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DEVELOPMENT OF INTERMEDIATE MOISTURE MEATS FOR USE IN MILITARY SHELF-STABLE SANDWICHES

Background

Intermediate moisture food (IMF) technology is the careful balancing of moisture, pH and water activity (A_w) that results in foods having soft, moist texture yet, will not support microbiological growth. IMF technology has been expanded to develop multi-component shelf-stable products, e.g., bread/meat, bread/salad spreads, burrito/pizza-type combinations. These products have received very high acceptance ratings (the nacho flavored beef pocket was rated 8 on a 9 point hedonic scale by soldiers during a field test,) and are proven to be not only microbiologically safe but structurally stable, based on accelerated tests for four weeks at 125°F (2 weeks at 125°F approximates three years at 70°F).

Microbial safety issues associated with combination products such as these shelf-stable sandwich components are of concern to the Food and Drug Administration and the U.S. Department of Agriculture. The production of these nontraditional foods containing components with different A_w and pH relies on innovative processing technology. The products were produced by manipulating the A_w by utilizing various humectants and processes, preventing lipid oxidation by exploiting the use of synergistic antioxidant systems and controlling the pH by adding acidulants or through fermentation. The purpose of this study was to develop a family of highly acceptable, shelf-stable components using IMF technology.

Methods

Processing of burrito filling

Ground beef was infused 1:1 with a solution consisting of 77% water, 21% glycerol, and 2% salt. The mixture was vacuum tumbled for 25 minutes, at 25 RPM and a vacuum 27-30 mmHg. Citric acid at 0.62% was added to the infusion solution after tumbling, and allowed to sit for 10 minutes. The mixture was then placed in a steam kettle to cook off all visible moisture. This was followed by cooking in a convection oven at 200°F for 20 minutes. The beef was then mixed with tomato paste, seasonings and cheese.

Processing of beefstick

The beefstick formulation included beef, water, salt, dextrose, black pepper, sodium nitrite, starter culture, ascorbyl palmitate, α-tocopherol, or butylated hydroxyanisole and different glycerol levels. Meat was ground through a 3/4" plate. Sodium nitrite was mixed with the meat for 3 minutes. The remaining ingredients were added and mixed for an additional 5 minutes and reground through a 5/12" plate. The mixture (33°F) was stuffed into a 20mm collagen casing using a vacuum stuffer. Fermentation was carried out in a smokehouse at 105°F with a relative humidity of 91%. When pH 4.7-4.8 was reached (approx. 24 h), the smokehouse temperature was increased to 165°F until the internal temperature of the beefstick reached 160°F. The cured products were air dried at 50°F until A_w was 0.85-0.87. The beefsticks were vacuum packed with a nitrogen flush in tri-laminated pouches. The samples were evaluated/tested initially and after 1, 2, 3, and 4 weeks storage at 125°F.

Production of the sandwich

The sandwich was made by enrobbing the bread dough around the shelfstable beefstick/burrito filling and proofing at 90°F and 90% RH for 40 minutes followed by baking at 350°F for 50 minutes. The sandwich was cooled to 120°F and packaged in tri-laminated pouches with an oxygen scavenger. The beefstick pockets were evaluated/tested initially and after 1, 2, 3, and 4 weeks storage at 125°F.

Analytical procedures

The A_w was determined in triplicate with an AquaLab Cx-2 Water Activity System (Decagon). Sample pH was measured from a 1:10 (meat:deionized water) dilution with an Orion pH/Millivolt meter. The antioxidants were analyzed using high pressure liquid chromatography on a reverse phase C_{18} column with a variable UV detector. Test panels were used to rate the sensory characteristics, i.e., appearance, odor, flavor texture and overall quality, on a 9 point quality scale. For microbiological analysis, 20g of the ground sample was homogenized with phosphate buffer pH 7.2 to make a 1:10 dilution. The mixture was used for the following microbiological analyses. (1) Aerobic plate counts (Plate Count Agar (Difco) 35°C for 48 h); (2) *Escherichia coli* (LST-MUG method, AOAC, 1990); (3) *Staphylococcus aureus* (Baird Parker agar (Difco), FDA Bacteriological Analytical Manual 7thed); (4) yeast and mold counts (Potato Dextrose Agar (Difco) with 10% tartaric acid solution at 25°C for 5 days, FDA Bacteriological Analytical Manual 7th ed).

Results and Discussion

A_w Control

A process was developed utilizing humectants in different combinations to lower the A_w. An infusion solution was used in a process called desorption (moist infusion), whereby fresh meat exchanges part of its water for solutes in the infusion solution. Nine runs were made (Table 1), the humectants used included sodium chloride, sucrose, glycerol, soy protein hydrolysate and casein hydrolysate. Soy and casein hydrolysate produced an ideal A_w but imparted an undesirable flavor. Infusion of ground beef (27% fat) with 21% glycerol and 3 % salt produced the best A_w (0.833 after kettle cooking). Based on sensory results, the 2% salt, 21% glycerol and 77% water combination was chosen for further development.

Methods of infusing ground beef, such as soaking, vacuum infusion or heating then soaking were tested to determine which process would give the lowest Aw without adversely affecting the sensory properties. The vacuum method resulted in the lowest and most rapid reduction of A_w. However, additional removal of moisture is required to ensure a final $A_w < 0.85$ for microbial safety. This was accomplished by kettle cooking to remove free liquid to a targeted moisture content of 35%, followed by an oven cooking process that

resulted in a final A_w of 0.68. When the remaining burrito ingredients were added, the A_w of the filling was 0.83-0.85. Modified processing methods resulted in the development of a burrito with an A_w of 0.82-0.84 and an acceptable sensory rating of 6.5 on a 9 point hedonic scale.

The beefsticks were processed with 0, 3, 6, and 9% glycerol to determine the level that would give the lowest A_w without negatively affecting the flavor or texture. The optimum level of glycerol is 3-6%, resulting with final A_w of 0.876 and 0.846, respectively. The texture of the product with no added glycerol became chewy and fibrous. At 6% and 9% glycerol levels, the products were less chewy and grainy, and had an objectionable sweet note from the glycerol. As the concentration of glycerol increased, the amount of oil which leeched out of the beefstick also increased, thus decreasing palatability. Products were found to be microbiologically safe, i.e., both E.coli and Staphylococcus aureus were found to be negative, yeast and mold counts were <10, and aerobic plate counts was <10,000.

Inhibition of lipid oxidation

Beefsticks prepared with a synergistic antioxidant system made up of ascorbyl palmitate, α-tocopherol (vitamin E) and butylated hydroxyanisole (BHA) were found organoleptically acceptable after storage at 125°F for 4 weeks. The mechanism of the synergism of the antioxidant system is apparent in that the ascorbyl palmitate was the only component in the system to degrade(Fig. 1); the BHA and α-tocopherol levels remained unchanged with time. The lower the level of glycerol, the more ascorbyl palmitate was retained. The use of α-tocopherols, ascorbyl palmitate, and chelating agents without BHA also appeared to be effective.

pH control

The inhibitory effects of acid were exerted whether acid was added directly to the food, was a natural constituent of the food, or is produced in the food by fermentation. In the burrito, the added citric acid was used to reduce the pH to 4.6. The acid not only reduced the pH to safer levels but also denatured the protein to cause shrinkage which further releases water from the meat, thereby reducing A_w. The beefstick undergoes fermentation until a targeted pH of 4.7 was reached. In addition acidulation by fermentation also influenced the flavor, aroma and color of the beefstick. The pH of the bread was lowered to 4.7 using an encapsulated glucono-δ-lactone (GDL). The encapsulated GDL was not activated until baking, allowing the bread to undergo a normal fermentation process beforehand.

Accelerated storage test of beefstick pocket sandwich

After a 4 week accelerated storage test at 125°F, sensory evaluation indicated slight browning of the bread and no textural changes. Acceptability was comparable to the non-stressed control. Though free fatty acids increased during storage of 4 weeks at 125°F (Fig.2), sensory attributes weren't negatively affected (Fig. 3). Initially the sandwich had a A_w of 0.82 and of 0.85 for the bread and meat, respectively. After storage, the A_w of the stressed pocket sandwich equilibrated to 0.84. The product remained microbiologically stable and acceptable to a consumer panel.

Conclusion

The utilization of IMF technology has led to the development of a family of intermediate moisture sandwiches by carefully manipulating A_w, pH and synergistic antioxidant systems. The A_w has been controlled utilizing various humectants and processes to give a final A_w < 0.85. The pH was controlled using fermentation, citric acid and GDL to give a final pH of 5.2-5.3 for the burrito and 4.8-4.95 for the beef pocket. Prevention of lipid oxidation has been achieved using a synergistic antioxidant system consisting of BHA, ascorbyl palmitate, and vitamin E. In addition to product development, research is ongoing to study water migration between components, microbial challenges, development of new humectants and improve hurdle technology to optimize quality and safety .

FIG. 1 Retention of Antioxidants @125°F

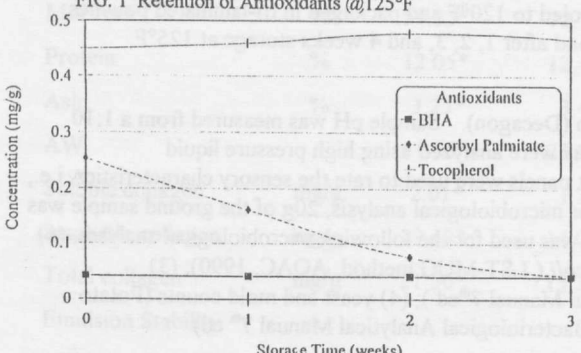

FIG. 2 %Free Fatty Acids In Stored BeefstickPocket Sandwiches

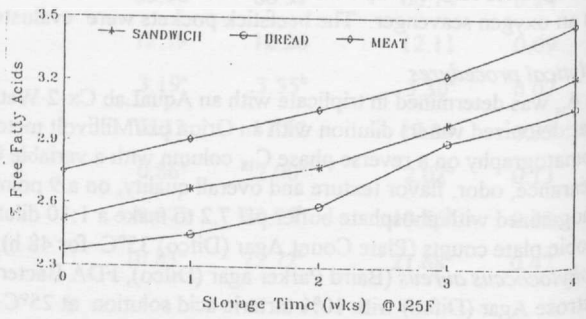

FIG. 3 Sensory Attributes of Pocket Sandwich @125

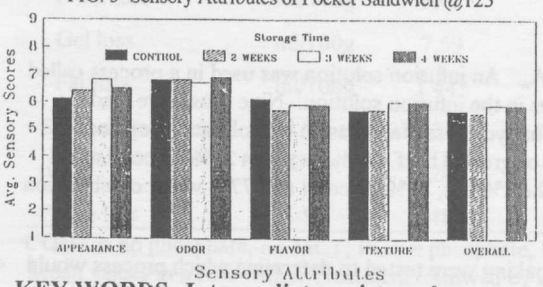

Table. 1 Humectant Combination for Burrito Filling

Ingredient	1	2	3	4	5	6	7	8	9
%Water	77.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0
%Glycerol	21.0	21.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
%Salt	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
%Sucrose	-	-	10.0	-	-	5.0	3.0	5.0	3.0
%Soy	-	-	-	10.0	-	5.0	7.0	-	-
%Casein	-	-	-	-	10.0	-	-	5.0	7.0
A_w	0.85	0.83	0.86	0.85	0.84	0.85	0.85	.864	0.86
Temp. (°F)	26.9	24.7	26.8	23.4	27.5	27.1	27.2	28.0	28.2

KEY WORDS--Intermediate moisture, humectants, glycerol, shelf-stable, lipid oxidation, antioxidants