Quality Attributes of Functional Pork Patties Incorporated with Kinnow (*Citrus reticulata*) Pomace Powder

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ABSTRACT

The objective of the study was to develop functional pork patties incorporated with dried kinnow pomace (DKP) powder as a fiber source. Four different levels of DKP powder viz. 0% (Control), 2% (T-1), 4% (T-2) and 6% (T-3) were used by the replacement of lean meat in the pre-standardized formulation. The cooked product was analyzed for various physico-chemical properties, proximate composition, instrumental texture and color profile, and sensory quality parameters. A significant improvement in quality attributes and functionality was observed in pork patties with addition of DKP powder. Cooking yield and emulsion stability significantly ($P<0.05$) increased with the incorporation of DKP powder and was reported highest for T-3. Fiber content increased amongst treated products. Color profile varies significantly, however, textural attributes improved positively with the incorporation of DKP powder. At 4% level of inclusion, sensory analysts rated the treated products in 'very good' quality. It can be concluded that functional fiber enriched pork patties with improved cooking yield, emulsion stability, textural profile and sensory quality can be successfully developed with incorporation of 4% Dried Kinnow Pomace powder.

Keywords: Dried Kinnow Pomace (DKP) powder, functional, pork patties, fiber, textural profile

Meat is considered as an integral part of the balanced diet. Around the globe, pork is the most commonly consumed meat accounting for about 38% of meat consumption followed by chicken and beef (McGlone, 2013). With rapid urbanization and globalization, an increasing trend in consumption of ready-to-eat, ready-to cook, and packaged processed products has been observed, particularly in meat industry. These products are concentered source of energy, protein and minerals, but inherently deficient in dietary fiber (Mehta *et al*., 2019). A number of studies have established strong link between consumption of fiber and human health. It has been proclaimed that daily dietary fibre intake helps in prevention of many nutritional disorders like gut related problems, cardiovascular diseases, type 2 diabetes, certain types of cancers and obesity. Dietary fibers can be classified in a number of ways like source, structure or solubility, however, most acceptable classification is on basis of enzymatic fermentation behavior in human

GIT and on that basis, it can be categorized as soluble or non-soluble dietary fiber (Esposito *et al.,* 2005). Apart from potential health benefits, dietary fiber has great technological functionality in food systems, particularly meat. Various physicochemical properties viz. water holding capacity(WHC), emulsion stability, cooking yield etc. are affected by addition of fiber source, which in turn affects processing characteristics of meat (Mehta *et al.,* 2019). As per recommendations of dietary associations, for adults, the acceptable intakes of dietary fiber are 28–36 g/day and out of that, 70–80% must be insoluble fiber.

Kinnow mandarins (*Citrus reticulata*) belong to the citrus family of fruits and are extensively grown in North India. Processing of kinnow into various products leads to generation of processing waste, particularly, kinnow peel and pomace that account for about 50% of citrus mass (Sharma *et al.,* 2013). Citrus fruit wastes

are known to contain a number of functional bioactive components such as phenolics, flavonoids like naringin, hesperdin, etc., along with dietary fiber (Tayengwa and Mapiye, 2018; Kawaii *et al.,* 1999). Due to their potential antioxidant, nutritional and therapeutic value, these can be used as functional ingredient in various food systems (Zia-ur-Rehman, 2006). Dietary fiber from cereal sources are frequently used, however, fruit fibers are considered to be of superior quality owing to balanced proportion of soluble and insoluble fractions (Garau *et al.,* 2007). Peels and pomace have been frequently used as a raw material for pectin extraction (Mamma *et al.*, 2008), however, their direct application in processed foods is still an area of research. Their potential application as dietary fiber sources in meat products may result in their utilization as a functional non meat ingredient with multiple applications such as improvement in water holding capacity and emulsion stability, modification of textural and rheological features along with reduction in total energy load of meat products (Verma *et al.,* 2016). Further, dehydration of pomace will result in an increase in total fibre content (Yadav *et al.,* 2018). Therefore, the present study was planned with an aim to develop fiber enriched functional Pork meat patties using dried kinnow pomace powder in the formulation.

MATERIALS AND METHODS

Sources of materials

Castrated 8-10 months old male pigs of Large White Yorkshire breed weighing around 90-100 Kg were purchased from Piggery Farm, Department of Livestock Production Management, GADVASU, Ludhiana. The pigs were scientifically slaughtered as per standard procedure in the experimental slaughter house of GADVASU. The dressed carcasses were brought to the laboratory immediately and chilled at 4±1ºC for 12-18 h and were deboned manually. The deboned pork was stored in low density polyethylene bags at -18ºC till further use. Pork fat was collected separately, packaged in LDPE bags and frozen. The frozen meat was thawed at refrigeration temperature before use. Citrus fruits (kinnow) were procured from local market and after extraction of juice, the pomace so obtained was debittered as per procedure of Singla *et al.* (2019). It was then subjected to drying

at 55±2ºC for 48 hours using industrial tray drier and the dried residue was pulverized to form powder in food processor (Inalsa, Max Plus) and stored in PET (polyethylene terephthalate) jars till further use. All other ingredients used in study including spice and condiment mixtures were procured locally.

Methodology for Preparation of functional pork patties

Frozen pork was thawed overnight in a refrigerator (4±1ºC), cut into small chunks and minced twice through meat mincer (MADO Eskimo Mew 714, Spain). Four groups of pork emulsions viz. control (C) and treatments (T-1, T-2 and T-3) with varying levels of DKP powder replacing lean pork at 0%, 2%, 4% and 6% respectively, were prepared (Table 1). The levels of incorporation were selected after several preliminary trials and upon perusal of relevant literature. For preparation of pork emulsion, minced meat and salt were mixed in a bowl chopper (Model: TC11, Scharfen, Germany) for 30 seconds and ice flakes, sodium nitrite and sodium tetra pyrophosphate (STPP) were added followed by further chopping for 1.5 min. Thereafter, refined soyabean oil was added and chopping for 1.5 minutes was done. The remaining ingredients as per Table 1 were added and chopped for 1 min to obtain four different batches of pork emulsion. About 50 g raw pork emulsion was filled compactly in aluminium moulds (80×20 mm) to shape it in form of patties and cooking was done in pre-heated hot air oven at 180±2°C for 20 min with one turning after 15 min for efficient cooking and colour development. Cooked patties were tempered at room temperature and analyzed for various quality attributes.

Physico-chemical parameters and proximate analysis

10 g of cooked pork patties was blended with 100 ml of deionized water and pH was determined by using digital pH meter equipped with a combined glass electrode (SAB 5000, LABINDIA, Mumbai). Water activity was recorded using digital using portable digital water activity meter at 25°C (Rotronix HYGRO Palm AW1 Set, Rotronix Instrument (UK) Ltd., West Sussex and UK). Emulsion stability of pork emulsion was assessed as per Townsend *et al*. (1968) by keeping 25 g meat emulsion in low density polyethylene (LDPE) bags in a thermostatically controlled stirred water bath (Equitron, Model: 8414,

Medica Instrument Co., Mumbai, India) at 80±1ºC for 20 min followed by draining off fluid and measuring weight of sample. Cooking yield of developed product was calculated by measuring the change in patties weight before and after cooking:

(weight of cooked pork patties/weight of uncooked pork patties) *100

Various proximate parameters such as moisture percent (by oven drying), fat percent by soxhlet method (Socs Plus SCS-6-AS, Pelican Industries, Chennai, India), protein percent by kjeldahl distillation (Kel Plus-KES 12L, Pelican Industries, Chennai, India), crude fibre (Fibra Plus, FES-6, F-09014, Pelican Industries, Chennai, India) and ash percent (by muffle furnace) of pork patties were determined as per method described by Association of Official Analytical Chemists (AOAC, 1995).

Table 1: Formulation of functional pork patties using DKPP as fiber source

Ingredients %	Control	T-1	T-2	T-3
Lean meat	69.5	67.5	65.5	63.5
Refined Oil	7.5	7.5	7.5	7.5
Spices	2.5	2.5	2.5	2.5
Salt	1.5	1.5	1.5	1.5
Condiments	3.0	3.0	3.0	3.0
Chilled water	7.5	7.5	7.5	7.5
Refined Wheat flour (Maida)	3.0	3.0	3.0	3.0
TSPP	0.3	0.3	0.3	0.3
Sugar	0.2	0.2	0.2	0.2
Egg Albumen	5.0	5.0	5.0	5.0
Sodium Nitrite (ppm)	120	120	120	120
DKP Powder	—	2	4	6
Total (%)	**100**	**100**	**100**	**100**

T-1: 2%; T-2: 4%; T-3: 6% dried kinnow pomace powder

Texture profile analysis

Texture profile analysis (TPA) of pork patties was carried out by using texture analyzer (TMS- PRO, Food Technology Corporation, USA) as per procedure described by Bourne (1978). Samples of size 1.0 cm × 1.0 cm × 1.0 cm were subjected to double compression with a load cell of 100 N using pre-test speed of 30mm/sec, Post-test speed of 100 mm/sec, distance of 10 m and exposure time of 3 seconds. Various textural parameters such as hardness, gumminess, stringiness, springiness, resilience, chewiness, and cohesiveness were estimated using in-built software.

Instrumental color profile

Color profile of the developed product was measured using Chroma Meter (CR-400, Konica Minolta, Japan). The instrument was calibrated with the calibration kit supplied with the instrument and $L*$, $a*$ and $b*$ values were recorded by directly putting the equipment on the surface of sample.

Sensory evaluation

A sensory panel of 7 experienced members comprising faculty members and postgraduate students of the department analyzed pork patties for appearance and colour, flavour, texture, juiciness and overall acceptability on 8-point descriptive scale (Keeton, 1983), where 8 = extremely desirable and 1= extremely undesirable. Samples were warmed (40-50°C) in microwave oven for 100 sec before serving to panelist. The samples were presented blind-coded and presented to the panelists in a random order. To confirm reliability, control sample was introduced two times in random order during sensory evaluation. Provision of drinking water was there to cleanse the palate between successive evaluations.

STATISTICAL ANALYSIS

The data obtained from each experiment were subjected to statistical analysis (Snedecor and Cochran, 1994) for one-way Analysis of Variance (ANOVA) on Completely Randomized design (CRD) and Duncan's multiple range test (DMRT) to compare the means with standard error (SE) by using SPSS-24 (SPSS Inc. Chicago IL, USA). Duplicate samples were drawn and whole set of experiments were repeated three times for the consistency of the results. For instrumental texture and color profile, 4 samples were drawn for analysis (n=12) and similarly seven panelist analyzed the samples for sensory attributes (n=21). The statistical difference was expressed at 5% level of experiment (P< 0.05).

RESULTS AND DISCUSSION

Physico-chemical characteristics and proximate analysis

Incorporation of DKP powder had a profound effect on various physico-chemical and proximate parameters of pork patties (Table 2). The pH of the developed patties decreased significantly (P<0.05) with increasing level of DKP Powder in the formulation. This could be due to inherent low pH of DKP powder (3.40) than meat. Similar trend in pH has been observed by Fernández-López *et al.* (2007) on progressive increase of dried orange fibre in dry cured fermented sausages. Water activity (a_w) and moisture content in pork patties followed a decreasing trend with the increase in the level of incorporation of DKP powder in the treated products and was found to be lowest in T-3. This could be due to replacement of lean meat with dried powder that contains relatively less moisture content. Fernández-Ginés *et al.* (2003) also observed decrease in moisture content on addition of citrus fibre in bologona sausage. Similar findings have also been reported by Mehta *et al.* (2013) in chicken patties incorporated with psyllium husk. Cooking yield and emulsion stability (%) were significantly (P<0.05) higher in all the treated products than control. Highest emulsion stability and cooking yield was recorded in T-3 followed by T-2, T-1 and control. Higher emulsion stability and cooking yield in products

containing various plant powders enriched in fibre could be due to formation of stable emulsion and better water binding properties of fibres. Similar findings have been reported in chevon patties incorporated with finger millet flour (Kumar *et al*., 2015), pork patties incorporated with sweet potato powder (Verma *et al*., 2015) and meat cutlets incorporated with carrot and broccoli powder (Singh *et al*., 2015 a and b). Fat and protein percentage exhibited decreasing trend with increasing levels of DKP powder in pork patties. This might be due to lower protein and fat content of DKP powder as compared to lean meat. Yadav *et al.* (2018) observed similar kind of results on addition of wheat bran and dried carrot pomace in chicken sausage. The results are in consonance with Mehta *et al.* (2016) who reported a relatively lower percentage of fat and protein in chicken meat rolls incorporated with psyllium husk as fiber source. The crude fiber content was recorded highest in T-3 followed by T-2, T-1 and C. This might be due to higher crude fiber content of DKP powder. Fiber and ash content of treated products increased simultaneously with increase in concentration of DKP powder in the products. Similar findings have been reported by Mehta *et al.* (2013; 2016).

Instrumental textural and colour profile

Textural profile characteristics of pork patties varied significantly (P< 0.05) with the incorporation of DKP

Table 2: Effect of different levels of incorporation of DKP Powder on physico-chemical characteristics and proximate composition of the functional pork patties (Mean ±S.E)*

Parameters	Treatments			
	C	T-1	T-2	T-3
pH	6.40 ± 0.02[a]	6.26 ± 0.01[b]	6.14 ± 0.01[c]	5.96 ± 0.03[d]
Water activity (aw)	0.92 ± 0.01[a]	0.89 ± 0.01[ab]	0.87 ± 0.01[b]	0.86 ± 0.01[b]
Cooking yield (%)	88.39 ± 0.50[d]	91.92 ± 0.39[c]	93.34 ± 0.54[b]	94.86 ± 0.41[a]
Emulsion stability (%)	90.55 ± 0.41[d]	92.73 ± 0.40[c]	94.15 ± 0.30[b]	95.33 ± 0.44[a]
Moisture (%)	58.14± 0.25[a]	57.51 ± 0.24[a]	56.59 ± 0.23[b]	55.77 ± 0.16[c]
Fat (%)	15.25 ± 0.17[a]	15.07 ± 0.10[ab]	14.90 ± 0.01[b]	14.57 ± 0.05[c]
Protein (%)	20.21± 0.02[a]	20.05 ± 0.10[ab]	19.90 ± 0.06[b]	19.70 ± 0.02[c]
Crude fibre (%)	0.86 ± 0.01[d]	1.26± 0.02[c]	1.57 ± 0.03[b]	1.76 ± 0.02[a]
Ash (%)	3.21 ± 0.02 [d]	3.98 ± 0.01[c]	4.27± 0.02[b]	4.78 ± 0.01[a]

n=6, C: Control; T-1: 2%; T-2: 4%; T-3: 6% dried kinnow pomace powder.

*Mean ±S.E with different superscripts row wise (a-d) differ significantly (P< 0.05).

powder (Table 3). Increase (P< 0.05) in hardness proportionately with increasing levels of DKP powder in the treated products as compared to control could be due to better binding properties of matrices of pork patties. The results are in consonance with sensory scores for texture, tenderness and juiciness as observed by sensory panelists. Similar findings gave been reported by Eim *et al.* (2008) and Viuda-Martos *et al*. (2010) in dry fermented sausage on addition of carrot dietary fibre and Spanish emulsified meat mortadella incorporated with orange dietary fiber, respectively. Springiness and stringiness of the products decreased significantly (P< 0.05) in treated products as compared to control, whereas a significant increase (P< 0.05) in gumminess and chewiness on addition of DKP powder in pork patties was reported. Similar findings have been reported by Yadav *et al.* (2018) in wheat bran and dried carrot pomace added chicken meat sausages.

Color is a very important benchmark for acceptability of meat products by the consumer and has a direct implication on its marketability. Objective assessment of colour parameters for the product is essential while incorporating non meat ingredients like fiber sources in meat products (Verma *et al.,* 2016). In the present study, an increase in product lightness *(L*)* and decrease in redness (*a**) was observed with the increasing level of DKP powder (Table 3). This could be due to dilution of bright red colour of pork with inclusion of DKP powder. The results of colour profile analysis are in consonance with sensory observations for colour parameter.

Sensory quality attributes

Mean sensory scores of fiber enriched functional pork patties are presented in Table 3 and Fig. 1. Sensory scores for color and appearance decreased significantly (P< 0.05)

Table 3: Effect of different levels of dried Kinnow Pomace Powder on Instrumental Textural, colour Parameters and sensory profile of Functional Pork patties (Mean ±S.E)*

Parameters	Treatments			
	Control	T-1	T-2	T-3
Instrumental Texture Profile				
Hardness(N)	12.40±0.31[d]	13.98±0.11[c]	14.94±0.19[b]	15.82±0.10[a]
Springiness(mm)	9.47±0.27[a]	9.41±0.29[a]	8.62±0.15[b]	7.67±0.31[c]
Stringiness(mm)	22.31±0.19[a]	21.70±0.25[b]	20.74±0.32[c]	19.87±0.20[d]
Cohesiveness	0.75±0.01	0.72±0.01	0.70±0.02	0.75±0.01
Gumminess(N)	6.97±0.01[d]	7.21±0.02[c]	7.50±0.01[bc]	8.77±0.01[a]
Chewiness(J)	60.24±0.73[c]	63.22±0.95[b]	64.52±0.57[ab]	65.10±0.67[a]
Resilience	0.83±0.02	0.85±0.01	0.84±.03	0.83±0.01
Instrumental Colour Profile				
L (Lightness)	45.19±0.66[a]	46.01±0.24[a]	47.52±0.38[b]	50.24±0.43[c]
a* (Redness)	12.98±0.31[a]	11.54±0.37[bc]	11.25±0.29[cd]	10.46±0.20[d]
b* (Yellowness)	19.82±0.27[c]	19.56±0.32[c]	20.15±0.40[ab]	20.89±0.45[a]
Sensory Profile				
Appearance/ Color	7.27±0.04[a]	7.03±0.15[b]	6.79±0.19[c]	6.05±0.31[d]
Flavour	7.37±0.05[a]	7.00±0.12[b]	6.52±0.23[b]	5.75±0.36[c]
Texture	7.01±0.14[a]	6.80±0.13[ab]	6.55±0.32[b]	5.89±0.25[c]
Juiciness	7.12±0.04[a]	6.88±0.18[a]	6.96±0.24[a]	6.23±0.35[b]
Overall Acceptability	7.50±0.30[a]	7.00±0.23[b]	6.78±0.24[b]	5.56±0.46[c]

n=12 (Texture analysis), n=21 (Sensory analysis) C: Control; T-1: 2%; T-2: 4%; T-3: 6% dried Kinnow Pomace powder.

*Mean ±S.E with different superscripts row wise (a-d) differ significantly (P< 0.05).

with increasing level of incorporation of DKP powder. This could be due to dilution of bright colour of meat with DKP powder and is in tune with results of instrumental colour profile analysis. Mean flavor scores decreased (P< 0.05) with the increasing levels of DKP powder incorporation and T-3 recorded lowest score (5.75), whereas, scores for T-1 and T-2 were comparable. The decreased flavor scores could be due to dilution of meaty flavour by replacement of lean with fiber source. Similar findings have been reported by (Mehta *et al.*, 2013 a and b).

Fig. 1: Sensory attributes of fiber enriched functional pork patties

Appearance Color	7.27	7.03	6.79	6.05
Flavour	7.37	7	6.52	5.75
Texture	7.01	6.8	6.55	5.89
Juiciness	7.12	6.88	6.96	6.23
Overall Acceptability	7.5	7	6.78	5.56

n=21, C: Control; T1-2%; T2-4%; T3-6% Dried Kinnow Pomace Powder.

Highest scores for texture attribute were reported in control followed by T-1, T-2 and T-3, however, scores for T-1 and T-2 were comparable with each other. Scores for Juiciness also followed similar trend and decreased with incorporation of fiber source in pork patties. Overall acceptability scores were highest for control and showed a decreasing trend amongst treated products, however, were found to be comparable in T-1 and T-2, but below acceptability range in T-3. It was noticed that after certain limits, continuous addition of dietary fiber influences the sensory characteristics of meat products, especially dilution of meaty flavour. The addition of DKP powder beyond 4% incorporation level decreased the overall acceptability of the functional pork patties. Mehta *et al.* (2013) also reported decrease in sensory scores of chicken rolls and patties with increasing levels of rice bran and psyllium husk.

CONCLUSION

It can be concluded from the present study that addition of fiber in meat products results in increase in cooking yield and modification of texture. Functional fibre enriched pork patties can be successfully developed with the incorporation of 4% DKP powder resulting an increase in fibre content by 1.83 times as compared to control. This approach will be helpful in utilization of agricultural by-products as a potential source of fiber and development of meat products with enhanced functionality.

CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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