ENHANCING STORAGE STABILITY AND QUALITY OF HYBRID BEEF-LENTIL SNACK BARS: THE ROLE OF STARCH GELATINIZATION AND LENTIL FLOUR ADDITION

Yun Lin, Yongfeng Ai, Phyllis Shand*

University of Saskatchewan, Saskatoon, Canada.

*Corresponding author email: Phyllis.shand@usask.ca

I. INTRODUCTION

Development of hybrid meat products created by integrating lentil into conventional meat products might address the growing demands for sustainable and healthier alternatives [1, 2]. Lentil has been associated with environmental and nutritional benefits, also provides potential functional properties, such as pasting and gelling, in meat products [3]. These benefits are attributed to the interaction between lentil carbohydrates with meat molecules, which might be influenced by starch gelatinization. This study explored the effect of addition level and starch gelatinization of infrared-heated lentil flour on the physicochemical properties and storage behavior of hybrid beef-lentil snack bars. Accelerated storage was utilized to simulate product deterioration during long term storage, which would be necessary for shelf-stable hybrid products to gain further acceptance for their convenience and long shelf life [4].

II. MATERIALS AND METHODS

Lentil flour with higher starch gelatinization (27% damaged starch/g flour, db) was obtained by tempering green lentil seeds, initially containing 10% moisture, to a target moisture level of 25% for 24 h. Subsequently, both the tempered (HG) and non-tempered (NT) seeds underwent infrared heating to a surface temperature of 150°C then were milled into flours. The beef-lentil snack bars were produced using procedures modified from jerky production [5]. Beef outside round (*Biceps femoris*) was trimmed and ground through a 9.5 mm plate. An all-beef formulation was prepared (Con). Flours were substituted for beef at 6, 12, 18% w/w (NT6, NT12, NT18, HG6, HG12). The meat mixture with HG flour at 18% addition was too thick to stuff and dropped from further testing. Other ingredients included brown sugar, salt, soy sauce, glucono-delta-lactone, encapsulated citric acid, sodium erythorbate, sodium nitrite, and spices. Mixtures were stuffed out as bar strips and then cooked and dried to a target water activity of 0.90. Samples of all treatments reached an internal temperature of 72 °C. Dried strips were equilibrated for seven days, then individually vacuum packaged in jerky pouches (thickness 3 μm, oxygen permeability < 60.0 cc / m2 / 24 h). Two storage conditions were employed: room temperature (RT), approximate 20 °C, 25% relative humidity (RH), and accelerated storage (HT), approximate 40 °C, 25% RH, for up to 90 days. Three replications of all treatments were prepared, and results were analyzed by a linear mixed model using R.

III. RESULTS AND DISCUSSION

Samples of all treatments reached a pH below 5.3 and water activity under 0.90, complying with Canadian regulations for shelf-stability. Cook yields were approximate 63%. As flour addition level increased, carbohydrate content of beef-lentil bars increased (14.5 to 28.1%), fat content decreased (8.3 to 4.3%), but protein content remained constant (around 33%). Beef-lentil bars effectively retained moisture under RT storage, while Con, the beef only treatment, showed significantly ($p<0.05$) lower moisture content (36.1 to 25.9%) after 90 d. Under accelerated HT storage, HG12 and NT18 bars maintained similar moisture levels after 90 d, while other treatments (Con, NT6, HG6, NT12) experienced significant moisture loss. This loss likely led to unfavorable physicochemical changes, also suggesting that the standard jerky pouch may not provide sufficient barrier properties for long-term storage. Samples of HG12 and NT18 displayed a lighter (higher *L**) and more yellow (higher *b**) color than Con. Samples of all treatments became darker, less red, and less yellow in color during storage, while those with increased lentil flour addition and starch gelatinization showed less change in color (more stable color over time). Product stability was defined here as maintaining similar physicochemical properties to day 1. Interestingly, Con exhibited the most consistent and stable *L**. Beef-lentil bars under accelerated HT storage had greater reduction in sample redness (*a**) than Con, as storage time increased. Beef-lentil bars with increased addition of lentil flours and greater starch gelatinization had higher WB shear values initially, also showing less change during storage than Con. Using a three-point bending test, the break force of the strips increased as flour addition level increased, but were not affected by starch gelatinization level. Only NT18 showed a significantly higher stiffness (defined as break force / deformation) than Con, a common indicator of cohesiveness of non-meat snack bars. Beef-lentil bars under accelerated HT storage showed greater increase in stiffness as storage time increase. NT18 also exhibited lower lipid oxidation level, as measured by thiobarbituric acid reactive substances (TBARS), on day 1, highlighting the potential benefit of lentil flour in inhibiting oxidation. NT18 consistently maintained lower lipid oxidation levels throughout 90 d of accelerated HT storage. HG12 also showed lower incremental increase in TBARS values than Con after 60 d. This aligns with earlier findings on the antioxidant properties of infrared-heated lentil flours and fractions in meat processing [3].

IV. CONCLUSIONS

This study demonstrates the significant benefits of integrating lentil flour into shelf-stable meat products, particularly in enhancing moisture retention, color stability, and reducing lipid oxidation under accelerated high temperature storage. Starch gelatinization played an important role in these improvements, suggesting its potential to maintain product quality in long-term and more extreme storage. However, significant time by condition interaction effects were identified, pointing to the need for more accurate storage simulations that better represent typical consumer conditions. Additionally, the detailed interactions between partially gelatinized lentil starch and meat molecules in dried meat systems are not fully understood. Further microscopic analysis could provide deeper insights into these molecular dynamics. There is also a strong recommendation for future products to incorporate better packaging solutions and ingredient selection to extend shelf life and maintain product integrity. These results underscore the promise of lentil ingredients as sustainable and functional ingredients in meat products, meriting further research to optimize hybrid product formulations.

ACKNOWLEDGEMENTS

Partial funding for this study was provided by the Saskatchewan Agriculture Development Fund. Thanks are expressed to InfraReady Foods (1998) Ltd. for providing the lentil flours.

REFERENCES

1. Godfray, H.C.J., et al. (2018). Meat consumption, health, and the environment. Science, 361(6399): p. eaam5324.
2. Tarrega, A., et al. (2020). Are mixed meat and vegetable protein products good alternatives for reducing meat consumption? A case study with burgers. Current Research in Food Science, 3: p. 30-40.
3. Pathiraje, D., et al. (2023). Generating multi-functional pulse ingredients for processed meat products—scientific evaluation of infrared-treated lentils. Foods, 12(8): p. 1722.
4. Font-i-Furnols, M. and Guerrero, L. (2014). Consumer preference, behavior and perception about meat and meat products: An overview. Meat Science, 98(3): p. 361-371.
5. American Association of Meat Processors (2004). The jerky journal: A guide for the production of jerky. Wenther, J. B. Ed.