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Effect of Potato Flakes as Fat Replacer on the Quality Attributes of Low-Fat Beef Patties

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Abstract: The objective of this study was to evaluate the chemical, physical and sensory characteristics of low-fat beef patties formulated by replacing different levels (25, 50, 75 and 100%) of fat with hydrated potato flakes. Uncooked and cooked beef patties formulated with potato flakes had higher ($p \le 0.05$) moisture, carbohydrate and ash content and lower ($p \le 0.05$) fat contents than that of the control. Caloric values of beef patties was lower ($p \le 0.05$) than control by between 7 and 57%, cholesterol content of patties decreased as level of potato flakes increased. Cooking yield, Water Holding Capacity (WHC) as well as moisture and fat retention were increased significantly ($p \le 0.05$) with increasing the levels of potato flakes. Overall acceptability values for beef patties formulated with potato flakes were higher ($p \le 0.05$) than the control samples. Beef patties formulated with 75% potato flakes as fat replacer had significantly ($p \le 0.05$) the highest score of overall acceptability. Hydrated potato flack could be an excellent replacement for fat in beef patties maintaining acceptable and desirable sensory properties.

Key words: Beef burger, caloric value, cholesterol, colour, flakes, sensory

INTRODUCTION

The consumption of convenience foods in the restaurants such as beef or chicken burgers is increasing now. These products should contain 20-30% of fat to give the desirable succulence and texture (Wilson *et al.*, 1981). The fat of beef burger is characterized by its high content of saturated fatty acids, and cholesterol which are associated with cardiovascular diseases (Oh *et al*., 2005), some types of cancer (Smith-Warner and Stampfer, 2007.) and obesity (Howarth *et al*., 2005; Fernandez-Gines *et al*., 2005). Due to the meat and meat products lead to certain diseases, the meat industry has been worst hit by adverse publicity. The role of fat as one of the main causes of cardiovascular disease has been well documented (Rossum *et al*., 2000). Fat, trans Fatty Acids (FAs), cholesterol and saturated FAs of meat products have also been associated with obesity and cancers (especially colon, prostate and breast) in developing countries (Slattery *et al*., 1999; Grundy, 1994). Extensive researches have been performed on fat replacement to improve quality of many products (Jimenez, 2000; Allen *et al*., 1999; Lucca and Tepper, 1994). Fat content has a basic effect on various physicochemical and sensory characteristics as flavour, moutfeel, juiciness, texture, handling, bite, heat transfer etc.) (Pearson and Gillett, 1999) and it can not be modified and/or reduced with improper less fat or another type of fat. The food industry has responded to consumer demand by offering an ever-increasing variety of low-fat meat choices. To achieve healthy meat products, it is recommended to reduce high fat content to appropriate limits and increase the levels of other substances with beneficial properties (Jo *et al*., 2003; Arihara, 2006). With the growing need for products with less fat or calorie content, it becomes necessary to develop meat products that are pertinent to consumer demand. Several studies have demonstrated possible use of different sources of starch and food hydrocolloids such as carrageenan, cellulose gum, konjac flour, guar gum , xanthan gum as fat replacements or the use of poultry meat as replacement for red meat in reduced-fat meat products (Troutt *et al*., 1992; Osburn and Keeton, 1994; Mansour and Khalil, 1997; Chin *et al*., 1998; Khalil, 2000; Mansour, 2003; Andrès *et al*., 2006; Bhattacharyya *et al*., 2007; El-Beltagy *et al*., 2007). Vegetable products added to raw or cooked meat products to improve its functional properties, minimize the product cost and improving

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Table 1: Beef patties formulation containing potato flakes

Fat replacer level [1]	Lean beef (g)	Kidney fat (g)	Potato flakes (g)[2]	Water (g)
Control	65	20	0	10
25%	65	15	5	10
50%	65	10	10	10
75%	65	5	15	10
100%	65	0	20	10

[1]: All treatments were formulated with 2 g salt, 1.5 g spices mixture, 1 g sugar, 0.2 g tripolyphosphate, 0.3 g ascorbic acid; [2]: potato flakes were rehydrated with water, potato flakes /water (1:5, w/v)

or at least maintaining nutritional and sensory qualities of end products that consumers expect (Turhan *et al*., 2007). Vegetables could also serve as fillers, binders, fat replacers and sources of dietary fiber and natural antioxidants in a meat system (Hedrick *et al*., 1994). In this respect, Starches are known to have water-binding properties (Chin *et al*., 1998; Kim and Lee, 1987; Prabhu and Sebranek, 1997). Therefore, incorporation of starch may be beneficial in low-fat, high-added-water processed meat. The potato (Solanum *tuberosum)* is an important food crop of the solanaceae family commonly grown for its starchy tuber. It is a grown in about 150 countries throughout the world. Potato is a widely used vegetable in all over the world as food item. Modern food technologists have developed variety of food products which are manufactured from potato. The popular potato products are potato chips, potato powder, potato flakes, potato granules, etc. These products are used for preparation of different variety of crispy food products (Sushant *et al*., 2010). Starch, comprising 65-80% of the dry matter content of the potato tuber, is calorically the most important nutritional component. The composition of potato starch is about 21% amylose, 75% amylopectin, 0.1% protein and 0.08% phosphorus (Friedman, 2003). Bouchon and Pyle (2004) use low-leach potato flake as the major ingredient in formulating restructured potato chips, since it is frequently used in the manufacturing of pellets or die-cutsheet snacks due to its high stickiness. In addition, it is a desirable ingredient because of the expanded texture and rapid palate clearance that it confers on finished products, mainly because the starch in potato flake is fully gelatinized (Bouchon, 2002).

The current investigation was performed to evaluate the effects of adding various levels of potato flakes as fat replacer on chemical composition, physical properties, colour and sensory attributes of beef patties.

MATERIALS AND METHODS

Site of study: This study was conducted from January2010 to January 2011 at the laboratories of special Food and Nutrition Department, Food Technology Research Institute; Agricultural Research Center, Giza, Egypt, and Department of Biochemistry, Faculty of Agriculture, Cairo University, Giza, Egypt.

Materials:

- Fresh lean beef and kidney fat were obtained from the slaughterhouse in Giza, Egypt. Lean beef samples were obtained from boneless rounds and trimmed from all subcutaneous and intermuscular fat as well as thick, visible connective tissue.
- Potato flakes (moisture content = 7%) was provided by Teba for food industry, Alexandria Borg el Arab new city part 8 bluke 11, Egypt
- Tripolyphosphate was purchased from El-Gomhoria Co. for trading Medicines, Chemical & Medical Appliances El-Sawah St., Amireya-Cairo, Egypt.
- Salt, sugar and spice mixture were obtained from local market in Giza, Egypt.

Methods:

Formulation of beef patties: The lean beef and kidney fat sources were separately ground in meat grinder (Moulinex 505, France). Fat content of the lean and fat portions were determined prior to the manufacture of beef patties. The lean beef (4% fat), kidney fat (90% fat), potato powder and water were used to formulate the beef patties (Table 1). The control patties were formulated to contain 65% lean beef and 20% kidney fat. Different levels of kidney fat (25, 50, 75 and 100%) were replaced by equal amounts of rehydrated potato flakes. Appropriate amounts of each formulation were mixed by hand, subjected to final grinding (0.5 cm plate) and processed into patties (100 g weight, 1.2 cm thick and 10 cm diameter). Patties were placed on plastic foam meat trays, wrapped with polyethylene film and kept frozen at -18°C until further analysis.

Cooking procedure: Frozen patties were cooked in a preheated (148ºC) electric oven (VEN MLW Medizinische, Greate, Berlin, Germany) which was standardized for temperature. The patties were cooked 6 min, turned over, cooked 6 min, turned again and cooked 4 min. The patties were weighed before and after cooking to determine percentage cooking yield as follows:

$$\text{Cooking yield (\%)} = (\text{Weight of cooked patty} / \text{Weight of uncooked patty}) \times 100$$

Proximate composition: Moisture, ash , crude protein and fat of uncooked and cooked patties were determined according to AOAC, 930.04, 930.05, 955.04, (2000) and Blight and Dyer (1959) methods, respectively. Carbohydrates was calculated by differences. All determinations were performed in triplicate (two determination for each replicate). Percentage of moisture and fat retention during cooking was calculated according to Khalil (2000) as follows:

Moisture retention (%) =
(Cooked weight × Moisture in cooked patties (%) / Uncooked weight × Moisture in uncooked patties (%)) × 100

Fat retention (%) =
(Cooked weight × Fat in cooked patties (%)/ Uncooked weight × Fat in uncooked patties (%) × 100

Caloric values: Total calorie (Kcal) for uncooked and cooked patties were calculated on the basis of 100 g sample using Atwater values for fat (9 Kcal/g), protein (4.02 Kcal/g) and carbohydrates (3.87 Kcal/g) as described by Mansour and Khalil (1997) .

pH and water holding capacity (WHC): The pH values of raw patties (aliquots of 10 g/ 90 mL distilled water) were determined at room temperature (~25ºC) using a digital pH meter (model MP 220, Mettler Toledo, USA). The Tsai and Ockerman (1981) press technique was used to measure the water holding capacity of raw patties. Raw patty (0.5 g) was placed on filter paper (Whatman No. 1, stored over night in saturated KCl) which was placed between tow glass sheets and pressed for 20 min by a 1 kg weight. The area of free water was measured using a compensating polar planimeter and the WHC was calculated as follows:

Free water (%) =
(Total surface area - meat film area, mm) (6.11)/ (Total moisture (mg) in meat sample) × 100

WHC (%) = 100- free water

Cholesterol assay: Cholesterol content was determined by the procedure described by Rhee *et al*. (1982) with the following slight modification for saponification: an aliquot of lipid extract (containing no more than 0.12 g lipid) was freed from the solvent and saponifid with 10 mL of 150 g/L KOH (in 900 mL/L ethanol) for 10 min in an 88ºC shaking water bath. When cooled, 5 mL of distilled water was added and unsaponifiable material was extracted once with 10 mL hexane.

Colour evaluation: The colour of raw and cooked patties was determined using a colourimeter (CR-400, Minolta, Japan) Colour values (lightness (L*), redness (a*), yellowness (b*), saturation index and hue angle were measured on surface of beef patties. The mean of five measurements was taken for each value.

Sensory evaluation: Sensory evaluation of cooked patties was performed according to Khalil (2000) by ten trained panelists who were staff of Food Technology Research Institute, Agriculture Research Center, Giza, Egypt. Cooked samples were cut into 4 equal-sized wedges and served at approximately 50C and assigned randomly to each panelist. Samples were presented in paper plates coded with 3-digit random numbers. Patties were evaluated for tenderness, juiciness, flavour intensity, connective tissue, and overall palatability. An eight-point scale was used where 1 = extremely tough, dry, devoid of ground beef flavour and abundant in connective tissue and 8 = extremely tender, juicy, intense in ground beef flavour and absence of connective tissue. Water was provided, so that panellists could cleanse their palates between samples.

Statistical analysis: Data were statistically analyzed in completely randomized design in factorial arrangement according to the procedures outlined by Gomez and Gomez (1984) and the treatments means were compared by least significant differences (L.S.D) and Duncan multiple range using SPSS program package.

RESULTS AND DISCUSSION

Proximate composition: The proximate composition of uncooked and cooked patties as affected by the addition of hydrated potato flakes instead of fat is presented in Table 2. Uncooked and cooked beef patties formulated with different levels of hydrated potato flakes had significantly ($p \leq 0.05$) higher moisture content than that of control. As fat replacement level increased moisture contents significantly($p \leq 0.05$) increased. This could be attributed to the ability of fat replacer to bind water (Mansour, 2003; Khalil, 2000; Bullock *et al*., 1995; Berry and Wergin, 1993). Cooking process caused reduction in moisture content, this reduction is attributed to the releasing of water, which was not bound tightly by proteins or hydrated potato flakes during cooking process (El-Beltagy *et al*., 2007; Mansour, 2003; Khalil, 2000). However beef patties formulated with hydrated potato

Table 2: Effect of replacing fat with various levels of potato flakes (rehydrated potato flakes) on the chemical proximate of raw and cooked beef patties[a]

Trait	Replacement level (%) 0.00	25.00	50.00	75.00	100.00	LSD
Uncooked						
Moisture	55.60^{e} ±0.98	59.57^{d} ±1.01	63.50^{c} ±0.95	67.45^{b} ±1.05	71.05^{a} ±0.92	1.77
Fat	21.90^{a}±0.56	16.12^{b}±0.49	11.79^{c}±0.52	7.51^{d}±0.20	2.89^{e}±0.54	0.76
Crude Protein	18.70^{a}±0.72	18.81 ^{a} ±0.32	18.85 ^{a} ±0.63	18.89 ^{a} ±0.25	19.12 ±0.54	0.95
Ash	02.34^{b}±0.09	02.40^{ab}±±0.05	02.45 ^{ab} ±0.12	02.51 ^{ab} ±0.08	02.62 ^{a} ±0.10	0.16
Carbohydrate	01.45^{d}±0.1	03.06^{c}±0.12	03.41^{b}±0.2	03.64^{b}±0.12	04.32^{a}±0.26	0.31
Calories (K.cal.)	277.97^{a}±2.53	229.56^{b}±5.95	195.07^{c}±1.88	157.60^{d}±2.60	119.58^{e}±1.58	6.01
Cooked						
Moisture	49.65^{e}±0.86	51.81^{d}±1.06	55.90^{c}±0.9	59.00^{b}±1.32	62.50^{a}±0.53	1.76
Fat	21.31^{a}±0.64	17.54^{b}±0.82	12.45^{c}±0.36	8.39^{d}±0.41	3.35^{e}±0.23	0.97
Crude protein	24.16^{a}±0.64	25.01^{a}±0.42	24.08^{a}±1.01	24.10^{a}±0.21	24.42^{a}±0.39	1.09
Ash	2.81^{c}±0.10	2.90^{bc}±0.12	3.11^{abc}±0.14	3.17^{b}±0.21	3.27^{a}±0.11	0.25
Carbohydrate	2.07^{e}±0.16	3.15^{d}±0.24	4.46^{c}±0.20	5.34^{b}±0.32	6.46^{a}±0.36	0.48
Calories (K.cal.)	290.9^{a}±13.34	270.6^{b}±5.29	224.8^{c}±7.51	193.04^{d}±5.40	15.31^{e}±1.22	13.92

[a]: Each value in the table is the mean of three replicates and two determinations were conducted for each replicate; Means in the same column with different letters are significantly different ($p \leq 0.005$)

Table 3: Effect of replacing fat with various levels of potato flakes (rehydrated potato flakes) on pH, Water-Holding Capacity (WHC), cooking yield, moisture and fat retention of beef patties[a]

Fat replacement treatment	pH	WHC (%)	Cooking yield (%)	Fat retention (%)	Moisture retention (%)
00.00	6.10^{a} ±0.02	60.75^{e} ±1.83	61.25^{e} ±1.56	59.6^{d} ±1.63	54.69^{d} ±0.67
25.00	6.10^{a} ±0.04	64.85^{d} ±0.95	65.45^{d} ±2.14	71.2^{c} ±1.13	56.92^{d} ±1.44
50.00	6.11^{a} ±0.05	69.80^{c} ±2.02	69.61^{c} ±1.22	73.5^{c} ±0.52	61.27^{c} ±1.82
75.00	6.11^{a} ±0.03	74.45^{b} ±1.68	73.58^{b} ±1.45	82.2^{b} ±1.84	64.36^{b} ±1.21
100.00	6.12 ^{a} ±0.067	9.90^{a} ±1.86	78.91^{a} ±1.71	91.4^{a} ±0.97	69.41^{a} ±0.85
LSD	0.077	3.11	2.99	2.37	2.30

[a]: Each value in the table is the mean of three replicates and two determinations were conducted for each replicate; [b]: Means in the same column with different letters are significantly different ($p \leq 0.005$)

flakes at any fat replacement level lost significantly ($p \leq 0.05$) less moisture during cooking than control, this could be explained as due to increased the water holding capacity of the ingredients to bind water (Mansour and Khalil, 1997). In this respect Mansour (2003) showed that patties formulated with corn starch, tapioca starch lost less moisture during cooking process than control samples. Control beef patties had higher fat content than those formulated with different levels of hydrated potato flakes.

As expected fat content of uncooked and cooked beef patties decreased significantly ($p \leq 0.05$) with increasing of potato flakes levels. When the beef patties were cooked, fat content tended to increase consistent with the level of hydrated potato flakes in low-fat beefpatties and decrease in control. Fat was more easily removed from higher fat patties because of a greater probability of encounter and expansion of fat droplets (Tornberg *et al.*, 1989). Replacement of fat with different levels of hydrated potato flakes resulted in significant ($p \leq 0.05$) increase in carbohydrates and ash of uncooked and cooked beef patties. Concerning to calories content, data showed that as fat content decreased or level of hydrated potato flakes increased, in both uncooked and cooked patties, total calories declined (Table 2). Reduction rates in calories content of uncooked patties formulated with different levels of hydrated potato flakes ranged from 17.41 to 56.98%. While, it ranged from 6.97 to 47.29% for cooked patties compared with their control. Caloric reduction positively correlated with fat reduction (El-Beltagy *et al.*, 2007; Mansour, 2003; Khalil, 2000; Mansour and Khalil, 1997; Osburn and Keeton, 1994). These results indicated that formulation patties with hydrated potato flakes considered a good method for caloric reduction which is very important for consumers restricted for their fat intake.

pH, Cooking yield, Water holding capacity (WHC) and Moisture and fat relation: The pH value of low-fat beef patties were not significantly affected ($p \geq 0.05$) by the level of fat replaces (potato flakes) (Table 3). Cooking yield was significantly ($p \leq 0.05$) improved by adding various levels of potato flakes. This improvement could be due to the increased in moisture binding by the added potato flakes. Control samples had significantly the lowest cooking yield was (61.25). This loss in control beef patties might be attributed to the excessive fat

Table 4: Effect of replacing fat with various levels of potato flakes (rehydrated potato flakes) on cholesterol content of uncooked and cooked beef patties (mg/ 100g)[a]

Trait	0.00	25.00	50.00	75.00	100.00	LSD
Uncooked sample						
Uncooked sample, wet weight basis	79[a]	70[b]	60.5[c]	45.3[d]	36.2[e]	4.44
Uncooked sample, dry weight basis	177.9[a]	173.2[ab]	165.7[b]	139.1[c]	125.04[d]	9.089
Cooked Sample						
Cooked sample, wet weight basis	102[a]	90.5[b]	73.8 [c]	55.2[d]	45.5[e]	3.364
Cooked sample, dry weight basis	202.5[a]	187.7[b]	167.3[c]	134.63[d]	121.33[e]	10.98

[a]: Each value in the table is the mean of three replicates and two determinations were conducted for each replicate; Means in the same column with different letters are significantly different ($p \leq 0.005$)

separation and water release during cooking (Mansour and Khalil, 1999; Cross *et al*., 1980; Troutt *et al*., 1992; Trius *et al*., 1994). However, beef patties formulated with 100% potato flakes, had significantly ($p \leq 0.05$) the highest cooking yield was (78.91%). Generally, as the fat replacement level increased, the cooking yield increased ($p \leq 0.05$). Starches have been shown to be effective water binds and to improve cooking yield in beef patties (Mansour, 2003; Khalil, 2000; Berry, 1997).

The Water holding capacity (WHC) was increased significantly ($p \leq 0.05$) with increasing the levels of potato flakes. Control samples had significantly ($p \leq 0.05$) the lowest value of (WHC) was 60.75% whereas the highest ($p \leq 0.05$) WHC was observed in beef patties formulated with 100% potato flakes as fat replaces (79.90%) followed by samples formulated by 75% potato flack (74.45%). This increase in water holding capacity may be due to the ability of starch in potato flack to absorb and keep more of water. The ability of potato flakes to hold moisture in meat samples has favorable implications in the final product quality by preventing excessive moisture loss in products thus avoiding undesirable crunchy and flaky texture.

Significant increases in moisture retention were noticed in beef patties formulated with various levels of potato flakes compared with control. Beef patties formulated with 100% potato flakes had significantly ($p \leq 0.05$) the highest moisture retention was 91.40% whereas control samples had the lowest retention of moisture was 54.69. Addition different levels of starch led to increase the retention of moisture in beef patties (El-Beltagy, 2007; Mansour and Khalil, 1997). Increasing the levels of potato flack (as fat replaces) resulted in significant ($p \leq 0.05$) increase in fat retention as a result of cooking. Control samples had significantly ($p \leq 0.05$) the lowest value of fat retention was 59.60% whereas the highest ($p \leq 0.05$) values of fat retention were observed in beef patties formulated with 100% potato flakes as fat replaces (91.40%) followed by samples formulated by 75% potato flakes as fat replaces (82.20%). Tornberg *et al*. (1989) concluded that fat was more easily removed from higher fat patties because of a greater probability of encounter and expansion of fat droplets. Also, they further concluded that the dense meat protein matrix of low-fat ground beef prevented fat migration. In this regard Hoelscher *et al*. (1987) and Khalil (2000) showed that at 100% fat replacement level by modified corn starch, beef patties had positive retention (130-183%) of initial fat.

Cholesterol content: Cholesterol content for uncooked and cooked beef patties are presented in Table 4. Data showed that Cholesterol content of uncooked and cooked control sample (full fat) was significantly ($p \leq 0.05$) the highest values were 177.9 and 202.5 g/kg as wet and dry weight basis respectively, this may have been caused by a high level of fat in control samples which resulted in an increase in cholesterol content. Whereas uncooked beef patties formulated with 100% potato flakes had significantly ($p \leq 0.05$) the lowest values of Cholesterol content were 125.04 and 121.33 g/kg as wet and dry weight basis, respectively. Generally, cholesterol content of uncooked and cooked beef patties decreased significantly ($p \leq 0.05$) as level of potato flakes as fat replaces increased. This decrease in cholesterol content was proportional to the increase in potato flack levels. Cholesterol content of row beef patties decreased as the amount of fat replaces increased and also decreased as the fat content decreased (Rhee and Smith, 1983; Mansour and Khalil, 1999). The cholesterol content of cooked beef patties was higher than that of uncooked beef patties when expressed either on a wet or dry weight basis. It should be pointed out that cholesterol did not increased due to cooking; cooking reduced the weight of the uncooked beef patties, making the cholesterol content g^{-1} of the cooked beef patties higher than that in an equivalent weight of uncooked beef patties (Mansour and Khalil, 1999). In this regard Kowale *et al*. (1996) reported that all burger formulations recorded significantly higher cholesterol content upon cooking. This observation may be due to loss of moisture during cooking.

Colour evaluation: Colour attributes of row and cooked low-fat beef patties are presented in (Table 5). L* values

Table 5: Effect of replacing fat with various levels of potato flakes (rehydrated potato flakes) on colour parameters of raw and cooked beef patties [a]

	Replacement level (%)					
Trait	0.00	25.00	50.00	75.00	100.00	LSD
Uncooked						
L (lightness)	32.62^{e} ±0.061	34.01^{d} ±0.02	34.49^{c} ±0.055	35.66^{b} ±0.040	36.17^{a} ±0.041	0.083
A (redness)	6.68^{a} ±0.0200	6.57^{b} ±0.020	6.41^{c} ±0.010	6.30^{d} ±0.020	5.90^{e} ±0.050	0.050
B (yellowness)	11.53^{e} ±0.015	11.64^{d} ±0.005	11.91^{c} ±0.005	12.30^{b} ±0.025	12.42^{a} ±0.020	0.030
Saturation index	13.33^{d} ±0.02	13.36^{c} ±0.015	13.52^{b} ±0.005	13.82^{a} ±0.03	13.78^{a} ±0.005	0.032
Hue angle	59.89^{e} ±0.04	60.56^{d} ±0.06	61.71^{c} ±0.037	62.87^{b} ±0.036	64.59^{a} ±0.22	0.199
Cooked						
L (lightness)	29.67^{e} ±0.040	30.72^{d} ±0.286	31.98^{c} ±0.174	32.50^{b} ±0.062	33.08^{a} ±0.070	0.285
A (redness)	4.62^{a} ±0.035	4.50^{b} ±0.025	4.05^{c} ±0.035	3.97^{d} ±0.055	3.50^{e} ±0.015	0.065
B (yellowness)	12.62^{e} ±0.020	12.83^{d} ±0.043	13.07^{c} ±0.037	13.71^{b} ±0.060	13.93^{a} ±0.077	0.094
Saturation index	13.43^{c} ±0.011	13.59^{b} ±0.040	13.68^{b} ±0.046	14.27^{a} ±0.065	14.36^{a} ±0.076	0.096
Hue angle	69.88^{e} ±0.163	70.64^{d} ±0.115	72.77^{c} ±0.106	73.85^{b} ±0.208	75.88^{a} ±0.075	0.258

[a]: Each value is the mean of five replicates; Means in the same column with different letters are significantly different ($p \leq 0.05$)

Table 6: Effect of replacing fat with various levels of potato flakes (rehydrated potato flakes) on sensory properties of cooked beef patties

	Replacement level (%)					
Sensory trait	0.00	25.00	50.00	75.00	100.00	LSD
Tenderness	5.0^{d} ±0.15	5.6^{c} ±0.10	6.3^{b} ±0.20	6.9^{a} ±0.15	7.0^{a} ±0.12	0.265
Juiciness	5.4^{d} ±0.10	6.1^{c} ±0.10	6.4^{b} ±0.05	7.2^{a} ±0.17	7.4^{a} ±0.18	0.204
Flavour intensity	6.0^{a} ±0.10	6.0^{a} ±0.05	6.1^{a} ±0.05	5.9^{a} ±0.34	4.9^{b} ±0.15	0.325
Connective tissue	6.1^{a} ±0.15	6.2^{a} ±0.05	6.2^{a} ±0.05	6.1^{a} ±0.10	6.0^{a} ±0.10	0.187
Overall acceptability	5.62^{d}	5.97^{c}	6.29^{b}	6.5^{a}	6.30^{b}	0.053

Means in the same column with different letters are significantly different ($p \leq 0.05$)

(lightness) of patties were significantly ($p \leq 0.05$) affected by hydrated potato flakes level. The lighter colour was observed for all patties formulated with hydrated potato flakes compared to control which could be attributed to the dilution of the meat pigment and in turn, increase the L* values. The low-fat patties formulated with different levels of hydrated potato flakes had lower ($p \leq 0.05$) red colours compared to the control sample. The reduction of red colour was most pronounced by replacing fat with hydrated potato flakes due to the effect of water in diluting the myoglobin concentration. On the other hand, the low-fat patties had higher ($p \leq 0.05$) yellow colours compared to control. The highest saturation values were observed in beef patties formulated with 75 and 100% of hydrated potato flakes. The increase in the saturation value could be attributed to the obvious increase in yellow colour.

Sensory evaluation: Sensory properties of beef patties are presented in Table 6. Data show that beef patties formulated with formulated with various levels of hydrated potato flakes as fat eplacer were significantly higher ($p \leq 0.05$) in tenderness than the control samples. This improvement in tenderness of low-fat beef patties is attributed to extensively hydrated starch granules, which opened the fibrous structure of patties (Berry and Wergin, 1993; Begges *et al*., 1997; Khalil, 2000; Mansour, 2003). Low-fat beef patties had higher ($p \leq 0.05$) sensory ratings for juiciness than control. Control samples (full fat) had significantly ($p \leq 0.05$) the lowest value of juiciness was 5.4, whereas, patties formulated with either 75 and 100% hydrated potato flakes as fat replacer had significantly ($p \leq 0.05$) the highest values were 7.2 and 7.4, respectively. The improved water holding capacity (Table 3) by using hydrated potato flakes could be detected through increased juiciness. The results of Khalil (2000) and Mansour (2003) indicated increased the juiciness of beef patties by using starches. No significant ($p \geq 0.05$) effects in flavour intensity were observed in beef patties formulated by potato flack and control sample except at 100% fat replacement which showed significant ($p \leq 0.05$) reduction in flavour intensity value, this reduction ay due to the presence of starchy flavour. Several studies have indicated decreased flavour intensity of beef patties by using starch or gums sources at 100% as fat replacers (Brewer *et al*., 1992; Troutt *et al*., 1992; Khalil, 2000; Mansour, 2003). The values of Connective tissue in beef patties were not significantly ($p \geq 0.05$) affected by replacing fat with potato flakes. Concerning to overall acceptability values for beef patties formulated with potato flakes were higher ($p \leq 0.05$) than the control samples. Beef patties formulated with 75% potato flakes as fat replacer had significantly ($p \leq 0.05$) the highest score of overall acceptability was 6.5.

In conclusion, the addition of hydrated potato flakes reduced the cholesterol content of beef patties by between 2.1 and 29.3% for uncooked beef patties and between 7.0 and 39.9% for cooked. In the same time the calories value was reduced by 17.4 to 47.5 and 6.9 to 46.9 for uncooked and cooked beef patties, respectively. Hydrated potato flack could be an excellent replacement for fat in beef patties maintaining acceptable and desirable sensory properties.

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