Utilizing Functional Meat-Based Proteins in Processed Meat Applications

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Protein ingredients play a vital role as a functional and essential component in meat products. Functionally, they are important because they impart unique properties to a variety of meat products. Potential functional benefits include improved water binding, improved texture, reduced syneresis, improved emulsifying capacity and enhanced organoleptic characteristics. Animal protein ingredients contribute nutritionally as they are a source of energy and required for growth and maintenance and due to their excellent amino acid profile, protein digestibility and bioavailability.

The type of protein, its structure and its environment determines the unique properties of protein ingredients. An array of protein ingredients is available commercially. Traditionally, protein ingredients from animal sources include collagen proteins, blood proteins (plasma), egg proteins, milk proteins, and fish proteins.

Pork collagen protein

One functional protein obtained from an animal source is collagen protein. It is the main protein component of tendons, bone, cartilage, skin, vascular tissues and basement membranes of any mammalian species.

Recent developments include pork collagen protein for the meat industry, produced from low temperature processing of fresh pork trimmings. During the manufacturing process, the protein undergoes extrusion and dehydration. The product is then dried and milled into granular form. This process creates a unique product, which contains over 85% protein and 12% fat. This protein will bind at least 5 times its weight in water to form a firm elastic cold gel with a texture similar to meat. The gel formed, contributes to the texture and works synergistically with the native meat proteins to bind fat, water and other components. Hence, under normal thermal processing conditions, moisture and fat purging is reduced or eliminated. This property is very useful in emulsified products such as hot dogs and bologna. This protein is more compatible in a meat system with respect to flavor and functionality than many of the currently used additives such as milk and vegetable protein.

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Poultry collagen proteins

A recent development is collagen proteins made from chicken and turkey skin. The poultry skins are ground and undergo a low temperature rendering process. The swollen colloidal collagen tissue then goes through a milling and dehydration process. This results in a product that contains more than 70% protein and less than 28% fat. These proteins can bind up to four times their weight in water to produce a firm thermally reversible gel. The gels have similar characteristics to pork collagen proteins. These proteins contribute to the texture of meat products by binding fat and water within the lean meat matrix.

Plasma proteins

Another functional protein obtained from an animal source is plasma. Plasma constitutes about two-thirds of the weight of blood. It is a colloidal suspension composed of 90% water and 7% protein. Beef plasma is produced under strict USDA inspection from the blood of healthy animals. The red cells are separated from the plasma. The liquid plasma is then filtered, spray dried and packaged. The resulting material is off-white in color, containing approximately 72% protein, less than 4% fat and has an excellent amino acid profile.

Plasma proteins are highly functional. They have excellent solubility, low viscosity and the ability to form strong, elastic irreversible gels that increase gel strength as the temperature increases. This property makes it an ideal protein for inclusion in products subjected to temperatures above 80°C such as sterilized or canned products. Plasma proteins can also enhance texture in processed meat and surimi.

In addition, plasma proteins have the ability to emulsify fat in a manner similar to meat proteins. Plasma proteins are good emulsifiers, due to their molecular structure which has two distinct regions: one hydrophilic (water loving) and one hydrophobic (fat loving). This characteristic makes plasma proteins ideal for use in emulsified meat products to im-

prove stability when low quality meat is used, or to replace some of the lean meat fraction.

Functional properties of meat based proteins

The functional properties of a protein are those physiochemical characteristics that affect the behavior of the proteins during preparation, processing, storage and consumption of the food product. These properties have a significant influence on the processing procedures as well as the quality of the end product.

In order to better understand and illustrate the physical properties and performance of animal based proteins compared to vegetable based protein such as soy protein isolate, gel strength and water losses for varying concentrations were measured at different temperatures in a model gel system. The proteins were heated to 75°C for 120 minutes with 2% salt to simulate similar condition experienced in meat processing. The results (Fig. 1a, 1b, 1c) show that plasma proteins as well as pork collagen proteins have the ability to form strong, elastic gels at concentrations as low as 10% compared to the soy protein. As the concentration of the protein increases, water losses are reduced, demonstrating excellent water binding properties compared to soy protein.

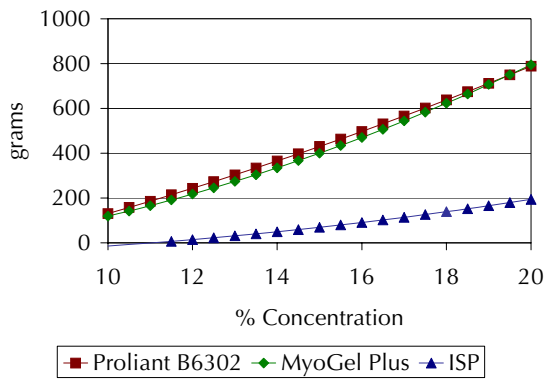

Figure 1a: Gel Strength vs. Concentration at 3°C

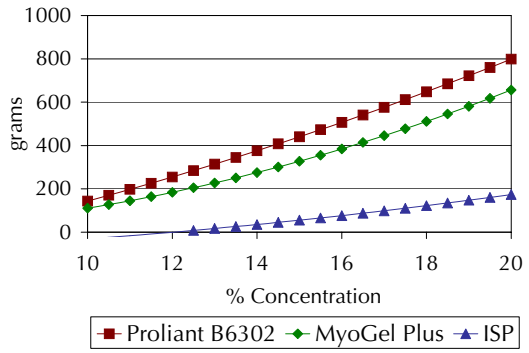

Figure 1b: Gel Strength vs. Concentration at 8°C

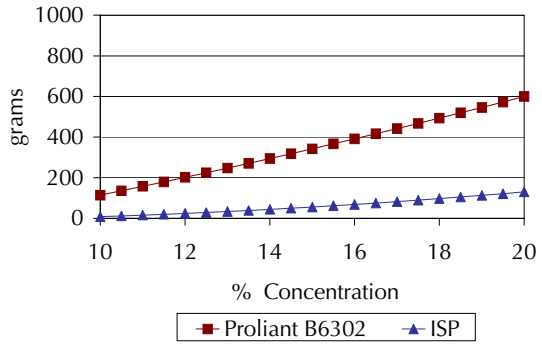

Figure 1c: Gel Strength vs. Concentration at 41°C

Processed meat applications

Pork collagen

Pork collagen is very versatile. It does not need to be prehydrated; however, it should be added to the bowl chopper with the lean meat and ice for better interaction with the salt soluble native meat proteins. A typical frankfurter formulation was used as a model to study the effects of dehydrated pork protein as a binder and extender in comminuted products (Table 1). The effects of incorporation of up to 3.5% pork collagen on yield, purge, texture, color and sensory evaluation was studied. As the results indicate, significant increases in cook yields were observed at levels of 1% and above (Figure 2). It is effective in controlling purge as indicated by significant decreases in free water content after both 4 and 8 weeks of storage (Figure 3). The addition of pork collagen produced a firmer texture as seen in Figure 4. Sensory difference testing only showed a significant difference when the level was increased to above 2%, although at higher levels (above 2.5%), the product was still acceptable.

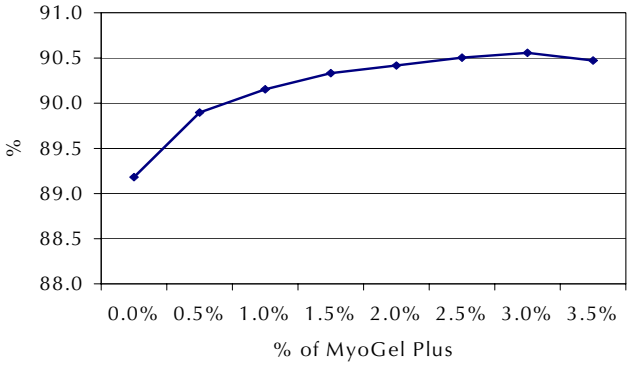

Figure 2. Cooked Yield for hot dogs with pork collagen (MyoGel Plus).

Table 1. Hot dog formula with pork collagen (MyoGel Plus).

	Usage level of Pork Collagen							
Ingredients	**0.0%**	**0.5%**	**1.0%**	**1.5%**	**2.0%**	**2.5%**	**3.0%**	**3.5%**
Pork 80's	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Pork 50's	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
MDC	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Water	20.66	20.66	20.66	20.66	20.66	20.66	20.66	20.66
MyoGel Plus	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Salt	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Spice	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mustard	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Dextrose	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Phosphate	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Erythorbate	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
Nitrite	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
TOTAL	100.00	100.50	101.00	101.50	102.00	102.50	103.00	103.50

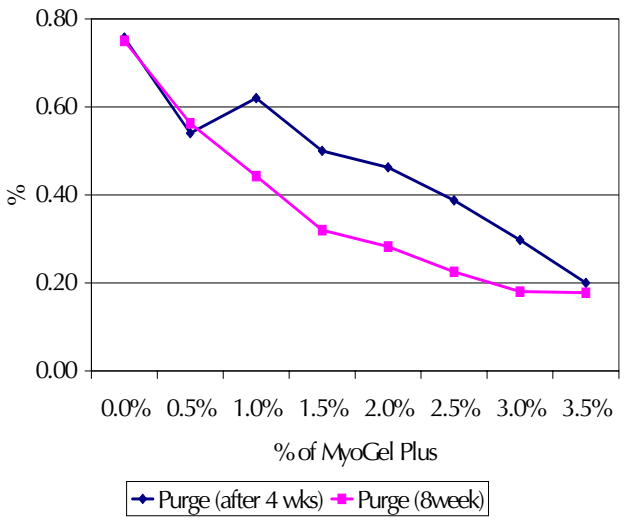

Figure 3. Purge for hot dogs with pork collagen (MyoGel Plus).

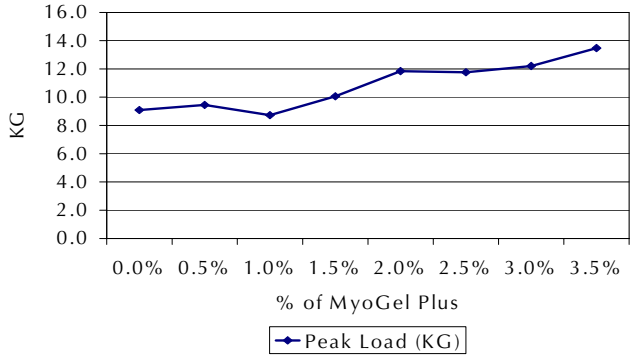

Figure 4. Instrumental texture analysis for hot dogs with pork collagen (MyoGel Plus).

Besides increasing cook yield, pork collagen also stabilizes shrinkage and improves the texture of meat products. In a ground beef patty formulation, 1% pork collagen hydrated 1:4 was used to replace 5% lean ground beef (Table 2). Results showed that cooked yields were increased by 4.3%, and the diameter shrink loss of the patties was reduced by 2.53%, when 1% of pork collagen was used. This relates to cost savings of 4% over the control formula.

Table 2. Ground beef patty formula with pork collagen (MyoGel Plus)

Beef 80/20	99.50	94.50
Water	0.00	4.00
Salt	0.50	0.50
MyoGel Plus	**0.00**	**1.00**
Total	*100.00*	*100.00*
Cooked Yield (%)	69.60	73.80
Diameter Shrink Loss (%)	19.90	17.40
Cost Reduction (%)	---	$4.00

In a 97% fat free pork breakfast sausage, pork collagen hydrated 1:4 was used at a level of 1% and 2% to replace 5% and 10% lean pork (Table 3). Results showed that cooked yields were increased by 5% and 9.1%, and the diameter shrink loss of the sausage was reduced by 2.7% and 5.5% respectively. This relates to a cost saving of 3.8% and 7.6% over the control formula. Sensory evaluation of the products indicated that treatments containing pork collagen was considered juicier and had a preferred flavor profile compared to the control.

Table 3. 97% fat free breakfast sausage formula with pork collagen (MyoGel Plus)

Ingredient	Control	1% MyoGel Plus	2% MyoGel Plus
Lean Ham	94.40	89.40	84.40
Spice Blend w/salt	2.25	2.25	2.25
Phosphate	0.35	0.35	0.35
Water	3.00	7.00	11.00
MyoGel Plus	**0.00**	**1.00**	**2.00**
Total	*100.00*	*100.00*	*100.00*
Results			
Cook Yield (%)	79.46	84.50	88.60
Shrinkage after cooking (%)	10.88	8.17	5.39
Treatment cost/ lb	$1.05	$1.01	$0.97
Cost Savings (%)	-----	3.80	7.60

Poultry collagen

The recommended usage level for poultry collagen is 1-2%. In a turkey burger, turkey collagen was used at 2%, hydrated 1:4, to replace 10% of turkey thigh meat and turkey skin in equal proportions. The cook yield was increased by 2.2% resulting in cost savings of 2.6% over the control formula. Less shrinkage during cooking was also observed (Table 4).

Table 4. Turkey burger with turkey collagen (Proliant T5501)

Ingredient	Control	2% T5501 Turkey Flavor
Line Run Turkey Thigh Meat	84.10	76.90
Turkey Skins	8.45	7.65
Water	6.00	12.00
Salt	0.75	0.75
Proliant T5501 Turkey Flavor	0.00	2.00
Onion Powder	0.30	0.30
Garlic Powder	0.10	0.10
Black Pepper	0.05	0.05
Herbalox HT25	0.25	0.25
Total	*100.00*	*100.00*
Cook Yield (%)	77.57	79.72
Diameter Shrink Loss (%)	12.44	10.02
Blend Cost Savings (%)	------	2.60

In a turkey-smoked sausage, 5% and 10% of the meat block was replaced by turkey collagen at 1% and 2% at a 1:4 hydration respectively (Table 5). Cook yields were increased, purge over 4 weeks was reduced and a cost saving of 3.1% was achieved.

Table 5. Turkey smoked sausage with turkey collagen (Proliant T5501).

Ingredient	Control	1% T5501 Turkey Flavor	2% T5501 Turkey Flavor
Line Run Turkey Thigh Meat	52.30	47.30	42.30
Turkey Skins	7.55	7.55	7.55
MDT	15.00	15.00	15.00
Water	15.25	19.25	23.25
Salt	2.20	2.20	2.20
Proliant T5501 Turkey Flavor	0.00	1.00	2.00
Dextrose	1.50	1.50	1.50
Corn Syrup Solids	1.50	1.50	1.50
Sodium Phosphate	0.05	0.05	0.05
Sodium Lactate	2.00	2.00	2.00
Flavor	2.60	2.60	2.60
Sodium Erythorbate	0.04	0.04	0.04
Sodium Nitrite	0.01	0.01	0.01
Total	*100.00*	*100.00*	*100.00*
Cook Yield (%)	80.03	80.62	81.41
Purge (%)			
Week 2	1.18	1.08	1.06
Week 4	1.42	1.34	1.20

In whole muscle products such as chicken breast or chicken wings, chicken collagen can be used to provide significant cost savings by meat replacement. Use of 1% chicken collagen hydrated 1:4 to replace 5% chicken breast meat resulted in a yield increase of 3.8%. A cost saving of 2.9% was achieved while reducing tumbling time by 40% (Table 6). Use of 1% chicken collagen in buffalo wings resulted in a yield improvement of 5.2% and a cost saving of 2.7% over the control (Table 7).

Table 6. Chicken breast with chicken collagen (Proliant C5501).

Ingredient	Control (%)	Test (%)
Torn breast fillets	89.29	84.29
Water	9.78	13.78
Proliant C5501 Chicken Flavor	0.00	1.00
Salt	0.50	0.50
Phosphate	0.43	0.43
Total	*100.00*	*100.00*
Cook Yield (%)	57.04	60.80
Cost Savings (%)	-----	2.90

Table 7. Buffalo wings with chicken collagen (Proliant C5501).

Ingredient	Control (%)	Test (%)
Chicken wings	77.76	72.76
Water	11.12	15.12
Buffalo seasoning	11.12	11.12
Proliant C5501 Chicken Flavor	0.00	1.00
Total	*100.00*	*100.00*
Cook Yield (%)	62.75	67.95
Cost Savings (%)	-----	2.70

Plasma proteins

The recommended usage level of plasma proteins in processed meat is 0.5%-2%. Plasma proteins are used as a functional ingredient in several types of meat products as outlined in Table 8. Due to the high protein (72%) and low fat content (4%), the use of beef plasma in processed meat applications provides significant opportunities for cost savings and nutritional improvement. With this proximate composition, a hydration ratio of five parts water to one part of plasma may be used to replace either pork or beef to reduce cost and fat content.

Table 8. Use of plasma proteins in various processed meat applications

Product category	Type of product	Functionality of beef plasma
Uncooked and ground products	hamburger patties, meat balls, bratwurst	increases fat and water binding, fat replacer in low fat product, reduces product shrink
Emulsified products	frankfurters, Vienna sausage, bologna, retort ham sausage	improves emulsion stability, improves quality (texture, flavor, juiciness), improves peelability, improves cooked yield
Whole muscle products	boneless ham, restructured ham	increases cooking yield, increases bind between meat pieces, improves texture

In a ground beef patty formulation, 1% beef plasma hydrated 1:5 was used to replace 6% of beef 80's (Table 9). Results showed that cook yields were increased by 5% and the diameter shrink loss of the patties was reduced by 4.4% in the formulation containing beef plasma. This relates to a cost saving of 4% over the control formula.

Table 9. Ground beef patty formulation with beef plasma (Proliant B6302)

Ingredient	Control	Test
Beef 80/20	99.50	93.50
Water	0.00	5.00
Salt	0.50	0.50
Proliant B6302	0.00	1.00
Total	*100.00*	*100.00*
Cook yield (%)	69.59	74.57
Diameter shrink loss (%)	19.94	15.54
Cost savings (%)	-----	4.00

In a 110% extended restructured ham (Table 10), beef plasma can be used to improve texture and reduce purge. Results showed that when beef plasma was used at 1.2%, the textural quality of the ham improved as indicated by the instrumental texture analysis. There was a significant reduction in purge over four weeks of refrigerated storage. In these types of highly extended products, plasma can be used to restore the meat like texture, lost due to the high level of extension.

Table 10. 110% extended restructured ham formulation with beef plasma (Proliant B6302)

Ingredient	Control %	Test %
Pork Shoulders 95/05	47.67	47.67
Water	38.96	37.76
Native potato starch	8.00	8.00
Proliant B6302	0.00	1.20
Lactose	2.00	2.00
Salt	2.19	2.19
Carrageenan	0.60	0.60
Phosphates	0.50	0.50
Sodium nitrite	0.02	0.02
Sodium erythorbate	0.06	0.06
Total	*100.00*	*100.00*
Texture		
Peak Load (Kg)	1.08	1.42
Purge (%)		
Week 1	5.88	4.38
Week 4	7.30	4.27

In a retorted ham sausage, plasma hydrated 1:5 can be used to replace six parts of lean meat as shown in Table 11. This is due to the ability of plasma to form heat stable gels, meaning that after cooling and re-heating; it will not separate from the protein even if the heat treatment is severe as in a retort process. The high temperature used for retorting the sausage, increases the firmness of the plasma containing meat emulsions when compared to plasma-free emulsions.

Table 11. Retort ham sausage formulation with beef plasma (Proliant B6302)

Ingredient	Control %	Test %
Pork 85/15	14.00	8.00
MDC	14.00	14.00
Pork skin emulsion (1:1)	6.00	6.00
Pork fat	12.00	12.00
Water	35.54	40.54
Native corn starch	9.00	9.00
Soy protein concentrate	3.00	3.00
Soy protein isolate	2.00	2.00
Proliant B6302	**0.00**	**1.00**
Color	0.00	0.00
Sugar	1.50	1.50
Salt	2.10	2.10
Phosphates	0.30	0.30
Erythorbate	0.10	0.10
Nitrite	0.01	0.01
MSG	0.10	0.10
Spice	0.35	0.35
Total	*100.00*	*100.00*
Texture		
Peak Load (KG)	5.82	6.17

Meat stocks

Meat stocks are another class of meat-based proteins derived from the cooking of animal bones (pork, beef, chicken and turkey) and adhering meat. The broth obtained is concentrated and spray dried into a powder form. They are highly soluble, high in protein (approximately 97%) and low in fat (less than 2%). Meat stocks can be used to enhance meat flavor that is lost during processing or due to high levels of extension of meat products. In a ground beef patty formulation, 1.5% beef stock improved the flavor, increased the juiciness and reduced the warmed over flavor in the product. Stocks can also be used to supplement the protein levels in highly extended formulations, maximize the non-meat protein allowed in a sausage formulation or mask the off-flavor from lactate in a formulation. Meat stock can also serve as a base for reaction flavors for other meat and savory applications.

Conclusions

Meat based protein ingredients can be viewed as cost effective functional ingredients that can improve quality of various meat products due to their water binding and gel forming ability. In addition, these ingredients are capable of increasing yield, improving texture, reducing syneresis and improving organoleptic characteristics while providing cost savings to the meat processor.