Middle East Journal of Agriculture Research
Volume: 10 | Issue: 04| Oct. – Dec.| 2021

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2021.10.4.91
Journal homepage: www.curresweb.com
Pages: 1335-1344

Effect of Packaging Materials and Modified Atmosphere of Shelf Life of Burger Products Fortificated of Pearl Millet

Sanaa S. H. Aly[1], Sanaa R. A. Rohaim[1] and Mona A. Abd El latif [2]

[1]Food Engineering & Packaging Dept., & [2] Experimental Kitchen Research Unit ,Food Tech. Res. Inst., Agric. Res. Center, Giza, Egypt

Received: 10 Nov. 2021 **Accepted:** 15 Dec. 2021 **Published:** 20 Dec. 2021

ABSTRACT

The aim of the study was to use dried ground pearl millet (PM) as meat extender in manufacture of beef burgers and also, as a new untraditional source dietary fiber to produce healthy beef burgers at lower cost. In this study, PM powder was added to beef burger dough formulations at different levels (10, 20, 30, 40, 50%) and the physiochemicals quality criteria (moisture, pH value, water holding capacity, (WHC), thiobarbituric acid (TBA) and free fatty acid (FFA) contents), cooking measurements, (cooking loss, cooking yield, shrinkage and moisture retention) were studied during 3 weeks of storage at 4ºC. Also, to prolong the shelf life of the product, this research investigated effect of packaging material poly ethylene/ Poly Ester (PEE) and Poly ethylene/ Polyamide (PEA) and modifying the atmosphere of these packages with CO_2 and N_2 flushing, on the microbiological quality and sensory properties of all samples during storage. The obtained results revealed that the incorporation of PM powder as a meat extender into beef burger by replacing of 10% and 20% of meat resulted in enhancing the physiochemical properties and cooking measurement of beef burger dough having good sensory properties which did not significantly different from the control sample. The current results revealed that PEE packages would be more effective in long term storage of samples to maintain microbial stability than PEA packages. Also, results showed significantly ($p<0.05$) lower values of microbial growth and exhibited a good sensory properties even after cold storage for 3 weeks at 4ºC especially, with packages flushed with nitrogen gas. In addition, the increasing of FFA in the samples during storage was more lesser. The present work recommended that it should be incorporated of these promising healthy nutrients into production of beef at the above mentioned replacing levels and packed in polyethylene ester containers flushed with nitrogen as modified atmosphere gas to prolong shelf life of the product up to 3 weeks at refrigerator, and to give, at the same time, economic cost price to the product, without detrimental effect on its sensory properties.

Keywords: *Ajuga iva,* anatomy*,* essential oils, phenolics, plant hormones

1. Introduction

Pearl millet (*Pennisetum glaucum* L., R.Br.) is one of the oldest millet belongs to section *Paniceae* of family *Poaceae*. It is an important food and forage crop in Africa and Asia, and important forage in Americas. It has great potential, because of its suitability to the extreme limits of agriculture, growing under dry, high-temperature conditions, adapted to poor, droughty and infertile soils and are also more reliable under these conditions than most other grain crops. Also the crop is favored due to its productivity and short growing season (Shweta Malik, 2015).

Pearl millet is regarded as one of the major source of dietary energy due to its nutritious benefits and gluten-free status. It has about 378 calories per 100 gm of weight. Its nutrition amount about 11.0% protein, 8.0% water, 3.0% ash, 67.00% total carbohydrates, 7.0% dietary fiber and 3.0% fat and fatty acids (Adeola and Orban, 1994). Millets are miles ahead of rice and wheat in terms of minerals.

Pearl millet is predominately starchy and the bran layer of pearl millet is a good a source of B-complex vitamins. It also serves as source of antioxidants in our diet. Thus, the presence of all the required nutrients

Corresponding Author: Sanaa, S. H. Aly, Food Engineering & Packaging Dept., Food Tech. Res. Inst., Agric. Res. Center, Giza, Egypt.

in pearl millet makes them suitable for large scale utilization in the manufacture of food products such as baby foods, snack foods and dietary food. The ground millet seeds may be as creamy as mashed potatoes or as fluffy as rice and had a delicious taste (Adebukola Adesina, 2021).

Nowadays, consumers are becoming more and more conscious about which any cheap food having various good effects on the body, especially, vegetarian ones, as a substitute of very expensive animal food. Thus, this is the idea of our research.

Packaging is an important aspect in the food processing industry as it serves the important functions of containing the food protecting against chemical and physical damage while providing information on product features, nutritional status and ingredient information (Lusia *et al.,* 2019).

Various packaging materials such as polyethylene terephthalate (PET) polyethylene high-density, poly vinylalanine (PV) and Polypropylene (PP) are commonly used for packaging of meat products (Adesina, 2021).

Recently, researchers classified packaging materials according to its degree of permeability to water vapor, aromas, and gases. High density polyethylene and polyamide had a high degree of gas permission and polyethylene/ polyamide had the second degree (Robertson, 2006).

Even under ideal conditions such as lack of oxygen and chilled temperature, food that is not cooked may harbour pathogenic and anaerobic bacteria. The burden of food borne illness and the number of food recalls associated with microbial contamination of these foods has risen in recent years, which they ae expected to have a lone shelf life, some up to 100 days. Thus, even an initial population of anaerobic of 10/g or less can multiply and achieve numbers that could cause deterioration or make the food insecure, and if the food is submitted to temperature abuses, the situation is aggravated, which some mesophilic and anaerobic bacteria that are unable to grow at temperature, drastically reducing the shelf life of the product (Sharaf *et al.,* 2009).

Therefore, modified atmosphere (MAP) is becoming an increasingly popular method of food preservation. MAP involving various gases such as CO_2 an N_2, has been used to extend both chemical and microbial shelf life of meat and bakery goods. However, it has been used sparingly as a method for extending the mold free shelf life of baked (Tiwari & Jha, 2017). Whereas, in North America, approximately 85% of fresh meat and most processed meats are packed in modified atmospheres, (Reg. EU 601, 2019). To date, no additive with antimicrobial activity is allowed on fresh minced meat and meat preparations, therefore several studies investigated the use of modified atmospheres for meat preservation through the reduction both of microbial growth and lipid oxidation during storage.

The American Heart Association (AHA, 2004) and other health groups have recommended a decrease in the consumption of animal fats. Decreases in calories of fat, from 40% to 30% and in saturated fat intake from 18% to 10% have also been recommended.

Meat extenders such as soy-bean protein are added to the meat products formulation for the former reason and to lower the cost of products. This protein has high biological value as well as good functional properties which lead to increasing the water binding capacity and improving the texture and the acceptability of the final product (Passos-Maria *et al.,* 2002).

Replacing of the commonly used traditional extenders will depend on the price, technological, nutritional properties and consumers acceptance of the used replacer (Lucia *et al.,* 2019).

By any nutritional parameter, pearl millet is miles ahead of rice and wheat in terms of their mineral content, dietary energy, nutritional security and offering excellent taste (Anoma and Fereidoon, 2011). It has more fiber than the same crops, as much as fifty times that of rice and thirty times more calcium compared to this crop. Besides, it is so rich in iron content, and has abundant quantities of Beta Carotene compared with rice and/ or wheat (Shweta Malik, 2015).

Semi meat products analogue are products processed from mixture of meat and vegetable protein to resemble the same meat product in texture, flavor, taste and nutritional value and to give, at the same time, economic cost price to the product.

The objective of this work was [1] to study the effects of incorporating pearl millet seed powder into production of beef burger at different levels, on the quality characteristics, cooking measurements, microbiological quality and sensory properties of beef burger patties. [2] The effectiveness of modified atmosphere packaging with CO_2 and N_2 to control the growth of the common contaminants of minced meat. [3] Special attention that is given to evaluate the effect of two packages with different materials on the microbial quality and the shelf life of the samples during cold storage at $4\pm1^{o}C$.

Middle East J. Agric. Res., 10(4): 1335-1344, 2021
EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2021.10.4.91*

2. Material and Methods

Pearl millet seeds were purchased from the local market. Fresh processed burger dough was obtained from one of the meat processed companies at 5 October City and stored in refrigerator at 4+1ºC until uses. Packaging materials (PE/ Polyester and PE/ Polymide) used in this study was obtained from a company of bags at El-Ashir City.

2.1. Preparation of millet powder

The pearl millet grains were cleaned to remove extraneous materials and milled into flour using hammer mill with screen 800 µm, then sieved with a 425 µm wire mesh to obtain finer flour. The pearl millet flour was moistened over night at refrigerator and then kept in polyethylene bags at the same temperature 4°C until uses.

2.2. Preparation of burger samples:

Six types of formulations were prepared in experimental lab, Food Engineering & Packaging Dept., Food Tech., Res. Institute, Agr. Res. Center. Tested samples were formulated to contain 0, 10, 20, 30, 40 and 50% moisten pearl millet powder (PM) by replacing meat burger, then homogenized and precisely mixed to obtain six batches of burger / PM dough, had a different percentages of vegetable protein.

Every batch divided into two parts, first one, packed in polyethylene/polyester and the second in polyethylene/polyamide packaging materials (60 gm for each package). The samples steeled under modified atmosphere, third part of them injected with CO_2 gas, the second third part with N_2 gas and the last third part without any modified atmosphere gas (control sample).

The samples stored at refrigerator for 3 weeks and a physiochemical analysis analysis, microbiological quality and sensory characteristics were carried out periodically every week.

2.3. Cooking of burger samples

The burger samples were cooked for measuring the diameter shrinkage, cooking loss and organoleptic evaluation. Whereas, 50 g of refined sunflower oil, placed in grill, heated at 165±5ºC for 6min. for each side; as described by Ou and Mittal (2006), then cooking yield, moisture retention and shrinkage were determined according to El-Magoli *et al.,* (1996), while cooking loss was calculated according to the following equation:

$$\text{Cooking loss} = \frac{\text{Weight of raw sample} - \text{weight of cooked sample}}{\text{Weight of raw sample}} \times 100$$

Cooking yield % = cooked weight × 100 / raw weight

$$\text{Moisture retention \%} = \frac{\text{Percent yield} \times \text{\% moisture in cooked burger}}{100}$$

2.4. Physiochemical composition

The moisture content of the raw and cooked samples was determined using the hot air oven method (AOAC, 2000). The samples were dried in an oven at 100 + 1ºC for 4 – 5 h or until constant weight was obtained. The pH value was determined by using a calibrated pH meter (Beckman model 3550, USA) according to Schoeni *et al.,* (1991). Water holding capacity (WHC was determined by filter press method (Honikel, 1998). The meat tissues (0.3 g) was carefully flattened in a glass plate and covered with shells filter paper (whatman No. 41) then pressed for 10 min using a mass of one kg weight. Two zones were formed on filter paper, their surface area was measured using planimeter. The W.H.C. was calculated as cm^2/0.3 g by subtracting the area of the internal zone from that of the outer. Thiobarbituric acid (TBA) value was determined according to Pearson (1976). Free fatty acids (FFA) determined using the A.O.A.C (2000).

2.5. Microbiological Aspects

2.5.1. Total aerobic bacterial colonies count

In brief, a portion of each sample (10g) was aseptically transferred into a stomacher filter bag containing 90 ml of sterile ringers solution, homogenized for 5 min. and afterward serially diluted. Appropriate dilutions were then plated in petri dishes containing Plate Count Agar (PCA; Oxoid, Basingstoke, UK) with cycloheximide 0.1 % solution (Oxoid). The plates were incubated for 24 h at 37°C. Bacterial colonies were counted from three replicates and the mean was expressed as log CFU (Colony Forming Unit)/g of burger ± standard deviation.

2.6. Organoleptic evaluation

Cooked burgers and control samples were carried out every week during three weeks of storage at refrigerator. Samples were cut into pieces of uniform size (2 cm^2) and served warm (45°C). The organoleptic characteristics of the cooked burger were sensory evaluated by twenty panelists, who had no perior knowledge of the formulation of the sample. And asked to evaluate for color, taste, tenderness, texture, flavor, appearance and overall acceptability, of cooked burger according to the method described by A.M.S.A. (1995), and then statistically analyzed.

2.7. Statistical analysis

Data for cooking measurements and sensory evaluation was analyzed according to SPSS, (1999) using analysis of variance (ANOVA) and least significance difference (LSD) at a significance of probability 5% to evaluate different burger samples, followed by Duncan's multiple range tests were carried out using out SPSS computer program.

3. Results and Discussion

3.1. Physio-chemical quality criteria of beef burgers

Physio-chemical properties of beef burger samples as affected by addition different levels of PM flour during cold storage at 4±1°C for 3 weeks were presented in Table (1). As shown, the replacing of PM resulted in a slight decrease in the samples pH values were compared with pH value of control sample. On the other hand, pH value increased continuously in all beef burger during frozen storage. The increment rate in that value was decreased with increasing PM level.

Data presented in the same table showed that there is significant difference in moisture content of different beef burger blends and control. Moisture content of burger samples were ranged from 59.94% for control sample to 37.46% for burger sample containing 50% PM powder and stored 3 weeks at 4±1°C. The highest moisture content was found for control sample. From the same table, it could be also observed that water holding capacity (WHC) of beef burger samples increased by increasing PM level from 10 to 50%. During cold storage, WHC values reduced continuously in all beef burger samples with progressing of storage period; as the result of breakdown hydrogen bonding between the water molecules and gross chemical components of beef burger (Oroszvari *et al.,* 2005). Table (1) also shows that TBA content of all beef burger increased gradually during cold storage, this increase could be mainly attributed to the oxidation of beef burger lipids and formation of some TBA-reactive compounds during the storage period as reported by (Sharaf *et al.,* 2009). But dcreased by increasing PM level in meat beef burger samples.

3.2. Free fatty acid (FFA)

Free fatty acid was determined to study the effect of packaging materials, packaging environment and storage days on FFA% of PM/burger samples compared to samples packaged without modified atmosphere gases (Table 2).

Table 2 shows that, after 3 weeks storage at 4±1°C, FFA varied from an initial value 0.72% to 1.64% and from 0.72% to 1.34% for PEA and PEE packets respectively in control sample, while it varied from 0.72 to 0.85% and from 0.72 to 0.79% for CO_2 flushed PEA and PEE packets respectively and it varied from 0.72 to 0.74% and from 0.72 to 0.73% for N_2 flushed PEA and PEE packets respectively, giving a negligible and slowest rate of increasing of FFA compared to control sample and CO_2 flushed samples. It could be ascribed to the lower concentration of oxygen content in the packages causing decreasing the lipid oxidation rate in PM/burger samples due to the inert gas (N_2) which flushed

Middle East J. Agric. Res., 10(4): 1335-1344, 2021
EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2021.10.4.91*

Table 1: Physiochemical properties of beef burger samples as affected by addition different levels of pearl miller powder (PM) during cold storage at 4±1oC for 3 weeks

Components	Storage period / week (at 4+1°C)																	
	1 week						3 weeks						3 weeks					
	PM addition %																	
	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50
Moisture %	59.94	57.11	54.26	50.34	45.00	40.35	59.20	55.15	51.27	47.00	41.41	38.80	59.00	53.12	50.15	43.07	42.33	37.46
pH value	6.91	7.03	7.17	7.25	7.30	7.33	6.95	7.26	7.41	7.50	7.46	7.48	6.99	7.30	7.54	7.69	7.52	7.56
WHC % bond water	82.35	80.10	80.74	81.35	82.66	83.94	81.70	79.16	79.80	80.43	81.00	82.90	80.28	78.00	78.70	79.43	80.05	80.80
TBA Mg/kg sample	0.2311	0.3010	0.2444	0.2071	0.1753	0.1262	0.4142	0.3459	0.2900	0.2462	0.2154	0.1809	0.8333	0.3715	0.3449	0.3276	0.2914	0.2530

Note: all experimental samples were taken from N_2 modified atmosphere samples which packed in polyethylene esters.

inside the samples packages, when compared to control (Tiwari and Jha, 2017). Further, both packages of different packaging materials had non-significant effect on the free fatty content in all tested PM/burger samples during 3 weeks of storage.

Table 2: Effect of packaging materials, packaging atmosphere and storage period on Free Fatty acid (%) of PM-burger dough.

Packaging material	Storage time (week)	Modified Atmosphere		
		Air*	CO_2	N_2
PEA	**0**	0.72	0.72	0.72
	1	0.96	0.77	0.72
	2	1.20	0.82	0.72
	3	1.64	0.85	0.74
PEE	**0**	0.72	0.72	0.72
	1	0.80	0.74	0.72
	2	0.95	0.76	0.72
	3	1.34	0.79	0.73

* Samples of meat burger packed in PEA or PEE without modified atmosphere gases (Control sample).

Generally, in all modified atmosphere tested samples, FFA is less than the critical level 1% which **Tiwari *et al.*, (2011)** reported that fried burger with FFA>1% are unfit for consumption.

3.3. Cooking measurement of beef burgers containing PM

As shown in Table (3) moisture retention value of beef burger samples increased with the increasing level of PM powder in beef burger samples, which was attributed to the high water binding capacity of PM powder. The moisture retention was proportionally increased with the increment of fiber content in beef burgers. The high amount of PM powder gives low loss of moisture during cooking.

Table 3: Cooking measurements* of beef burger samples as affected by addition different levels of PM flour during cold storage at 4 ± 1ºC.

Item	Storage (weeks)	Moisture retention %	Shrinking %	Cooking Loss %	Cooking yield %
Control sample	**1**	38.17^{c}	37.58^{a}	12.46^{a}	80.15^{c}
	2	38.00^{c}	38.70^{a}	12.19^{a}	79.18^{c}
	3	37.35^{d}	39.94^{a}	11.88^{b}	78.26^{d}
Burger + 10% PM	**1**	38.99^{d}	34.00^{b}	11.57^{b}	81.10^{b}
	2	38.21^{d}	34.52^{b}	10.94^{b}	80.66^{b}
	3	37.35^{d}	34.99^{c}	10.50^{c}	80.11^{b}
Burger + 20% PM	**1**	39.18^{d}	33.62^{b}	10.23^{b}	81.67^{d}
	2	38.49^{d}	34.51^{b}	10.08^{c}	81.14^{d}
	3	37.61^{d}	34.89^{c}	9.46^{c}	80.41^{ab}
Burger + 30% PM	**1**	42.14^{c}	27.55^{b}	7.03^{d}	83.05^{b}
	2	41.86^{c}	28.00^{c}	6.62^{d}	82.50^{b}
	3	41.00^{d}	28.39^{c}	6.09^{c}	82.09^{b}
Burger + 40% PM	**1**	45.22^{c}	26.19^{d}	6.00^{d}	85.44^{ab}
	2	44.50^{d}	26.75^{d}	5.72^{c}	84.93^{ab}
	3	43.82^{d}	27.14^{c}	5.40^{c}	84.12^{c}
Burger + 50% PM	**1**	48.37^{c}	23.80^{d}	4.42^{b}	87.84^{d}
	2	47.10^{d}	24.20^{d}	4.30^{b}	86.27^{d}
	3	47.00^{d}	24.84^{c}	4.19^{b}	85.20^{b}

* Means in the same raw with different superscripts are different significantly (P<0.05).

In addition, cooking shrinkage increased slightly and linearly for all beef burger samples during cold storage, but it was more evident in control sample than other samples containing PM powder.

Cooking yield was significantly (P>0.05) higher in burger incorporated with PM. The increasing in cooking yield ranged from 81.10 to 87.84 with proportionally increasing the level of PM powder from 10% to 50% in beef burger samples.

Cooking loss refers to the reduction weight of beef meat during the cooking process. From the results in Table (3) it could be noticed that cooking loss was affected by the water retention level. The high cooking loss from control sample could be attributed to the high loss of moisture and fat during cooking.

Non-significant decreasing level was observed in the moisture retention, cooking yield, and cooking loss with increasing cold storage time in all burger samples.

Regarding, cooking shrinkage which is considered one of the most important physical quality changes that occurs in beef burgers during cooking process due to protein denaturation and releasing of fat and water from beef burger samples (Drummond and Sun, 2005). It could be noticed from the data, in the same table, that cooking shrinkage percentage of burger samples containing 10, 20 & 30% PM powder were significantly lower than the control sample, ($P > 0.05$) then it decreased slightly with samples containing 40 & 50% PM powder.

3.4. Microbiological quality criteria of beef burgers containing PM

Table (4), displays the aerobic bacterial count (ABC) determined every week during the storage time of 3 weeks at 4±1°C on burger/PM samples which packed under modified atmosphere gases in different two packaging materials (PEA & PEE).

The initial ABC value evaluated on PCA was 2.82 log cFu/g in all samples (both PEA and PEE samples) and during 3 weeks increased with progressing the storage time in all samples, but with considerable differences depending on; percentage of PM powder in meat burger samples, variety of atmosphere gas, and the kind of packaging material.

Results illustrates that the total bacterial, slightly decreased with increasing the addition level of PM powder, which may be due to the reducing of free water resulting from the high water binding capacity of PM flour. Total counts registered the lowest values in N_2 modified atmosphere gas compared to CO_2 modified atmosphere samples.

Also, total count registered that PEE samples had lower value than PEA samples.

At the end of storage the best results were obtained by the samples packed in PEE under N_2 modified atmosphere (3.15 log cFu/g) followed by the samples packed in the same packaging material under CO_2 modified atmosphere (3.61 log cFu/g).

Generally, while the total count of the control sample rapidly increased at the end of storage exceeding the limit of 7.24 and 7.20 log cFu/g in PEA and PEE samples respectively (fixed by the European regulation Reg EC 2073, 2005) for total aerobic colony count, microbiological quality criteria of all beef burger-PM samples were within permissible counts reported by E.O.S (2005) recommended that the total bacterial count not exceed 5.0 log cFu/g, indicatively, all samples had a good hygienic condition at the end of storage. (3 weeks), contrary to that of control sample.

3.5. Sensory quality criteria of beef burgers containing PM flour:

Organoleptic evaluation of cooked burger that supplemented its meet with PM flour at different level of supplementation represented in Table (5). One of the limiting factor for consumer acceptability is the sensory properties. Therefore, color, flavor, texture, taste tenderness, appearance and overall acceptability of consumer were performance for evaluated and compared to the control sample.

Data shows that there no significant differences among control and samples containing of 10 and 20% PM in color, taste, flavor texture and appearance. From results presented in Table (5), it confirmed that 10% and 20% blends and control possessed the best scores in these sensory attributes, with no significant difference in between, but were significantly differed than 30%, 40% and 50% blends.

With respect to the tenderness of the tested burger 30, 40 & 50% blends recorded the lowest value of tenderness compared to 10 & 20% blends and control and were significantly different ($P < 0.05$).

Also, the same table shows that there no significant differences among samples with different storage periods (3 weeks) at 4±1°C.

With regard to the overall acceptability, the samples containing 10% and 20% of PM flour scored highest scores and they were the most preferable by the panelists with non-significant differences. These findings revealed that PM flour did not change the sensory properties and consumer acceptability at level 10% or 20% in the PM-based beef burger.

Generally, it could be concluded that the incorporation of PM flour into beef burger as a good functional and nutritional properties meat replacer at the tested levels 10 – 20% of meat weight used in

Middle East J. Agric. Res., 10(4): 1335-1344, 2021
EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2021.10.4.91*

Table 4: Microbiological counts (log cFu/g) of beef burger samples as affected by addition different levels of pearl millet powder and packed in different two packaging materials under modified atmosphere gases during cold storage at 4 ºC ± 1 for 3 weeks.

Packing material	Storage period (week)	Modified Atmosphere gases																	
		Air* (control sample)						CO_2						N_2					
		Percentage of Pearl Millet powder in meat burger dough samples																	
		0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50
PEA	0	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
	1	3.84	3.76	3.62	3.51	3.44	3.20	3.95	3.31	3.47	3.65	3.86	2.93	3.24	3.20	3.13	3.00	2.91	2.88
	2	5.79	5.55	5.41	5.38	4.20	4.11	4.38	3.63	4.40	4.18	3.33	3.20	3.93	3.60	3.55	3.49	3.28	3.00
	3	7.24	7.00	6.32	5.58	4.62	5.73	4.95	4.55	4.14	4.09	3.98	3.90	4.90	4.11	4.00	3.97	3.79	3.76
PEE	0	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
	1	3.49	3.42	3.36	3.29	3.21	3.15	3.54	3.20	3.30	3.26	3.18	2.88	3.16	3.10	3.50	3.33	3.00	2.94
	2	5.55	5.26	5.09	4.81	4.50	4.00	4.07	3.44	3.51	3.48	3.39	3.18	3.77	3.33	3.25	3.20	3.14	3.00
	3	7.20	6.94	6.72	5.53	4.30	5.49	4.71	4.37	4.25	4.00	3.80	3.61	4.81	3.80	3.71	3.60	3.55	3.15

PEA: Polyethylene/ polyamide **PEE:** Polyethylene/ ester
* Samples of meat burger packed in PEA or PEE without modified atmosphere gases.

burger dough formulation resulted in producing burger patties without detrimental effect on the sensory attributes besides improving cooking measurements of the product.

Table 5: Sensory descriptors (rank sums*) of beef burger samples as affected by addition different levels of PM flour during cold storage at 4 ± 1°C for 3 weeks.

Storage period (week)	% of addition	Color	Taste	Texture	Flavor	Tenderness	Appearance	Overall acceptability
1	Control**	9.40^{a}	9.40^{a}	9.20^{a}	9.30^{a}	9.20^{a}	8.90^{a}	9.25^{a}
	10	9.25^{a}	9.25^{a}	9.35^{a}	9.20^{a}	8.95^{ab}	9.20^{a}	9.20^{a}
	20	9.10^{a}	9.00^{a}	9.38^{a}	9.10^{a}	8.95^{ab}	9.20^{a}	9.10^{a}
	30	8.36^{ab}	8.50^{ab}	8.97^{ab}	8.70^{ab}	7.66^{c}	8.90^{ab}	8.35^{b}
	40	8.45^{ab}	7.78^{c}	8.90^{ab}	7.80^{c}	7.63^{c}	8.85^{ab}	8.20^{b}
	50	8.15^{b}	7.70^{c}	8.85^{ab}	7.35^{c}	7.60^{c}	8.76^{ab}	8.00^{b}
2	10	9.17^{a}	9.30^{a}	9.10^{a}	9.15^{a}	8.80^{ab}	9.20^{a}	9.10^{a}
	20	9.00^{a}	9.10^{a}	9.22^{a}	9.00^{a}	8.70^{ab}	9.10^{a}	9.10^{a}
	30	8.50^{ab}	8.20^{b}	8.75^{ab}	8.50^{ab}	7.56^{c}	8.80^{ab}	8.20^{b}
	40	8.20^{b}	7.69^{c}	8.68^{ab}	7.40^{c}	7.52^{c}	8.80^{ab}	8.10^{b}
	50	8.00^{b}	7.65^{c}	8.60^{ab}	7.20^{c}	7.40^{c}	8.65^{ab}	7.90^{c}
3	10	9.14^{a}	9.25^{a}	9.05^{a}	9.10^{a}	8.70^{ab}	9.10^{a}	9.00^{a}
	20	9.05^{a}	9.25^{a}	9.10^{a}	9.00^{a}	8.66^{ab}	9.10^{a}	8.95^{a}
	30	8.35^{b}	8.70^{ab}	8.70^{ab}	8.00^{b}	7.53^{c}	8.85^{ab}	8.00^{b}
	40	8.10^{b}	7.66^{c}	8.55^{ab}	7.50^{c}	7.50^{c}	8.60^{ab}	7.90^{c}
	50	7.90^{c}	7.60^{c}	8.50^{ab}	7.10^{c}	7.39^{c}	8.45^{ab}	7.80^{c}

* Rank sums with different superscripts in the same row are significantly different.
** Fresh meat samples with no PM addition.
Note: all experimental samples was taken from N2 modified atmosphere samples which packed in polyethylene/ester.

4. Conclusion

It could be concluded that using of ground PM into beef burger dough as a good functional, and nutritional properties replacer resulted in improving the physiochemical, microbiological, cooking measurements and sensory quality criteria with lowering the product cost.

Sensory evaluation of beef burgers revealed that, beef burger incorporated with 10 and 20% PM powder have the highest level of acceptance for all sensory characteristics, there were no significant differences could be detected among these samples and control even after cold storage for 3 weeks and without detrimental effect on the sensory attributes.

In addition, results showed that the increase of free fatty acids and microbial growing was lesser in packages flushed with nitrogen gas than Carbon dioxide gas.

Based on the microbial quality, PEE packages would be more effective in long term storage of samples to maintain microbial stability than BEA packages essential for prolonged shelf life.

The results obtained in this study support the idea of proposing the use of ground PM into beef burger dough, analogously to other different vegetable species and origins (GSFA, 2018) as a natural additive of beef burger dough formulations for maintaining all quality parameters.

Further studies will be addressed to assess the influence of this flour, on the technological characteristics of the cooked meat products and on its overall sensory acceptability.

References

A.M.S.A., 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. American Meat Science Association and National livestock and Meat Board, Chicago, IL, 475.

A.O.A.C., 2000. Official Methods of Analysis, 17th ed. Standard Official Method Association of Official Agricultural Chemists. Gaithersburg MD., USA.

Adebukola, A., 2021. Effect of packaging material and storage conditions on the microbial quality of pearl millet extruded snack. J. Food process Technol, Vol. 12: 47 – 51.

Adeola, O., and J.I. Orban, 1994. Chemical composition and nutrient digestibility of pearl millet fed to growing pigs. J. of General Science, 22: 177 – 184.

Adesina, A., 2021. Effect of packaging Material and Storage Conditions on the Microbial Quality of Pearl Millet Extruded Snack. J. Food Process Technol. 12: 857.

AHA, 2004. American Heart Association. Heart and Stroke encyclopedia. Dietary guidelines for healthy American adults. Cholesterol Fat.

Anoma, C., and S. Fereidoon, 2011. Bioactivities and Antiradical properties of Millet Grains and Hulls. J. Agric. Food Chem., 59: 9563 – 9571.

Drummond, L.S. and D.W. Sun, 2005. Feasibility of water immersion cooking of beef joints: Effect on product quality and yield. J. Food Eng., 77: 289 – 294.

E.O.S., 2005. Egyptian Organization for Standerdization and Quality Control. Frozen beef burger No. 1688/2005.

El-Magoli, S., S. Laroia, and P. Hansen, 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. Meat Sci., 42: 179 – 193.

FAO, 1979. Manuals of Food Quality Control, 4. Microbiological Analysis Food and Agriculture Organization of the United Nations, Rome, 9-12 on Di – 133.

GSFA, 2018. General standard for food additives, GSFA online, updated up to the 41st session of the condex Alimentarius commission.

Honikel, K.O., 1998. Reference methods for assessment of physical characteristics of meat. Meat Sci., 49: 447 – 457.

Lucia, P., P. Rosa, T. Daniela, R. Cristina, and F. Biagio, 2019. Quality maintenance of beef burger patties by direct addition or encapsulation of a prickly pear fruit extract. Microbiology J., 10:1720 – 1726.

Oroszvari, B.K., I. Sjoholm, and Tornberg, 2005. The mechanisms controlling heat and mass transfer on frying beef burgers. 1. The influence of the composition and comminution of meat raw material. J. Food Eng., 67: 499 – 506.

Ou, D. and G.S. Mittal 2006. Double-sided pan-frying of unfrozen/ Frozen hamburgers for microbial safety using modeling and simulation. Food Res. Int., 39: 133 – 144.

Passos-Maria, H.C.R. and A.Y. Kuaye, 2002. Influence of the formulation, cooking time and final internal temperature of beef hamburgers on the destruction of listeria monocytogenes. Food Control, 13: 33-40.

Pearson, S., 1976. Chemical analysis of Food. 8th Ed. Harold Egan, Ronald S. Kirk Roland Saweyer. London.

Reg. EC 2073, 2005. European Commission Regulation (EC) No. 2073/2005 of 15 Nov. 2005 on microbiological criteria for foodstuffs. Off. J. Euro. Union L. 338.

Reg. EU 601, 2019. Commission Regulation (EU) No. 270/2019 amending Annex 11 to Regulation (EC) No. 601/2014 of the European Parliament and of the Council in meat Preparation off. J. Euro. Union L. 186.

Robertson. G.L., 2006. Food Packaging: Priciples and Practice. Boca. Raton. Florida: GRC Press, 61: 417 – 446.

Sharaf, A.M., M.E. Ebrahim, M.S. Ammar, and M.E. Abd El-Ghany, 2009. Influence of using moringa flour as meat extender on quality characteristics of beef burger patties during frozen storage. J. of Dairy & Food Sciences, 4(1): 42-40.

Shweta, M., 2015. Pearl Millet-nutritional value and medicinal uses. Cereal Science, 23: 414 – 420.

SPSS, 1999. SPSS for Windows. Release 10 (October 1999), Standard Version.

Tiwari, A., and S.K. Jha, 2017. Effect of nitrogen gas enriched packing on quality and storage life of pearl millet based fried snaks. J. of Biosystems Eng. 42(1): 62-68.

Tiwari, U., M. Gunasekaran, R. Jaganmohan, K. Alagusundaran, and B.K. Tiwari, 2011. Quality characteristics and shelf life studies of deep fried snack prepared from rice brokens and legumes by-product. Food Process Technology, 4: 1172 – 1178.