D14

QUALITY CHARACTERISTICS OF LOW-FAT GROUND BEEF PATTIES FORMULATED WITH WHEY PROTEIN CONCENTRATE

SALWA B. EL-MAGOLI[1], S. LAROIA[2], AND P.M.T. HANSEN[2]

[1] Department of Food Science and Technology, Faculty of Agriculture, Cairo University, Egypt and [2] Department of Food Science and Technology The Ohio State University, Columbus, Ohio, 43210

Introduction

The increase in consumer concern and interest in reduced-fat foods, has created a growing need for low fat meat products in the market. Developing a lean or extra lean ground product while assuring the necessary palatability characteristics, demanded by consumers, is not as simple as just removing fat (Troutt *et al* 1992). The active approach to fat replacement is to add fat-mimetic ingredients, which either replace fat or modify the interactions of the remaining components (Miller, 1994). Among milk proteins, whey protein concentrate has been reported in many studies to exibit functional properties that have been proven useful in fat replacment (Lucca and Tepper 1994). Especially important are their gelation characteristics, their high water- and fat binding abilities and their effect on emulsion stability. The objective of this study was to assess the influence of whey protein concentrate as a functional ingredient in low-fat ground beef patties. The possible enhancement of WPC performance by the addition of TPP, HPM, $CaCl_2$, and lactose was also investigated. A comparative study was undertaken to examine the volatile components (DHA) generated in beef patties formulated with different fat levels, WPC and lactose.

Materials and Methods:

Formulation of low-fat ground beef patties: In three sets of separate experiments, samples were prepared using coarsely ground beef (10% fat), from local suppliers. Controls were formulated to have 10, 20 and 27% fat using minced ground round beef (10% fat), beef tallow (90% fat) and 0.5% encapsulated salt (Morton Salt Inc.). Whey protein concentrate (WPC) was obtained from New Zealand Milk Products Incorporated (Alacen 878: 79.5% protein, 4.5% ash, 4.2% moisture, 4.6% fat and 6% lactose). The material was first hydrated with the required amount of water to be added to the meat, by mixing for 15 min. using an electrical stir plate. The resulting thick slurry was kept overnight at 4°C before it was added with the salt to the meat and mixed thoroughly. The different texture modifying additives (TPP, HPM and $CaCl_2$) were added(0.3%) to the WPC solution during hydration, while lactose was added (0.24% and 1.2%) separately to the meat. The patties were were cooked to 71°C internal temperature for a total of 10.5 minutes (3 min., 2 min., and 15 sec. on each side), using an electric household grill heated to 177°C. Cooking yield, fat retention and shrinkage were calculated according to Berry, (1992) and Adams, (1994)

Texture Profile Analysis (TPA): After cooking and cooling to room temperature, two whole patties were compressed (at three different locations) to 75% of their height, for two cycles using a Universal TA-XT2 Texture Analyzer (Texture Technologies Corp.) equipped with a 1/2" flat surface plunger. The instrument was programmed for a 50 kg. load cell and cross head speed of 200 mm/min. Hardness, chewiness and springiness were obtained using the available computer software. All measurements were replicated.

Dynamic Head Space Analysis (DHA): The method described by Laye *et al* (1993) was used for analysis of volatile compounds. Compounds were tentatively identified by computer-matching of full or partial mass spectral database (NIST/EPA/MSDC 49K). The reproducibility for recovery of head space volatile compounds was calculated by the percent relative standard deviation (%RSD) method (Sensel and Griffiths, 1990 and Ha et. al., 1992). The data are averages of duplicates.

Sensory Evaluation : Sensory characteristics (flavor and texture) of controls and samples were determined by 10-15 untrained panelist, using the forced ranking method (Gacula and Singh, 1984).

Statistical Analysis: The sensory data was analyzed using the method of Kramer (1956). Analysis of variance using one and two- way ANOVA was employed on the objective data using StatWorks. Individual degree of freedom analysis was computed by the method described by Ostle (1963).

Results and Discussion

1. Cooking Characteristics of Low-fat ground beef patties

Effect of WPC and fat level: The cooking characteristics i. e. cooking yield, shrinkage, fat retention, cooked moisture and TPA of low-fat ground beef patties differed depending on WPC and fat level used, (Table1). The cooking yield increased with an increase of WPC level ($p>0.05$). A comparison of the two controls (27% fat and 10% fat) showed a decrease in cooked yield with increasing fat level. Thus, cooking yield was directly related to fat content, in agreement with the observations of Berry, (1993) and Huffman and Egbert, (1990). WPC was effectively better in increasing cooking yield at higher concentration levels i. e. 3 and 4% than at the lower concentrations of 1% level. A possible explanation is that at higher concentrations, WPC forms gels which will entrap more moisture and increase the water holding capacity of the meat system. These results are correlated with shrinkage and fat retention values (Table1). Samples containing 4% WPC revealed the highest cooked yield and the lowest shrinkage percentage among all samples tested. The fat retention percentage was significantly higher ($p>0.01$) in WPC samples compared to the two controls. This may be the result of whey proteins having excellent surface active properties,which allow them to reorient and reduce the interfacial tension and therefore increase emulsion stability (Lucca and Tepper, 1994). It was concluded that addition of WPC (4%) will increase fat binding in the meat system, even at lower fat levels (10% fat), and therefore will improve both flavor and texture. Fat levels shown to have a direct effect on all cooking characteristics studied. Controls containing 10% fat were significantly better ($p>0.01$) than controls containing 27% fat with respect to improved cooked yield, reduced shrinkage, and better fat retention and cooked moisture. However, the TPA showed that controls containing 27% fat were less hard and less chewy compared to both controls with 10% fat and samples containing higher levels of WPC (Table 1). It seems that incorporation of WPC somewhat modifies the textural properties of the low-fat beef patties making them less crumbly. Crumblyness may be a desirable feature in hamburger patties and TPA results for hardness and chewiness were correlated with the taste panel forced ranking

(Table 3). The 27% fat control rated significantly better for texture but the 4% WPC sample rated significantly better for flavor among all samples tested.

Effect of texture modifying additives: The panel results did not demonstrate a significant improvment in texture related to incorporation of WPC inspite of the significantly better moisture retention. Therefore, trials were conducted to determine if texture- modifying additives would improve texture quality. Addition of three texture-modifying additives i. e., TPP, HPM and CaCl2 at the 0.3% level to low-fat (10% fat) ground beef patties containing 4% WPC influenced the cooking parameters studied (Table 2). WPC samples without any addition were significantly better ($p>0.05$) in cooked yield and cooked moisture, while no differences ($p<0.05$) were observed in the other parameters i. e. shrinkage, fat retention and TPA. A comparison between the three additives revealed that TPP was significantly better ($p>0.05$) than HPM and $CaCl_2$ in cooked yield, cooked moisture and shrinkage. This is mainly related to the effect of phosphate in increasing the muscle protein functionality by changing the protein structure (Trout and Schmidt, 1987). On the other hand, addition of $CaCl_2$ to WPC samples decreased both cooked yield and cooked moisture and increased shrinkage percentage when compared to the other additives. This could be due to calcium ions tending to weaken the WPC gel structure and reduce its water-binding ability (Lucca and Tepper, 1994). Fat retention and TPA results did not differ significantly ($p>0.05$) within all the treatments (Tables 2). The panel detected no significant difference between samples in texture(Table 3). However, samples containing HPM ranked significantly better ($p>0.05$) and samples containing TPP ranked significantly worse ($p<0.05$) for flavor compared to other samples, possibly due to the bitter aftertaste of the phosphate salts.

Effect of added lactose: WPC contains varing amount of lactose depending upon the degree of protein concentration. For the WPC used in this study, the lactose content was 6%, resulting in 0.24% lactose in the 4% WPC meat formulation. The possibility that lactose acts as a flavor enhancer was studied. The results clearly indicated that increasing the lactose in the meat formulation up to1.2% significantly ($p>0.05$) enhanced flavor in low-fat beef patties (Table 3). This lactose level was the maximum amount which could be used without imparting an undesirable sweet taste to the meat patties. Overall, panelists preferred samples with added lactose over the other samples. This may be related to the effect of lactose as a reducing sugar in increasing the non-enzymatic browning reaction. On the other hand, the increased in lactose content (1.2%) in the meat had no significant effect ($p>0.05$) on any of the cooking characeristics studied.

2. Head space analysis (DHA):

Volatile compounds from low-fat ground beef patties were identified at different fat levels, with and without WPC and added lactose. Pentane, hexane and heptane, were found to decrease with the addition of WPC and lactose. These compounds are aliphatic, acyclic hydrocarbons which result from thermal oxidation of lipids. The effect of WPC and lactose on these compounds are not fully understood but suggest a possible interaction, such as postulated by Schirle-Keller *et al* (1992) for model systems affecting the volatility, vaporization and perception of these compounds (Jasinski and Kilara 1985). Pentane described as related to a burnt-green flavor in meat (Shahidi *et. al*, 1986), was higher in 10% fat samples than in 20 and 27% fat samples. On the other hand, heptane, described as cooked meat flavor, decreased with a decrease of fat content in meat samples underscoring the role of fat in meat flavor. Octane recognized as characteristic in meaty flavors showed inconsistent variation among samples studied .

Hexanal, an aldehyde related to lipid auto-oxidation was only detected in 27% and 20% fat samples, which suggests that the beef tallow used to increase fat content of the meat samples in this study was some what oxidized. Hexanal was not detected in samples without added fat (10% fat). It is noteworthy that addition of 4% WPC significantly decreased the hexanal in beef patties containing 20 and 27% fat. These results support the findings of Schirle-Keller *et. al*, 1992, who found that WPC interacted quite strongly with hexanal and trans-2-hexanal in model systems. The possibility that WPC masks some oxidized volatiles in the meat systems needs more investigation. Ketones identified in this study i. e. 2-butanone , 2-pentanone and 3-hydroxy-2-butanone described as "sickly, buttery and dull meat broth", respectively (Shahidi *et al*, 1986), were mainly related to fat content as their relative concentration was higher in samples containing 27 and 20% fat than in samples containing 10% fat . These ketones may also be the result of beef tallow used in this study, as ketones normally arise from saturated fatty acids.

4,4 dimethyl-2-oxetanone and 2-methyl-butanal, were found to increase significantly with an increase in lactose level in the meat, regardless of the fat level used. 2-Methyl butanal, an aliphatic aldehyde, has been identified in thermal degradation of glucose (Fagerson, 1969), and therefore might also occur as the result of an increase of lactose in the meat system. The suggestion has been made that 4,4 dimethyl 2-oxetanone which might form lactones could also originate from lactose. Lactones have been identified in non-enzymatic browning of lactose (Ferretti, *et. al* 1970 and Ferritti and Flanagan, 1973), and were found to contribute to the total flavor of cooked meat. In this study, volatile components were only tentatively identified, therefore, more research are needed to confirm their relation to lactose. However, our results clearly indicate that increasing lactose significantly enhances the flavor scores of low-fat ground beef patties.

References

Adams, S. M. (1994). Development of low-fat ground beef patties with extended shelf life. M. S.Thesis, Texas A&M University, College Station, TX.

Berry, B. W. (1993). J. Food Sci. 58, 34.

Gacula,M. Jr. and Singh, J. (1984). Statistical Methods in Food and Consumer Research. Academic Press, Inc.

Ha, E. Y. W., Morr, C. V. and Seo, A. (1992). J. Food Sci. 57, 414.

Huffman, D. L. and Egbert, W. R. (1990). Advances in lean ground beef production. Alabama Agri., Exp. Sta. Bull. No. 606. Auburn Univ., Ala.

Jasinski, E. and Kilara, A. (1985). Milchwissen Schaft, 40, 596.

Kramer, C. V. (1956). Biometrics, 12, 307.

Laye, I., Karleskind, D. and Morr, C. V. (1993). J. Food Sci. ,58, 991.

Lucca, P. A. and Tepper, B. J. (1994). Trends in Food Science & Technology, 5, 12.

Miller, M. S. (1994). Proteins as fat substitutes. In "Protein Functionality in Food Systems". Hettiarachchy, N. S. and Ziegler, G. R. (eds). Marcel Dekker, Inc.,435.

Ostle, B. (1963). Statistics in research; basic concepts and techniques for research workers. 2nd. ed. Ames, Iowa State University Press.

Schirle-Keller, J. P., Chang, A. H. and Reineccius, G. A. (1992). J. Food Sci., 57, 1448.

Sensel, K. A. and Griffiths, J. E. (1990). The use of summa canisters for whole air sampling on an automatic thermal desorber. Presented at the 41st Pittsberg conference, New York, NY.

Shahidi, F., Rubin, L. J. and D'souza, L. (1986). CRC Critical Review in Food Sci. and Nutrition, 24, Issue 2, 141.

Troutt, G. R. and Schmidt, G. R. (1987). Meat Sc., 20, 229.

Troutt, E. S., Hunt,, M. C., Johnson, D. E., Claus, J. R. Kastner, C. L., Kropf,D. H. and Stroda, S. (1992). J. Food Sci.,57, 25.

Table 1: Effect of Different Levels of Whey Protein Concentrate on Cooking Charateristics of Low-Fat Ground Beef Patties

	Cooking Parameters				Texture Profile Analysis		
Sample	Yield (%)	Shrinkage	Fat retention %	Cooked moisture %	Hardness Kg	Chewyness	Springyness
27% fat	59.30	17.40	41.60	51.10	2.38	0.85	0.90
10% fat	70.40	12.20	58.40	58.90	3.68	1.59	0.86
1%WPC	67.60	13.00	57.20	60.00	3.13	1.03	0.86
2%WPC	71.80	10.00	59.50	61.10	4.20	1.68	0.84
3%WPC	71.50	11.10	68.20	62.60	3.71	1.64	0.88
4%WPC	74.60	8.60	64.60	59.70	3.99	1.75	0.86

Table 2: Effect of Texture-Modifying Additives with WPC on Cooking Characteristics of Low-Fat Ground Beef Patties (10% fat).

	Cooking Parameters				Texture Profile Analysis		
Sample	Yield (%)	Shrinkage	Fat retention %	Cooked moisture %	Hardness Kg	Chewyness	Springyness
WPC	76.9	8.57	71.3	62.1	3.29	1.39	0.88
WPC+TPP	77.6	5.04	75.8	62.7	2.95	1.35	0.95
WPC+HPM	74.6	8.45	68.2	60.4	4.41	1.66	0.87
WPC+CaCl2	72.7	13.50	63.5	59.5	4.22	1.65	0.86

WPC=whey protein concentrate (4%), TPP=tripolyphosphate (0.3%), HPM=hydroxypropyl methyl cellulose (0.3%) CaCl2=calcium chloride (0.3%).

Table 3: Forced Ranking of Low-Fat Ground Beef Patties

	Different WPC levels		Different Texture Modyfying Additives			WPC with Added Lactose (L)		
Sample	Flavor	Texture	Sample	Flavor	Texture	Sample	Flavor	Texture
27%fat	2.2	2.1*	4% WPC	2.5	2.5	10%fat	2.7	3.2
10%fat	3.2	3.2	WPC+TTP	3.2**	2.1	10%fat+1.2%L	3.2	2.8
2%WPC	2.6	3.1	WPC+HPM	1.9*	2.3	4%WPC	3.3	2.0*
4%WPC	2.1*	2.6	WPC+CaCl2	2.3	2.5	10%fat+W+1.2L	1.7*	2.9

* = significantly better at the 5% level, ** = significantly worse at the 5% level,. W = WPC