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Efficacy of Sweet Potato Powder and Added Water as Fat Replacer on the Quality Attributes of Low-fat Pork Patties

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ABSTRACT: The present study was conducted to investigate the efficacy of sweet potato powder (SPP) and water as a fat replacer in low-fat pork patties. Low-fat pork patties were developed by replacing the added fat with combinations of SPP and chilled water. Three different levels of SPP/chilled water viz. 0.5/9.5% (T-1), 1.0/9.0% (T-2), and 1.5/8.5% (T-3) were compared with a control containing 10% animal fat. The quality of low-fat pork patties was evaluated for physico-chemical (pH, emulsion stability, cooking yield, a_w), proximate, instrumental colour and textural profile, and sensory attributes. The cooking yield and emulsion stability improved ($p<0.05$) in all treatments over the control and were highest in T-2. Instrumental texture profile attributes and hardness decreased, whereas cohesiveness increased compared with control, irrespective of SPP level. Dimensional parameters (% gain in height and % decrease in diameter) were better maintained during cooking in the low-fat product than control. The sensory quality attributes juiciness, texture and overall acceptability of T-2 and T-3 were ($p<0.05$) higher than control. Results concluded that low-fat pork patties with acceptable sensory attributes, improved cooking yield and textural attributes can be successfully developed with the incorporation of a combination of 1.0% SPP and 9.0% chilled water. (**Key Words:** Pork, Low-fat Patties, Sweet Potato Powder, Physico-chemical, Sensory Attributes)

INTRODUCTION

Meat and meat products are generally recognized as a source of high biological value proteins, fat-soluble vitamins, minerals, trace elements and bioactive compounds (Mehta et al., 2013). However, simultaneously it is maligned with the fact of high calorie, high-cholesterol and low-fiber content. High dietary fat has always been correlated with the increase in incidence of cardiovascular diseases and obesity (Cierach et al., 2009; Verma and Banerjee, 2010; Biswas et al., 2011). Various health organisations has recommended the consumption of not more than 30 percent of calories from fats, and not more than 10 percent of calories should be from saturated fat (American Heart Association, 1986). Hence, the impetus in demand of low-fat meat products has directed the meat technologists to formulate strategies for the development of low-fat meat products.

However, the reduction in fat in meat products lead to increase in hardness and rubbery texture of the products (Mendoza et al., 2001), low juiciness, low cooking yield and poor nutritive value with respect to fat soluble vitamin and essential fatty acids (Giese 1992; Kumar and Sharma, 2004). Various approaches for the reduction of fat content in finished products include selection of lean carcass, trimming of excess fat from carcass and cuts, addition of water and incorporation of fat replacers/fat substitute. The active approach of use of fat replacer is considered as effective and easily adoptable in meat industries.

Various fat mimics and fat replacers are also commonly being employed during processing such as added water (Kumar and Sharma, 2004), carbohydrates and starches (Aktas and Genccelep, 2006), plant proteins (Kumar et al., 2007) and animal proteins (Serdaroglu, 2006). These resulted in improved physico-chemical and sensory properties like cooking yield, emulsion stability and overall

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acceptability. Various types of starches viz. tapioca starch (Berry, 1997), corn starch (Khalil, 2000), carrageenan (Lin and Keeton, 1998), starches (Kumar et al., 2007), hydrocolloids (Bloukas et al., 1997), barley flour (Kumar and Sharma, 2004a) and potato starch (Kumar et al., 2007) have been used to formulate reduced fat meat emulsions (Claus and Hunt, 1991; Dexter et al., 1993). These starches are widely available, economical and help in stabilizing the water in gel matrix resulting in lubricity and moisture release similar to high fat products. Low-fat pork patties developed with 2% level of barley flour (Kumar and Sharma, 2004) and low fat beef burgers with 3% tapioca starch (Desmond et al., 1998) has better cooking yield, moisture retention, higher moisture content, reduced shrinkage and better overall acceptability. Aktas and Genccelep (2006) reported that incorporation of modified starches in meat batter lead to increase in emulsion stability. Thus, the development of low-fat meat products by using fat replacer like flour not only benefits the human health but, also improve the overall acceptability of products.

Pork meat is one of popular meat world-wide; it contributes 37% of meat consumed in the world (McGlone, 2013). However, processed pork products have high-fat and high-calories and traditionally pork patties considered to have 15% to 25% fat (Picouet et al., 2007). As per the definition, the low-fat meat product should have less than 10% fat, whereas ultra-low-fat products should have <5% fat (Keeton, 1994). The ideal meat additive should have low-cost and should be a source of the nutrients, which are deficient in meat. Sweet potato, which is rich in complex carbohydrates, dietary fibres, protein, minerals and vitamins such as vitamin C and beta carotene and contains 77% water, 20% carbohydrates, 3% fibre, 1.6%, protein, 14,187 IU vitamin A and 8,509 μg beta carotene (USDA, 2003). In addition it has inherent properties of water retention. In view of above discussion, the present study was conducted with an objective to optimize the level of incorporation of sweet potato powder (SPP) as fat replacer along with added chilled water in low-fat pork patties on the basis of physico-chemical, processing and sensory quality attributes.

MATERIALS AND METHODS

Three pigs of slaughter weight of 70 to 80 kg of Large White Yorkshire breed were procured from instructional livestock farm GADVASU, Ludhiana. The pigs were slaughtered in departmental experimental slaughter house considering animal welfare aspects. The carcass were hot deboned and meat was chilled over-night in refrigerator and packed in low density polyethylene bags and stored under frozen condition (–18°C) till further use. Sweet potato tubers were procured from local market. After removal of rind and washing with water, the tubers were sliced into thin cuts of circular shape and heated in microwave oven at low frequency (914 Hz) for 12 minutes. It was further dried in hot-air oven to reduce the moisture level to 8% or below. The dried sweet potato chunks were ground in a grinder (Inalsa) to make fine powder. All other ingredients including spice and condiments (onion, garlic, ginger; 3:1:1) mixture used in the study were procured from the local market.

Preparation of patties

Pork patties were prepared using the formulation as per Table 1. Emulsions were prepared in four groups for control (C) and treatments viz. T1, T2, and T3 with varying combinations of SPP/chilled water as 0.5/9.5%, 1.0/9.0%, and 1.5/8.5%, respectively. The deboned frozen pork was cut into small chunks and minced twice in a meat mincer (Mado Eskimo Mew-714, Mado, Germany) through 6 mm and 4 mm plates. Then, emulation was prepared as per the detailed formulation (Table 1) in a bowl chopper (Model: TC11, Scharfen, Germany). The emulsions obtained were moulded in a mould of dimensions of (75×15 mm). The patties were cooked in pre heated hot air oven at 180±5°C for 25 min. with intermittent turning upside down to have better colour and appearance to attain the internal core temperature of about 72°C. The cooked patties were tempered to room temperature and samples were collected for various analysis.

Proximate analysis

Moisture (oven drying), protein (Kjeldahl distillation), fat (Soxhlet method) and ash (muffle furnace) content of both control and low-fat pork patties were determined by

Table 1. Formulation for preparation of low-fat pork patties using sweet potato powder (SPP)/water[1]

Ingredients (% w/w)	Control[2]	Treatment[3]		
		T1	T2	T3
Pork meat	72.32	72.32	72.32	72.32
Pork fat	10.0	0.0	0.0	0.0
Sweet potato powder	0.0	0.5	1.0	1.5
Chilled water	0.0	9.50	9.00	8.50
Condiments	3.0	3.0	3.0	3.0
Salt	1.5	1.5	1.5	1.5
Sodium tetra pyro-phosphate	0.30	0.30	0.30	0.30
Refined wheat flour	3.0	3.0	3.0	3.0
Spices mix.	2.0	2.0	2.0	2.0
Sugar	0.3	0.3	0.3	0.3
Ascorbic acid	0.07	0.07	0.07	0.07
Hydrated Texturized soya protein (1:3)	7.5	7.5	7.5	7.5

[1] Sodium nitrite 100 ppm in all treatment and control.
[2] Control = pork patties without SPP and chilled water.
[3] T1 = pork patties with SPP 0.5% and chilled water 9.5%; T2 = pork patties with SPP 1.0% and chilled water 9.0%; T3 = pork patties with SPP 1.5% and chilled water 8.5%.

using standard procedure described by AOAC (2000).

Physico-chemical analysis

Emulsion stability was determined using the method described by Townsend et al. (1968) with some modifications. About 25 g emulsion samples were placed in polyethylene bags, sealed and heated at 80°C in a thermostatically controlled water bath for 20 min. After draining out the exudate, the cooked mass was cooled, weighed and the yield was expressed as percent emulsion stability.

Cooking yield was determined by measuring the difference in the sample weight before and after cooking (Murphy et al., 1975).

$$\text{Cooking yield (\%)} = \frac{\text{weight of cooked pork patties}}{\text{weight of uncooked pork patties}} \times 100$$

The dimensional parameters of the pork patties were measured by vernier calliper at three different places. The percent gain in height and decrease in diameter percent were determined according to equations of Kumar and Sharma (2004).

Reduction in pork patty diameter (%)
= [(uncooked pork patty diameter
– cooked pork patty diameter)
/ uncooked pork patty diameter]×100

Gain in height (%)
= [(cooked pork patty height
– uncooked pork patty height)
/ uncooked pork patty height]×100

The moisture and fat retention value represents the amount of moisture or fat retained in the cooked product per 100 g of raw sample (Kumar and Sharma, 2004).

Moisture retention (%)
= [(% yield)×(% moisture in pork patty)]/100

Fat retention (%)
= {[(cooked wt.)×(% fat in cooked pork patty)]
/[(uncooked wt.)×(% fat in uncooked pork patty)]}
×100

Estimates of total calories content were calculated on the basis of 100 g portion using Atwater values for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (4 kcal/g). An analysis of the percentage of carbohydrate in the samples was determined by numerically formulae (carbohydrate = 100 – moisture + protien + fat + ash).

The pH of pork patties was measured as per the procedure of Trout et al. (1992) using combined glass electrode of Elico pH meter (Model LI 127, Elico Limited Hyderabad, India). Water activity was determined using potable digital water activity meter (Rotronix HYGRO Palm AW1 Set, Rotronix Instrument (UK) Ltd., West Sussex, UK). Briefly, finely ground pork patties were filled up (80%) in a moisture free sample cup. The sample cup was placed into the sample holder, and then sensor was placed on it for five min for a_w value. Duplicate reading was performed for each sample.

Colour profile analysis

Colour profile was measured using Lovibond Tintometer (Model: RT-300, The Tintometer Limited, Amesbury, UK) set at 2° of cool white light (D_{65}) and known as '*L*', *a*, and *b* values. '*L*' value denotes (brightness 100) or lightness (0), *a* (+redness/–greenness), *b* (+yellowness/–blueness) values. The instrument was calibrated using a light trap (black hole) and white tile provided with the instrument. Then the above colour parameters were selected. The instrument was directly put on the surface of pork patties at different points.

Texture profile analysis

Texture profile analysis of pork patties were performed using a Texture Analyser (TMS-PRO, Food Technology Corporation, Maries Road, Suite 120 Sterling, VA, USA) following the procedures of Bourne (1978). The samples were cut into uniform cube size of 1.0×1.0×1.0 cm. and subjected to double compression cycle to 50% of their original height using pre-test speed of 5 mm/s, test speed of 1 mm/s, post-test speed of 1 mm/s, distance 10 mm and exposure time 3s. Texture profile parameters such as hardness, adhesiveness, cohesiveness, springiness chewiness and gumminess were estimated using software (TMS-Pro, USA).

Sensory evaluation

A seven member trained panel comprising of scientists and postgraduate students evaluated the samples for the attributes viz. appearance and colour, flavour, tenderness, juiciness and overall acceptability using 8 point descriptive scale (Keeton, 1983), where 8 = extremely desirable and 1 = extremely undesirable. Three sittings (n = 21) were conducted for each replicate. The panelists carried out evaluation in a room free of noise and odours and suitably illuminated with natural light. Coded samples at a temperature of 37°C were presented to the panelists. The potable water was provided in between samples to cleanse the mouth palate.

Statistical analysis

The data obtained from various trials under each

Table 2. Effect of incorporation of sweet potato powder (SPP)/water on emulsion parameters of low-fat pork patties

Parameters	Control[1]	Treatment[2]		
		T1	T2	T3
Emulsion				
pH of emulsion	6.10^{b} ±0.01	6.15^{a} ±0.01	6.16^{a} ±0.01	6.17^{a} ±0.01
Emulsion stability (%)	89.87^{b} ±0.81	94.59^{a} ±0.40	95.84^{a} ±0.40	94.29^{a} ±0.28
Moisture in emulsion (%)	59.03^{c} ±0.20	67.25^{b} ±0.30	68.30^{a} ±0.19	67.86^{ab} ±0.41
Fat in emulsion (%)	13.54^{a} ±0.13	6.03^{b} ±0.07	5.94^{b} ±0.01	5.86^{b} ±0.05

[1] Control = pork patties without SPP and chilled water.
[2] T1 = pork patties with SPP 0.5% and chilled water 9.5%; T2 = pork patties with SPP 1.0% and chilled water 9.0%; T3 = pork patties with SPP 1.5% and chilled water 8.5%.
Means bearing different superscripts in a row differ ($p<0.05$) n = 6.

experiment was subjected to statistical analysis (Snedecor and Cochran, 1989) for one way analysis of variance using completely randomized design and Duncan's multiple range test to compare the means by using SPSS-16 (SPSS Inc., Chicago, IL,USA). Each experiment was replicated thrice and the samples were analysed in duplicate leading to total observation 6 (n = 6), whereas for sensory attributes n = 21. The statistical significance was expressed at ($p<0.05$).

RESULTS AND DISCUSSION

Physico-chemical quality

The pH value of treated emulsion was comparable however, it was ($p<0.05$) higher than control (Table 2). It is attributed to innate pH (6.56) of the SPP and water incorporated in meat emulsion. Similar observations were recorded by Tay (2002) while incorporating in cassava flour in frankfurters.

Emulsion stability was ($p<0.05$) higher in treated products irrespective of level of incorporation of SPP and water than control (Table 2). This might be due to the formation of three dimensional solid lattice structure of protein- starch gel in the sweet potato incorporated pork patties as compared to control (Carballo et al., 1996). These results can also be correlated with higher pH of the emulsion, leading to higher water holding capacity. Similar findings were also reported by Verma et al. (2008) in buffalo meat patties and Kumar and Tanwar (2011) in chicken nuggets. The moisture percent in emulsion was found to be higher and fat percent found to be lower than control due to differences in formulation.

The pH of cooked low-fat pork patties was ($p<0.05$) higher than control. Among treatments, the pH of the T2 was ($p<0.05$) than T1 and T3. Further, it was observed that cooked pH was higher than raw pH in both the treated and control groups. It can be attributable to concentration of components in the cooked product and deamination of proteins during cooking. The findings are in accordance with Singh et al. (2010) and Verma et al. (2012).

The a_w of the treated product was greater than control and it followed an increasing ($p<0.05$) trend with the increase in level of incorporation of SPP. It might be due to the combined effect added water and water binding properties of SPP, leading to higher moisture retention in the cooked product.

Cooking yield increased ($p<0.05$) for treatment groups as compared to control and higher ($p<0.05$) cooking yield was recorded for T2 (85.9±0.46) as compared to T1 and T3. The increase in the cooking yield might be due to water holding capacity and water retention properties attributed to SPP. Khalil (2000) also reported improved cooking yield upon replacement of fat with starch and water combinations in cooked patties. The cooking loss was significantly higher in control than treatments and lower ($p<0.05$) cooking loss values was recorded in the T2 as compared to the other treatment. This might be due the formation of the stable protein-starch solid lattice structure that prevents the loss of the water and fat from the cooked patties (Goll et al., 1992). These results are in conformity with our results of moisture and fat retention. Similar findings were reported by the Kumar et al. (2007) in low-fat ground pork patties.

An overall ($p<0.05$) increase in moisture content of low-fat pork patties incorporated with SPP and water as compared to control was observed. The moisture content of the treated group also showed significant difference with an increasing trend from T1 to T3. This might be due to higher addition of the water in treatment group, hygroscopic nature of the SPP and higher pH of the product. Similar findings were also reported by many researchers on addition of different fat replacer in meat products (Troutt et al., 1992; Mansour and Khalil, 1999; Troy et al., 1999; Kumar and Sharma, 2004).

Protein content decreased with the increase in the level of incorporation of SPP and water in pork patties and significantly higher protein content was observed in control (21.67) and T1 (21.46) than T2 (19.89) and T3 (19.12). This might be due to the lower protein content of SPP than meat. The decrease in protein content might be due to higher moisture in treatment groups. Fat content of the treatment groups decreased ($p<0.05$) as compared to control but did not differ significantly among treatments. This might be due to the replacement of pork fat with the combination of chilled water and SPP in the treatments. The fat percent in final products in treatment groups was less than 10%, which is in accordance with the prescribed limit/standard for low-fat meat products (Keeton, 1994). The estimated carbohydrates content in the low-fat pork patties was higher than control. It was attributed to higher starch content in added SPP in low-fat pork patties. The calorie content was lower ($p<0.05$) in treated product than control and a decreasing ($p<0.05$) trend was also observed among treatments with the increasing level of SPP. The calories content decreased 22% to 26% in low fat products than control. It was attributed to lower fat content in treated group replaced with water and SPP. This might be helpful for the consumers who need protein rich diet having low calorific value. Moisture protein ratio was higher ($p<0.05$) in treated products than control and it increased ($p<0.05$) with the increase in the level of incorporation of SPP. The results were also supported by higher cooking yield in treatment group as compared to the control. Percent ash content increased ($p<0.05$) with the addition of increasing levels of SPP. This might be due to high mineral content in the SPP.

The dimensional parameters viz. decrease in diameter, increase in height and shrinkage percent ($p<0.05$) varied with the level of incorporation of fat replacer. The shrinkage (decrease in diameter) % decreased ($p<0.05$) in T2 and T3 as compared to control and T1. The percent gain in height increased ($p<0.05$) in low-fat patties as compared to control and an increasing ($p<0.05$) trend was also observed with the increase in level of incorporation of SPP in the products. The dimensional parameters were better maintained in the low-fat pork patties incorporated with 1.5 percent SPP and 8.5 percent chilled water (T-3) as than all other products including control. This might be due to higher fiber content in SPP attributed to higher water holding capacity, better moisture retention, increased cooking yield. Similar results were reported by Nisar et al. (2009) in low-fat buffalo meat patties and Berry (1997) in low-fat beef patties.

The moisture retention increased ($p<0.05$) in low-fat patties as compared to control and an increasing ($p<0.05$) trend was also observed with the increase in level of incorporation of SPP in the products. Garcia et al. (2002) also reported the higher moisture retention in meat products on addition of starch. The fat retention was recorded an 84.81% in control, whereas it varied between 85.75% to 91.12% among the treatments with a higher value ($p<0.05$) for T2. It can be correlated with higher emulsion stability in treated product than control. The fat globules are embedded in gel structure of protein lattice hence leaching out of fat during cooking of the product is minimum. Whereas there was higher leakage attributed to melting of the fat globules during cooking in the control. While in case of the low-fat pork meat patties it got trapped in the dense matrix of the protein-starch network. This result was also supported by the higher cooking yield of the treated groups than control. Similar findings were reported by the Hoelscher et al. (1987) and Khalil (2000) in beef patties.

Instrumental colour profiles

Increasing levels of SPP increased the L* and a* value as compared to control. Redness (a*) increased in treated product, this result was also supported by the sensory attributes that indicates increased in the appearance and colour and overall acceptability of the treated patties than control. It could be due to the non-enzymatic browning reaction between the sugars (CHO group) present in the SPP and meat protein (NH2 group) during cooking (Dutra et al., 2012). Yellowness (b* values) differ ($p<0.05$) in treatments as compared to control, however as compared to T1, a higher ($p<0.05$) values were observed in T_2 but the values for T2 and T3 were comparable. The yellow colour of SPP presumably increased b* values of all the treatments. Lee and Ahn (2005) reported that the incorporation of plum extract puree increased a* and b*, while decreased in L* of turkey breast rolls due to the colour of plum puree extract. However, incorporation of chick hull flour (CHF) in low salt (LS), low fat (LF) nuggets (LS/LF/CHF) decreased ($p<0.01$) the redness and yellowness values (Verma et al., 2012).

Texture profile analysis

Hardness of low-fat pork patties decreased proportionately with the increasing levels of SPP. Hardness values was lower ($p<0.05$) in T_3 (10.25 N/cm^2) as compared to control and other treatments. Reduction in hardness value might be due to moisture retention properties of the SPP and formation of weaker three dimensional network of protein matrix attributed to incorporation of SPP. Several authors have reported that the dilution effect of non-meat ingredients in meat protein systems primarily accounted for softer texture (Comer and Dempster, 1981; Tsai et al., 1998; Kotwaliwale et al., 2007). The springiness and resilience value did not differ ($p>0.05$) among low-fat pork patties and control. Similar finding were also reported by the Choi et al. (2012) in low-fat pork patties. A ($p<0.05$) lower value for stringiness was observed in low fat pork patties as compared to control, however the stringiness values were comparable among treatments. The cooking process of low-fat pork patties added with SPP and chilled water might have lead to some modifications in their structure, which would have decreased the stringiness. The cohesiveness and gumminess value increased with increase in level of incorporation of SPP and among treatments the highest level of SPP resulted in a ($p<0.05$) higher cohesiveness and gumminess value as compared to other treatment as well as control. The chewiness value were ($p<0.05$) higher for

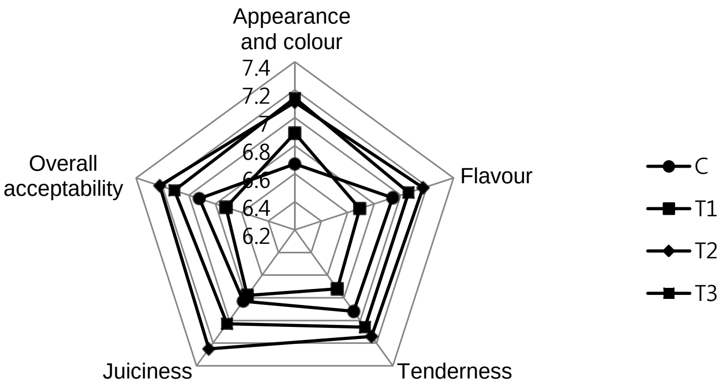

Figure 1. Sensory attributes of low-fat pork patties. C (Control) = pork patties without sweet potato powder (SPP) and chilled water; T1 = pork patties with SPP 0.5% and chilled water 9.5%; T2 = pork patties with SPP 1.0% and chilled water 9.0%; T3 = Pork patties with SPP 1.5% and chilled water 8.5%.

treatments compared to control and increased with increase in level of incorporation of SPP with a ($p<0.05$) higher values for T3 as compared to other treatments.

Sensory quality

Mean sensory scores for the control and low-fat pork patties with different levels of SPP and water are given in Figure 1. The colour and appearance score of the T3 was found to be the highest among all treatment and control but comparable to T2. The flavour scores were comparable for low-fat pork patties except T1 with control, whereas highest in T2 (7.17). Hughes et al. (1998) reported increased flavour intensity of frankfurters incorporated with starch. The juiciness scores were highest for the 1.0 percent SPP (T2) amongst the low-fat pork patties. This could be due to the greater moisture retention and water binding properties of SPP as observed/recorded in Table 3. By the inclusion of SPP, the tenderness was found to be improved ($p<0.05$) in T2 and T3 as compared to control and T1. These results indicated that incorporation of SPP enhanced tenderness of the patties and this was also accordance with decreased in hardness values as observed in Table 4. Giese (1992) reported that starches have been used as binders to maintain juiciness and tenderness in low-fat meat products. The low-fat pork patties incorporated with combination of 1.0% SPP and 9.0% water (T2) was rated highest for overall acceptability by the sensory panellists. The result showed overall acceptability score of the T2 differ ($p<0.05$) as

Table 3. Effect of incorporation of sweet potato powder (SPP)/water on the physicochemical and processing parameters of low-fat pork patties

Parameters	Control[1]	Treatment[2]		
		T1	T2	T3
Product				
pH	$6.25^{c}\pm0.01$	$6.33^{b}\pm0.01$	$6.37^{a}\pm0.01$	$6.35^{ab}\pm0.01$
Water activity (a_W)	$0.85^{d}\pm0.006$	$0.87^{c}\pm0.005$	$0.89^{b}\pm0.002$	$0.91^{a}\pm0.008$
Moisture (%)	$57.42^{d}\pm0.41$	$62.16^{c}\pm0.40$	$63.87^{b}\pm0.31$	$65.18^{a}\pm0.58$
Protein (%)	$21.67^{a}\pm0.21$	$21.46^{a}\pm0.20$	$19.89^{b}\pm0.30$	$19.12^{b}\pm0.42$
Fat (%)	$14.57^{a}\pm0.16$	$6.85^{b}\pm0.17$	$6.63^{b}\pm0.19$	$6.41^{b}\pm0.10$
Ash (%)	$3.05^{b}\pm0.09$	$3.13^{ab}\pm0.09$	$3.20^{ab}\pm0.03$	$3.30^{a}\pm0.03$
Carbohydrate (%)	3.30 ± 0.59	3.73 ± 0.48	3.75 ± 0.71	3.86 ± 1.01
Energy (Kcal)	$231.38^{a}\pm0.87$	$186.82^{b}\pm0.84$	$178.61^{c}\pm0.84$	$169.17^{d}\pm2.16$
Moisture protein ratio (M:P ratio)	$2.65^{d}\pm0.02$	$2.90^{c}\pm0.03$	$3.21^{b}\pm0.04$	$3.41^{a}\pm0.05$
Cooking yield (%)	$78.81^{c}\pm0.51$	$82.18^{b}\pm0.67$	$85.59^{a}\pm0.46$	$81.39^{b}\pm0.85$
Cooking loss (%)	$21.19^{a}\pm0.51$	$17.82^{b}\pm0.67$	$14.42^{c}\pm0.46$	$18.62^{b}\pm0.85$
Decrease in diameter (%)	$13.79^{a}\pm0.92$	$12.84^{a}\pm0.57$	$9.90^{b}\pm0.42$	$8.91^{b}\pm0.42$
Gain in height (%)	$22.91^{d}\pm1.21$	$31.25^{c}\pm0.43$	$35.12^{b}\pm0.88$	$38.96^{a}\pm1.05$
Moisture retention (%)	$45.25^{d}\pm0.32$	$51.08^{c}\pm0.43$	$54.65^{b}\pm0.28$	$53.05^{a}\pm0.81$
Fat retention (%)	$84.81^{b}\pm1.16$	$85.77^{b}\pm2.02$	$91.12^{a}\pm1.32$	$85.75^{b}\pm1.16$

[1] Control = pork patties without SPP and chilled water.
[2] T1 = pork patties with SPP 0.5% and chilled water 9.5%; T2 = pork patties with SPP 1.0% and chilled water 9.0%; T3 = pork patties with SPP 1.5% and chilled water 8.5%.
Means bearing different superscripts in a row differ ($p<0.05$) n = 6.

Table 4. Instrumental colour and texture profile of the low-fat pork patties

Treatment	Control[1]	Treatment[2]		
		T1	T2	T3
Instrumental colour profile				
Lightness (L*)	45.48±0.54	46.53±0.72	46.77±0.73	46.30±0.97
Redness (a*)	11.49±0.62	11.36±0.50	12.81±0.42	12.92±0.58
Yellowness (b*)	13.61[c]±0.36	18.77[b]±0.62	20.97[a]±0.62	20.12[ab]±0.54
Texture profile				
Hardness N/cm^2	13.74[a]±0.25	13.66[a]±0.61	12.69[a]±0.31	10.25[b]±0.53
Springiness (cm)	26.73±0.98	27.34±0.12	27.46±0.11	26.83±0.50
Stringiness	26.75[a]±1.40	21.14[b]±0.61	20.36[b]±0.40	19.67[b]±0.60
Cohesiveness (ratio)	0.83[b]±0.04	0.96[ab]±0.04	0.97[b]±0.05	1.08[a]±0.05
Chewiness (N/cm)	277.36[c]±14.75	406.10[b]±21.61	442.25[b]±11.76	510.49[a]±16.38
Gumminess N/cm^2	10.84[b]±1.04	11.89[b]±0.51	12.81[b]±0.50	17.73[a]±0.46
Resilience (N)	0.94±0.08	0.87±0.03	0.86±0.03	0.87±0.02

SPP, sweet potato powder.
[1] C = pork patties without SPP and chilled water.
[2] T1 = Pork patties with SPP 0.5% and chilled water 9.5%; T2 = pork patties with SPP 1.0% and chilled water 9.0%; T3 = pork patties with SPP 1.5% and chilled water 8.5%.
Means bearing different superscripts in a row differ ($p<0.05$) n = 6.

compared to C and T1 whereas, comparable to T3. Lyons et al. (1999) reported on addition of starch had a positive effect on the sensory attributes of low-fat sausages.

CONCLUSIONS

Results concluded that the physical and sensory characteristic problems associated with low-fat pork patties could be reduced by replacing fat with SPP and water combination. Low-fat pork patties developed with the incorporation of 1% SPP and 9% water combination has higher moisture content, cooking yield, better dimensional characteristics with a reduction in the calorie values by 23%. Textural attributes including hardness and springiness were comparable with high-fat product. Hence, the developed product can be marketed as a functional meat product with improved processing and sensory characteristics.

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