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Effect of Whey Powder, Skim Milk Powder and their Combination on Yield and Textural Properties of Meat Patties

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ABSTRACT

Effects of addition of whey powder (WP 0, 1 & 2%), skim milk powder (SMP 0, 1 & 2%) and their combination on yield and textural properties of meat patties were studied. Yield, moisture, moisture retention, sensory characteristics and textural properties were determined in the meat patties. Addition of 1 or 2% WP, SMP and their combination significantly ($p<0.01$) increased cooking yield, moisture and moisture retention of cooked samples. WP, SMP and combination of WP-SMP addition did not affect sensory characteristics except chewiness and elasticity of the patties. SMP and combination of WP-SMP caused a significant ($p<0.05$) difference in elasticity and WP caused a significant ($p<0.05$) difference in chewiness. Cooked meat patties formulated with WP, SMP and their combination at all tested ratios were significantly ($p<0.01$) different in strength of fracture and work of fracture. Hardness of cooked patties decreased with the addition of SMP. However, this property increased by the addition of WP compared to the control. Significant differences ($p<0.05$) from added ingredients occurred in chewiness. Addition of SMP decreased cohesiveness of meat patties. © 2010 Friends Science Publishers

Key Words: Meat patty; Whey powder; Skim milk powder; Textural properties

INTRODUCTION

Meat and meat products are usually marketed in small butcher shops as steaks and or in the ground form. Most people prefer to consume meat and meat products (such as meat patties, meatballs & kebabs) in the ground form in Turkey (Yılmaz & Dağlıoğlu, 2003; Ulu, 2004). In the production of patty usually red meat used but chicken and fish meat can be used (Gökoğlu, 1994; Chen *et al*., 1999; Du *et al*., 2000; Tang *et al*., 2001). In the preparation of Turkish style patty, ground meat is mixed with fat, various spices, onion and moistened bread or rusk flour (Serdaroğlu & Değirmencioğlu, 2004; Yılmaz, 2004). Patty shaped and then cooked by frying or baking.

Many functional properties of proteins, such as water-holding capacity, gelation and emulsification depend on water-protein interactions. In low and intermediate moisture foods, such as bakery and comminuted meat products, the ability of proteins to bind water is critical to the acceptability of these foods (Damodaran, 1996).

Non-meat proteins such as soy protein, egg, whey protein and carbohydrates such as starch, cereal flours are often used to enhance the texture of meat products (Hongsprabhas & Barbut, 1999). These ingredients play a significant role in the modification of functional properties, such as emulsification, water-and fat-binding capacity and textural properties (El-Magoli *et al*., 1996; Gujral *et al*., 2002). Overall, they are added as another gelling system that may improve yield and potentially reduce cost of the meat formulation (Hung & Smith, 1993).

Dairy products are widely used to improve the functional properties of meat products. These ingredients have been used as fillers and binders in comminuted meat products to improve texture and sensory properties and minimize cooking losses (Hung & Zayas, 1992). The properties of milk proteins are related to immobilization of water, texture and consistency control, color improvement and enhancement of sensory properties (Ulu, 2004).

There is extensive research on the using whey protein concentrate in emulsion and emulsion type meat products (Ensor *et al*., 1987; Hung & Zayas, 1992; Özdemir *et al*., 1994; Zorba *et al*., 1994; Hughes *et al*., 1998; Lyons *et al*., 1999; Serdaroğlu & Sapancı-Özsümer, 2003; Serdaroğlu & Deniz, 2004). However, there are a few studies on the effect of whey powder and skim milk powder on yield, textural properties and sensory characteristics of patty. The aim of this study was to determine the effect of whey powder and skim milk powder on the yield, moisture retention, sensory characteristics and textural properties of meat patties.

MATERIALS AND METHODS

Meat patty preparation: Formulation of meat patties is given in Table I. Beef as boneless rounds was obtained from the Vanet Meat Company Inc., Van, Turkey. All subcutaneous fat and intramuscular fat was removed from

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the muscles and used as the fat source. Besides, sheep tail fat was used to standardize fat ratio to 15%. Lean and fat were ground in a 3-mm plate grinder. Two kg batches of appropriate amounts of each formulation were mixed and cylindrical samples (15 mm thick & 70 mm diameter) were prepared using a metal shaper. Prepared patties were wrapped with plastic stretch cover and were put in the refrigerator until analysis of uncooked samples and cooking.

Chemical analysis: Moisture of cooked and uncooked patty samples was determined according to the methods described by the AOAC (1990). Cooking yield and moisture retention were calculated according to the following equations:

% cooking yield = Cooked weight/Raw weight × 100

% Moisture retention = % Cooking yield × % Moisture of cooked meat patty/100

Moisture retention can be described as the amount of moisture retained in the cooked product per 100 g of raw samples (El-Magoli *et al*., 1996; Berry *et al*., 1999).

Sensory evaluation: Sensory evaluation of cooked patties was performed by ten trained panelists who were staffing members in the University of Yüzüncü Yıl, Department of Food Engineering. Numerical hedonic evaluation system was used in sensorial analyses of the patties (Gökalp *et al.*, 2002).

Texture profile analysis: Texture profile analysis (TPA) parameters were determined by using TAXT Plus Machine, (UK) equipped with a 5 kg load cell. Stainless ball probe with 1 inch (P/1s) for TPA was attached to moving crosshead. The patty was placed on the platform of the texture analyzer. The patty samples was compressed (at three different locations) to 7 mm distance, a cross head with speed of 2 mm/s twice in two cycles in the TPA analyses. The following parameters were obtained:

Hardness = maximum peak height of first compression (N)

Springiness = time difference for 2^{nd} compression/time difference for 1^{st} compression

Cohesiveness = ratio of A2/A1; (where A1 is area under first compression & A2 is area under second compression)

Chewiness = Hardness x Springiness x Cohesiveness.

Texture analysis: Fracture test was determined by using TAXT Plus Machine, (UK) equipped with a 5 kg load cell. Fracture wedge set (A/WEG) was used for fracture test.

The operating conditions were: pre-test speed 1 mm/sec., post-test speed 10 mm/sec., test speed 2 mm/sec. and distance 10 mm

Statistical analysis: The experiment was a 3 x 3 factorial design with three levels of WP (0, 1 & 2%) and three levels of SMP (0, 1 & 2%). Experiment was performed on two replicates. Each analysis was done in duplicate following analytical procedure. All data were subjected to an analysis of variance (ANOVA) and separated by Duncan Multiple Range Test perform using the SPSS statistical software (SPSS, 1999). These tests were also applied to mean values of WP and SMP to bring out of the overall effects of additives. Principal Components Analysis (PCA) was also performed to show relationships among groups of variables and between objects (Piggott & Sharman, 1986).

RESULTS AND DISCUSSION

The effects of whey powder and skim milk powder on moisture, yield and moisture retention of patties were given in Table II. Addition of WP ($p<0.05$), SMP ($p<0.01$) and their combination ($p<0.01$) altered the moisture content of raw patty due to the increase in dry matter in the patty formulation. Similar results reported by Desmond *et al*. (1998) and Serdaroğlu (2006) for WP.

In the cooked samples, differences between the moisture contents of control and treatments (WP 1%, 2%, SMP 1%, 2% & combination of WP-SMP) were significant ($p<0.01$). It was found that the moisture content of cooked patties with WP and SMP significantly higher than those of control samples, as reported earlier (Hung & Zayas, 1992). The highest moisture content among treatments was obtained from sample with 2% WP. Also effect of treatment combinations on the moisture of cooked meat patties was significant ($p<0.01$). Ulu (2004) reported that the addition of 0.2% WP increased moisture content of meatball. Serdaroğlu (2006) stated that the addition of 2% and 4% WP decreased the moisture of meatball standardized to 5% fat level, while increased the moisture content of samples standardized to 10-20% fat level.

WP, SMP and combination of WP-SMP improved cooking yield values of the samples ($p<0.01$). Cooking yields were highest in the patties formulated with 2% WP (87.44±1.08%) and 1% WP-2% SMP combination (88.73±0.09%). Serdaroğlu (2006) reported that the addition of 2% or 4% WP significantly increased cooking yield regardless of the fat level. El-Magoli *et al*. (1995) stated that whey protein concentrate (WPC) at the rate of 1-4% improved the cooking yield compared to a non-formulated control of 10% fat. They further stated that fat retention also improved with more addition level of WPC. However, it was indicated by Ensor *et al.* (1987) that the additions of whey protein concentrate (1.75%, 2.0% & 3.5%) and calcium-reduced nonfat dry milk (3.5%) did not provide an advantage in the cooking yield.

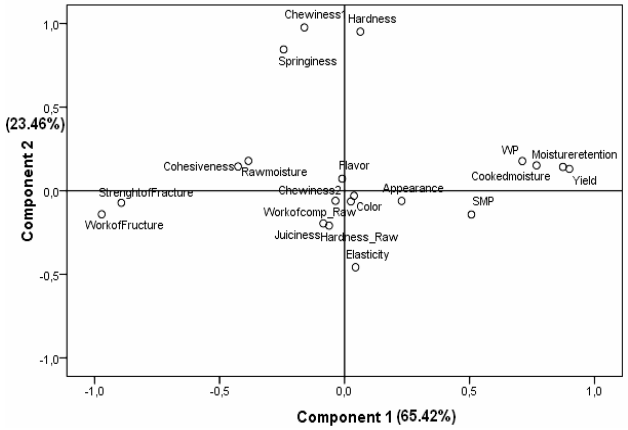
Addition of WP, SMP and their combination significantly increased ($p<0.01$) moisture retention values of meat patties. This result can be explained by the high cooking yield and moisture values of cooked patties. Patties formulated with WP had higher moisture retention values (formulated with 1% WP 44.59%±2.01 & 2% WP 46.36±0.61%) than those formulated with SMP and control samples. Patties formulated with 2% WP and 2% SMP combination had highest moisture retention value (47.13±0.28%) in all of the combinations. Serdaroğlu

Table I: Formulation of meat patties

Ingredient (%)	Samples								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Fat	15	15	15	15	15	15	15	15	15
Onion	3	3	3	3	3	3	3	3	3
Rusk flour	3	3	3	3	3	3	3	3	3
Salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Parsley	1	1	1	1	1	1	1	1	1
Red pepper	1	1	1	1	1	1	1	1	1
$NaHCO_3$	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Black pepper	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cumin	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Whey powder	0	0	0	1	1	1	2	2	2
Skim milk powder	0	1	2	0	1	2	0	1	2

Fig. 1: Principal component biplot of textural properties, sensorial characteristics and some chemical properties of meat patties

Chewiness 1 = textural properties; Chewiness 2 = sensorial characteristics



(2006) stated that WP (2%, 4%) significantly increased the moisture retention values of meatballs at each fat level used in his study (5%, 10% & 20%).

The highest moisture content, yield and moisture retention among treatments were obtained from the sample with 2% WP. These results can be attributed to higher water binding capacities (hydration capacity) of WP than casein. It is reported that the water binding capacity of WP and casein are 0.45-0.52 and 0.40 g water/g protein, respectively (Damodaran, 1996).

As for sensory characteristics of patties there were no significant differences in appearance, interior color, juiciness and flavor scores of patties formulated with 1% and 2% WP, SMP and combination of WP-SMP (Table III). WP and SMP caused a significant ($p<0.05$) difference in elasticity and chewiness, respectively. These results are in good agreement with those reported by Serdaroğlu (2006) for the flavor score of meatballs. Addition of WP to comminuted beef patties has been reported to increase flavor scores (Holland, 1984). Contrarily, Lyons *et al*. (1999) reported that increasing concentrations of WP decreased flavor scores. El-Magoli *et al*. (1996) reported that 4% WPC level was preferred than the lower WPC levels in terms of juiciness and overall acceptability. Desmond *et al*. (1998) reported that whey protein and oat fibre in Low-fat Beef Burgers had been tested. In this study, the panelists rated the beef burgers to be more acceptable in terms of flavor and texture and off-flavors were not detected in the samples. Hughes *et al*. (1998) stated that whey protein did not affect the sensory characteristics of Frankfurters.

Table IV shows the effects of added WP and SMP on the textural properties of the patties. SMP did not affect hardness and work of compression of raw patties. However, addition of WP to the patties decreased ($p<0.05$) hardness. The effect of combination of these treatments was significant ($p<0.05$) on hardness and work of compression values of raw patties. Strength of fracture and work of fracture of cooked samples were adversely affected ($p<0.01$) by WP, SMP and combination of these treatments. Strength of fracture and work of fracture of meat patties formulated with WP and SMP (1-2%) were lower than control samples. Hardness of cooked patties increased with the addition of WP ($p<0.01$) and decreased by the addition of SMP ($p<0.05$) compared to the controls. Hardness of cooked patties was affected ($p<0.05$) with combination of WP-SMP. Both additives and combination of these treatments had a significant ($p<0.05$) effect on the chewiness. Ulu (2004) reported that addition of 0.2% WP increased hardness of cooked meatball compared to control samples and WP had a significant effect on the chewiness of meatballs. A study showed that hardness and chewiness increased when WP was added to Frankfurters (Hughes *et al*., 1998). El-Magoli *et al*. (1996) found that hardness and chewiness increased with the addition of 3% WPC whereas El-Magoli *et al*. (1995) stated that hardness and chewiness were not affected by WPC addition (1-4%) but increased with higher cooking temperature.

Increasing of hardness and chewiness of comminuted meat products formulated with WP can be explained with following features of WP. Proteins that contain both cysteine and cystine groups can undergo polymerization via sulfhydryl-disulfide interchange reactions during heating and form a continuous covalent network upon cooling. Such gels e.g., ovalbumin and whey protein gels (Fox, 2009) are usually thermally irreversible. It was recognized that acid whey contains two groups of proteins: lactalbumins and lactoglobulins. The lactalbumin fraction contains two principal proteins, β-lactoglobulin and α–lactalbumin. β-Lactoglobulin represents 50% of the whey proteins and has very good thermo-gelling properties (Fox, 2009). Springiness and cohesiveness of meat patties was not affected by the addition of WP; however, cohesiveness was affected ($p<0.05$) by SMP and combination of WP-SMP. Ulu (2004) stated that addition 0.2% WP had no significant effect on the cohesiveness and springiness. Similar results reported by El-Magoli *et al*. (1996) for springiness.

Results of the principal component analysis (PCA) showed that principal components (PC) 1 and 2 described had about 88.88% of the total variation of the events:

Table II: Effect of whey powder, skim milk powder and their combination on moisture, yield and moisture retention of meat patties

Treatments		Characteristics			
		[1]Moisture (%)	[2]Moisture (%)	[2]Yield (%)	[2]Moisture retention (%)
WP	0	59.47 ± 0.54 a	49.71 ± 1.03 c	78.65 ± 1.83 c	39.11 ± 1.57 c
	1	59.62 ± 0.39 a	52.16 ± 0.54 b	85.46 ± 3.22 b	44.59 ± 2.01 b
	2	59.06 ± 0.45b	53.02 ± 0.26 a	87.44 ± 1.08 a	46.36 ± 0.61 a
Significance		*	**	**	**
SMP	0	59.78 ± 0.48 a	51.16 ± 2.01 b	81.31 ± 4.29 c	41.67 ± 3.77 c
	1	59.34 ± 0.35 b	52.01 ± 0.93 a	84.47 ±3.64 b	43.96 ± 2.61 b
	2	59.03 ± 0.40 b	51.73 ± 1.64 a	85.76 ± 4.39 a	44.42 ± 3.61 a
Significance		**	**	**	**
WP	SMP				
0	0	59.93 ± 0.40 a	48.70 ± 0.80 f	76.29 ± 0.44 f	37.15 ± 0.40 h
	1	59.52 ± 0.37 ab	50.85 ± 0.26 d	79.73 ± 0.75 e	40.55 ± 0.59 f
	2	58.97 ± 0.40 bc	49.59 ± 0.05 e	79.92 ± 0.40 e	39.63 ± 0.24 g
1	0	59.99 ± 0.07 a	51.61 ± 0.40 c	81.46 ± 0.29 d	42.04 ± 0.47 e
	1	59.55 ± 0.08 ab	52.46 ± 0.56 b	86.18 ± 0.70 c	45.21 ± 0.12 d
	2	59.32 ± 0.50 abc	52.41 ± 0.17 b	88.73 ± 0.09 a	46.51 ± 0.20 b
2	0	59.44 ± 0.69 abc	53.17 ± 0.01 a	86.18 ±0.03 c	45.82 ± 0.01 c
	1	58.95 ± 0.04 bc	52.71 ± 0.04 ab	87.50 ± 0.33 b	46.13 ± 0.14 bc
	2	58.81 ± 0.12 c	53.17 ± 0.27 a	88.64 ± 0.09 a	47.13 ± 0.28 a
Significance		**	**	**	**

[1] = raw samples; [2] = cooked samples; WP = whey powder; SMP = skim milk powder
(a–f): Different letters in the same column and section indicate significant differences
*: $p<0.05$, **: $p<0.01$

Table III: Effect of whey powder, skim milk powder and their combination on sensory characteristics of meat patties

Treatments		Sensorial Characteristics					
		Appearance	Interior color	Elasticity	Juiciness	Chewiness	Flavor
WP	0	4.13 ± 0.31 a	4.08 ± 0.30 a	3.98 ± 0.43 a	3.92 ± 0.22 a	4.10 ± 0.26 ab	4.00 ± 0.37 a
	1	4.29 ± 0.30 a	4.20 ± 0.23 a	3.81 ± 0.22 a	3.78 ± 0.41 a	3.89 ± 0.24 b	4.04 ± 0.48 a
	2	4.35 ± 0.41 a	4.14 ± 0.38 a	4.00 ± 0.24 a	3.90 ± 0.34a	4.22 ± 0.35 a	3.83 ± 0.44 a
Significance						*	
SMP	0	4.33 ± 0.32 a	4.14 ± 0.39 a	3.79 ± 0.20 b	3.80 ± 0.28 a	4.15 ± 0.42 a	4.07 ± 0.36 ab
	1	4.15 ± 0.33 a	4.16 ± 0.20 a	4.10 ± 0.33 a	3.91 ± 0.38 a	3.97 ± 0.25 a	3.70 ± 0.48 c
	2	4.29 ± 0.39 a	4.13 ± 0.33 a	3.89 ± 0.33 ab	3.90 ± 0.34 a	4.09 ± 0.22 a	4.09 ± 0.34 a
Significance				*			
WP	SMP						
0	0	4.17 ± 0.29 a	4.25 ± 0.43 a	3.60 ± 0.09 b	3.77 ± 0.20 a	4.22 ± 0.38 a	4.11 ± 0.19 a
	1	4.00 ± 0.33 a	4.11 ± 0.19 a	4.22 ± 0.38 a	3.89 ± 0.20 a	3.92 ± 0.14 a	3.78 ± 0.39 a
	2	4.22 ± 0.38 a	3.89 ± 0.20 a	4.11 ± 0.51 ab	4.11 ± 0.19 a	4.19 ± 0.17 a	4.11 ± 0.51 a
1	0	4.39 ± 0.98 a	4.03 ± 0.29 a	3.89 ± 0.20 ab	3.97 ± 0.30 a	3.89 ± 0.20 a	4.16 ± 0.44 a
	1	4.16 ± 0.44 a	4.28 ± 0.25 a	3.86 ± 0.34 ab	3.64 ± 0.53 a	3.77 ± 0.20 a	3.67 ± 0.58 a
	2	4.33 ± 0.33 a	4.30 ± 0.05 a	3.69 ± 0.05 ab	3.75 ± 0.47 a	4.00 ± 0.33 a	4.28 ± 0.25 a
2	0	4.44 ± 0.51 a	4.14 ± 0.56 a	3.89 ± 0.20 ab	3.66 ± 0.33 a	4.36 ± 0.60 a	3.94 ± 0.49 a
	1	4.28 ± 0.25 a	4.08 ± 0.14 a	4.22 ± 0.19 a	4.19 ± 0.17 a	4.22 ± 0.19 a	3.66 ± 0.66 a
	2	4.33 ± 0.58 a	4.19 ± 0.50 a	3.89 ± 0.20 ab	3.86 ± 0.34 a	4.08 ± 0.14 a	3.89 ± 0.20 a
Significance				*			

WP = whey powder; SMP = skim milk powder
(a–c): Different letters in the same column and section indicate significant differences
*: $p<0.05$

65.42% PC1 and 23.46% PC2 (Fig. 1). PC1 was heavily loaded on WP, SMP, appearance, color, yield, moisture of cooked patties, moisture retention, hardness of raw patties, strength of fracture, work of fracture, cohesiveness, moisture of raw patties; whereas PC 2 was loaded on hardness of cooked patties, chewiness (textural), flavor, work of compression of raw patties, springiness, elasticity, juiciness and chewiness (sensorial). The PCA analysis presented a strong positive correlation between WP and moisture of cooked patties, moisture retention and yield. Water binding capacity of WP is higher than casein (Damodaran, 1996). However, there was weak negative correlation between WP and hardness of raw patties and strength of fracture and strong negative correlation between WP and work of fracture (Fig. 1). The PCA results also showed a strong correlation between SMP and strength of

Table IV: Effect of whey powder, skim milk powder and their combination on textural properties of meat patties

Treatments		Textural properties							
		[1]Hardness (N)	[1]Work of Compression (mNs)	[2]Strength of fracture (N)	[2]Work of Fracture (mNs)	[2]Hardness (N)	[2]Springiness	[2]Cohesiveness	[2]Chewiness
WP	0	6.08 ± 0.72 a	11.29 ± 1.64 a	22.28 ± 1.58 a	72.47 ± 5.60 a	32.05 ± 2.69 b	1.00 ± 0.14 a	0.728 ± 0.01 a	23.68 ± 4.84 b
	1	5.87 ±0.76 ab	11.52 ± 1.41 a	20.06 ± 2.01 b	62.58 ± 7.73 b	36.27 ± 3.12 a	1.05 ± 0.13 a	0.731 ±0.02 a	28.06 ± 4.75 a
	2	5.36 ± 0.62 b	10.40 ± 1.37 a	20.09 ± 1.48 b	59.97 ± 5.54 b	33.96 ± 3.00 ab	0.98 ± 0.12 a	0.721 ± 0.01 a	24.10 ± 3.81 b
Significance		*		**	**	**			*
SMP	0	5.63 ± 0.52 a	10.70 ± 1.06 a	22.04 ± 1.89 a	69.58 ± 8.13 a	35.35 ± 3.34 a	1.06 ± 0.14 a	0.735 ± 0.02 a	27.68 ± 4.76 a
	1	5.88 ± 1.07 a	11.37 ± 2.25 a	20.96 ± 1.59 a	65.56 ± 8.24 a	32.49 ± 3.46 b	0.96 ± 0.13 a	0.725 ± 0.01 ab	22.83 ± 5.15 b
	2	5.79 ± 0.56 a	10.15 ±0.94 a	19.43 ± 1.53 b	59.87 ± 5.67 b	34.45 ± 2.85 ab	1.02 ± 0.10 a	0.721 ± 0.01 b	25.33 ± 3.35 ab
Significance				**	**	*		*	*
WP	SMP								
0	0	5.65 ± 0.63 bc	10.31 ± 1.52 bc	23.52 ± 0.34 a	75.72 ± 3.11 a	33.63 ± 3.11 abc	1.10 ± 0.13 a	0.743 ± 0.01 ab	27.72 ± 4.50 a
	1	6.85 ± 0.56 a	12.93 ± 1.38 a	22.63 ± 1.46 ab	75.35 ± 5.03 a	29.63 ± 1.74 c	0.89 ± 0.05 a	0.725 ± 0.01 abc	19.20 ± 1.28 c
	2	5.73 ± 0.18 abc	10.62 ± 0.62 abc	20.68 ± 1.15 bcd	66.33 ± 2.40 bc	32.90 ± 1.60 bc	1.02 ± 0.16 a	0.716 ± 0.02 c	24.12 ± 4.12 abc
1	0	5.38 ± 0.68 bc	10.72 ± 1.02 abc	21.80 ± 2.18 abc	71.04 ± 6.73 ab	38.19 ± 3.77 a	1.06 ± 0.16 a	0.745 ± 0.02 a	30.20 ± 5.89 a
	1	6.00 ± 0.77 ab	11.75 ± 2.09 abc	19.98 ± 0.99 bcd	59.89 ± 3.88 cd	36.37 ± 0.76 ab	1.10 ± 0.15 a	0.725 ± 0.01 abc	29.14 ± 3.29 a
	2	6.23 ± 0.84 ab	12.10 ± 0.98 ab	18.42 ± 1.33 d	56.82 ± 3.29 d	34.25 ± 3.55 abc	1.00 ± 0.12 a	0.722 ± 0.01 bc	24.84 ± 4.54 abc
2	0	5.85 ± 0.23 abc	11.06 ± 0.84 abc	20.81 ± 1.94 bcd	61.98 ± 7.91 cd	34.22 ± 1.49 abc	1.03 ± 0.17 a	0.715 ± 0.01 c	25.13 ± 4.07 abc
	1	4.80 ± 0.81 c	9.42 ± 2.09 c	20.27 ± 0.82 bcd	61.45 ± 3.78 cd	31.49 ± 2.82 bc	0.88 ± 0.04 a	0.723 ± 0.01 abc	20.14 ± 2.85 bc
	2	5.43 ± 0.95 bc	10.73 ± 0.39 abc	19.20 ± 1.51 cd	56.47 ± 4.28 d	36.19 ± 3.03 ab	1.03 ± 0.03 a	0.723 ± 0.01 abc	27.03 ± 0.56 ab
Significance		*	*	**	**	*		*	*

[1] = raw samples; [2] = cooked samples; N = Newton; mNs = milli Newton second; WP = whey powder; SMP = skim milk powder
(a–d): Different letters in the same column and section indicate significant differences
*: $p<0.05$, **: $p<0.01$

fracture, work of fracture and moisture of raw patties; negative low correlation between SMP and cohesiveness and positive low correlation between SMP and yield. Results also showed no significant relationship between treatment and the other characteristics of meat patties (Fig. 1).

CONCLUSION

Addition of WP and SMP either 1% or 2% increased moisture, yield and moisture retention of patties and did not cause any negative effects on the sensory properties of the patties. According to textural analysis both additives decreased strength of fracture and work of fracture in cooked samples. Likewise, SMP decreased hardness, cohesiveness and chewiness. However, WP increased hardness and chewiness. Thus WP and SMP can be recommended as binder in the patties. Nonetheless, WP is better binder than SMP in the formulation of meat patties.

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