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Controlling of heavy metals residues in raw meat

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Abstract

Date palm trees, *Phoenix dactylifera* L., are traditionally cultivated in Egypt and have recently spread globally which incorporate their co-products in food formulations for their health properties. The marinades of meat with plant origin co-products is an effective strategy established by consumers and the meat industry for improving the meat quality and extending their shelf-life. Therefore, this study evaluates the efficacy of Dates Seeds Powder (DSP) as a natural adsorbent for mitigating lead and cadmium contamination in meat marinades. The meat samples were divided into three groups for different treatment. First group (G1) without marinades with date seeds powder and kept as control. Second group (G2) of beef marinated with 5g of date seed powder (5%), meanwhile the third groups (G3) of beef marinated with 10g of date seed powder (10%). The results demonstrate a clear inverse relationship between DSP concentration and levels of lead and cadmium. The untreated control group (G1) had the highest mean lead and cadmium concentration. The group marinades with 10% DSP (G3) showed the most significant decrease, with a mean lead and cadmium concentration of 0.010 and 0.102 ppm respectively. Meat marinades with 5% DSP (G2) resulted in a 44% and 35% reduction in lead and cadmium concentration respectively. While, meat marinades with 10% DSP (G3) led to a more significant 71% and 53% reduction respectively. In conclusion, the significant reduction in Pb and Cd concentration, particularly at the 10% DSP level, highlights its potential as a natural food additive for heavy metal decontamination. The risk of non-cancer health effects from lead and cadmium through meat consumption in the studied population is low. the cumulative risk from both metals in meat is considered low to the study population.

Keywords: Date Seeds; *Phoenix dactylifera*; Lead; Cadmium; Meat

1. Introduction

Meat is an excellent source of human nutrients mainly proteins, because of their high biological value, which supporting various body functions [1-2]. Based on their biological values, it is necessary to pay attention to their safety from all hazards especially chemical residues. Meat safety issues have been challenges the investigators all over the world to seek the safe way for controlling and preventing the chemical hazards of meat.

Globally, date palm, *Phoenix dactylifera* L. is considered the oldest tree. It has been cultivated in North Africa and the Middle East for millennia. Dates were of great importance in ancient Egypt and extended to the Greek and Roman eras.

Generally, fruits and their by-products have several bioactive compounds promoting human health including carotenoids, sterols, and phenolics [3-4]. Palm have many variations in date fruits that display variances in the size, shape, and colour which arise due to differences in growing conditions and soil nature [5]. Dates, *Phoenix dactylifera* L., as fruits offer many nutrients for human, recently their seeds involve in enhancing food safety and quality [6]. Date

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seeds used for human consumption, to produce safe foods that could promote optimal exploitation of date wastes in date producing regions like Egypt [7].

Date seeds are frequently thrown away or used as livestock feeds [8-9], resulting in environmental issues and economic losses stemming from poor disposal systems [10-11]. In 2025, Egypt is projected to be the world's largest date producer by annually 1,733,433 tonnes [12], therefore, over 260,000 tons of date seed could be annually produced. North Sinai governorate, especially at El-Arish city, is one of the most important date cultivated areas in Egypt, which share to about 21.7% of the total palms production [13]. Currently, in North Sinai all date seeds are exploited for animal feed in the sheep and goat farms.

Numerous researches have shown that the date seed is ridiculous in chemicals and nutrients [14]. Date seeds have been shown to be a carbon-rich compounds including lignin, cellulose, and hemicelluloses [15]. Date seeds are known as waste products of date fruits [16]. Despite that, the date seeds are a good source of natural antioxidants [17-18]. The recommended amount of date seeds powder for improving meat quality is ranged between 15g and 20g per kilograms. This recommendation complies with the property of date seed which consists of a bioactive substance that has a significant outcome on meat texture, pH, colour, cooking loss, meat tenderness and water holding capacity [19].

Date seeds considered a good source of total phenolics and natural antioxidants which could be used as a functional food ingredient [20]. Former investigations recorded that date seeds used as a coffee substitute [21], antioxidant of fried oils [22], plants fertilizer [23], in some traditional medicines for treatment of sore throats, bronchial asthma, colds, fever, oedema, cystitis, tumor [24-25], as meat preservatives [26] and to tenderize the meat [27]. Dates are rich in flavonoid compounds such as quercetin, kaempferol, luteolin and proanthocyanidins [28-29]. Dates seeds have total phenolic compounds extending from 3102 to 4430 mg gallic acid equivalents per 100g fresh weight [30]. Recent study conducted on Siwi date seeds recoded the total phenolic compounds in seeds were 172.98, 100.90, 89.35 and 63.21µg/g, for catechin, chlorogenic, syringic and gallic acid respectively [31]. Flavonoid in dates have many important benefit for protective effects on human health, there are strong antioxidants and act as scavengers of free radicals, metal chelators, antimutagens, and signalling agents [32-33-34]. In addition, the use of date seeds could provide several human's health benefits, such as antigenotoxic activity; anti-inflammatory activity; protection against diabetes, liver diseases, and gastrointestinal disorders [35-36-37-38].

Several studies confirmed that date seed can be converted into activated carbon, exhibiting good adsorbent properties for removal of toxic chemical substances as heavy metals from wastewater [39-40], and chelation of toxic chemical pollutants from drinking water [41]. Therefore, the use of DSP for marinades meat as sorbents for lead and cadmium removal has been a focus for the present study. Hence the present work intends to investigate removals of lead and cadmium toxic metals from meat obtained from El-Arish markets, North Sinai, Egypt by using DSP as marinades.

2. Material and methods

2.1. Sample preparation

A total of 2 Kg of dates, *Phoenix dactylifera* L, Hayani, were purchased from the El-Arish markets. Date seeds were hand-picked from the fruits and eliminate the damaged ones. Seeds were prepared according to method described by **[19],** the selected seeds were washed by deionized water and oven-dried at 60°C for 72 hrs. The dried seeds were turned it into powder in a heavy-duty grinder to pass 1–2 mm screens and then preserved in an airtight container at -20°C until used. The 3 kg of beef (neck cuts) was obtained from the local butcher in El-Arish markets.

2.2. Experimental design

The beef was cut into 2×2 cm pieces with a weight of 100 g for each beef sample. The meat pieces were then divided into three groups for different treatment group. First group (G1) without treatment with date seeds powder and kept as control. Second group (G2) of beef marinated with 5g of date seed powder (5%), meanwhile the third groups (G3) of beef marinated with 10g of date seed powder (10%). Each beef was kept inside the plastic bag to ensure each meat was fully covered. The marinated meats were then covered with polyethylene film and stored at 3 ±1°C for 2 hrs. Then, all the marinated meats were cooked using a microwave oven set at a power 124 of 70 W and a frequency of 2450 MHz for 50 mins [19].

2.3. Heavy metals residues evaluation

The technique of determination of heavy metal residues for lead and cadmium was applied according to [43]. Prepared samples and standard solution as well as blanks were directly aspirated into the flam for analysis of lead and cadmium.

Analysis of lead and cadmium were conducted by air/ acetylene flow (5.5/1.11 /m) flame Atomic Absorption Spectrophotometer.

2.4. Statistical analyses

All experiments were conducted in duplicate, and the results are expressed as means ± standard error. A probability value of $P<0.05$ was considered to indicate a statistically significant outcome. Analysis of variance (ANOVA) was carried out, and mean comparisons were assessed using Tukey's test with the Statistical Package for Social Science software [44].

3. Results and Discussion

The study was conducted in El-Arish, North Sinai, Egypt, where a high distribution of dates Palm, *Phoenix dactylifera* L. The presence of heavy metal residues in meat is a major international distress, posing significant risks to public health. Therefore, meat investigators have been challenged to explore safe, cost-effective, and natural solutions to mitigate these contaminants.

3.1. Lead (Pb) in cattle meat

Lead contamination in meat is a serious public health concern. The statistical results of Pb concentrations in meat marinades with different concentrations of DSP are displayed in Table 1. The control group had a mean lead concentration of 0.034 ±0.007 ppm. Meat marinades with 5% DSP (G2) reduced the mean lead concentration to 0.019 ±0.003 ppm, while marinades with 10% DSP (G3) additional lowered it to 0.010 ±0.002 ppm. Generally, the presence of heavy metal in the environments is of major concern due to their toxicity, bio-accumulation, and threat to human life [45-46]. The use of DSP is the best choice for meat marinades in order to heavy metal removal spirally their mineral composition are free from the majority of heavy metals like arsenic, cadmium, chromium, lead, and mercury [47]. Former studies recorded that DS has high adsorption capacity for Pb [48].

The findings are consistent with other studies that have explored the use of various plant-based materials for heavy metal sequestration. Date seed can be used as a functional food ingredient and potentially be an inexpensive source of fibre and antioxidants [49]. Date seeds have been used in meat industry for enhancing the nutritional value, reducing calories, extending shelf-life, improving the texture, improved the cooking properties, antioxidant activity and improve tenderness [50-51-52-26-19].

The application DSP to meat texture as marinades is more complex than in an aqueous solution, meanwhile the principal metal adsorption remains the same. A marinade containing DS would allow these active compounds to interact with the surface of the meat, potentially sequestering heavy metals. The action reflects the current results which show a statistically significant reduction ($P<0.05$) in lead concentration in the marinades meat samples compared to the control group. Meat marinades with 10% DSP (G3) recorded a significant reduction ($P<0.05$) than other meat groups. The results showed a very high removal capacity of heavy metals except for manganese. This revealed that PADS are very good adsorbent for metals ion removals from aqueous solution. Ajwaa dates seeds powder is capable of removing trace levels of toxic metal ions [53].

3.2. Cadmium (Cd) in cattle meat

Cadmium, a toxic heavy metal, poses significant health risks. The statistical results of Cd concentrations in meat marinades with different concentrations of DSP are displayed in Table 2. The results show a statistically significant reduction ($P<0.05$) in cadmium concentration in the meat marinades samples compared to the control group. The control group (G1) had the highest mean cadmium concentration at 0.214 ±0.025ppm. Meat marinades with 5% DSP (G2) reduced the mean cadmium concentration to 0.142 ±0.016ppm, while marinades with 10% DSP (G3) further lowered it to 0.102 ±0.011ppm. This result indicated that DSP are very goods adsorbent for cadmium removals from meat for their bond strengths [54]. This indicates date seeds powder have high bond strength to heavy metals [55].

The obtained results show a statistically significant reduction ($P<0.05$) in cadmium concentration in the marinades meat samples compared to the control group. Meat marinades with 10% DSP (G3) recorded a significant reduction ($P<0.05$) in cadmium concentration than other meat groups. The ability of a DSP to remove metals residues from a meat in vitro is known as adsorption. This process relies on the presence of specific functional groups on the DSP surface that can bind to the target metals. Date seeds are known to be rich in various functional groups, including Carboxyl groups (-COOH), Hydroxyl groups (-OH) and Phenolic which can serve as adsorption sites for heavy metal ions [56].

3.3. Reduction % of heavy metals in marinades meat

Date seed, a major byproduct of the date processing production, are emerging as a promising natural alternative food additive. It Rich in bioactive compounds offers a multifaceted solution for controlling chemical residues, enhancing product quality, and improving sustainability in meat production [51]. Lead contamination in food is a serious public health concern due to its neurotoxic and nephrotoxic effects. The results in Table 3, show a statistically significant reduction in lead concentration in the marinades meat samples compared to the control group. The control group (G1) had a total lead residue of 0.686 ppm. Meat marinades with 5% DSP (G2) resulted in a 44% reduction, with total lead residues of 0.384 ppm. The most significant reduction ($P<0.05$) was observed in the 10% DSP group (G3), which achieved a 71% reduction and had total lead residues of 0.199 ppm. Cadmium contamination in food is a serious public health concern due to its potential to cause severe health issues, including kidney and bone damage. The results in the Table 4, show a statistically significant reduction in cadmium concentration in the marinades meat samples compared to the control group. The control group (G1) had a total cadmium residue of 4.356 ppm. Meat marinades with 5% DSP (G2) resulted in a 35% reduction, with total cadmium residues of 2.8314 ppm. The most significant reduction ($P<0.05$) was observed in the 10% DSP group (G3), which achieved a 53% reduction and had total cadmium residues of 2.04732 ppm.

Marinades meat with date seeds powder is safe, efficient, simple, low cost and green alternative to overcome the problems of heavy metals residues [55]. The DS is highly rich of bioactive compounds, such as vitamins, minerals, essential amino acids, organic acids, phenolic compounds, sugars, dietary fiber, and antioxidants [56]. The current results suggests that a component within the DSP is actively binding to the lead and cadmium ions by adsorption mechanism through their including functional groups, the biopolymers in the DSP matrix provide binding sites for the cadmium ions. DS showed very high values of radical scavenging capacity and chelating activity [57].

Meat marinades, traditionally used for flavor, tenderness, and in certain case as preservatives to address some contaminants. Other investigations have highlighted the use of plant-based marinades to inhibit lipid oxidation and prolong the shelf-life. The specific application of DSP as meat marinades for removing heavy metals is an emerging field due to its unique chemical composition. The findings of the current study are consistent with research on other natural adsorbents, highlighting the potential of agricultural byproducts for meat safety. The use of DSP is a natural and sustainable alternative to chemical methods for removing lead and cadmium from meat to the safe permissible levels.

4. Conclusion

In conclusion, the use of DSP as meat marinades represents a novel, safe and simple opportunity for reducing the Pb and Cd residues, ensuring meat safety and protect consumers' health. This research supports the potential for DSP to be utilized as a natural food additive for heavy metal decontamination. The study successfully demonstrates that DSP is an effective and dose-dependent agent for reducing Pb and Cd contamination in marinades meat. The significant reduction in Pb and Cd concentration, particularly at the 10% DSP level, highlights its potential as a natural food additive for heavy metal decontamination. These findings are considered the first record on heavy metal contamination in the study region. However, further research is warranted to identify the specific active compounds and to fully elucidate the mechanism of action. Continuous monitoring of meat contamination is essential due to the chronic and cumulative nature of heavy metal toxicity.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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