DEVELOPMENT OF FORTIFIED BEEF PATTIES WITH ENHANCED PROTEIN CONTENT SUITABLE FOR ELDERLY CONSUMERS

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Abstract – There is growing potential to develop novel market niches by optimising meat products specifically for the elderly population segment as they provide excellent potential vehicles for nutritional fortification. This study was carried out to investigate technological and shelf life parameters of model meat products (beef patties) enriched in clean label protein ingredients: pea protein isolate (PPI), rice protein (RP) and lentil flour (L) at two inclusion levels (3% and 7%) compared to a control (C). Protein content in all treatments was significantly higher than controls ($P < 0.05$) especially in PPI7, RP3 and RP7. Addition of PPI and LF increased L* values. Redness (a*) was increased ($P < 0.001$) following the addition of PPI and RP at both levels on days 1, 3, 6 of storage, relative to the controls. Lentil treated patties were most promising for textural parameters. An increase ($P < 0.001$) of lactic acid bacteria, psychrotrophic bacteria and *Enterobacteriaceae* over the storage period was observed to be below 6log$_{10}$ CFU/g. Irrespective of the treatments, most of the parameters mentioned above were significantly ($P < 0.001$) affected by storage period. Preliminary experimental results for the parameters tested indicated that rice protein and lentil protein demonstrate potential in the development of healthy beef products for the elderly.

Key Words – Sarcopenia, elderly, fortification, beef

I. INTRODUCTION

Ageing is a complex biological phenomenon in which nutritional deficiencies combined with the specific needs of an elderly individual contribute to the risk of age-related disorders, for example osteoporosis, sarcopenia, dysphagia and dementia. These changes are compounded by the effects of functional impairments that have an impact on ability to access, prepare and consume food. Protein is considered a key nutrient in older age [1]. As nutrient-dense high quality protein foods, red meats can play a major role in helping the elderly meet their essential nutrient needs [2]. In Europe, the recommended average daily intake is at least 1.0 - 1.2g/kg protein of bodyweight/day for healthy elderly and 1.2 to 1.5 g/kg bodyweight/day for elderly with acute or chronic diseases [3]. Currently, food product innovation targets the general population, whilst foods specifically formulated for the elderly population are still lacking. Fortification of meat products with vegetable and legume protein in order to obtain 'functional food products', offers a potential health benefit to this population and understanding the technological properties of such products would enhance the innovation capacity of the meat industry. The aim of this research was to determine the impact of biologically relevant inclusion levels of PPI, RP and LF on colour stability, microbial spoilage and lipid oxidation, in beef patties (95% visual lean (VL) bovine muscle).

II. MATERIALS AND METHODS

Beef muscle (95 % VL) was obtained from a commercial abattoir and trimmed of fat and connective tissue before mincing and incorporation of added ingredients. Minced beef from each treatment was formed into 75g patties using a meat former and placed in laminated low oxygen permeable polystyrene retail packs. The raw patties were gas flushed (Ilpra Foodpack VG 400 packaging machine, Ilpra, Vigevano, Italy) using modified atmosphere packaging (MAP) of 80% O_2: 20% CO_2 (Air products and Chemicals, Inc.,) sealed with a low oxygen permeable barrier film (3cm^3/m^2/24h at STP) polyvinyl-chloride film (Versatile Packaging, Dublin Ireland) for up to 12 days at 4˚C. Only the meat and protein ingredients were used to formulate beef patties.

Protein Determination: Leco (Nitrogen Determinator, Model. FP-428, LECO Corporation, 3000 Lakeview Ave., St. Joseph, MI 49086-23, USA) was determined according to the method of Sweeney and Rexroad [4].

Measurement of colour stability: Instrumental colour values CIE L* (lightness), a* (redness), b* (yellowness) were measured using a CIE L*a*b system with a dual beam xenon flash spectrophotometer (UltraScan Pro, Hunter Associates Laboratory., Inc., Reston, VA).

Measurement of Texture profile analysis (TPA): TPA was applied on cooked product based on a method described by Bourne (1978) [5]. It was performed on an Instron Universal Testing Machine (Instron Model 5543 (UK) Ltd, High Wycombe, UK).

Microbial Analysis: Minced samples (10g) were aseptically transferred into sterile filter stomacher bags and stomached for 30 seconds using a model BA6024 Colworth stomacher (Seward, London, UK) in 90 ml of Oxoid maximum recovery diluent (MRD) to form a mince homogenate. The total viable counts (TVC) for aerobic psychrotrophic bacteria were enumerated following (ISO4833) using plate count agar (PCA). For total *Enterobacteriaceae* counts (TEC) were determined on violet red bile glucose agar (VRBGA) following (ISO21528). Lactic acid bacteria were obtained on de Man-Rogosa-Sharpe (MRS) according to (ISO15214).

Statistical Analysis: Data were analysed using one-way analysis of variance (ANOVA) and F-Protected LSD test in Genstat Release (14.1). Each experiment was performed three times and carried out in duplicate.

III. RESULTS AND DISCUSSION

Across all treatments protein content was higher in PPI7 (24.5%), RP7 (25.28%) compared to PPI3 (22.65%), RP3 (24.19%), L3 (21.69%), L7 (21.79%) and control (22.17%).

Instrumental colour evaluation revealed highly significant ($P < 0.001$) effects of plant protein ingredients on CIE L*a*b* colour values. Inclusion of rice protein (3% and 7%) and lentil protein (7%) increased the L* value (Figure 1). PPI7, RP3, RP7, L3, L7 increased L* values significantly ($P < 0.001$) compared to C and PPI3 over 12 days storage. However patties with added pea protein did not show any significant difference in L* value compared to controls. The highest lightness was observed in 7% rice protein patties. L* was quite stable throughout storage across treatments, as has been reported by others [6].

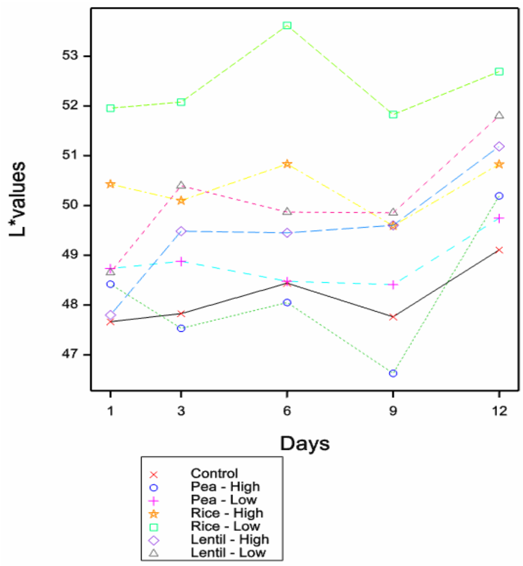

Figure 1. Comparison of CIE L* value (lightness) of protein enriched beef patties packed in MAP during chilled storage at 2 ± 1^0C.

Redness (a*) was increased ($P < 0.001$) following the addition of pea protein (3% and 7%) and rice protein (3% and 7%) at both levels on days 1, 3, 6 of storage (Figure 2).

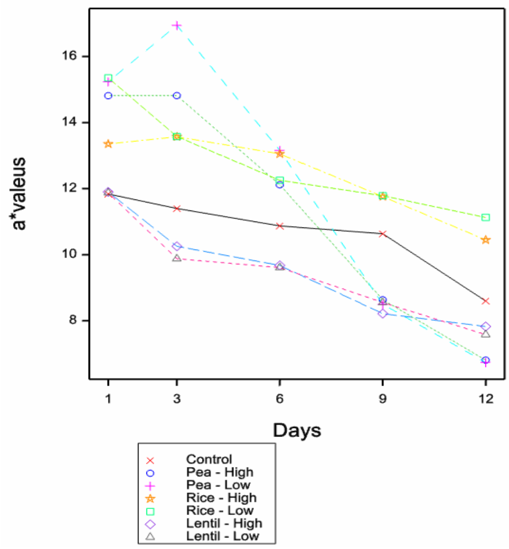

Figure 2. Comparison of CIE a* value (redness) of protein enriched beef patties packed in MAP during chilled storage at 2 ± 1^0C.

A significant decline in a* with storage time (P < 0.001) was observed for treatments PPI3, PPI7, L3 and L7. The addition of lentil flour at both inclusion levels (3% and 7 %) had a negative effect on colour stability because a* values decreased (P < 0.05) for these treatments over the storage period. However the reduction in the intensity of red colour during storage could be explained due to the interdependence between lipid oxidation and colour oxidation in meat [7].

Hardness values were lower (P < 0.001) in L treated patties at both levels compared to control. At both concentration levels of PPI and RP treated patties resulted in an increase in hardness (P < 0.05), and this may be related to the reduction in moisture. Increase in hardness values over storage period has been previously described in food emulsions and is related to the process of emulsion destabilisation due to water and fat separation from the protein matrix [8]. Chewiness values were reduced with the addition of L compared to C but not in PPI and RP treated patties. Cohesiveness values were lower in all treated samples in comparison to control. Addition of PPI, RP and L reduced cohesiveness of beef patties. Gumminess was lowest in L7% (29.00) compared to C (45.74) and highest in RP7% and PPI7 % (67.77 and 66.40 respectively) (Table 1).

Table 1 Mean values (± standard deviations) of the texture profile analysis

	Hardness	**Chewiness**	**Cohesiveness**	**Gumminess**
C	82.5 ± 4.48^{a}	263.9 ± 15.69^{ab}	0.8889 ± 0.00^{c}	45.74 ± 2.70^{ab}
PPI 3	101.2 ± 15.48^{ab}	353.4 ± 62.47^{bc}	0.8858 ± 0.01^{c}	55.7 ± 10.67^{bc}
PPI 7	128.2 ± 9.69^{b}	471.9 ± 39.20^{c}	0.8689 ± 0.01^{bc}	66.40 ± 12.14^{c}
RP 3	102.6 ± 14.66^{ab}	366.1 ± 57.47^{bc}	0.8876 ± 0.01^{c}	54.25 ± 11.65^{bc}
RP 7	123.2 ± 5.66^{b}	430.6 ± 14.11^{c}	0.8837 ± 0.01^{c}	67.77 ± 4.69^{c}
L3	73.9 ± 3.40^{a}	209.6 ± 19.50^{ab}	0.8379 ± 0.01^{ab}	33.46 ± 3.39^{a}
L7	69.4 ± 2.53^{a}	183.5 ± 57.87^{a}	0.8239 ± 0.04^{a}	29.00 ± 11.98^{a}

For each parameter, means within a line with different letters are significantly different (P < 0.001) according to Fisher's protected least significant difference test

Texture profile analysis of beef patties showed a highly significant (P < 0.001) decrease in hardness and gumminess in L treated patties. This is an indication that the use of legumes and vegetables protein in beef patties aided in moisture absorption and retention in the products during cooking in comparison to the control, thus having an effect on the beef patties textural properties (P < 0.001).

Enterobacteriacaee (TEC) counts were lowest in P3 (2.160 log_{10} CFU/g) and R7 (2.153 log_{10} CFU/g) over the storage period. TEC counts below 3Log CFU/g were detected in all groups throughout storage. The working environment and hygienic handling ensured the absence of TEC in beef patties after 12 days storage.
Over the storage period, LAB counts increased significantly (P < 0.001) reaching lower values in R7 and L3 in comparison to C, P3, P7, R3 and L7 (above 5Log10 CFU/g) as presented in Table 2.
Finally, it was observed that only storage time had a significant (P < 0.001) effect on the psychrotrophic aerobic bacteria counts over 12 days storage period and counts ranged from (3.196 to 5.181 Log_{10} CFU/g). Initial bacteria counts (Day 0) were below 4log10 CFU/g. All patties showed a significant (P < 0.001) increase in psychotropic aerobic bacterial counts during storage period (above 5log10 CFU/g).

Table 2 Effect of MAP storage on microbiological characteristics of beef patties formulated with pea protein isolate, rice protein and lentil flour at 3 and 7%

	Storage Days (Log CFU/g)		
	0	**6**	**12**
TVC Psychrotrophic	3.196 ± 0.24^{a}	4.448 ± 0.18^{b}	5.181 ± 0.21^{c}
Lactobacilli	2.854 ± 0.07^{a}	4.525 ± 0.15^{b}	5.058 ± 0.11^{c}
Enterobacteriaccaee	2.174 ± 0.05^{a}	2.192 ± 0.12^{a}	2.521 ± 0.26^{b}

^{abc} Means with different superscripts are significantly different (P < 0.001)

The physico-chemical and microbiological characteristics of the patties were found to be acceptable after 12 days at refrigerated storage conditions. This indicates an increase in shelf life with the addition of PPI, RP and L compared to C in all microbiological parameters tested. Other studies indicated a shelf life of around 7 days in refrigeration and aerobiosis, depending on hygiene and preservation conditions.

IV. CONCLUSION

Comminuted meat products meeting the targeted protein content requirements of elderly consumers (1.2 – 1.5 g/kg) can be produced by inclusion of legume and vegetable protein in meat products. The development of novel muscle-based food products presenting acceptable technological characteristics combined with enhanced functional ingredients will provide a basis to improve nutritional quality in the elderly cohort.

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REFERENCES

1. Wolfe, R.R., Miller, S.L. & Miller, K.B. (2008). Optimal protein intake in the elderly. Clinical Nutrition 27: 675-684
2. Binnie, M.A., Barlow, K., Johnson, V. & Harrison, C. (2014). Red meat: Time for a paradigm shift in dietary advice. Meat Science 98: 445-451
3. Bauer, J., Biolo, G., Cederholm, T., Cesari, M., Cruz-Jentoft, A.J, Morley, J.E., Phillips, S., Sieber, C., Stehle, P., Teta, D., Visvanathan, R., Volpi, E. & Boirie, Y. (2013). Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. J Am Med Dir 14: 542-559.
4. Sweeney, R. A. & Rexroad, P.R. (1987). Comparison of LECO FP-228 ‘nitrogen determinator’ with AOAC copper catalyst Kjeldahl method for crude protein. J Assoc of Anal Chem 70: 1028-1030.
5. Bourne, M. C. 1978. Texture Profile Analysis. Food technology, 21, 62-66 72.
6. Alakali, J. S., Irtwange, S.V. & Mzer, M. T. (2010). Quality evevaluation of beef patties formulated with Bambara groundnut (Vigna subterranean L.) seed flour. Meat Science 85: 215-223
7. Bañón, S., Díaz, P., Rodríguez, M., Garrido, M.D. & Price, A. (2007). Ascorbate, green tea and grape seed extracts increase the shelf life of low sulphite beef patties. Meat Science 77: 626-633
8. Fernández-Ginés. J. M., Fernández-López, J., Sayas-Barberá, E. & Pérez-Alvarez, J.A. 2005. Meat Products as Functional Foods: A Review. Journal of Food Science, 70, R37-R43