seed and safflower seed. Acta Aliment. 1990;19(2):163-176.
3. Deshpande SS, Cheryan M, Salunkhe DK, Luh BS. Tannin analysis of food products. Crit Rev Food Sci Nutr. 1986;24(4):401-449.
4. Dwivedi P, Majumdar A, Thakkar B, Saxena S, Tripathi V. Physicochemical properties of brown top millet and evaluation of its suitability in product formulation. Acta Sci Nutr Health. 2023;7(9):03-09.
5. Gowthamraj G, Jubeena C, Sangeetha N. The effect of γ-irradiation on the physicochemical, functional, proximate and anti-nutrient characteristics of finger millet (CO14 & CO15) flours. Radiat Phys Chem. 2021;183:109403.
6. Jukanti AK, Arora A, Gowda CL, Rai KN, Manga VK, Bhatt RK. Crops that feed the world 11. Pearl millet (*Pennisetum glaucum* L.): An important source of food security, nutrition and health in the arid and semi-arid tropics. J Food Sci. 2016;8:307-329.
7. Lokeswari R, Sharanyakantha PS, Jaspin S, Mahendran R. Cold plasma effects on changes in physical, nutritional, hydration and pasting properties of pearl millet (*Pennisetum glaucum*). IEEE Trans Plasma Sci. 2021;49(5):1745-175.
8. Narayana K, Narasinga Rao MS. Functional properties of raw and heat processed winged bean (Psophocarpus tetragonolobus) flour. J Food Sci. 1982;47(5):1534-1538.
9. Pradeep SR, Guha M. Effect of processing methods on the nutraceutical and antioxidant properties of little millet (*Panicum sumatrense*) extracts. Food Chem. 2011;4:1643-1647.
10. Sarkar A, Niranjan T, Patel G, Kheto A, Brijesh K, Tiwari, *et al*. Impact of cold plasma treatment on nutritional, antinutritional, functional, thermal, rheological and structural properties of pearl millet flour. Food Res Int. 2023;46(5):22-33.
11. Slinkard K, Singleton VL. Total phenol analysis: automation and comparison with manual methods. Am J Enol Vitic. 1977;28(1):49-55.
12. Soo MH, Nabilah AS, Zaidel DNA, Jusoh YMM, Muhamad II, Hashim Z. Extraction of plant based protein from moringa oleifera leaves using alkaline extraction and isoelectric precipitation method. Chem Eng Trans. 2021;89:253-258.
13. Stojceska V, Ainsworth P, Plunkett A, Ibanoglu E, Ibanoglu S. Cauliflower by products as a new source of dietary fibre, antioxidants and proteins in cereal based ready to eat expanded snacks. J Food Eng. 2008;87(7):554-563.
14. Tavakovli AL, Shahidi F, Habibian M, Koocheki A, Behdad SY. Effect of atmospheric nonthermal plasma on sun pest-damaged wheat flour. Food Sci Nutr. 2022;22(4):334-338.