

Utilization of amaranth as a fat replacer and germinated red beans to prepare low- fat beef burgers with a long shelf life storage period

Safaa M. Faid

Department of Home Economics, Faculty of Specific Education, Ain Shams University,
Cairo, Egypt

E mail: safaafaid73@gmail.com

ABSTRACT

Amaranth with germinated red beans was utilized as a fat replacer in the manufacture of healthy wholemeal beef burgers. Four formulas beef burgers with at 2.5, 5.0, 7.5, and 10.0% of amaranth and 10.0% and germinated red beans were investigated compared with a beef burger as a control-free addition. Phenolic and flavonoids levels were determined in raw and germinated amaranth. The physico-chemical, sensory evaluation, Texture Profile Analysis (TPA), and keeping quality indices during the storage period were determined in a beef burger and its four formulas.

The results indicated that amaranth and germinated red beans are good sources of protein, crude fiber, ash content and total carbohydrates. Meanwhile, germinated red beans had the highest contained total phenolic and flavonoid compounds than amaranth whole meal. Using amaranth with 2.5, 5.0, 7.5, and 10.0% in beef burger was increased protein, crude fiber, ash content and total carbohydrates to 20.28, 3.75, 2.87, and 7.67%, respectively. Using amaranth (5%) with 10% in beef burger (F4) gave the best significant value of WHC, plasticity, shrinkage, cooking loss and cooking yield (as quality properties) followed by formulas 3, 2, and 1, respectively. Also, the sensory evaluation of the cooking beef burger F4 in addition to germinated red beans has greatly improvement color, odor, juiciness, and taste than other formulas. Texture profile analysis of beef burger formulas prepared from amaranth as alternative fat at different levels indicated that there were significant differences in all texture indices between different beef burgers formulas. Keeping quality indices during the storage period as total volatile nitrogen (TVN) and thiobarbitutic acid (TBA) were improved in all formulas during the storage period which can be attributed to the germinated red beans that contain a high amount of total phenolic acid and flavonoid compounds that act as natural antioxidants which scavenging the rancidity from beef burgers formulas.

The results found that the germinated red bean is recommended to be a high potential based-meat ingredient during the storage period, and also, amaranth was used as an alternative fat to be utilized in the low-fat beef burger as a functional food, in addition to its health and nutritional benefits.

Keywords: Amaranth whole meal, germinated red beans, total volatile nitrogen (TVN), thiobarbitutic acid (TBA), Texture Profile Analysis (TPA),

INTRODUCTION

In fact, there is a greater tendency to consume healthy / super foods, such as amaranth because it has a high nutritional value. Amaranth can be considered a "super food" because the grain is gluten-free, and contains a decent amount of

vegetable protein, essential amino acids, and large amounts of calcium, dietary fiber, omega-3s, omega-6s, vitamins, and antioxidants (García *et al.*, 2018). Also, it has health benefits such as improving nutrition and health because it is a vegetable protein source that works to reduce cholesterol, oxidative stress,

osteoporosis, stomach problems, and for patients with gluten sensitivity, and is important for diabetics because it contains high amounts of dietary fiber (García *et al.*, 2018).

Meat products contain high amounts of saturated fats and salts which cause diseases such as obesity, high blood pressure and cardiovascular diseases. Therefore, the production of products from healthy meat is important (Jimenez-Colmenero *et al.*, 2015). There are many alternatives to produce the healthiest meat products, by using fat substitutes, but these alternatives do not give the characteristics of animal fats (Horita *et al.*, 2011).

Red kidney beans are legume crops that are high amounts of protein, total carbohydrates, and dietary fiber. Therefore, their consumption is associated with a decrease in non-communicable diseases such as diabetes, cancer, obesity, and chronic heart disease. In addition, they contain natural antioxidants such as flavonoids, and polyphenols which protect the body against many diseases (Shehzad *et al.*, 2015).

Partial substitution of animal meat or fats with vegetable crops is an important strategy to reduce meat and animal fat consumption (Spencer and Guinard, 2018) and to produce healthier meat products that find consumer acceptance. The organoleptic characteristics of processed meat products that are low in animal fat and replaced by vegetable crops are important for the acceptability of the products. Therefore, taste and texture are very important characteristics of acceptability (Elzerman *et al.*, 2011). Meal format (Neville *et al.*, 2017) and repeated exposure (Hoek *et al.*, 2013) are important for the acceptance of meat substitutes. The

meat products of lower-fat that have been replaced with plants have indicated that they can give the same level of consumer acceptance (Neville *et al.*, 2017).

Antioxidants are added to meat products to prevent fat oxidation, delay the rancidity process, and improve colorfastness. There are both natural and synthetic antioxidants, thus, the processed meat products industry is now choosing natural products over synthetic ones (Kumar *et al.*, 2015).

The objective of this study was to produce a low fat beef burger which contained function properties and high nutritional value by using amaranths as alternative fat and 10% red beans to give color and provides natural antioxidants to increase shelf life during the storage period and improve function characteristics of the product.

MATERIALS AND METHODS

Materials:

Red beans (*Phaseolus vulgaris* L.) were purchased from Field Crops Institute, and Amaranth light seeds (*Amaranth hypochondriacus* L.) were obtained from Horticulture Institute, Agricultural Research Center, Giza Egypt. While, Imported Brazil meat was obtained from local market.

Methods:

Production of germinated red bean flour

A portion of 400 g of red bean seeds was soaked in 1,000 ml of 0.1% sodium hypochlorite for 10 min. Then, these seeds were washed with distilled water and soaked in 1,000 ml of distilled water at 25°C for 12 h. The hydrated seeds were placed in germination trays with small holes at the bottom. The trays were introduced in the germination chamber

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with controlled temperature. The relative humidity within the chamber was maintained in the range of 80-90% using recipes with distilled water. The germination of seeds was carried out at 12h light /12h darkness per day, white illumination source was used. During germination period (3 days) samples in the germination trays were wetted by spraying water containing 0.02% sodium hypochlorite twice daily. After germination, the red bean seeds were dried at 50 °C for 8h, and ground to obtain germinated red bean flours (GRBF). GRBF were packed and kept at 4 °C in tightly sealed containers until further analysis and use (Salas-López *et al.*, 2018).

Chemical composition of raw and germinated seeds and its formulates

Proximate analysis including crude protein, crude lipids, ash, crude fibers and total carbohydrates were determined in the amaranths and raw and germinated red bean according to the methods of AOAC (2010).

Extraction of free and bound phenolic compounds in raw and germinated seeds

Free phenolic compounds were extracted according to Dewanto *et al.* (2002). 0.5 g of a dry ground sample was shaking in 10 ml ethanol-water (80:20, v/v). Then, the supernatant was recovered by centrifugation (3000xg, 10 min), and the extraction step was repeated two more times. The extracts were evaporated to dryness and stored at low temperature (-20 °C).

The methodology reported by Adom and Liu (2002) was used to extract bound phenolic compounds. The pellets obtained after the extraction of free phenolics compounds were hydrolyzed

with 10 ml of sodium hydroxide (2 M) at 95 °C and 25 °C for 30 and 60 min, respectively using a water bath with agitation (60 rpm). After, chloride acid was employed to neutralize, followed by a removal of lipids with hexane. The bound phenolic compounds were extracted with 10 ml of ethyl acetate. The extraction step was repeated two more times. The extracts were evaporated to dryness and stored at low temperature (-20 °C).

Dry extracts of free and bound phenolic compounds were reconstituted in 2 ml of methanol to the measurement of total phenolic and flavonoid compounds contents.

Total Phenolic and Flavonoid Contents (TPC, TFC) in raw and germinated seeds

Colorimetric methods reported by Singleton *et al.* (1999) and Heimler *et al.* (2005) were used to determine TPC and TFC in free and bound extracts, respectively. A microplate Reader (Synergy TM HT Multi-Detection, BioTek Inc, Winooski, VT, USA) was used to measure the absorbance. TPC and TFC were expressed as milligrams of Gallic acid equivalents (mg GAE)/100 g dry weight sample, and milligrams of Quercetin equivalents (mg QE)/100 g dry weight sample. All measurements were made in triplicate.

Formulation of beef burger

The beef burger from minced lean meat was used as control. Four formulates of beef burger with amaranths at 4 different levels (12.5, 10.0, 7.5 and 5.0%) have been prepared as shown in Table (1). Appropriate amounts of control as well as from each formulation were mixed by

hand, subjected to final grinding (1.0 cm plate), and processed into burgers (50 g weight and 10 cm diameter). Burgers were

placed on plastic foam trays, wrapped with polyethylene film and kept frozen at -18°C until further analysis.

Table (1): Beef burger formulations

Components	Control	F1	F2	F3	F4
Minced meat %	65.0	65.0	65.0	65.0	65.0
Beef fat %	15.0	12.5	10.0	7.5	5.0
Amaranths %	-----	2.5	5.0	7.5	10.0
Germinated red bean %	10.0	10.0	10.0	10.0	10.0
Onion %	5.0	5.0	5.0	5.0	5.0
Salt %	1.7	1.7	1.7	1.7	1.7
Skimmed milk %	1.0	1.0	1.0	1.0	1.0
Spices %	1.3	1.3	1.3	1.3	1.3
Starch %	1.0	1.0	1.0	1.0	1.0

Physico-chemical properties of beef burger and their formulas

Proximate analysis including crude protein, crude lipids, ash, crude fibers and total carbohydrates were determined in beef burgers and their formulas according to the methods of AOAC (2010).

Water Holding Capacity (WHC) was measured by method described with Lorenzo *et al.*, (2015) where, 2 g of the dough and cooked samples of the meat analogue were put in a 15 ml conical tube with gauze underneath then centrifuged at 3000 rpm for 10 min at 35 °C. WHC was calculated using the following equation:

$$\text{WHC (\%)} = (\text{W2/W1}) \times 100$$

W1: weight of meat analogue before centrifugation (g).

W2: weight of meat analogue after centrifugation (g).

Cooking loss (CL) was determined by Pathare and Roskully (2016). The cooking conditions were set at a temperature of 110 °C for 5 min. After cooking, the CL was calculated using the following equation:

$$\text{Cooking loss (\%)} = \{(\text{Fresh sample} - \text{Cooking sample}) / \text{Fresh sample}\} \times 100$$

Cooking yield weight before and after cooking was determined according to the method of Akwetey and Knipe (2012) according to the following equation:

$$\text{Cooking yield (\%)} = (\text{Cooking weight} / \text{Fresh weight}) \times 100$$

Cooking shrinkage ratio was determined according to the method of Berry (1992), in beef burgers after cooking were cooled to 21°C for 1 hr. Beef burger diameter was measured before cooking (A1) and after cooking (A2) was calculated according to the following equation: Cooking Shrinkage (%) = (A1 – A2)X100

Sensory evaluation

Burgers were assessed for a number of sensory characteristics by ten members of the Department of Home Economics, Faculty of Specific Education, Ain Shams University, Cairo, Egypt in sensory for evaluation and availability. Panelists were instructed to evaluate color, texture, taste, flavor, odor and overall-acceptability using 10 point scale for grading the quality of samples according to Crehan *et al.* (2000).

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Texture Profile Analysis (TPA)

TPA was measured by modifying a method described previously by Lin *et al.* (2000) using a texture analyzer (CT3, Brookfield Engineering Labs Inc., Stoughton, MA, USA). The samples were shaped like a cylindrical column (30 mm in diameter and 25 mm in height). They were compressed to 50% deformation of its original thickness and were measured under the conditions of test speed (2.5 mm/s) and trigger load (100 g). A cylindrical probe (38.1 mm in diameter) was used for the test and the hardness, cohesiveness, springiness, and chewiness data were recorded.

Keeping quality indices during storage period

Total volatile nitrogen (TVN) and thiobarbituric acid number (TBA) were determined during storage period for three months in deep-freeze at -18°C according to Egan *et al.* (1981) and Vyncke (1970).

Statistical analysis

The data generated in this research were subjected to statistical analysis using one-way analysis of variance (ANOVA) and Duncan multiple range tests to compare the mean values at $P < 0.05$ level of significance (SAS, 2004).

RESULTS AND DISCUSSION

Chemical composition of amaranths and raw and germinated red bean

The nutritional value of amaranth seeds and red bean raw and germinated seeds were shown in Table (2). It was obvious that the total protein, total lipids,

crude fiber, ash content and total carbohydrates in raw red bean seeds were 17.28, 7.58, 8.82, 4.34, and 61.98%, respectively, while these were 15.43, 4.17, 11.53, and 6.76, and 62.11%, respectively in germinated red bean seeds. The reduction in protein content during germination process may be caused by an increase in the activity of a protease enzyme that broken the protein for utilizing to bud growth (Megat Rusydi *et al.*, 2011). In addition, the decrease in fat is the reason for the oxidation of fats to carbon dioxide and water. Moreover, germination is a vital process to improve the nutritional value of the grains to increase the antioxidant and nutritional value (Perales-Sánchez *et al.*, 2014). The germination process increased the nutritional value of legumes by increasing the total carbohydrates, and other components. In addition, improving the functionality of the legumes may be causing the subsequent increments in antioxidant activity and bioactive compounds (Wu *et al.*, 2011). Megat *et al.* (2016) found that the influence of germination in legumes was significant which increased the fibers in all the germinated legumes samples.

On the other hand, data in Table (2) indicated that amaranth seeds contain a high amount of nutrition value of total protein, total lipids, crude fiber, ash content and total carbohydrates (14.28, 5.37, 9.51, 5.75 and 66.09%, respectively). Seeds and leaves of amaranth (*Amaranthus sp*) are rich sources of proteins, balanced amino acid composition and elevated nutrition value (Repo-Carrasco-Valencia *et al.*, 2009; López *et al.*, 2019).

Table (2): Chemical composition of amaranths and raw and germinated red beanon wet weight

Chemical compositions	Amaranths	Raw red bean	Germinated red bean
Protein content %	14.28±0.84	17.28±0.73	15.43±0.89
Total lipids %	5.37±0.05	7.58±0.06	4.17±0.28
Crude fiber %	9.51±0.17	8.82±0.14	11.53±0.91
Ash content %	5.75±0.02	4.34±0.02	6.76±0.53
Total carbohydrates %	66.09±3.28	61.98±2.18	62.11±3.27

Values are mean of three replicates ± SD

Phenolic and flavonoid content of amaranths and raw and germinated red bean

Phenolic and flavonoid contents were determined of amaranths and raw and germinated red bean and the results were shown in Table (3). Data indicated the germinated red bean seeds have the highest free, bound and total content of phenolic and flavonoids; 182.37, 177.12, and 359.49 mg Gallic acid equivalents (GAE)/100 g DW, respectively in phenolic, 102.11, 87.15, and 189.66 mg Quercetin equivalents (QE)/ 100 g DW, respectively in flavonoids. Meanwhile, the amaranth seeds have the lowest content in free, bound and total phenolic and flavonoid content (10.57, 65.60, and 76.17 mg Gallic acid equivalents (GAE)/100 g DW, respectively in phenolic content and 23.28, 46.30, and 69.58 mg Quercetin equivalents (QE)/ 100 g DW, respectively in flavonoids content).

From the results, it could be noticed that the germinated red bean

contain the highest amount from polyphenols, since during germination the phenolic compounds in seeds were increased (Duodu, 2014). There are positive changes through germination with an association between phenolic compounds and dietary fiber that improve the nutritional quality and increase the healthy characteristics of legumes (Dueñas *et al.*, 2016). Moreover, the total phenolic and flavonoid compounds increased during germination times as a result of the breakdown process and synthesis during germination (Lopez-Amoros *et al.*, 2006).

Polyphenols are one of the antioxidant compounds which increase during the germination process. It reduces the oxidative damage of the cell membranes by scavenging free radicals in the human body and preventing rancidity in foods (Fernandez-Orozco *et al.*, 2009). Also, nutrition which has contained the polyphenolic compounds has been related to the reduction of different diseases and improving human health (Shams-Ardekani *et al.*, 2011).

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Table (3): Phenolic and flavonoid content of amaranths and raw and germinated red bean

Properties Antioxidant	Amaranths	Raw red bean	Germinated red bean
Antioxidant activity ABTS			
$\mu\text{mol Trolox equivalents (TE)}/100 \text{ g (DW)}$.			
Free phytochemicals	2.95±0.04	3.52±0.014	15.29±0.97
Bound phytochemicals	3.86±0.09	6.71±0.18	10.38±0.96
Total phytochemicals	6.81±0.15	10.23±0.23	25.67±1.24
Phenolic content			
$\text{mg Gallic acid equivalents (GAE)}/100 \text{ g sample (DW)}$			
Free phenolics	10.57±0.43	16.12±0.92	182.37±10.38
Bound phenolics	65.60±1.27	93.28±5.28	177.12±9.76
Total phenolics	76.17±2.38	109.40±7.39	359.49±15.38
Flavonoid content			
$\text{mg Quercetin equivalents (QE)}/100 \text{ g sample (DW)}$.			
Free flavonoids	23.28±0.86	32.25±2.16	102.11±7.38
Bound flavonoids	46.30±0.51	56.19±4.38	87.15±5.12
Total flavonoids	69.58±0.76	88.44±6.18	189.66±8.67

Values are mean of three replicates \pm SD

Chemical composition of beef burgers and their formulas

The data in Table (4) indicated results of the measured moisture, protein, total lipids, crude fiber, ash content, and total carbohydrate in the beef burger and its formulas made from amaranth seeds flour as alternative fat at different levels. It was clear that the protein content increased from 18.26% in F1 to 20.28% in F4, this increase is related to the presence of high amounts from protein content in amaranth and germinated red bean as shown in Table (2). Protein content was (16.15%) in control beef without additives. The total lipids was high in the control beef burger (15.00%), whilst, the beef burger formulas had lower content of total lipid ranged

from 5% to 12.50% in F4 and F1, respectively. This decrease may be caused by the amaranth substituted from fat at different levels.

In addition, the lowest contents of crude fiber, ash content, and total carbohydrates were recorded in the control beef burger (2.46, 1.62, and 3.49%, respectively). These were increased gradually to reach 3.75, 2.87, and 7.67%, respectively in F4 (Table 4) due to their high content in amaranth and germinated red bean (Table 2). The amaranth seeds are a super food which contain high nutritional values of high-quality essential amino acids, omega-3 and 6, dietary fiber and natural antioxidants (Soriano-García *et al.*, 2018).

Table (4): Chemical composition of beef burgers formulas

Chemical compositions	Control	F1	F2	F3	F4
Moisture content	61.28±3.15	61.11±3.59	60.82±4.12	60.65±3.92	60.43±4.21
Protein content	16.15±1.49	18.26±1.34	18.37±1.17	19.86±2.15	20.28±1.96
Total lipids	15.00±1.28	12.50±0.94	10.00±0.76	7.50±0.94	5.00±0.73
Crude fiber	2.46±0.04	2.77±0.07	3.19±0.05	3.48±0.05	3.75±0.12
Ash content	1.62±0.07	2.45±0.06	2.59±0.04	2.75±0.01	2.87±0.04
Total carbohydrates	3.49±0.09	2.91±0.06	5.03±0.03	5.76±0.04	7.67±0.56

Values are mean of three replicates ± SD

Physical properties of beef burger and their formulas

Plasticity, water holding capacity (WHC), shrinkage, cooking loss and cooking yield were determined in beef burger and their formulas and the results were reported in Table (5). From these results, it could be noticed that F4 has the best significant value of WHC, plasticity, shrinkage, cooking loss and cooking yield (as quality properties) followed by formulas 3, 2, and 1, respectively. This may be due to F4 is higher in protein and having lower lipid content when compared with other formulas. It is known that fat is a hydrophobic substance (water-repelling and do not blend with water with

emulsifying, while the protein work as a binder for water). WHC was determined in fresh meat and its products, thus influencing the acceptability of consumers' to obtain the product. Juiciness is an exclusively subjective property of meat and it was determined using WHC. It was also contributing to eating quality in addition, playing a role in texture (Warner, 2017).

The cooking loss showed the degree of meat shrinkage during cooking, to estimate the meat quality and the yield of the final product. In common the cooking loss of processed meat products is influenced by preparation constituents.

Table (5): Physical properties of beef burger and their formulas

Physical properties	Control	F1	F2	F3	F4
Plasticity (cm ²)	2.55 ^c ±0.07	2.60 ^d ±0.05	2.72 ^c ±0.07	2.83 ^b ±0.03	2.95 ^a ±0.04
Water holding capacity (cm ²)	3.55 ^a ±0.04	3.35 ^b ±0.04	3.12 ^c ±0.03	2.95 ^d ±0.07	2.88 ^e ±0.06
Shrinkage (%)	12.12 ^a ±0.15	12.56 ^b ±0.53	12.04 ^c ±0.47	11.63 ^d ±0.29	11.27 ^e ±0.61
Cooking loss (%)	21.15 ^a ±0.94	20.94 ^b ±1.10	20.76 ^c ±1.27	20.57 ^d ±1.58	20.41 ^e ±1.38
Cooking yield (%)	78.25 ^e ±5.37	79.63 ^d ±6.12	80.91 ^c ±6.83	81.12 ^b ±7.16	82.23 ^a ±7.28

Values are means ± SD (n = 3). Means followed by different letters in the same column are significantly different (P ≤ 0.05)

Sensory evaluation of the cooking beef burger and their formulas

Color, odor, juiciness, and taste are the most important sensory attributes which influence the acceptability of meat products by consumers (Aliakbarlu and KhaliliSadaghiani, 2015). Sensory

evaluation results of cooked beef burgers are shown in Table (6). Generally, incorporating amaranth as alternative fat and red bean, into beef burger formulations had an improvement significant influence on their sensory properties. Although samples formulated

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had contained 12.5, 10.0, 7.5, and 5% fat, yet they were gradually obtained the highest taste scores acceptability by panelists ($P < 0.05$). This may be due to the amaranth as an alternative fat was high dietary and reduce the rancidity when it increases in the formulas.

The results found that addition of 2.5% amaranth and 10.0% fat, could be noticed reducing the hardness of the taste cooked beef burger. The reduction in hardness and the best taste was significant for the control beef burger which was prepared from 15% fat followed by 12.5, 10.0, and 7.5% fat.

Moreover, the addition of 10.0% amaranth and 5.0% fat has reduced the juiciness of the cooked beef burger from 9.5 to 7.5. However, the juiciness increased as the particle size of the added amaranth decreased, and the juiciness of the cooked patty with 2.5% amaranth and 12.5% fat was statistically the same as that of the control beef burger ($p < 0.05$). The

increased juiciness of the beef burger with amaranth can be explained by the high water holding capacity of amaranth due to it had contained high amounts of fiber.

These results indicated that the addition of 10% germinated red beans improved the color, meanwhile, the formula beef burger prepared from 5% amaranth and 10% fat minimally affect the color of the beef burger. Similarly, it has been reported that the addition of oat fiber and carrageenan had little effect on the color of cooked hamburger patty (Hughes *et al.*, 1997), while the addition of rice bran fiber changed the cooked color of meat batter (Choi *et al.*, 2009).

Moreover, the antioxidant characteristics of germinated red beans were the major reason for the elevated sensory scores of the formulations preventing the formation of rancidity and off-odors during storage (Mohamed and Mansour, 2012).

Table (6): Sensory evaluation of cooking beef burger and their formulas

Sensory evaluation	Taste	Juiciness	Odor	Color	Overall acceptability
Control	9.5 ^a ±0.95	9.5 ^e ±0.76	9.5 ^e ±0.83	9.5 ^c ±0.61	9.5 ^e ±0.76
F1	9.0 ^a ±0.81	9.0 ^a ±0.73	9.0 ^a ±0.84	9.0 ^a ±0.57	9.0 ^a ±0.88
F2	8.5 ^b ±0.38	8.5 ^b ±0.49	8.5 ^b ±0.71	8.5 ^b ±0.78	8.5 ^b ±0/79
F3	8.0 ^c ±0.46	8.0 ^c ±0.57	8.0 ^c ±0.38	8.0 ^c ±0.54	8.0 ^c ±0.61
F4	7.5 ^d ±0.24	7.5 ^d ±0.28	7.5 ^d ±0.37	7.5 ^d ±0.41	7.5 ^d ±0.52

Values are means ± SD (n = 3). Means followed by different letters in the same column are significantly different ($P \leq 0.05$)

Texture profile analysis of beef burger and their formulas

Table (7) showed the textural parameters (hardness, adhesiveness, gumminess, chewiness, and springiness) of beef burgers with amaranth as alternative fat at different levels. From statistical

analysis of these results, it could be noticed that there were significant differences in all texture indices between different beef burgers formulas. The hardness of beef burgers formulas was significantly increased by reducing the fat levels and increasing fat replacers. Beef

burgers formulas prepared by amaranth (as fat replacer) had higher hardness values. The highest hardness value (13.52N) was recorded for beef burgers formula prepared with 10% amaranth at 5% fat level followed by beef burgers formula prepared with 7.5% amaranth at 7.5% fat level (13.11N), formula 3 prepared from 5.0% amaranth and 10% fat level was 12.53N, formula 3 prepared from 2.5% amaranth and 12.5% fat level was 11.28 N and control beef burgers prepared with 15% fat level has hardness value 10.43N. The hardness of a cooked patty was explained by moisture and fat retention after heating (Selani *et al.*, 2016).

Adhesiveness values ranged from 30.25 to 30.57 M showed significant differences between different beef burgers formulas. The highest adhesiveness value was recorded for beef burgers prepared with 10% amaranth at a 5.0% fat level. On the contrary, the lowest value (30.25M) was recorded for high-fat control. No significant differences in adhesiveness were observed between the low-fat control samples and beef burgers formulas.

Gumminess of different beef burgers formulas ranged from 2.98 to 17.60 g showed significant differences ($p > 0.05$). Gumminess of beef burgers

formulas was significantly increased by reducing fat levels or increasing fat replacers. Beef burgers formulas prepared by amaranth (as fat replacer) had higher Gumminess values (17.60g) and it was recorded for beef burger prepared with 10.0% amaranth at 5.0% fat level followed by beef burger prepared with 17.5% amaranth at 7.5% fat level (13.64 g) with significant differences between them ($p < 0.05$). On the other hand, non-significant differences were recorded between fat 5% being gumminess (9.75g) and beef burger formula prepared with 12.5% amaranth at 2.5% fat level (5.88g), respectively.

Chewiness values ranged from 3.51 to 13.80 for beef burgers formulas prepared with amaranth as alternative fat and germinated red beans. Chewiness values were significantly increased by fat replacer percentages increment. Previous reports showed that gumminess, springiness, and chewiness decreased when the usage level of vegetable fibers increased, while the addition of 5% rice bran increased only springiness of pork patty (Choi *et al.*, 2008).

Springiness value for all beef burgers formulas was ranged from 0.52 to 0.47 showed no significant differences between all treatments.

Table (7): Texture profile analysis of beef burger and their formulas

Texture analysis	Hardness (N)	Adhesiveness (Mj)	Gumminess (g)	Chewiness (g/mmj)	Springiness (mm)
Control	10.43 ^d ± 0.94	30.25 ^c ± 2.57	2.98 ^e ± 0.17	3.51 ^e ± 0.54	0.52 ^a ± 0.09
F1	11.28 ^c ± 1.25	30.29 ^c ± 2.49	5.88 ^d ± 0.29	5.42 ^d ± 0.49	0.50 ^a ± 0.04
F2	12.53 ^b ± 1.38	30.37 ^b ± 2.68	9.75 ^c ± 0.35	8.37 ^c ± 0.83	0.49 ^b ± 0.06
F3	13.11 ^a ± 1.64	30.48 ^a ± 3.01	13.64 ^b ± 1.08	10.59 ^b ± 1.08	0.48 ^{ab} ± 0.07
F4	13.52 ^a ± 1.59	30.57 ^a ± 3.12	17.60 ^a ± 1.34	13.80 ^a ± 1.32	0.47 ^b ± 0.03

Values are means ± SD (n = 3). Means followed by different letters in the same column are significantly different ($P \leq 0.05$)

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Total volatile nitrogen (TVN) and thiobarbituric acid number (TBA) analysis of cooking beef burger and their formulas during storage periods

The Results in Table (8) indicated that the high TBA value of the control beef burger was 0.37 mg malonaldehyde/kg at zero time whilst, after three months it was 0.96 mg malonaldehyde/kg with a significant difference from other formulas. This might be due to the control beef burger had contained 15% fatter, than other formulas. On the other hand, the different formulas containing amaranth whole-meal and germinated red bean at different ratios had lower TBA values and formula 4 gives the best result (0.52 mg malonaldehyde/kg) followed by formulas 3, 2 and 1 (0.61, 0.77, and 0.85 mg malonaldehyde/kg, respectively), after three months of the storage period. Furthermore, from the results, it could be observed that the treatments containing amaranth at different levels and Germinated red beans had lower TBA values as compared to the control beef burger due to low-fat beef burgers formulas, therefore, lowering the fat content in all the formulations gives the formulas beef burger lowering TBA. The decrease in TBA after three months with increasing amaranth and with 10% germinated red beans can be attributed to the presence of high amounts of natural antioxidants, which could be preventing lipid oxidation (El- Naggar, 1999). The

TBA value was used for measuring rancidity in fat-containing fish and meat and their products. Therefore, it was a sensitive evaluation of the analysis of highly unsaturated fatty acids in the different products (Melton, 1983).

It was observed from the results of TNV in Table (8) that the frozen storage at zero time was 11.87mg /100g and after three months was 20.81 mg/100g), the TVN was highest for the control sample. Meanwhile, when increased amaranth in a beef burger, fat was lowering after three months (11.71, 11.21, 12.29, and 13.17 mg/100g, respectively). These results agrees that of El-Naggar, (1999) who reported that TVN was elevated in the control sausage and followed by sausages formulas that contain soy flour with 8% fat. El- Kholy (1994) found that the elevation TVBN values during storage of the beef burger sample may cause the bacterial breakdown connected with some alkaline substances which caused rancidity. Soltanizadeh and Ghiasi-Esfahani, (2015) found that the lower values of PV and TBA values in the fortified beef burgers compared to the control one may be due to the presence of high amounts from polyphenolic content and natural antioxidant activity in amaranth whole meal and germinated red beans which have the ability to scavenge free radicals, thereby reducing the rate of lipid oxidation.

Table (8): TBA and TVN analysis of cooking beef burger and their formulas during storage periods.

Texture analysis	Formulas	Storage period/day			
		Zero time	30	60	90
TVN mg/100g	Control	11.78 ^a ±1.24	15.84 ^a ±1.15	18.39 ^a ±1.86	20.81 ^a ±1.98
	F1	11.75 ^a ±1.26	14.78 ^b ±1.38	15.37 ^b ±1.76	17.76 ^b ±1.56
	F2	11.73 ^a ±1.31	13.59 ^c ±1.54	14.34 ^c ±1.63	15.47 ^c ±1.37
	F3	11.70 ^a ±1.28	12.41 ^d ±1.69	13.31 ^d ±1.68	14.21 ^d ±1.71
	F4	11.71 ^a ±1.17	11.21 ^e ±	12.29 ^e ±1.24	13.17 ^e ±1.53
TBA mg/kg	Control	0.37 ^a ±0.04	0.64 ^a ±0.03	0.81 ^a ±0.04	0.96 ^a ±0.08
	F1	0.36 ^a ±0.05	0.50 ^b ±0.04	0.65 ^b ±0.03	0.85 ^b ±0.07
	F2	0.35 ^a ±0.08	0.45 ^c ±0.01	0.55 ^c ±0.05	0.77 ^c ±0.04
	F3	0.35 ^a ±0.06	0.42 ^d ±0.08	0.50 ^d ±0.07	0.61 ^d ±0.02
	F4	0.34 ^a ±0.04	0.40 ^e ±0.02	0.45 ^e ±0.06	0.52 ^e ±0.03

TVN: Total volatile nitrogen (mg/100g) - TBA: Thiobarbituric acid (mg/kg)

Values are means ± SD (n = 3). Means followed by different letters in the same column are significantly different (P ≤ 0.05)

CONCLUSION

From the research results, fat levels can be successfully reduced by adding fat replacers (amaranth whole meal) at different ratios and germinated red bean to get a best function diet and the better health benefits from the beef burger formulas. The thiobarbituric acid number (TBA) value of the control beef burger has elevated value than other formulas containing low fat. Amaranth whole meal as fat substitutes and germinated red beans reduced the level of Total volatile nitrogen (TVN) contents which may be due to germinated red beans had the highest amounts of natural antioxidants that can scavenging the free radicals and lowering fat in different formulas. The beef burger prepared in this study has contained low fat and contained the function properties, therefore it may be recommended to comprise in the function diet for overweight persons in addition to diabetes, and hyperlipidemia.

REFERENCES

- Adom, K.K. and Liu, R.H. (2002). Antioxidant activity of grains. *J. Agric. Food Chem.*, 50(21): 6182–618
- Akwetey, W.Y. and Knipe, C.L. (2012). Sensory attributes and texture profile of beef burgers with gray. *Meat Sci.*, 92 (4): 745-748.
- Aliakbarlu, J. and Khalili Sadaghiani, S. (2015). Effect of chemical and sensory properties of ground sheep meat during refrigerated storage. *J. Food Quality*, 38(4): 240–247
- AOAC (2010). *Official Methods of Analysis of Association of Official Chemists*. (18th ed.), Washington, D.C., USA.
- Berry, B.W. (1992). Low fat level effects on sensory, shear, cooking, and chemical properties of ground beef patties. *J. Food Sci.* 57: 537–540
- Choi, Y. S.; Choi, J.H.; Han, D.J.; Kim, H.Y.; Lee, M.A.; Kim, H.W.; Jeong, J.Y.; Paik, H.D., and Kim, C.J. (2008). Effect of adding levels of rice bran fiber on the quality characteristics of ground pork meat product. *Korean J. Food Sci. An.*, 28: 319-326.
- Crehan, C.M.; Hughes, E.; Troy, D L. and Buckley, D.J. (2000). Effects of fat level and maltodextrin on the functional properties of frankfurters formulated with 5, 12

Utilization of amaranth as a fat replacer and germinated red beans to prepare low fat beef burgers with long shelf life storage period

- and 30% fat. *Meat Sci.*, 55: 463-469.
- Dewanto, V.; Wu, X. and Liu, R.H. (2002). Processed sweet corn has higher antioxidant activity. *J. Agric. Food Chem.*, 50(17): 4959-4964
- Duodu, K.G. (2014). Effects of processing on phenolic phytochemicals in cereals and legumes. *Cereal Foods World*, 59(2):64-70
- Dueñas, M.; Sarmiento, T.; Aguilera, Y.; Benitez, V.; Mollá, E.; Esteban, R.M. and Martín-Cabrejas, M.A. (2016). Impact of cooking and germination on phenolic composition and dietary fibre fractions in dark beans (*Phaseolus vulgaris* L.) and lentils (*Lens culinaris* L.). *Lebensmittel-Wissenschaft + Technologie*, 66: 72-78.
- Egan, H.; Kirk, R.S. and Sawyer, R. (1981). *Pearsons Chemical Analysis of Food*. 8th ed. Churchill Livingstone. Longman Group Limited U.K.
- El-Kholy, M.E. (1994). The role of Lactic acid bacteria on meat preservation. M.Sc. Thesis, Food Science and Technology Dept., Faculty of Agric., Ain Shams Univ., Egypt.
- El-Naggar, S. M. (1999). Production and Evaluation of Low-fat Meat Products. M. Sc Thesis, Food Science and Technology Dept., Faculty of Agric., Ain Shams Univ., Egypt.
- Elzerman, J.E.; Hoek, A.C.; van Boekel, M.A.J.S.; Luning, P.A. (2011). Consumer acceptance and appropriateness of meat substitutes in a meal context. *Food Qual. Prefer.*, 22: 233–240
- Fernandez-Orozco, R.; Frias, J.; Zielinski, H.; Muñoz, M.; Piskula, M.K.; Kozłowska, H. and Vidal, C. (2009). Evaluation of bioprocesses to improve the antioxidant properties of chickpeas. *Food Res. Technol.*, 42: 885-892.
- García, M.S.; Olguín, I.I.A.; Montes, J.P.C.; Ramírez, D.G.R.; Figueroa, J.S.M.; Valverde, E.F. and Rodríguez, M.R.V. (2018). Nutritional functional value and therapeutic utilization of Amaranth. *J. Anal. Pharm. Res.*, 7(5):596–600.
- Heimler, D.; Vignolini, P.; Dini, M.G. and Romani, A. (2005). Rapid tests to assess the antioxidant activity of *Phaseolus vulgaris* L dry beans. *J. Agric. Food Chem.*, 53(8): 3053-3056.
- Hoek, A.; Elzerman, J.E.; Hageman, R.; Kok, F.J.; Luning, P.A.; de Graaf, C. (2013). Are meat substitutes liked better over time? A repeated in home use test with meat substitutes or meat in meals. *Food Qual. Prefer.*, 28: 253–263.
- Horita, C.; Morgano, M.; Celeghini, R.; Pollonio, M. (2011). Physico-chemical and sensory properties of reduced-fat mortadella prepared with blends of calcium, magnesium and potassium chloride as partial substitutes for sodium chloride. *Meat Sci.*, 89: 426–433.
- Hughes, E.; Cofrades, S. and Troy, D.J. (1997). Effects of fat level, oat fiber and carrageenan on

- frankfurters formulated with 5, 12 and 30% fat. *Meat Sci.*, 45: 273-281.
- Jimenez-Colmenero, F.; Salcedo-Sandoval, L.; Bou, R.; Cofrades, S.; Herrero, A.M.; Ruiz-Capillas, C. (2015). Novel applications of oil structuring methods as a strategy to improve the fat content of meat products. *Trend Food Sci. Technol.*, 44: 177–188.
- Kumar, Y.; Yadav, D.N.; Tanbir A. and Narsaiah, K. (2015). Recent trends in the use of natural antioxidants for meat and meat products. *Food Sci. Food Safety*, 14:796-512
- Lopez-Amoros, M.L.; Hernandez, T. and Estrella, I. (2006). Effect of germination on legume phenolic compounds and their antioxidant activity. *J. Food Comp. Anal.*, 19: 277-283.
- López, D.N.; Galante, M.; Raimundo, G.; Spelzini, D.; Boeris, V. (2019). Functional properties of amaranth, quinoa and chia proteins and the biological activities of their hydrolyzates. *Food Res. Int.*, 116, 419–429.
- Lorenzo, J.M.; Cittadini, A.; Munekata, P.E. (2015). Domínguez, R. Physicochemical properties of foal meat as affected by cooking methods. *Meat Sci.*, 108: 50–54.
- Megat, R.M.R.; Noraliza, C.W.; Azrina, A. and Zulkhairi, A. (2011). Nutritional changes in germinated legumes and rice varieties. *Int. Food Res. J.*, 18: 705-713.
- Megat, R. M. R.; Azrina, A. and Norhaizan, M.E. (2016). Effect of germination on total dietary fibre and total sugar in selected legumes. *Int. Food Res. J.*, 23: 257-261.
- Melton, S.L. (1983). Methodology for following lipid oxidation in muscle foods. *Food Technol.*, 37: 105
- Mohamed, H.M.H. and Mansour, H.A. (2012). Incorporating essential oils of marjoram and rosemary in the formulation of beef patties manufactured with mechanically deboned poultry meat to improve the lipid stability and sensory attributes, *LWT. Food Science and Technology*, 45(1): 79–87
- Neville, M.; Tarrega, A.; Hewson, L.; Foster, T. (2017). Consumer-orientated development of hybrid beef burger and sausage analogues. *Food Sci. Nutr.*, 5: 852–864.
- Pathare, P.B. and Roskilly, A.P. (2016). Quality and energy evaluation in meat cooking. *Food Eng. Rev.*, 8: 435–447.
- Perales-Sánchez, J.X.; Reyes-Moreno, C.; Gómez-Favela, M.A.; Milán-Carrillo, J.; Cuevas-Rodríguez, E.O.; Valdez-Ortiz, A. and Gutiérrez-Dorado, R. (2014). Increasing the antioxidant activity and total phenolic and flavonoid contents by optimizing the germination conditions of amaranth seeds. *Plant Foods for Human Nutrition (Dordrecht, Netherlands)*, 69(3): 196-202.
- Repo-Carrasco-Valencia, R.; Peña, J.; Kallio, H.; Salminen, S. (2009). Dietary fiber and other functional components in two varieties of crude and extruded kiwicha (*Amaranthus caudatus*). *J. Cereal Sci.*, 49: 219–224.

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- Salas-López, F.; Gutiérrez-Dorado, R.; Milán-Carrillo, J.; Cuevas-Rodríguez, E.O.; Canizalez-Roman, V.A.; León-Sicairos, C.R. and Reyes-Moreno, C. (2018). Nutritional and antioxidant potential of a desert underutilized legume—tepany bean (*Phaseolus acutifolius*). Optimization of germination bioprocess. Food Sci. Technol. Campinas, 38(1): 254-262,
- SAS, (2004). Statistical Analysis System. SAS User's Statistics SAS Institute Inc. Editors, Cary, NC.
- Selani, M.M.; Shirado, G.A.N.; Margiotta, G.B.; Saldana, E.; Spada, F.P.; Piedade, S. M.S.; Contreras-Castillo, C.J. and Canniatti-Brazaca, S.G. (2016). Effects of pineapple byproduct and canola oil as fat replacers on physicochemical and sensory qualities of low-fat beef burger. Meat Sci., 112: 69- 76.
- Shams A.M. R.; Hajimahmoodi, M.; Oveisi, M.R.; Sadeghi, N.; Jannat, B.; Ranjbar, A. M.; Gholam, N. and Moridi, T. (2011). Comparative antioxidant activity and total flavonoid content of Persian pomegranate (*Punica granatum* L.) cultivars. Iran. J. Pharm. Res., 10(3): 519-524.
- Shehzad, A.; Chander, U.M.; Sharif, M.K.; Rakha, A.; Ansari, A. and Shuja, M.Z. (2015). Nutritional, functional and health promoting attributes of red kidney beans; A review, Pak. J. Food Sci., 25(4): 235-246
- Singleton, V.L.; Orthofer, R. and Lamuela-Raventós, R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods in Enzymology, 299: 152-178.
- Soriano-García, M.; Arias-Olguín, I.; Montes, J.P.C.; Ramírez, D.G.R.; Figueroa, J.S.M.; Flores-Valverde, E. and Valladares-Rodríguez, M.R. (2018). Nutritional functional value and therapeutic utilization of Amaranth. J. Anal. Pharm. Res., 7(5):596–600.
- Soltanizadeh, N. and Ghiasi-Esfahani, H. (2015). Qualitative improvement of low meat beef burger using *Aloe vera*. Meat Science, 99(1):75-80
- Spencer, M. and Guinard, J.X. (2018). The Flexitarian Flip.: Testing the modalities of flavor as sensory strategies to accomplish the shift from meat-centered to vegetable-forward mixed dishes. J. Food Sci., 83: 175–187.
- Vyncke, W. (1970). Direct determination of thiobarbituric acid value in trichloroacetic acid extracts of fish as a measure of oxidative rancidity. Fette Seifen Anstreichmittel, 72: 1084-1087.
- Warner, R.D. (2017). The Eating Quality of Meat IV Water-Holding Capacity and Juiciness, Chapter 14 p, 419, Wood head Publishing Series in Food Science, Technology and Nutrition, Lawrie's Meat Science, Eighth Edition, Edited by Fidel Toldrá , Woodhead Publishing is an imprint of Elsevier, The Officers' Mess Business Centre, Royston Road, Duxford, CB22 4QH, United Kingdom

Wu, Z.; Song, L. and Huang, D.
(2011). Food grade fungal stress on
germinating peanut seeds induced

phytoalexins and enhanced
polyphenolic antioxidants. J. Agric.
Food Chem., 59(11): 5993-6003.

استخدام الأمانس كبديل للدهون والفاصوليا الحمراء المنبئة لتحضير برجر لحم بقري قليل الدهن ولزيادة فترة التخزين

صفاء مصطفى عبد الفتاح فايد

قسم الأقتصاد المنزلي- كلية التربية النوعية-جامعة عين شمس

E mail: safaafaid73@gmail.com

المستخلص

استخدم الأمانس مع الفاصوليا الحمراء النابتة كبديل للدهون لتحضير البرجر الصحي من اللحم البقري. تم تحضير أربع خلطات من برجر اللحم البقري مع الأمانس بنسبة 2.5 و 5.0 و 7.5 و 10% كبديل للدهن مع إضافة 10.0% من الفاصوليا الحمراء المنبئة الى كل خلطة مقارنا مع برجر اللحم كعينة قياسية. تم تقدير الفينول والفلافونويد الكلية في الأمانس والفاصوليا الحمراء النابتة كما تم عمل التقييم الفيزيائي الكيميائي ، التقييم الحسي ، تحليل المظهر (TPA) ، وتقدير مؤشرات الجودة خلال فترة التخزين في برجر اللحم البقري و خلطات الأربعة.

أوضحت النتائج أن الأمانس والفاصوليا الحمراء المنبئة مصادر جيدة للبروتين والألياف الخام ومحتوى الرماد والكربوهيدرات الكلية واحتوت الفاصوليا الحمراء المنبئة على أعلى نسبة من مركبات الفينول والفلافونويد الكلية مقارنا بالأمانس. تبين أن استخدام الأمانس كبديل للدهن بنسبة 2.5 و 5.0 و 7.5 و 10.0% في برجر اللحم زاد من نسب البروتين والألياف الخام ومحتوى الرماد والكربوهيدرات الكلية إلى 20.28 و 3.75 و 2.87 و 7.67% على التوالي. كما أعطى استخدام 5% دهون مع 10% من الأمانس لتحضير خلطة برجر اللحم البقري. كما أظهرت النتائج أن (F4) أعطت أفضل قيمة معنوية لـ WHC ، اللدونة ، الانكماش ، فقد أثناء الطهي وإنتاجية الطهي (كخصائص جودة) تليها الصيغ 3 و 2 و 1 على التوالي. كما أن التقييم الحسي لبرجر اللحم البقري باضافة الفاصوليا الحمراء المنبئة له تحسن كبير في اللون والرائحة والعصارة والطعم في الخلطة F4 أكثر من الخلطات الأخرى. أشار تحليل المظهر للقوام لخلطات برجر اللحم البقري المحضرة من الأمانس كبديل للدهن بمستويات مختلفة إلى وجود فروق معنوية في جميع مؤشرات القوام بين خلطات برجر اللحم البقري المختلفة.

كما جاءت مؤشرات الجودة خلال فترة التخزين الى تحسن إجمالي النيتروجين المتطاير (TVN) وحمض الثيوباربيتوتيك (TBA) في جميع الخلطات خلال فترة التخزين والتي يمكن أن تُعزى إلى الفاصوليا الحمراء النابتة التي تحتوي على كمية عالية من إجمالي حمض الفينول ومركبات الفلافونويد التي تعمل كمضادات أكسدة طبيعية في برجر اللحم البقري .

في ضوء النتائج السابقة نوصي باستخدام الفاصوليا الحمراء المنبئة لتكون مكوناً عالي القيمة الغذائية مع مكونات اللحم خلال فترة التخزين ، وأيضاً نوصي باستخدام الأمانس كدهن بديل لاستخدامه في برجر اللحم البقري قليل الدسم كغذاء وظيفي ، بالإضافة إلى فوائده الصحية والغذائية.