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EFFECT OF PARTICLE SIZE AND FAT LEVELS ON THE PHYSICO-CHEMICAL, TEXTURAL AND SENSORY CHARACTERISTICS OF LOW-FAT GROUND PORK PATTIES

Manish Kumar Chatli

Associate Professor, Department of Livestock Products Technology, Punjab Agricultural University, Ludhiana -141004(INDIA)

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Introduction

Dietary fat and cholesterol content are considered to be controllable factors in multifactorial etiology of heart diseases and obesity. Meat and meat products are maligned with a fact of high- fat, high cholesterol and high calorie diet. This has lead to increase in demand of low-fat meat products. Pork patties generally contain 30-40% fat and warrants reduction in fat contents. However rheological, structural, processing, nutritional and sensory characteristics of comminuted meat products are directed by the fat content in the formulation and particle size of ground meat system (Kregel et al, 1986; Manish Kumar and Sharma, 2003)

Objectives

The present study was envisaged with a twin objectives to standardize the level of particle size and added fat levels in the processing of low-fat ground pork patties(LFGPP) on the basis of physico-chemical, textural and sensory characteristics. The effect of varying fat levels on cholesterol and calorie content was also evaluated.

Methodology

The study involved two experiments each with three trials. Experiment I was carried out to investigate the influence of three particle sizes viz 3,4 and 6 mm at constant fat level of <10%. (4 added fat level). The experiment II was carried out to examine the influence of fat levels viz 3, 4 and 5% at a constant grind size of 3 mm on the quality of low-fat pork patties.

Formulation and Processing of pork patties

Market age crossbred (Landrace × Local) hogs (N=3) weighing 60-70kg were humanely slaughtered at Divisional Experimental Abattoir. Prerigor raw materials were obtained with in 1hr post mortem by fabricating each carcass into boston butt, picnic shoulder, loin and ham. All skin, external fascia, subcutaneous and seam fat and all adhering connective tissues were removed. Hand deboned lean meat and back fat free

from adhering skin were stored separately at -18±2°C in low density polyethylene (LDPE) packs and were used after partial thawing at 5°C for 12-15hr. The spice mixture, condiments and other additives were purchased from local market. The refined wheat flour used as binder has composition 18.73±2.11 moisture, 74.43±0.85 carbohydrates percent.

Meat and back fat were cut into small cubes and minced separately through 3mm, 4mm and 6 mm grind plate in Electrolux meat mincer (Model 9512) as per requirements of Experiment I.

The formulation and processing of control and low-fat patties were standardized by preliminary trials (Manish Kumar and Sharma 2004). the formulation consist of added fat 4.0%, binder 4.0%, added water 15%, condiment mix 3%, table salt and spice mix 1.5%. All the ingredients and minced meat constituents were thoroughly mixed along with slowly adding chilled water by electrically operated meat mixer (Hobart Paddle Mixer, N-50) for 3min. Thereafter, 75g of each mix was moulded into patties with the help of a Petri dish of defined size (75mm×15mm). The moulded patties were cooked in preheated hot air oven at 190±5°C to an internal end point temperature of 75±2°C recorded at geometrical center of each patty using probe thermometer. The patties were turned upside down twice at 5min interval for better appearance, color and texture. Samples from each batch were analyzed on the same day.

The moisture, fat and protein content of buffalo meat and patties was determined by methods of AOAC (1995). Cooking yield was calculated from raw and cooked weights of 9 patties for each treatment. The dimensional parameters of cooked patties were recorded using vernier callipers minimum at three different positions respectively to obtain the mean values. The percent shrinkage, moisture and fat retention of patties were determined as per El-Magoli *et al*, 1996.

The shear force value of 1cm^2 of the sample was recorded as per Berry and Stiffler (1981) using Warner- Bratzler Shear press (Model: 810310307 G.R Elect. Mfg. Co. USA) and expressed as kg/cm^2. An experienced sensory panel consisting of seven scientists and post graduate students evaluated the sensory characteristics of warmed product viz., appearance and color, flavor, juiciness, texture and overall acceptability using 8- point objective scale (Keeton, 1983), where 8- denoted extremely desirable and 1 denoted extremely undesirable.

The textural profile was determined on Instron Universal Testing Machine (Model 4464) following the procedure described by Brady et al (1985). The fat content of the samples were extracted adopting the method described by Folch *et al.*, (1957) and Total lipids were determined gravimetrically. The different components of lipids included total phospholipids, total cholesterol, glycolipids and free fatty acids were measured by standard procedures described by Marinetti (1962), Hanel and Dam (1955), Roughan and Batt (1968) and Koniecko (1979) respectively, whereas total glycerides were indirectly calculated by subtracting all these from total lipid values.

Gross energy of sample was determined by Gallenkamp and Ballistic Bomb Calorimeter (Haque and Murarilal, 1999) using Benzoic Acid as a standard and expressed as Kcal/100g. Total calorie estimates of raw and cooked sausages were calculated on the basis of 100g portion using Atwater values for fat (9.0 kcal/g), protein (4.02 kcal/g) and carbohydrates (4.0 kcal/g) calories. Since analysis of per cent carbohydrates in the meat samples was not performed, the calorie values were estimates and not actual values.

The data obtained from various trials under each experiment was pooled and processed at Institute's computer centre. The statistical design of the study was 4(treatment) × 3 (replication) randomized block design. All chemical and physical determinations were conducted in triplicate. There were seven sensory determinations (judges) for each treatment × replication combination. Data were subjected to one way analysis of variance. Duncan's Multiple Range test and critical difference were determined at 5% significance level (Snedecor and Cochran, 1989).

Result and Discussion

Particle Size

The effect of different particle size on physico-chemical properties of cooked low-fat ground pork patties are presented in table 1. Percent cooking yield, moisture and moisture retention were significantly ($P<0.05$) better at lower particle size (3mm) than higher particle size (6mm). It could be due to more compact binding at lower particle sizes which do not allow the release of moisture. Lin and Keeton (1994) and Small et al. (1995) also reported the increase in cooking losses with the increase in particle size. The shear force value increased significantly ($P<0.05$) with an increase in particle size. Mean sensory scores (table 2) were significantly ($P<0.05$) better in juiciness, texture and overall acceptability for particle size 3mm than higher particle size. It appears that smaller particle size provided increased binding and compactness to low-fat ground pork patties. Our results are in conscience of Small et al. (1995) and Berry et al. (1999). Texture Profile showed an increase in hardness and springiness with the increase in particle size. Since cooking determinants and sensory attributes were better with 3mm particle size, hence it was adopted as optimum particle size for further studies.

Fat levels

The fat percent increased linearly with the increase in added fat levels (table 3). Cooking yoeld and moisture retention were recorded maximum at 4% added fat level. The percent gain in height increased significantly ($P<0.05$) at 4 and 5% added fat levels. However shear force value decreased significantly ($P<0.05$) with the increase in fat levels. These findings are in accordance with Trout et al. (1992). There was marginal decrease in the fat retention of the product with increasing fat levels. Mean sensory scores (table 4) are significantly ($P<0.05$) better for 5% added fat level than 3% added fat level whereas patties with 4 % added fat were comparable to patties with 5 % added fat level. the juiciness scores of the product were marginally higher for increased fat levels.

Perusal of table 5 showed that in raw product total lipid content, phospholipids, cholesterol content and calorific value (wet weight basis) increased significantly ($P<0.05$) with increasing added fat levels. However on dry weight basis, cholesterol content increased significantly ($P<0.05$) only at 5% added fat level. As for calorific value, the relationship was linear with fat levels in raw patties. In cooked product the total lipid content increased significantly ($P<0.05$) with increasing added fat levels, whereas phospholipids and cholesterol content showed only a marginal increase. The cholesterol

retention did not show any trend in the present study. Calorific value increased significantly ($P<0.05$) with increasing added fat levels. It is obvious because fat contributes 9.2 kcal/g energy which is about 2.25 times more than carbohydrates and proteins.

Conclusions

Cooked patties with 5 % added fat levels have mean total fat level more than 10, which does not fit into the definition of low-fat meat products (Keeton, 1994). Since cooking determinants and sensory attributes are better for 3mm particle size and 4% added fat level. Therefore the optimum level of particle size 3mm and added fat level 4% are recommended for formulation of low-fat ground pork patties.

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Table 1. Effect of particle size on physico-chemical properties of cooked low-fat ground pork patties.

Parameters	**Particle size (mm)**		
	3	4	6
pH	6.14±0.007	6.15±0.009	6.15±0.009
Moisture (%)	61.63±0.24^{a}	60.44±0.27^{b}	57.53±0.55^{c}
Fat (%)	9.12±0.13	9.21±0.09	9.03±0.10
Protein (%)	18.57±0.04	18.51±0.09	18.51±0.1
Moisture Protein Ratio	3.32±0.01^{a}	3.27±0.04^{a}	3.10±0.04^{b}
Cooking Yield (%)^{A}	75.86±0.21^{a}	73.95±0.38^{b}	67.82±0.30^{c}
Cooking Loss (%)^{B}	24.47±0.25^{c}	26.05±0.38^{b}	32.18±0.30^{a}
Decrease in Diameter (%)	15.04±0.27^{c}	18.74±0.17^{b}	22.80±0.44^{a}
Gain in Height (%)	21.46±0.99	20.68±0.28	20.28±0.17
Shrinkage (%)^{C}	10.79±0.24^{c}	12.10±0.15^{b}	15.55±0.44^{a}
Moisture Retention (%)^{D}	46.76±0.27^{a}	44.09±0.24^{b}	39.02±0.35^{c}
Fat Retention (%)^{E}	77.98±0.32^{a}	76.24±0.38^{a}	70.47±0.49^{b}
Shear Force Value (kg/cm^{2})	0.37±0.007^{c}	0.40±0.006^{b}	0.47±0.005^{a}

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

N=6 for each treatment

A per cent yield= (raw weight-cooked weight/raw weight) ×100

B cook loss= per cent cook loss: 100-per cent yield

C Shrinkage %= (Raw thickness- cooked thickness) + (raw diameter- cooked diameter)/ (raw thickness+ raw diameter)

D % Moisture retention= % yield × % moisture in cooked patties/100

E % Fat Retention= (cooked weight × %fat in cooked patties/raw weight×% fat in raw patties) ×100

Table 2. Effect of particle size on sensory attributes of low- fat ground pork patties. (Mean ± S.E.)*

	Particle size (mm)		
Attributes	3	4	6
Appearance	6.98	6.93	6.81
	±0.08	±0.12	±0.12
Flavor	7.00	6.95	6.91
	±0.077	±0.048	±0.074
Texture	7.29[a]	7.10[a]	6.58[b]
	±0.095	±0.074	±0.14
Juiciness	6.93[a]	6.83[ab]	6.62[b]
	±0.079	±0.072	±0.097
Overall Acceptability	6.98[a]	6.77[b]	6.43[c]
	±0.064	±0.056	±0.093

* Mean ±S.E. with same superscript in a row do not differ significantly (P<0.05)
Means are scores given by sensory panelists on 8-point scale where
1: extremely poor and 8: extremely desirable
N=21 for each treatment

Table 3. Effect of added fat levels on physico-chemical properties of cooked low-fat ground pork patties.

Parameters	**Added fat levels (%)**		
	3	4	5
pH	6.14±0.008	6.16±0.004	6.16±0.015
Moisture (%)	61.27±0.18^{a}	61.73±0.27^{a}	60.32±0.22^{b}
Fat (%)	8.18±0.11^{c}	9.08±0.07^{b}	10.64±0.08^{a}
Protein (%)	19.04±0.04	18.87±0.09	18.64±0.04
Moisture Protein Ratio	3.22±0.009^{b}	3.27±0.015^{a}	3.24±0.01^{b}
Cooking Yield (%)^{A}	74.14±0.22^{b}	75.34±0.28^{a}	74.87±0.38^{ab}
Cooking Loss (%)^{B}	25.87±0.22^{a}	24.66±0.28^{b}	25.13±0.38^{ab}
Decrease in Diameter (%)	24.74±0.15	25.13±0.28	25.19±0.14
Gain in Height (%)	18.61±0.48^{b}	20.28±0.48^{a}	21.12±0.17^{a}
Shrinkage (%)^{C}	17.51±0.14	17.56±0.29	17.40±0.11
Moisture Retention (%)^{D}	45.42±0.25^{b}	46.51±0.21^{a}	45.62±0.32^{ab}
Fat Retention (%)^{E}	79.46±0.50	79.22±0.38	79.01±0.39
Shear Force Value (kg/cm^{2})	0.55±0.009^{a}	0.50±0.004^{b}	0.47±0.006^{c}

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

N=6 for each treatment

A per cent yield= (raw weight-cooked weight/raw weight) ×100

B cook loss= per cent cook loss: 100-per cent yield

C Shrinkage %= (Raw thickness- cooked thickness) + (raw diameter- cooked diameter)/ (raw thickness+ raw diameter)

D % Moisture retention= % yield × % moisture in cooked patties/100

E % Fat Retention= (cooked weight × %fat in cooked patties/raw weight×% fat in raw patties) ×100

Table 4. Effect of added fat levels on sensory attributes of low- fat ground pork patties. (Mean ± S.E.)*

Attributes	**Added fat levels (%)**		
	3	4	5
Appearance	6.88	6.91	6.98
	±0.06	±0.04	±0.04
Flavor	6.74[b]	6.93[ab]	6.98[a]
	±0.09	±0.05	±0.04
Texture	6.74[b]	6.93[a]	6.95[a]
	±0.08	±0.05	±0.03
Juiciness	6.88	6.95	7.00
	±0.06	±0.06	±0.05
Overall Acceptability	6.74[b]	6.93[a]	7.02[a]
	±0.08	±0.05	±0.05

* Mean ±S.E. with same superscript in a row do not differ significantly ($P<0.05$)

Means are scores given by sensory panelists on 8-point scale where 1: extremely poor and 8: extremely desirable

N=21 for each treatment

Table5. Effect of added fat levels on total lipids, phospholipids, cholesterol and calorific value of raw low-fat ground pork patties.

Parameters	**Added fat levels (%)**					
	3		**4**		**5**	
(mg/g)	Mean	SEM	Mean	SEM	Mean	SEM
Total Lipids	41.36[c]	0.96	58.50[b]	0.60	76.55[a]	0.57
Phospholipids	13.75[c]	0.13	15.02[b]	0.19	17.42[a]	0.15
Cholesterol (wet weight basis)	1.15[c]	0.02	1.21[b]	0.01	1.28[a]	0.004
Cholesterol (dry weight basis)	362.82[b]	7.23	371.55[ab]	3.03	378.81[a]	2.71
Calorific Value* (Kcal/100g)	128.60[c]	0.35	162.82[b]	0.64	178.98[a]	0.81

N=6 for each treatment

*Calorific value measured by Gallenkamp and Ballistic Bomb calorimeter

Table 6. Effect of added fat levels on total lipids, phospholipids, cholesterol and calorific value of cooked low-fat ground pork patties.

Parameters	**Added fat levels (%)**					
	3		**4**		**5**	
(mg/g)	Mean	SEM	Mean	SEM	Mean	SEM
Total Lipids	42.97[c]	0.34	61.55[b]	1.02	71.28[a]	1.09
Phospholipids	19.75[b]	0.32	21.96[a]	0.35	21.92[a]	0.23
Cholesterol (wet weight basis)	1.34[b]	0.18	1.45[a]	0.15	1.49[a]	0.01
Cholesterol (dry weight basis)	346.46[b]	4.98	378.46[a]	3.86	376.00[a]	2.81
Cholesterol Retention (%)	86.38[b]	1.41	90.43[a]	0.93	87.35[b]	0.25
Calorific Value* (Kcal/100g)	171.52[c]	1.93	184.49[b]	1.01	208.96[a]	0.67

N=6 for each treatment

*Calorific value measured by Gallenkamp and Ballistic Bomb calorimeter

Table 7. Effect of refrigerated storage on physico-chemical, microbiological and sensory characteristics of aerobically packaged low-fat ground pork patties. (Mean ± S.E.)*

Treatments	Storage Period (Days)			
	0	7	14	21
Physico-Chemical Characteristics				
	TBA Value (mg malonaldehyde/kg)			
Control	0.41±0.02^{d1}	0.52±0.01^{c1}	0.78±0.02^{b1}	0.98±0.01^{a1}
Low-Fat Patties	0.28±0.007^{d2}	0.39±0.01^{c2}	0.59±0.07^{b2}	0.67±0.01^{a2}
	pH			
Control	6.13±0.009^{c}	6.20±0.007^{bc}	6.27±0.004^{b}	6.38±0.008^{a}
Low-Fat Patties	6.12±0.002^{c}	6.17±0.004^{b}	6.24±0.004^{ab}	6.33±0.012^{a}
Microbiological Characteristics				
	Total Plate Count (log cfu/g)			
Control	1.65±0.03^{d2}	1.94±0.02^{c1}	2.29±0.05^{b}	2.86±0.04^{a}
Low-Fat Patties	1.73±0.11^{d1}	2.13±0.04^{c2}	2.24±0.08^{b}	2.74±0.07^{a}
	Psychrophilic Count (log cfu/g)			
Control	ND	ND	1.15±0.02^{b}	1.40±0.09^{a}
Low-Fat Patties	ND	ND	1.19±0.01^{b}	1.42±0.05^{a}
	Coliform Count (log cfu/g)			
Control	ND	ND	ND	ND
Low-Fat Patties	ND	ND	ND	ND
Sensory Characteristics**				
	Appearance			
Control	7.12±0.11^{a}	6.86±0.10^{ab}	6.76±0.12^{b}	6.69±0.12^{b}
Low-Fat Patties	7.18±0.06^{a}	7.05±0.12^{ab}	6.89±0.08^{b}	6.72±0.14^{b}
	Flavor			
Control	6.97±0.07^{a}	6.88±0.09^{a}	6.71±0.10^{ab}	6.63±0.11^{b}
Low-Fat Patties	6.94±0.10^{a}	6.91±0.11^{a}	6.78±0.09^{ab}	6.72±0.12^{b}
	Juiciness			
Control	7.12±0.09^{a}	6.94±0.07^{ab}	6.71±0.10^{bc}	6.67±0.11^{c}
Low-Fat Patties	6.99±0.08^{a}	6.96±0.05^{a}	6.81±0.09^{ab}	6.70±0.13^{b}
	Texture			
Control	7.07±0.09^{a}	7.00±0.09^{a}	6.86±0.09^{ab}	6.74±0.08^{b1}
Low-Fat Patties	7.00±0.09	6.96±0.08	6.89±0.09	6.81±0.11
	Overall Acceptability			
Control	7.05±0.09^{a}	6.98±0.08^{ab}	6.76±0.09^{bc}	6.64±0.12^{c}
Low-Fat Patties	7.02±0.09^{a}	6.93±0.04^{a}	6.81±0.07^{ab}	6.69±0.07^{b}

*Mean±S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly (P<0.05)

ND= Not Detected

N=21 no. of observations for sensory parameters and N=6 for other parameters

** Means are scores given by sensory panelists on 8-point scale where 1: extremely poor and 8: extremely desirable

Table 8. Effect of refrigerated storage on physico-chemical, microbiological and sensory characteristics of vacuum packaged low-fat ground pork patties. (Mean ± S.E.) *

Treatments	Storage Period (Days)					
	0	7	14	21	28	35
Physico-Chemical Characteristics						
			TBA Value (mg malonaldehyde/kg)			
Control	0.41±0.018^{b1}	0.44±0.007^{b1}	0.47±0.08^{ab1}	0.49±0.012^{a1}	0.54±0.012^{a1}	0.56±0.004^{a1}
Low-Fat Patties	0.28±0.007^{2}	0.32±0.04^{2}	0.31±0.007^{d2}	0.34±0.019^{c2}	0.37±0.01^{b2}	0.37±0.009^{a2}
			pH			
Control	6.13±0.009^{a}	6.12±0.01^{a}	6.09±0.005^{a1}	6.00±0.01^{b1}	5.95±0.02^{bc1}	5.82±0.07^{c}
Low-Fat Patties	6.12±0.002^{a}	6.12±0.007^{a}	6.08±0.002^{ab}	6.00±0.007^{b}	5.89±0.011^{bc}	5.81±0.02^{c}
Microbiological characteristics						
			Total Plate Count (log cfu/g)			
Control	1.65±0.03^{f}	1.86±0.008^{e}	2.10±0.02^{d}	2.41±0.04^{c}	2.80±0.018^{b}	3.26±0.016^{a}
Low-Fat Patties	1.74±0.01^{f}	1.94±0.15^{e}	2.21±0.015^{d}	2.49±0.004^{c}	2.78±0.013^{b}	3.16±0.04^{a}
			Psychrophilic Count (log cfu/g)			
Control	ND	ND	ND	1.75±0.03^{c}	1.95±0.018^{b}	2.25±0.04^{a}
Low-Fat Patties	ND	ND	ND	1.84±0.02^{b}	2.02±0.03^{ab}	2.13±0.03^{a}
			Anaerobic Plate Count (log cfu/g)			
Control	ND	ND	ND	ND	1.26±0.013^{b}	1.48±0.05^{a}
Low-Fat Patties	ND	ND	ND	ND	1.22±0.012^{b}	1.43±0.03^{a}
			Lactic Acid Bacteria Count (log cfu/g)			
Control	ND	ND	ND	ND	1.05±0.024^{b}	1.18±0.007^{a}
Low-Fat Patties	ND	ND	ND	ND	1.15±0.007^{b}	1.22±0.008^{a}
			Coli form Count (log cfu/g)			
Control	ND	ND	ND	ND	ND	ND
Low-fat Patties	ND	ND	ND	ND	ND	ND
Sensory Characteristics						
			Appearance			
Control	7.12±0.11^{a}	7.00±0.08^{ab}	6.95±0.08^{ab}	6.81±0.11^{bc}	6.67±0.10^{c}	6.67±0.12^{c}
Low-Fat Patties	7.18±0.05^{a}	7.11±0.07^{a}	7.02±0.09^{ab}	6.93±0.09^{bc}	6.79±0.09^{c}	6.81±0.07^{bc}
			Flavor			
Control	7.02±0.07^{ab}	7.02±0.08^{a}	6.98±0.07^{a}	6.83±0.09^{abc}	6.71±0.07^{bc}	6.60±0.13^{c2}
Low-Fat Patties	6.95±0.10^{ab}	6.98±0.04^{a}	7.00±0.12^{a}	6.86±0.09^{ab}	6.81±0.06^{ab}	6.76±0.07^{b1}
			Juiciness			
Control	7.12±0.10^{a}	7.00±0.07^{ab}	6.90±0.09^{abc}	6.86±0.09^{abc}	6.76±0.06^{c}	6.53±0.12^{d}
Low-Fat Patties	6.99±0.08^{a}	7.00±0.05^{a}	6.98±0.09^{a}	6.88±0.08^{b}	6.71±0.07^{b}	6.65±0.13^{b}
			Texture			
Control	7.07±0.07^{a}	7.05±0.07^{a}	6.95±0.07^{ab}	6.79±0.08^{bc}	6.81±0.07^{bc}	6.67±0.11^{c}
Low-Fat Patties	7.00±0.08^{a}	7.00±0.05^{a}	6.93±0.09^{ab}	6.84±0.08^{ab}	6.78±0.06^{b}	6.71±0.10^{b}
			Overall Acceptability			
Control	7.05±0.07^{a}	7.02±0.07^{a}	6.93±0.08^{ab}	6.87±0.08^{ab}	6.71±0.07^{b}	6.59±0.12^{b}
Low-Fat Patties	7.02±0.09^{a}	7.00±0.08^{a}	7.00±0.05^{a}	6.83±0.09^{ab}	6.79±0.09^{ab}	6.72±0.09^{b}

*Mean±S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly (P<0.05)

ND= Not Detected

N=21 no. of observations for sensory parameters and N=6 for other parameters

** Means are scores given by sensory panelists on 8-point scale where 1: extremely poor and 8: extremely desirable

Fig.1. Comparative instrumental Texture Profile of control and formulated low-fat patties.