APPLICATIONS OF COLD SET WHEY PROTEIN GELATION IN IMPROVING MEAT BATTERS

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Abstract

The effect of using pre-heated whey proteins to replace part of the proteins in poultry meat batters formulated with different salt levels was studied. Substitution with 2% pre-heated whey proteins significantly (P<0.05) improved binding in raw batters. In the cooked state, it enhanced water holding capacity, reduced cook loss and improved textural parameters, especially at ≤1.5% salt. Un-heated whey proteins (i.e., lacking the ability to gel at low temperature) did not show any negative effect on the texture of the cooked batters, but reduced water holding capacity of the raw batters.

Overall, the study demonstrated the potential new use of whey proteins to improve the binding of raw and cooked meat batters, particularly in reduced salt meat products.

Introduction

Salt-soluble proteins (myosin and actin) are the main components responsible for binding and texture in processed meat products. Therefore, adequate salt level and proper mixing are essential to obtain optimal water retention and acceptable mouth feel. Non-meat ingredients (proteins, carbohydrates) which are often added to processed meat products can also affect the type of gel formed, and consequently the texture of the final product. Overall, non-meat proteins are used in meat formulations to improve yield, modify textural properties and reduce costs (Hung and Smith, 1993). Proteins such as soy, egg white or whey are usually added to enhance the gel structure of meat products; however, sometimes can exhibit negative effects. Lanier (1991) reported that substituting soy protein for turkey or surimi increased the cohesiveness of the gels, but slightly dropped the rigidity at high replacement levels. Substitution with whey proteins (0.74%) increased gel cohesiveness of a surimi system. However, higher whey levels (2.96%) resulted in higher rigidity and lower strain. Burgarella *et al.* (1985) indicated that using egg white and WPC diluted or interfered with the gelation of the fish proteins in surimi. Their mechanical testing suggested that the initial work values obtained for either the fish and egg white gels or fish and whey mixtures were lower than those for each single protein system, mainly because of a dilution effect of the proteins by one another. Another suggestion was that whey and egg white proteins became reactive at temperatures above the gelation temperature of the fish protein and, therefore, the mixed gels are weaker. Overall, a better understanding of the contribution of non-meat proteins to the texture forming process of meat protein gels is important.

Previous work has indicated that a pre-heated WPI suspension could gel at a low protein concentration (2% w/v) and low temperature (1-3°C) in the presence of >20 mM Ca^{2+} (Hongsprabhas and Barbut, 1997). Gels formed at low temperature and [$CaCl_2$] are more transparent and less rigid than those formed at higher temperature and [$CaCl_2$] above 30 mM $CaCl_2$. Thus, it is possible that Ca^{2+}-induced gelation of WPI would be beneficial in meat systems as it can provide binding prior to cooking. Furthermore, the mechanisms of WPI gelation could be manipulated by modifying the ionic strength of the system and hence the gel characteristics. Thus, the objective of this study was to examine the effect of pre-heated WPI and NaCl concentration on the properties of poultry meat batters.

Materials and Methods

Hand-deboned chicken breast meat was trimmed of all visible fat and connective tissue and chopped in a bowl chopper to produce a homogeneous mass. The meat was vacuum packed and frozen for up to one month prior to use.

Whey protein isolate (Davisco, MN) suspensions (10%) were prepared in double distilled water and half was pre-heated at 80°C for 30 min and then cooled at room temperature. The other half was kept without heating. The meat was thawed at 1°C for 24 hr, portioned and mixed with the other ingredients.

Salt (NaCl; 0-2%) was added and mixed by hand for 1 min followed by the addition of water or WPI suspensions (pre-heated or non-heated) and mixed for another 4 min. Treatments consisted of: (i) whey protein:meat protein = 0:16% (control); (ii) pre-heated whey protein:meat protein = 2:14%; and (iii) non-heated whey protein:meat protein = 2:14%. Portions of the mixtures were stuffed into 50 mL test tubes, which were divided into two sets. The first was used for a pre-cooking evaluation and the second for a post-cooking evaluation (78°C internal temperature). Both sets were kept overnight (16 hr) at 1°C to allow for cold-set gelation of the WPI.

Water holding capacity (WHC) was evaluated by centrifugation at 15,300g for 20 min. Supernatant was collected and WHC calculated as the proportion of liquid retained. Colour was determined by a Minolta Chroma Meter CR-200b. Penetration force was determined by a 20-mm diameter stainless steel rod mounted on a Nene Texture Analyzer descending into the meat samples. Cook loss was determined as the proportion of liquid separating from the cooked batters.

Results and Discussion

The substitution of WPI, either in the pre-heated or non-heated form, significantly (P≤0.05) affected WHC and textural properties (Table 1). It also affected colour and cook loss of the raw and cooked meat batters. Salt concentration significantly affected WHC, colour, cook loss and penetration force of the raw and cooked batters.

Water holding and penetration force markedly increased when pre-heated WPI suspensions were used to substitute for part of the chicken meat protein (Table 1). Although the non-heated WPI substitution consisted of the same amount of protein as the other two treatments, the structures of the non-heated WPI batters were significantly weaker. When no salt was added, no penetration force was detected because the batter was too soft. In addition, WHC of the samples were much lower than that of treatments (i) and (ii).

It should be noted that a solution of 2% pre-heated WPI does not form a gel even in the presence of 10 mM $CaCl_2$ when incubated at 1-3°C for 4 days. Thus, the structure formed within the meat batter prepared with 0% NaCl was possibly due to an interaction between the WPI and meat proteins in the presence of salt naturally occurring within the muscle. It is possible that the pre-heated whey proteins, which have more reactive groups than the non-heated ones, could react with the soluble meat proteins (present in the aqueous phase) of the meat batters.

As NaCl was raised, WHC increased and the meat became significantly darker. Replacing 2% of the meat proteins with pre-heated WPI did not affect the lightness of the batter at salt level <2%, but replacement with non-heated WPI resulted in a significantly darker appearance in all the salt levels but the 2%.

Within the all-meat batters and the ones substituted with non-heated WPI, the increase in salt slightly increased the penetration force at the raw stage (Table 1). In the pre-heated WPI group, the meat batters became significantly more firm. This was the result of forming a cold-set gel. However, increasing the salt level resulted in decreasing the penetration force indicating that higher salt levels produce softer gel structures. This was expected since increasing the Na level in a WPI cold-set system is known to shift the gel structure from fine strands to aggregates (Hongsprabhas and Barbut, 1996). Thus, the results indicate that increasing the salt in raw meat batters, containing pre-heated WPI, reduced the penetration force. In most processed meats, salt is required to extract salt-soluble proteins such as myosin, actin, actomyosin (Smith, 1991) and their amounts in the aqueous phase are proportional to the NaCl used (Gordon and Barbut, 1992). In the present study, the lower penetration force of samples containing pre-heated WPI with higher salt levels might have resulted from changes in the charge distribution on the WPI molecules which caused more aggregation or the higher salt level resulted in more meat soluble proteins which have interfered with the WPI gel network formation.

References

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Table 1. Effect of WPI substitution and NaCl concentration on functional properties of raw and cooked chicken breast meat batters. Total protein content in all batters was 16%.

Treatment	NaCl (%)	WHC (%)	Raw penetration force (N)	Cooked penetration force (N)
(i) No substitution	0.0	66.5[g]	0.27[de]	3.06[d]
	1.0	89.3[d]	0.35[cde]	5.52[cd]
	1.5	99.1[ab]	0.54[cd]	6.10[cd]
	2.0	99.3[ab]	0.73[c]	6.10[cd]
(ii) Substituted with 2% (g/g protein) pre-heated WPI	0.0	83.7[e]	2.96[a]	7.99[abc]
	1.0	97.4[b]	2.13[b]	10.29[ab]
	1.5	99.3[ab]	2.14[b]	10.71[a]
	2.0	99.8[a]	2.11[b]	8.02[abc]
(iii) Substituted with 2% (g/g protein) non-heated WPI	0.0	53.7[h]	na*	2.91[d]
	1.0	78.6[f]	0.10[e]	6.32[c]
	1.5	88.2[d]	0.25[de]	6.83[c]
	2.0	92.5[c]	0.41[cde]	7.25[bc]

Means followed by a different superscript are significantly different ($p \leq 0.05$).
* not available; batters too soft.