Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Replacement of Phosphate as Preservative by Natural Products in Burger

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Abstract

THIS study investigates the effect of beef burger natural replacers (pectin and plum powder) of synthetic phosphate on the quality and shelf life of beef burger patties over the 12 days refrigeration storage. Four groups were prepared: a control group with 0.2% phosphate, a group with 1.2% plum powder and 0.25% pectin, a group with 1.2% plum powder only, and a group with 0.25% pectin only. All samples were analyzed every two days for sensory, chemical analysis (pH, thiobarbituric acid (TBA) value, total volatile basic nitrogen (TVBN), water holding capacity (WHC) and cooking loss) and bacteriological quality. Results showed that the group containing both pectin and plum powder had significantly lower TBA and TVBN values, improved WHC, reduced cooking loss, and better microbial mitigation compared to the control. These findings suggest that the combination of natural pectin and plum powder is a promising natural alternative to chemical phosphate, enhancing both the safety and functional quality of meat products while aligning with clean-label consumer preferences and meeting their needs in accordance with legislation and health requirements.

Keywords: Phosphate replacement, Plum powder, Pectin, Beef burger, TVBN. TBA, WHC.

Introduction

Phosphates are widely utilized in processed meat formulations because of their proven capacity to improve water holding capacity (WHC), reduce cooking loss, enhance texture, and extend shelf-life, while being cost-effective and easy to incorporate [1]. However, excessive dietary phosphate intake has been associated with potential health risks, including cardiovascular and kidney disorders [2]. Consequently, recent research has focused on reducing phosphate concentration incorporated in meat products or substituting them with natural alternatives such as plant fibers, hydrocolloids, and fruit extracts that can achieve comparable functional benefits without adverse health impacts [3] [4]. However, increasing consumer demand for clean-label and naturally preserved foods has led to growing interest in replacing synthetic additives with natural alternatives [5]. Among these, dietary fibers such as pectin, and natural antioxidants from fruits like plum powder, have shown promising potential in improving the functional and preservative qualities of meat products including water retention, emulsification, and gelation properties in various food matrices [6]. On the other hand, plum powder is rich in polyphenols and organic acids, offering potent antioxidant and antimicrobial effects. These properties help in delaying lipid oxidation and microbial spoilage in meat products, thereby extending shelf-life without synthetic preservatives [7]. Moreover, the phenolic compounds helps stabilize pH and inhibit the formation of volatile nitrogenous compounds such as TVBN, key markers of protein degradation.

Consumers are demanding meat products containing natural ingredients due to factors such as enhanced taste, improved nutritional value, long-term health benefits, and its recognized freshness [8]. Food components made from plums have been shown to have antibacterial, flavoring, fat-replacement, and antioxidant properties. Plum goods contain a number of useful components such as sorbitol, which helps preserve moisture, malic acid, which improves flavor, and pectin, which helps retain moisture [9]. Dried plum ingredients can have as high 17% sorbitol [10]. Sorbitol has long been

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(Received 17 August 2025, accepted 01 October 2025)
DOI: 10.21608/ejvs.2025.414304.3051

used as a humectant chemical structure contains hydroxyl groups that form hydrogen bonds with water, inhibiting moisture loss [11].

This study aims to evaluate the effectiveness of using pectin and plum powder, either alone or in combination, as replacer for phosphates in beef burger patties. Key parameters assessed include water holding capacity (WHC), cooking loss, pH, lipid oxidation (TBA), total volatile basic nitrogen (TVBN), and microbiological quality over 14 days of refrigerated storage. The goal is to determine whether these natural ingredients can match or exceed the performance of traditional phosphate in preserving meat quality.

Material and Methods

Beef Burger Manufacture and Experimental Design

Beef burger was prepared following the Egyptian Organization for Standardization (EOS) guideline [12]. Fresh lean beef and animal fat were procured, trimmed of visible connective tissue and fat, and then minced through a 4–6 mm plate. The basic burger formulation consisted of approximately with the following ingredients: 65% minced meat, 20% fat, 5% soybean, 0.3% black pepper and 1.8% salt. This recipe ensures good manufacturing practices for beef burgers. The ingredients was thoroughly mixed for five minutes. Four experimental groups were formulated: the first group (T1) served as the control and included 0.2% sodium tripolyphosphate (STPP); the second group (T2) contained 1.2% plum powder and 0.25% pectin; the third group (T3) included only 1.2% plum powder; and the fourth group (T4) contained 0.25% pectin only. Burger patties were manually formed into uniform discs of about 100 grams each, with a diameter of 10 cm and a thickness of 1 cm, as per the EOS specifications. The formed burgers were stored in polyethylene bags and kept under refrigeration at 4 ± 1 °C and examined every 48hrs until the sample groups deteriorated or become unaccepted.

Sensory Evaluation

The investigators in this study were specialists from the Animal Health Research Institute's Food Hygiene Department, ARC staff. The study evaluated each treated group. The most frequently cited descriptors includecording to the scheme adopted by [13] Using the 9-point hedonic scale. The specialists were asked to rank samples according to their intensity for each of the four descriptors. The examiners considered the sample rejected if the scores were less than five or exhibited clear sensory signs of spoilage (off-odor, off-color, sour taste, or visible spoilage) were considered spoiled and marked with "S" in the results table.

Microbiological analysis

For microbiological analysis 25 grams from each prepared beef burger samples were homogenized in an aseptic blender jar containing 225 mL of sterile peptone water, blended at 2000 rpm for 1-2 minutes to create a homogenate. From each homogenate, tenth-fold serial dilutions were prepared and were subjected to various bacteriological examinations: For aerobic Plate Count (APC), 0.1mL of appropriate dilutions from each sample were plated on Plate Count Agar and incubated at 35°C for 48 hours [14]. Coliforms were enumerated by pouring method using VRBA and the plates were inverted and incubated at 35c for 18- 24h [15] and one ml of each dilution was transferred and distributed over the surface of TBX medium for counting of *E,coli* and the plates were inverted and incubated for 24 hours at 44c and the typical colonies were counted [16].

Chemical Analysis

Determination of Total Volatile Basic Nitrogen (TVB-N) [17]

Approximately ten grams of previously prepared and homogenized beef burger sample was put on a mental flask with 300 mL of D.W. Then, two grams of MgO were added followed by an antifoaming agent as some glass beads. The distillate was received in an Erlenmeyer-flask containing 25 mL of 2% boric acid solution until the final distillate reached 125 mL volume. Titration of the distillate occurred by using H2SO4 solution (0.1N) till the endpoint. The same procedures occurred by using D.W. instead of the samples for blank detection (EOS, 2006). TVB-N (mg N/100g) of the burger sample was calculated as follows:

TVB-N (mg N/100g) = (S – B) × 14

Where:

S = H_2SO_4 volume that was used for sample titration

B = volume of H2SO4 (0.1N), which was titrated for blank

Determination of Thiobarbituric Acid (TBA) [18]

In a distillation flask about ten grams of the beef burger, sample was blended with 97.5ml distilled water, 2.5ml HCl solution (4 N) till ph reach 1.5, and anti-pumping stones. The distillation process was continued until 50 mL of distillate was collected in an empty flask. In a test tube placed in boiling water for 35 minutes, five mL of distillates and five mL of TBA reagent were combined. Instead of utilizing the sample with the 5 ml of TBA reagent, 5 ml of D.W. was used to complete the blank. On the spectrophotometer, the sample optical density (D) was measured at a wavelength of 538 nm in comparison to the blank.

Calculation: TBA (mg MDA /Kg) = D × 7.8

Determination of Water Holding Capacity (WHC)

Water Holding Capacity (WHC**)** was determined using the filter paper press method as described by

[19], with slight modifications. Briefly, a 0.3 g meat sample was placed between two pre-weighed Whatman No. 1 filter papers and pressed between two plexiglass plates under a constant pressure of 10 kg for 5 minutes at room temperature. The total moisture area and meat area were measured using image analysis, and WHC was calculated according to the formula proposed by [19]. Results were expressed as the percentage of water retained in the sample.

Determination of Cooking Loss

Cooking loss was measured according to the method described by [20] with slight modifications. Beef burger samples were weighed to obtain their initial raw weight (W_1) and then cooked on a preheated electric grill at 180 ± 2 °C until the internal temperature reached 75 °C, monitored with a calibrated digital thermometer. The cooked samples were blotted with absorbent paper to remove surface moisture and reweighed to determine the final cooked weight (W_2). Cooking loss (%) was calculated using the formula: Cooking Loss (%) = Weight before cooking−Weight after cooking/Weigh t before cooking x 100

Statistical Analysis

Statistical comparisons were performed using one-way analysis of variance (ANOVA). The experiment was repeated three times. The data were logarithmically transformed and analyzed by SPSS software (version 20, IBM CO).

Results and Discussion

Sensory Evaluation

Sensory testing and shelf-life tests need to be conducted to make sure the product meets the final consumer's expectations. The sensory evaluation results (Table 1) clearly indicate that the addition of plum powder and pectin significantly influenced the taste, odour, color, and overall acceptability of beef burgers during chilled storage, compared to the phosphate control (T_1). For taste at zero day, all treatments scored highly in taste, with no significant differences observed between them (T_1 to T_4 scores ranged from 8.4 to 8.5). However, as storage progressed, a gradual decline in taste scores was observed across all treatments due to oxidative and microbial changes typically occurring during storage of meat products. By the 8th day, T_1 and T_4 samples were considered spoiled (marked "S"), correlating with microbial spoilage. T_2 (plum + pectin) and T_3 (plum only) maintained acceptable taste scores until the 10th and 8th days, respectively, reflecting the antioxidant and antimicrobial properties of plum polyphenols and pectin's water-binding effect [4]. The taste stability in T_2 and T_3 can be linked to plum polyphenols delaying lipid oxidation, which is a major cause of off-flavors in stored meats [21]. Odour scores followed a similar trend to taste initially high (8.6–8.8) in all treatments. T_1 and T_4 samples dropped to unacceptable levels by the 8th day, with significant deterioration in odour due to microbial activity and volatile compound formation. T_2 maintained acceptable odour scores up to the 10th day, and T_3 until the 8th day, supporting findings by [3] who reported that phenolic compounds in fruits can significantly inhibit microbial growth and retard off odours. The synergy between plum and pectin in T_2 appeared to be most effective in maintaining odour quality, likely due to a combined antimicrobial effect.

Color is a critical quality parameter influencing consumer acceptance: T_1 and T_4 samples showed significant declines in color scores by the 6th day, aligning with oxidative discoloration. The presence of plum polyphenols in T_2 and T_3 provided protection against myoglobin oxidation, allowing these treatments to retain better color up to the 10th day (T_2) and 8th day (T_3), as supported by the work of [8]. Anthocyanins and flavonoids present in plums possess strong antioxidant properties that can scavenge reactive oxygen species, thereby potentially delaying lipid oxidation and maintaining the stability of meat color during storage [22]. Samples containing plum progressed a red color, that aligns with previous studies, which noted that plum powder reduces lightness and imparts a darker color to meat emulsions [23] and the inclusion of dried plum puree in sausage reduced the lightness values internally as well as on the surface in comparison to the control one [24].

Similarly, [24] noticed that fortified of plum ingredients up to 5% into precooked roasted beef had negligible impact on color and appearance in comparison to the control. [23] Also noticed that the addition of plum powder up to 4% in meat emulsion did not affect the color and appearance in comparison to the control.

Overall acceptance scores paralleled the trends observed in individual sensory attributes. T_1 and T_4 were unacceptable after day 6 due to early spoilage. Furthermore, T_2 showed the highest sensory stability, with acceptable overall scores even on the 10th day of storage, highlighting the synergistic benefit of combining plum and pectin.T_3 maintained acceptable overall acceptance until the 8th day, slightly lower than T_2 but still superior to T_1 and T_4. These findings are consistent with [25] who reported that incorporating fruit-derived polyphenols and dietary fibers in meat products can enhance sensory properties and extend shelf life.

The results indicated the high potential use of natural additives as combination of plum powder and pectin significantly improved the sensory quality and extended the shelf life of beef burgers under chilled storage so it could be effective methods for replacing

synthetic phosphate in meat products with quality enhancement.

Microbiological analysis

Each time all samples were tested for Aerobic plate count (APC), coliform and *E. coli* counts which expressed as (mean log10 cfu /g ±SD). In this study, the results in table (2) revealed that the mean value of total bacterial count in all treated samples were nearly similar at the zero day of storage as they recorded 4.45 ± 0.02 , 4.21 ± 0.04, 4.35 ±0.048 and 4.57 ±0.17 cfu/g in T_1, T_2, T_3 and T_4 respectively, after that their counts increased to be 5.47 ± 0.62, 4.64± 0.08 ,4.73 ± 0.07 and 5.67 ± 0.01 at the 4th day with marked higher values in both phosphate and pectin treated samples (T_1,T_4) respectively and the count in all samples continued to increase throughout the storage period which varied from one sample to another as shown in table (2).

Data in table (3) revealed that the count of coliform in phosphate and plum contained samples (T_1,T_2 and T_3) at zero time showed 2.05 ± 0.11 and 1.88 ±0.27 and 1.98 ± 0.05 cfu/g and decreased to be 1.99 ±0.08 and 1.66 ±0.05 in (T_1 and T_2) after 4 days and reached to < 1 cfu/g after 6 days of storage in plum with pectin treated samples (T_2) when in sample that treated with plum only (T_3) the count decreased to 1.23± 0.33cfu /g before spoilage at the 8th day . While in pectin treated samples the count of coliform was nearly similar during its storage time as it recorded 2.10 ±0.19 to be 2.11 ± 0.16 cfu/g at the 4th day and immediately before spoilage).

Our result in Table (4) also demonstrated the effect of the different treatments on *E. coli* count but among all the tested groups its count was highly affected by addition of plum with pectin (T2 sample) as its count decreased from 1.49 ± 0.19cfu/g to be 1.31± 0.27 at the 4th day and to <1 cfu/g after 6 days of storage.

For other samples, both phosphate and plum treated samples (T1, T3) the *E. coli* count decreased also from 1.76 ± 0.15 and 1.54 ± 0.27 to be 1.70 ± 0.34 and 1.66 ± 0.31 cfu/g, respectively at the 4th day then to <1 cfu/g at the 6th and 8th day, respectively. While in pectin treated sample its recorded count was 1.94 ±0.12 at zero time then 1.66 ± 0.31 cfu/g at the 6th day and before spoilage of the sample (at the 8th day) .

Plum is rich in phenolic compounds, exhibit significant antioxidant and antimicrobial activities. These bioactive compounds like phenolic acids can disrupt bacterial cell membranes and inhibit bacterial growth [26] also [24] concluded that the addition of plum powder resulted in a decline in the pH of raw and cooked meat emulsions.

Our results agree with different previous studies as [27] recorded that dried plum were effective in controlling aerobic bacteria on ground beef. Plum sauce with different concentrations showed higher antimicrobial effect on *E. coli* in chilled chicken breast [28] and Plum seed ethanol extract (EE) was effective extract against Pseudomonas aeruginosa, and Escherichia coli**,** [29]. Our results are almost similar to [30] who recorded that the antibacterial action of pectin showed no effect on *E. coli* unlike gram positive bacteria where it showed antibacterial effect and they explained that by the high resistance of gram negative bacteria is linked to the complexity of the cell envelop.

Chemical Analysis

Total Volatile Basic Nitrogen (TVBN)

TVBN values are connected to protein degradation due to various microorganisms' activity and their proteolytic enzymes [31]. The findings shown in table 4, revealed that the TVBN values (measured in mg/100gm) within the control group (T_1) ranged from 10.29 ± 0.6 to 25.23 ± 0.2 between day 0 and day 10, while T_2 group (Plum power and pectin), the values ranged from 10.08 ± 0.76 to 20.3± 0.2 between day 0 and day 12. While, in the T_3 group (plum powder) , the values ranged from 10.19 ± 0.36 to 21.16 ± 0.15 between day 0 and day 10, and in T4 group (pectin group) the values ranged from 10.35 ± 0.5 to 22.2± 0.1 between day 0 and day 8, respectively.

On the 8th day of the experiment, the control group (T_1) exhibited spoiled results, while the T_2 and T_3 treated groups showed a slow increase of values and remained below 20mg/100g. This reduction in TVBN in treated samples (T_2, T_3) can be attributed to the antimicrobial and antioxidant properties of plum extract and pectin, which are known to inhibit bacterial growth and slow down protein degradation. The findings are in agreement with [24], who reported lower TVBN levels in pork sausages containing dried plum ingredients (TVBN < 25 mg/100g after 10 days), compared to controls.

Moreover, [32] observed that meat emulsions containing pectin had significantly reduced TVBN values (19.6–21.5 mg/100g on day 10) compared to untreated samples, supporting the trend seen in plum and pectin treatment in our study.

High TVBN levels were seen in T_4 (pectin only). These indicate that pectin alone may not be as effective as the combination with plum extract in delaying spoilage, possibly due to its limited antimicrobial action in its own.

These results demonstrate that the addition of plum and pectin, particularly in combination, can effectively slow down spoilage as indicated by TVBN accumulation, thereby enhancing the shelf life and quality of beef burgers during chilled storage.

Thiobarbituric Acid (TBA)

Thiobarbituric acid (TBA) is a commonly used method for measuring secondary oxidation products the primary product of MDA is believed to be the root cause of oxidative rancidity and may also be responsible for the off-flavor of oxidized fat [7]. Based on the data presented in table (6), it can be observed that the control group (T_1) treated with 0.2% phosphate exhibited TBA values ranging from 0.21± 0.01 to 1.20 ± 0.01 on day zero and day 10, respectively. Conversely, the T_2 group had values ranging from 0.20± 0.01 to 0.93 ± 0.01 on day zero and day 12, while the T_3 group had values ranging from 0.21 ± 0.05 to 0.85 ± 0.015 on day zero and day 10 and the T_4 group had values ranging from 0.21 ± 0.01to 1.74 ± 0.01on day zero and day 10, respectively.

The TBA results quantified as thiobarbituric acid reactive substances (TBARS) in mg malondialdehyde (MDA)/kg clearly illustrate differences in lipid oxidation among the four treatments over the 12-day chilled storage period. The control group (T_1) treated with 0.2% phosphate exhibited high levels of TBARS, reaching approximately 1.4 mg/kg by day 12, which suggests significant oxidative degradation. While phosphates can enhance water retention and protein solubility, they lack strong antioxidant activity [5], which explains the unchecked rise in lipid oxidation in this group.

In contrast, the T_2 group (1.2% plum powder + 0.25% pectin) consistently recorded the lowest TBA values, culminating at 0.93 mg/kg, confirming its superior antioxidant protection. The synergy between plum-derived polyphenols, which are effective radical scavengers, and pectin, which may limit oxygen diffusion in the matrix, likely underpins this protective effect. Similar observations have been made in meat systems where dried plum ingredients significantly reduced TBARS formation [24]. Furthermore, natural fruit-derived antioxidants in meat products have been demonstrated to lower lipid oxidation and be used as effective alternatives to synthetic antioxidants [25].

The T_3 group (plum powder only) showed intermediate TBA values, rising from 0.21 mg/kg at day zero to approximately 1.16 mg/kg by day 12. This indicates that plum powder alone has appreciable antioxidant effects, though less potent than when combined with pectin (as seen in T_2). These results are consistent with previous findings in pork sausages where plum ingredients (3–6%) matched or exceeded the performance of synthetic antioxidants in reducing lipid oxidation [24].

Finally, the T_4 group (pectin only) exhibited the highest TBARS levels after day 6, rising sharply and reaching approximately 2.8 mg/kg by day 12, indicating substantial oxidation. This aligns with findings that while pectin offers functional benefits (e.g., texture, water retention), its antioxidant capability is limited when used solo [33]. Supporting this, hydrocolloid-only treatments such as pectin were ineffective at preventing oxidative degradation without antioxidant companions [33].

The results clearly demonstrate that plum powder, especially when combined with pectin, significantly delays lipid oxidation in beef burgers, outperforming phosphate alone.

Water Holding Capacity (WHC)

The results of the present study demonstrated that the water holding capacity (WHC) of beef burger samples varied significantly among different treatment groups. The control group (T1), which included 0.2% phosphate, showed high WHC values, ranging between 73.43 ± 0.25 and 66.35 ± 0.16 on day zero and day 12, which aligns well with previous findings [5] of that phosphate enhances WHC due to its ability to increase meat pH, ionic strength, and protein solubility.

Interestingly, the second group (T2), which was formulated with 1.2% plum powder and 0.25% pectin, recorded WHC values close to the phosphate group ranged from 73.13 ± 0.32 to 67.43 ± 0.37 on day zero and day 12. This suggests that the combined use of pectin and plum powder could act synergistically to retain water within the meat matrix. Plum powder is rich in polyphenols and natural sugars, which can bind water and form a gel-like structure, while pectin is a known hydrocolloid that enhances water retention through gelation and network formation [32].

The third group (T_3), which included 1.2% plum powder only, showed slightly lower WHC values ranged from 72.46 ± 0.41 to 65.25 ± 0.25 on day zero and day 12. This result is still considered acceptable and indicates that plum powder alone has a positive influence on water retention, though not as effectively as when combined with pectin.

The lowest WHC values were observed in the fourth group (T_4), where only 0.25% pectin was added. Values ranged from 72.16± 0.208 to 62.63 ± 0.39, which is still within acceptable limits for meat products, but lower than the other treatments. This suggests that while pectin alone contributes to water retention, its effect is enhanced when combined with other ingredients like plum powder.

These findings are consistent with the results of [34], who reported that the use of fruit-derived powders (such as prune and plum) in meat formulations improved water retention and texture. Furthermore, [25] reported a similar gradual decline in WHC in beef burgers stored under refrigeration, where the use of natural antioxidants (plum and pectin) helped reduce the loss of WHC compared to untreated controls. Their results confirmed that plum

and pectin combinations can form a protective matrix around muscle fibers, helping to retain water. In the same regards, [35] found that adding plant-based fibers and antioxidants significantly improved WHC and textural properties in meat products, which supports the better performance of T_2 in this study.

Therefore, the results of this study highlight the potential of combining plum powder and pectin as promising natural alternatives to phosphates for enhancing WHC in meat products.

Cooking Loss

Table (8) showed the results of cooking loss % and it can be observed that the control group (T_1) treated with 0.2% phosphate exhibited TBA values ranging from 28.3 ± 0.02 to 35.27 ± 0.25 on day zero and day 12, respectively. Conversely, the T_2 group had values ranging from 28.76 ± 0.15 to 34.23 ± 0.25 on day zero and day 12, while the T_3 group had values ranging from 29.10 ± 0.1 to 36.25 ± 0.25 on day zero and day 12 and the T_4 group had values ranging from 29.36 ± 0.15 to 38.41± 0.36 on day zero and day 12, respectively.

The cooking loss results of beef burger samples during chilled storage revealed a gradual increase in cooking loss percentage with the progression of storage days across all treatment groups. This trend aligns with the findings of [36] and [37], who reported that prolonged storage leads to protein denaturation and reduced water-holding capacity, which in turn results in higher cooking losses.

Among the treatment groups, beef burgers containing plum and pectin (T_2) consistently showed lower cooking loss compared to the control with phosphate (T_1) and the other groups throughout the storage period. This suggests that the combination of plum polyphenols and pectin may enhance the gel-forming ability and water-binding properties of the meat matrix, thereby reducing moisture loss during cooking. Similar observations were reported by [38], where incorporation of dietary fibers and natural antioxidants improved the cooking yield of meat products.

In contrast, the T_4 group (burger with pectin alone) exhibited the highest cooking loss at all storage intervals. This result may be attributed to the fact that pectin alone, without the synergistic effect of plum polyphenols or phosphates, may not sufficiently stabilize the muscle protein matrix during cooking. This aligns with [39] who observed that while pectin can improve initial water retention, its thermal stability alone is not enough to prevent cooking-induced water expulsion.

Furthermore, the phosphate-containing control group (T_1) exhibited moderate cooking loss, reflecting the well-established technological role of phosphates in enhancing water retention and improving cooking yield by modulating pH, ionic strength, and protein functionality in processed meats [40]. However, the slightly better performance of T_2 over T_1 indicates that the natural antioxidants in plum, combined with pectin, may offer an effective alternative to synthetic phosphates, aligning with the growing consumer demand for clean-label meat products [41].

[42] found that Addition of 5% plum puree in low-fat beef patties resulted in the highest cooking yield (50% moisture retention) and significantly reduced cooking loss, reflecting improved WHC over control.

Overall, the progressive increase in cooking loss over time can be explained by protein degradation, lipid oxidation, and structural changes in the meat matrix during storage, as supported by [43]. The superior performance of combined plum and pectin treatment highlights its potential in maintaining the quality of beef burgers during chilled storage.

Conclusion

Plum powder and pectin can serve as natural, functional ingredients in meat product formulations, offering a clean-label alternative to chemical phosphates. Their use can help improve the technological properties of meat products while meeting consumer demand for healthier and more natural food choices. Future research should performed for further explore optimizing their concentrations and evaluating their effects on shelf life and nutritional value in various meat matrices.

Acknowledgments

Not applicable.

Funding statement

This study didn't receive any funding support

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study did not involve human participants or live animals. Beef meat used for burger preparation was obtained from authorized sources. The experimental procedures were conducted in the laboratories of [AHRI] in accordance with institutional guidelines for research on food of animal origin.

TABLE 1. Statistical analysis (mean log10cfu/g±SD) of Sensory evaluation of examined samples

	Burger treatment groups	Storage time (days)						
		Zero	2nd day	4th day	6th day	8th day	10th day	12th day
Taste score	T_1	8.5 ± 0.1	8.5± 0.1	8.0 ± 0.5	7.5^{A} ± 0.0	S	S	S
	T_2	8.5± 0.1	8.5 ± 0.05	8.3^{B} ± 0.15	8.0^{aB} ± 0.0	7.5^{B} ± 0.0	7^{b} ± 0.0	S
	T_3	8.4 ± 0.1	8.4 ± 0.1	7.9 ± 0.15	7.5^{b}± 0.5	7^{b} ± 0.0	S	S
	T_4	8.4 ± 0.15	8.4 ± 0.1	7.7^{b}± 0.0	7.0^{b}± 0.5	S	S	S
Odour scores	T_1	8.7 ± 0.1	8.5^{A}± 0.1	7.9^{A} ± 0.1	6.5^{A}± 0.0	S	S	S
	T_2	8.8^{B} ± 0.1	8.5^{B}± 0.1	8.5^{aB} ± 0.1	8.1^{aB}± 0.28	7.5± 0.0	6.0± 0.0	S
	T_3	8.6± 0.05	8.5^{C}± 0.5	8.1^{abC} ± 0.0	7.5^{abC}± 0.1	6± 0.0	S	S
	T_4	8.6^{b} ± 0.1	8.0^{abc}± 0.0	7.7^{bc} ± 0.0	6.1^{abc} ± 0.1	S	S	S
Color scores	T_1	8.5^{A} ± 0.1	8.5^{A} ± 0.1	8.1^{A} ± 0.1	6.5^{A} ± 0.1	S	S	S
	T_2	8.5^{B} ± 0.1	8.5^{B} ± 0.1	8.5^{aB} ± 0.5	8.1^{aB} ± 0.	7.5^{B} ± 0.0	7± 0.0	S
	T_3	8.5^{C} ± 0.0	8^{C} ± 0.5	8.3^{abC} ± 0.5	8^{aC} ± 0.0	6^{b} ± 0.0	S	S
	T_4	8.0^{abc}± 0.1	7^{abc} ± 0.1	7.8^{bc} ± 0.0	6.5^{bc} ± 0.5	S	S	S
Overall scores	T_1	8.5± 0.1	8.5 ± 0.1	7.6^{A} ± 0.1	6.5^{A} ± 0.1	S	S	S
	T_2	8.5 ± 1	8.5 ± 0.1	8.1^{aB} ± 0.1	7.5^{aB} ± 0.1	7^{B} ± 0.0	7± 0.0	S
	T_3	8.5 ± 0.0	8.5 ± 0.1	8.0^{aC} ± 0.05	7.5^{aC} ± 0.1	6.0^{b} ± 0.0	S	S
	T_4	8.4 ± 0.1	8.4± 0.1	7.5^{bc}± 0.5	6.0^{bc}± 0.0	S	S	S

There is sig. diff. (P<0.05) between means having the same capital and small letters (A, a) in the same column for each score.
T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin S: Spoiled samples
*: results revealed the means of triplicates of each group.

TABLE 2. Total APC count log (mean ± SD) of the burger treated groups during chilling storage period.

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	4.45^{A} ± 0.02	4.21^{aB} ± 0.04	4.35^{C} ± 0.048	4.57^{bc} ± 0.17
2nd day	4.67^{A} ± 0.06	4.41^{aB} ± 0.06	4.46^{aC} ± 0.17	5.13^{abc} ± 0.18
4th day	5.47^{A} ± 0.62	4.64^{aB} ± 0.1	4.73^{aC} ± 0.07	5.67^{bc} ± 0.1
6th day	5.63^{A} ± 0.11	4.87^{a} ± 0.1	4.92^{aB} ± 0.25	5.97^{bc} ± 0.04
8th day	S	5.08^{B} ± 0.08	5.37^{b} ± 0.07	S
10th day	S	5.25 ± 0.16	S	S
12th day	S	5.61 ± 0.15	S	S

T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin S: Spoiled samples
There is sig. diff. (P<0.05) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group.

TABLE 3. Coliform log count (mean ± SD) of the burger treated groups during chilling storage period.

Storage periods days	Treated groups & centered*			
	T_1	T2	T3	T_4
Zero day	2.05 ± 0.11	1.88 ± 0.27	1.98 ± 0.05	2.10 ± 0.19
2nd day	2.06^{A} ± 0.19	1.97^{B} ± 0.15	2.35^{abC} ± 0.1	2.15^{c} ± 0.1
4th day	1.99^{A} ± 0.08	1.66^{B} ± 0.05	1.79^{C} ± 0.1	2.11^{bc} ± 0.1
6th day	$< 1^{A}$	$<1^{B}$	1.23^{abC} ± 0.33	1.81^{abc} ± 0.47
8th day	S	<1	<1	S
10th day	S	<1	S	S
12th	S	S	S	

T_1: Control positive with phosphate **T_2:** burger with plum and pectin **T_3:** burger with plum **T_4:** burger with pectin **S:** Spoiled samples
There is sig. diff. (P<0.05) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group**.**

TABLE 4. Escerichia coli log count (mean ± SD) of the burger treated groups during chilling storage period.

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	1.76 ± 0.15	1.49^{B} ± 0.2	1.54^{C} ± 0.2	1.94^{bc} ± 0.15
2nd day	1.89 ± 0.17	1.80± 0.18	1.81 ± 0.1	2.03± 0.229
4th day	1.7 ± 0.34	1.31 ± 0.27	1.66 ± 0.31	1.77 ± 0.26
6th day	$< 1^{A}$	$< 1^{B}$	1.15^{abC} ± 0.2	1.84^{abc} ± 0.47
8th day	S	< 1	< 1	S
10th day	S	< 1	S	S
12th day	S	S	S	S

T_1: Control positive with phosphate **T_2:** burger with plum and pectin **T_3:** burger with plum **T_4:** burger with pectin **S:** Spoiled samples
There is sig. diff. (P<0.05) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group**.**

TABLE 5. Total volatile basic nitrogen (mean ± SD) of the burger treated groups during chilling storage period (mg/100g)

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	10.29^{A} ± 0.6	10.08^{aB} ± 0.76	10.19^{C} ± 0.36	10.35^{bc} ± 0.5
2nd day	12.35^{A} ± 0.05	11.20^{aB} ± 0.2	11.48^{abC} ± 0.2	12.66^{abc} ± 0.15
4th day	15.3^{A} ± 0.1	13.13^{aB} ± 0.15	13.8^{abC} ± 0.1	16.2^{abc} ± 0.1
6th day	17.2^{A} ± 0.1	14.6^{aB} ± 0.1	15.7^{abC} ± 0.1	18.6^{abc} ± 0.1
8th day	20.8^{A} ± 0.1	16.2^{aB} ± 0.1	17.4^{abC} ± 0.1	22.2^{abc} (s)± 0.1
10th day	25.23^{A}(s)±0.2	18.3^{aB} ± 0.1	21.16^{abC} ± 0.15	29.20^{abc} (s)± 0.1
12th day	28.2^{A} (s)± 0.2	20.3^{aB} ± 0.2	26.23^{abC} (s)± 0.2	35.23^{abc}(s)± 0.15

T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin
S: Spoiled samples SD: Standard Deviation
There is sig. diff. (P<0.05) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group.

TABLE 6. Thiobarbituric acid (mean ± SD) of the burger treated groups during chilling storage period (mg mal. /kg)

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	0.21± 0.01	0.20± 0.01	0.21 ± 0.05	0.21 ± 0.01
2nd day	0.32^{A} ± 0.01	0.21^{aB} ± 0.01	0.27^{abC} ± 0.01	0.35^{abc} ± 0.01
4th day	0.51^{A} ± 0.015	0.27^{aB} ± 0.01	0.38^{abC} ± 0.01	0.55^{abc} ± 0.01
6th day	0.67^{A} ± 0.01	0.35^{aB} ± 0.01	0.51^{abC} ± 0.01	0.72^{abc} ± 0.01
8th day	0.92^{A} ± 0.01	0.46^{aB} ± 0.01	0.67^{abC} ± 0.01	0.95^{abc} ± 0.01
10th day	1.20^{A} ± 0.01	0.65^{aB} ± 0.01	0.85^{abC} ± 0.015	1.74^{abc} ± 0.01
12th day	1.4^{A} ± 0.01	0.93^{aB} ± 0.01	1.16^{abC} ± 0.07	2.80^{abc} ± 0.1

T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin
S: Spoiled samples SD: Standard Deviation
There is sig. diff. (P<0.05) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group.

TABLE 7. Water holding capacity (mean ± SD) of the burger treated groups during chilling storage period

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	$73.43^{A} \pm 0.25$	$73.13^{B} \pm 0.32$	$72.46^{ab} \pm 0.41$	$72.16^{ab} \pm 0.208$
2nd day	$72.34^{A} \pm 0.31$	$72.7^{aB} \pm 0.2$	$71.13^{abC} \pm 0.15$	$68.71^{abc} \pm 0.22$
4th day	$70.7^{A} \pm 0.1$	$71.17^{aB} \pm 0.15$	$69.22^{abC} \pm 0.2$	$66.40^{abc} \pm 0.36$
6th day	$69.6^{A} \pm 0.2$	$70.3^{aB} \pm 0.28$	$67.48^{abC} \pm 0.27$	$66.30^{abc} \pm 0.3$
8th day	$68.51^{A} \pm 0.15$	$69.4^{aB} \pm 0.35$	$67.2^{abC} \pm 0.25$	$65.31^{abc} \pm 0.30$
10th day	$67.2^{A} \pm 0.26$	$68.3^{aB} \pm 0.3$	$66.28^{abC} \pm 0.27$	$64.31^{abc} \pm 0.28$
12th day	$66.35^{A} \pm 0.16$	$67.43^{aB} \pm 0.37$	$65.25^{abC} \pm 0.25$	$62.63^{abc} \pm 0.39$

T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin S: Spoiled samples
There is sig. diff. ($P<0.05$) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group.

TABLE 8. Cooking loss (mean ± SD) of the beef burger treated groups during chilling storage period:

Storage periods days	Treated groups & centered*			
	T_1	T_2	T_3	T_4
Zero day	$28.3^{A} \pm 0.02$	$28.76^{aB} \pm 0.15$	$29.10^{ab} \pm 0.1$	$29.36^{ab} \pm 0.15$
2nd day	$29.25^{A} \pm 0.12$	$28.68^{aB} \pm 0.125$	$30.54^{abC} \pm 0.25$	$16.3^{abc} \pm 0.20$
4th day	$31.3^{A} \pm 0.3$	$30.53^{aB} \pm 0.1$	$32.14^{abC} \pm 0.15$	$34.32^{abc} \pm 0.20$
6th day	$32.31^{A} \pm 0.2$	$31.48^{aB} \pm 0.12$	$33.46^{abC} \pm 0.37$	$35.20^{abc} \pm 0.26$
8th day	$33.36^{A} \pm 0.12$	$32.13^{aB} \pm 0.15$	$34.31^{abC} \pm 0.3$	$36.21^{abc} \pm 0.22$
10th day	$34.45^{A} \pm 0.31$	$33.43^{aB} \pm 0.37$	$35.23^{abC} \pm 0.25$	$37.38^{abc} \pm 0.35$
12th day	$35.27^{A} \pm 0.25$	$34.23^{aB} \pm 0.25$	$36.25^{abC} \pm 0.25$	$38.41^{abc} \pm 0.36$

T_1: Control positive with phosphate T_2: burger with plum and pectin T_3: burger with plum T_4: burger with pectin
S: Spoiled samples SD: Standard Deviation
There is sig. diff. ($P<0.05$) between means having the same capital and small letters (A. a) in the same raw.
*: results revealed the means of triplicates of each group.

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استبدال الفوسفات كمادة حافظة بمنتجات طبيعية في البرجر

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الملخص

تهدف هذه الدراسة إلى تقييم تأثير بدائل الفوسفات الطبيعية (البكتين ومسحوق البرقوق) على جودة وفترة صلاحية برجر اللحم البقري أثناء التخزين المبرد لمدة 14 يومًا. تم إعداد أربع معاملات: معاملة ضابطة تحتوي على 0.2% فوسفات، ومعاملة تحتوي على 1.2% مسحوق برقوق و0.25% بكتين، ومعاملة تحتوي على 1.2% مسحوق برقوق فقط، وأخرى تحتوي على 0.25% بكتين فقط. خضعت العينات للتحليل كل يومين لقياس الأس الهيدروجيني (pH)، وقيمة الثيوباربيتيوريك (TBA)، والنيتروجين القاعدي الكلي المتطاير (TVBN)، وقدرة الاحتفاظ بالماء (WHC)، ومعدل فقدان الطهي، إضافةً إلى التقييم البكتريولوجي. أظهرت النتائج أن معاملة البكتين مع مسحوق البرقوق سجلت انخفاضًا ملحوظًا في قيم TBA وTVBN، مع تحسن واضح في WHC وانخفاض فقدان الطهي، فضلًا عن كفاءة أعلى في الحد من النمو الميكروبي مقارنةً بالمعاملة الضابطة. وتؤكد هذه النتائج أن دمج البكتين مع مسحوق البرقوق يُعد بديلًا طبيعيًا واعدًا للفوسفات الصناعي، حيث يسهم في تحسين الخصائص الوظيفية وسلامة منتجات اللحوم، مع توافقه مع توجهات المستهلك نحو المنتجات التي تحتوي علي اضافات طبيعية.

الكلمات الدالة: استبدال الفوسفات، مسحوق البرقوق، البكتين، برجر اللحم البقري.