Hindawi
Journal of Food Quality
Volume 2019, Article ID 3930908, 6 pages
https://doi.org/10.1155/2019/3930908

Research Article

Quality Characteristics of Beef Patties Fortified with Husk Tomato and the Effect on Tannic Acid-Induced Anaemia in Rats

Amal N. Al-Kuraieef, Amal H. Alshawi, and Amnah M. A. Alsuhaibani

Nutrition and Food Sciences Dept., Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia

Correspondence should be addressed to Amnah M. A. Alsuhaibani; amalsuhaibani@pnu.edu.sa

Received 2 December 2018; Accepted 17 March 2019; Published 28 March 2019

Academic Editor: Márcio Carocho

The study evaluated the properties of beef burgers prepared with different concentrations of husk tomato (HT) powder at levels of 2.5%, 5%, and 10% as a natural source of bioactive compounds and also assessed the effectiveness of the powder in the treatment of anaemia. Rats were classified into the negative control group and anaemic rats that were positive control (untreated) and three treated groups which were fed basal diet had 10% of control beef patties, 2.5% husk tomato beef patties, and 5% HTB groups (CBP, 2.5 HTB, and 5% HTB groups). The obtained results revealed that HT powder is rich in carbohydrates, protein, and fat. The addition of 5% husk tomatoes to burgers decreased the contents of fat and ash and increased fiber and carbohydrates. The addition of 2.5 or 5% husk tomatoes to beef patties gave high scores sensory evaluation. The addition of HT to beef patties reduced lipid oxidation compared to CBP at zero time and after a week of storage. It is concluded that the addition of husk tomatoes increases the quality of the beef burger and has high efficiency in retarding lipid oxidation in the burger. 5% HTB is a functional meat product and could improve the nutritional values and treat iron deficiency anaemia in rats.

1. Introduction

A great deal of interest has been focused on the beef industry. Ground beef consumption is expected to increase in the near future. Many efforts have been made to improve the stability and quality of burgers [1]. Beef burgers have high biological value and are rich in nutritional compounds, such as proteins and bioactive compounds including iron, zinc, conjugated linoleic acid, and vitamins [2]. The nutritional profile of meat products could be further improved by the addition of health-promoting nutrients and nonnutrients, thus transforming them into functional foods with increased levels of bioactive compounds, greater biological efficacy in humans, and enhanced stability while preserving other quality parameters such as colour, flavour, and texture [3].

Meat products are good sources of proteins, minerals, trace elements, and bioactive compounds of high biological value, but it is highly deficient in dietary fiber, so addition of cheap and agricultural dietary fiber sources could reduce the overall cost of meat products and enhance their desirability [4].

Husk tomatoes are recognized for its nutritional profile and health benefits. *Physalis peruviana L.* is also known as the golden berry, tomatillo, and ground cherry that is eaten either raw or dehydrated in sauces and jams and also is used as dish decorations. The husk tomato (HT) fruit is consumed for its nutritional value attributed to vitamins C and A, minerals (particularly P and Fe), and fibers [5]. Husk tomatoes have been used as a folk medicine for treating malaria, asthma, hepatitis, dermatitis, and rheumatism, as well as diuretics, enhancing the secretion of bile acids and activating the liver function [6, 7]. Husk tomato extract exhibits antihepatoma, hypoglycaemic, anti-inflammatory activities, and antihypertensive properties [8, 9]. Its potential anticarcinogenic properties are due to high β-carotene content and antioxidant levels [10].

Iron deficiency anaemia is one of the most prevalent nutritional deficiencies all over the world and is characterized by weakness, learning dysfunction, and an increased risk for infectious diseases. It causes several health problems such as bone loss and hyperlipidaemia because iron is important for haemoglobin, myoglobin, and the formation of some enzymes [11]. Other than the nutritional properties of husk tomatoes, fiber is recently used as functional ingredients as the volume enhancer, fat replacer, binder, and stabilizer that enhance the texture in meat products, improve in cooking yields and rheological properties, and reduce formulation costs [12].

Addition of husk tomatoes has not been tested in meat. Therefore, the main objective of the present study was to evaluate the properties of the beef burger prepared with different concentrations (2.5, 5, and 10%) of husk tomato powder as a natural source of bioactive compounds such as antioxidants and to assess the effectiveness of the powder in the treatment of anemia.

2. Materials and Methods

2.1. Preparation of Husk Tomato Powder. Husk tomatoes were washed in water, sliced, dried in an electric oven at 50°C for 12 hours and then ground in a blender until pulverized. The gross chemical composition (moisture, protein, fat, carbohydrates, and ash) of husk tomato powder was analysed according to AOAC [13].

2.2. Preparation of Beef Patties. Beef meat, fat, fresh mushrooms, onions, spice mixture, and defatted soy flour were obtained from the local market. Control beef patties (CBPs) were prepared from 40% minced beef meat, 8% defatted soy flour, 3% onion, 2.3% garlic, 20% fat, 1.4% salt, 1.8% spices mixture, and 23.5% crushed ice. The husk tomato powders were added in concentrations of 2.5, 5, and 10% in place of fat, thoroughly mixed and shaped using a commercial burger maker to obtain patties of approximately 70 g and 1 cm thickness to prepare husk tomato beef patties (2.5, 5, and 10% HTB). Plastic packaging film was used to help maintain the shape of the patties prior to freezing at −30°C in a commercial plate freezer, and patties were stored at −18°C for one week. The method used for preparing beef burger was carried out according to Aleson-Carbonell et al. [14].

2.3. Sensory Evaluation. The experimental beef patties were cooked using an electric grill at 300°C for 10 min on both sides and then cooled at room temperature, cut into quarters, and served to panelists under fluorescence light. Ten members of the Department's staff were selected based on their experience in sensory evaluation and availability. The panelists were instructed to evaluate appearance, juiciness, flavour, colour, texture, and overall acceptability using a 10-point scale for grading the quality of samples, as follows: (10) excellent, (9) very good, (8) good, (7) medium, (6) fair, (5) poor, (4) very poor, and (3) extremely poor according to Rohall et al. [15].

2.4. Chemical Analyses of the Experimental Beef Patties. The nutritional values of the burgers were determined according to AOAC [13]. Acid value, peroxide value, and thiobarbituric acid were estimated in burgers before cooking and after storage in the refrigerator for one week according to AOCS [16].

2.5. Biological Study. Thirty-five white albino rats weighting 160 ± 7 g were provided by the experimental animals' center in the Research Center in Prince Sultan Military Medical City, Riyadh. Food and water were provided *ad libitum*. Ethical guidelines for investigations involving experimental animals were followed throughout the study. The experiments were carried out with the help of the staff of the Scientific Research Center of the MSD at their experimental animal facility. Rats were placed in separate cages and kept under suitable airflow with a 12 h light-dark cycle at 22 ± 2°C during the whole period of experimentation. Animals received a basal diet according to Reeves et al. [17] and water *ad libitum*. After 2 weeks of acclimatization, blood samples were taken. Seven rats fed on a basal diet act as the negative control. Next, to induce anaemia, the rest of rats was fed a basal diet containing 20 gm/kg tannic acid for three weeks that has been confirmed to lower blood haemoglobin [18]. The anaemic rats were then classified as follows:

(i) Positive control (untreated) group that were fed basal diet

(ii) Control beef patties (CBP) that were fed basal diet containing 10% control beef patties

(iii) 2.5% husk tomato beef patties that were fed basal diet containing 10% of 2.5 HTB beef patties.

(iv) 5% HTB groups that were fed basal diet containing 10% of 5 HTB beef patties

The choice of the dose was related to previous studies [19]. The composition of the experimental diets was illustrated in Table 1. The daily food intake (FI) and weekly body weight were used to calculate the body weight gain (BWG) and food efficiency ratio (FER) of the rats.

After 30 days, rats were sacrificed to obtain blood for estimation of blood haemoglobin (HB), haematocrit (HCT), iron, ferritin, and total iron binding capacity (TIBC) according to Bauer [20], Carr and Acott [21], Carter [22], Punnonen et al. [23], and Morgan and Carter [24], respectively.

2.6. Statistical Analysis. All measurements were analysed using the SPSS package for Windows. Mean values among concentrations/animal groups were compared using one-way analysis of variance (ANOVA) and least significant differences (LSD). Means were considered to be significantly different at $P \leq 0.05$.

3. Results

Chemical composition of husk tomato powder is found in Table 2. The husk tomatoes were rich in carbohydrate

Table 1: Composition of the experimental diets.

	Casein	Corn starch	Corn oil	Cellulose	Salt	Vitamins	Choline	Burger
Basal diet	15	65	10	5	3.8	1	0.2	—
CBP	15	55	10	5	3.8	1	0.2	10
2.5% HTB	15	55	10	5	3.8	1	0.2	10
5% HTB	15	55	10	5	3.8	1	0.2	10

Table 2: Chemical composition of husk tomato powder.

Moisture	Protein	Fat	Ash	Carbohydrate	Fiber
7.81%	25.61%	19.66%	3.55%	27.60%	15.77%

(27.60 g/100 g), protein (25.61 g/100 g), fat (19.66 g/100 g), fiber (15.77 g/100 g), and moisture (7.81 g/100 g). The lowest value was recorded in ash (3.55 g/100 g).

The chemical compositions of beef patties prepared with different concentrations of husk tomatoes are presented in Table 3. The differences in the composition of the different treatments may be attributed to the amount of husk tomato powder added. The moisture content was higher at 2.5% HTB. The higher moisture content could be due to water from the meat matrix being retained during the cooking process. Increase in the amount of husk tomatoes in the burger (10%) could lower moisture content. The addition of 2.5% husk tomatoes to burgers had no significant effect on the protein, fat, fiber, and carbohydrate contents, while the addition of 5% husk tomatoes significantly lowered the fat and ash contents while significant increased the fiber and carbohydrate contents. Beef patties with 10% husk tomatoes had significant higher content of protein but lower contents of fat and ash.

The acid value, peroxide value, and thiobarbituric acid level are indicators of fat oxidation and lipolytic changes in beef burgers. The results in Table 4 show that the addition of 2.5, 5, and 10% HT to beef patties caused a reduction in acid values, peroxide values, and thiobarbituric acid levels compared to those of the control beef patties at zero time and after a week of storage. However, the acid value increased, but the thiobarbituric acid level decreased in 2.5% HTB after a week of storage compared to the values at zero time. The peroxide value and thiobarbituric acid level decreased in 5% HTB after a week of storage compared to the values at zero time. At 10% HTB, the differences between these values after a week of storage were not significant.

The results from sensory evaluations are presented in Table 5. The addition of 2.5 or 5% husk tomatoes to beef burgers did not affect the scores in the appearance, juiciness, flavour, texture, and overall acceptability of the beef burgers compared to the control beef burgers. The colour was improved by a different ratio amount of husk tomato addition. On the contrary, the addition of 10% husk tomatoes to beef burgers resulted in lower scores in appearance, juiciness, flavour, and overall acceptability although colour scored highly.

The data in Table 6 show a significant decrease in body weight gain, feed intake, and feed efficiency ratio of tannic acid-induced anaemic rats (positive control). Tannic acid reduces the availability of iron by forming an insoluble complex, resulting in lower plasma thyroid hormone levels and growth [25–28]. Meanwhile, BWG and FER were significantly decreased in the anaemic rat group fed on CBP and 2.5% HTB compared to that of the negative control group although the consumption of 2.5% HTB increased these parameters compared to those of the positive control group. The rat group fed on 5% HTB showed the most increase in BWG, FI, and FER (compared to the positive control group) and is comparable to the negative control group.

The effect of the beef burger fortified with different ratios of husk tomato powder on blood HB, HCT, iron, ferritin, and TIBC of anaemic rats is presented in Table 7 compared to the negative control group, and results showed a significant decline in HB, HCT, iron, ferritin, and TIBC in the positive control group to levels that were similar to the groups consuming CBP. The rat group fed on 2.5 HTB showed no significant differences in HB, HCT, and TIBC compared to that of the negative control group but showed significant higher levels of iron and ferritin compared to the positive control group. On the contrary, the rat group fed on 5% HTB showed improvements in these anaemic indicators of negative control levels.

4. Discussion

Chemical composition of husk tomato powder results agree with Zhang et al. [29], who estimated 17.8% protein, 6.6% moisture, 28.7% crude fiber, 3.10% ash, and 24.5% carbohydrates in husk tomatoes. However, our results disagreed with those of Rodrigues et al. [9] and Yildiz et al. [30]. The difference may be due to varieties, climate, harvest period, and the methods of estimation. The high protein content of 10% husk tomato beef patties may be due to the decrease of moisture content. Carbohydrate and fiber contents were dependent on the husk tomato concentration. The protein, fiber, and carbohydrate levels of beef burgers with added husk tomato were higher than those found in control beef patties and thus confirmed the nutritional advantages of burgers amended with this nonmeat protein source [3]. These results of the acid value, peroxide value, and thiobarbituric acid level are in good agreement with the results of Zhang et al. [29], who found high levels of antioxidant compounds such as kaempferol and quercetin di- and triglycosides with anolides, phygrine, and flavonoids in husk tomato. Amarowicz et al. [31], Yen et al. [32], and Shaker and Mnaa [33] also reported that the antioxidant capacity of husk tomato is related to the scavenging nature of phenolic compounds, especially physalines and with anolides, that inhibit lipid oxidation and degradation of beef burger meat

Table 3: Nutritional value of beef patties prepared with different concentrations of husk tomatoes (mean values ± SD).

	Protein	Fat	Ash	Fiber	Carbohydrate	Moisture
CBP	29.66 ± 1.88bc	38.07 ± 3.45a	5.11 ± 0.41a	2.67 ± 0.16c	12.29 ± 1.42c	12.20 ± 1.78bc
2.5% HTB	31.07 ± 2.07b	35.60 ± 3.08ab	4.30 ± 0.66b	2.82 ± 0.18c	11.88 ± 1.71bc	14.33 ± 1.57a
5% HTB	32.77 ± 2.18ab	33.44 ± 2.14b	4.56 ± 0.51b	3.26 ± 0.22b	12.96 ± 1.16b	13.01 ± 1.17ab
10% HTB	34.10 ± 2.68a	29.33 ± 1.70c	4.66 ± 0.42b	5.83 ± 0.43a	14.33 ± 1.60a	11.75 ± 1.76c

Values followed by different letters in each column differ significantly.

Table 4: Effect of different concentrations of HT on the acid value, peroxide value, and thiobarbituric acid in beef at zero time and after one week of storage (mean values ± SD).

	Acid value		Peroxide value		Thiobarbituric acid	
	Zero time	One week	Zero time	One week	Zero time	One week
CBP	2.55 ± 0.11a	5.19 ± 0.58a	4.25 ± 0.33a	10.11 ± 1.61a	0.45 ± 0.04a	0.98 ± .02a
2.5% HTB	1.44 ± 0.09c	2.53 ± 0.22b	2.85 ± 0.27b	5.01 ± 0.50b	0.31 ± 0.03c	0.38 ± 0.01d
5% HTB	1.99 ± 0.16b	2.65 ± 0.33b	2.90 ± 0.25b	4.88 ± 0.45bc	0.34 ± 0.01b	0.45 ± 0.02c
10% HTB	1.54 ± 0.12bc	2.49 ± 0.21bc	2.75 ± 0.21b	5.08 ± 0.66b	0.35 ± 0.02b	0.89 ± 0.01b

Values followed by different letters in each column differ significantly.

Table 5: Sensory properties of fresh beef patties prepared with different concentrations of husk tomatoes (mean values ± SD).

	Appearance	Juiciness	Flavour	Colour	Texture	Overall acceptability
CBP	9.80 ± 1.11a	9.77 ± 1.21a	9.66 ± 1.15a	7.88 ± 0.55b	8.15 ± 1.03ab	9.51 ± 1.04a
2.5% HTB	8.77 ± 1.03ab	8.96 ± 1.17ab	8.31 ± 1.04ab	8.30 ± 1.14ab	8.88 ± 1.21ab	8.66 ± 1.01ab
5% HTB	9.01 ± 1.05a	9.41 ± 1.14a	8.11 ± 1.03ab	9.11 ± 1.10a	9.35 ± 1.14a	8.65 ± 1.04ab
10% HTB	7.60 ± 1.01b	7.54 ± 1.07b	7.66 ± 1.11b	9.41 ± 1.12a	9.41 ± 1.15a	7.40 ± 1.03b

Table 6: Effect of the beef burger fortified with different ratios of husk tomato powder on BWG, FI, and FER of anaemic rats (mean values ± SD).

	Positive control	Negative control	CBP	2.5% HTB	5% HTB
BWG	53.67 ± 5.11ab	35.41 ± 3.11d	38.61 ± 3.61cd	43.66 ± 5.07c	55.11 ± 5.22a
FI	18.67 ± 1.95a	15.66 ± 1.02b	17.31 ± 1.14a	18.11 ± 1.66a	18.33 ± 1.81a
FER	0.095 ± 0.08b	0.075 ± 0.003d	0.074 ± 0.001de	0.080 ± 0.006c	0.100 ± 0.002a

BWG: body weight gain; FI: food intake; FER: food efficiency ratio. Values followed by different letters in each row differ significantly.

Table 7: Effect of the beef burger fortified with different ratios of husk tomato powder on blood HB, HCT, iron, ferritin, and TIBC of anaemic rats (mean values ± SD).

	Positive control	Negative control	CBP	2.5% HTB	5% HTB
HB (g/dl)	13.96 ± 1.30a	9.66 ± 0.98c	11.02 ± 1.22b	12.80 ± 1.19ab	13.61 ± 1.25a
HCT (%)	36.77 ± 4.23a	27.61 ± 2.44bc	31.61 ± 3.18b	34.03 ± 3.66ab	34.51 ± 4.07ab
Iron (μg/dl)	265.60 ± 42.16a	180.66 ± 29.88d	202.66 ± 35.17c	237.33 ± 40.66b	245.16 ± 39.66ab
Ferritin (ng/dl)	199.66 ± 15.55a	140.31 ± 12.94d	155.77 ± 13.33c	185.41 ± 14.51b	189.66 ± 16.08ab
TIBC (μg/dl)	481.66 ± 39.65a	388.55 ± 31.14c	455.66 ± 33.68b	475.11 ± 35.60a	470.41 ± 38.72a

HB: haemoglobin; HCT: haematocrit; TIBC: total iron binding capacity. Values followed by different letters in each row differ significantly.

and thus delay rancidity and stabilize the beef burger colour, resulting in increases in shelf life, overall acceptability, and nutritional values.

The sensory and textural properties and the overall acceptability were very good when fiber was present in sufficient amounts [34, 35]. The soft texture, fiber, and higher moisture content of husk tomato were possible contributing factors to the overall acceptability of 2.5% and 5% husk tomato amendments in the beef burger. However, the addition of husk tomatoes significantly reduced the flavour of beef burgers, depending on the ratio, and can be attributed to the taste of the husk tomato which could mask the flavour of meat. Generally, the beef burgers with 2.5% and 5% husk tomato had good acceptability indexes for juiciness, appearance, tenderness, and overall acceptability, and thus, these levels of husk tomatoes are considered acceptable in terms of sensorial properties while they are good from the nutritional point of view [36].

Since the beef burger is rich in nutritional compounds, such as protein, vitamins, minerals, and trace elements, the fortification with husk tomatoes increased food intake due to the unique and suitable flavour. The improvement in nutritional results occurred because the fortified burgers are an excellent source of protein, carotene, sugars, vitamins A and C, minerals (phosphorus and iron), organic acids, and antioxidants derived from husk tomato fruits [5].

Tannic acid is typically used to study the reductions in iron bioavailability and/or lowered iron status in rats. Tannic acid could reduce Fe absorption and deplete the serum and haemoglobin iron concentrations, and it induced severe Fe-deficient anaemia [18, 37]. Aside from the macronutrients protein and fat, the meat of beef patties contains micronutrients (vitamins, minerals, and antioxidant), as well as higher levels of available haem iron, with additional non-haem iron (inorganic iron) that are involved in essential metabolic processes [38]. The consumption of husk tomatoes could help in anaemia treatment because they are a good source of vitamins, minerals (mainly iron and potassium), tocopherols, carotenoids, ascorbic acid, and high amounts of phenolic compounds, including quercetin, myricetin, and kaempferol [9, 10]. Physalis fruit and juice are nutritious, containing higher amounts of crude protein, crude fat, crude fiber, and ash, and iron is the most predominant of microelements and particularly high levels of niacin, carotenoids, and minerals. Therefore, our results agree with Stoltzfus and Dreyfuss [39], who reported that the higher content of iron in husk tomatoes is essential for hundreds of enzymes and proteins and for the prevention of iron deficiency anaemia.

5. Conclusion

The addition of husk tomatoes to beef burgers improves the nutritional quality of the burgers, thus converting them into a functional meat product. The husk tomato powder acts as a natural antioxidant with highly efficient means to retard the lipid oxidation in the burger. Five percent husk tomato burger functional meat product could treat iron deficiency anaemia in rats. Further investigation could be applied on anemic patients.

Abbreviations

HT: Husk tomato
BWG: Body weight gain
FER: Food efficiency ratio
HB: Haemoglobin
HCT: Haematocrit
TIBC: Total iron binding capacity.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors are profoundly grateful to the Princess Nourah Bint Abdulrahman University for its financial and moral support in accomplishing this research paper. The authors are also grateful to the staff of the Scientific Research Center of the MSD, Riyadh, for their help in experimental work.

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