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DETERMINATION OF BASELINE PRODUCT CHARACTERISTICS AND PRODUCTION METHODS IN SMALL AND VERY SMALL JERKY PLANTS

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Introduction

Jerky products have long been a popular meat based food in the United States. For much of its history, these products have enjoyed production with minimal supervision or intervention by regulatory entities. However, in the light of a jerky related Salmonellosis outbreak during October 2003, new scrutiny has been turned to jerky production nationwide. The USDA FSIS (2004) response to this outbreak was the issuance of the "Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants," which provide thermal processing guidelines, humidity requirements and end product recommendations that may be applied to any jerky production scenario. The USDA did not stop with simply issuing these new guidelines. In Spring 2004, USDA solicited proposals to conduct research focused on providing small and very small manufacturing plants a means for validating their HACCP plans, specifically by achieving a 6.5 log reduction in pathogenic microorganisms. In order to develop validation studies, there was a need to determine the current state of the jerky industry in these facilities.

Objectives

The objective was to develop a survey tool and collect information relative to manufacturing equipment, processing techniques, ingredients and end item characteristics typical of jerky products. The targeted segment of the jerky industry were small and very small manufacturers primarily in Kansas, Nebraska, Missouri, and Wisconsin. This information will be used as a baseline for the design of lethality challenge studies in whole muscle and ground and formed jerky.

Methodology

Development of a four page survey tool was a coordinated effort between Kansas State University and the University of Wisconsin, with input from the University of

Nebraska. It contained questions directed at detailing equipment, ingredients and processing techniques used in jerky manufacture to gain very specific information providing up to 168 data points. Surveys were mailed to 78 small and very small manufacturers of jerky that were identified through state meat processing associations, state and federally inspected plant lists and internet resources such as state or county health department listings. The packet mailed to processors included a cover letter, the four page survey, and a request to provide four samples of each jerky product they manufactured for complimentary NaCl, pH and water activity (a_w) analysis. Approximately one month after surveys were mailed, a follow-up telephone call was made to processors who had not yet returned the completed survey. In some cases, another copy of the survey was sent to processors if the first copy had been misplaced.

Survey data were compiled and means generated for quantitative data. Qualitative data were compared to determine if consensus existed among industry practices. Jerky samples that were returned with surveys were stored in original packaging at ambient temperature for up to two weeks before analysis. All lab analyses were done by KSU or UW, with one exception. NaCl analyses for jerky samples received by UW were done at KSU or a commercial lab. All samples were pulverized in a blender (Waring Blender 700 Model 33BL79, Waring Products Division, New Hartford, CT) with a 10 cm blending cup by two 30 sec bursts, pausing for 120 sec between bursts to help minimize heat buildup. Water activity was measured at ambient temperature using an AquaLab Series 3 TE (Decagon Devices, Pullman, WA), using standard seven ml disposable sample cups. Measurement of pH was based on a 10 g sample of pulverized sample material, blended with 110 ml distilled, deionized water for two min in a stomacher (Seward Stomacher 400 laboratory blender, Seward Medical, London, UK) and tested immediately with a pH meter (Accumet Portable model AP61 Fisher Scientific, Fair Lawn, NJ). NaCl content was determined using Quantab® titrators for chloride (0.05-1.0% NaCl, Hach Company, Loveland, CO), using five g pulverized sample material combined with 45 ml distilled, deionized water according to manufacturers instructions. Resulting measurements were plotted against one another and mean and standard deviation determined for each of the three parameters, by species and as a full lot. Results from whole muscle versus formed products were not separated. Upon completion of all analyses, each plant received their individual results plotted against results for all plants. Anonymity of plant results was maintained on all but their own sample data.

Results & Discussion

Of the 78 plants contacted, 37 contributed surveys for a 47% response rate. Of these, 33 plants contributed 61 product samples. Analytical results of product samples revealed a mean a_w of 0.74 (SD 0.10); mean NaCl of 6.85% (SD 2.5%); and mean pH of 5.85 (SD 0.33). Specific results broken down by species are shown in Table 1. Some key results garnered from the survey include thermal processing extremes and nearly a complete lack of relative humidity instrumentation. These ranged from processing jerky at 51.6C for 45 min followed by 3C increases every 45 minutes to reach an oven temperature of 62.8C maximum, to processing jerky at 93.3C for 6-7 h. Perhaps the single most important finding is the depth of variability within this industry. The survey tool provided the

means to quantify some of the extremes in this variability and in that way will serve as a pivotal source of information for developing challenge studies.

The survey instrument revealed that approximately 56% of all product produced is the whole muscle type and 44% is ground or chunked and formed. Total plant output was not requested nor reported. NaCl concentration in mixes ranged from 1% to more than 85%, and pickup of wet marinade ranged from 3% or less to 100%.

Survey results further revealed that 34 of 37 manufacturers (92%) used only a smokehouse for thermal processing, 3 of 37 (8%) used a commercial oven and one manufacturer (3%) used both a smokehouse and an oven for thermal processing. Within the thermal environment, nine manufacturers determined the wet bulb temperature to yield relative humidity and only one employed a relative humidity instrument. However, 35 of 37 manufacturers claimed they are able to control humidity. Controls employed are closing the dampers (35%), steam injection (8%), direct addition of water (8%), placing a pan of water in the house (3%) or a combination of these methods (43%). All respondents who claimed a combination of these methods used steam as one component, indicating that 51% of these manufacturers are using steam injection to increase their humidity. Manufacturers reported an average of 44% cooked yield.

Ingredients used in the production of jerky may be grouped into two broad categories, those with a functional purpose besides flavor and those added solely for flavor. Functional ingredients found included sodium nitrite, sodium erythorbate, lactic acid, and potassium sorbate. Thirty-two of 37 respondents (86%) indicated the use of sodium nitrite, however only 15 (41%) also indicated the use of sodium erythorbate as a cure accelerator. Those manufacturers not using a cure accelerator reported time spans ranging from 45 min (wet marinade) up to 7 d (dry cure) between the time seasonings are added until the drying process is begun. Only five (14%) manufacturers reported the use of potassium sorbate for mold inhibition and one (3%) reported using lactic acid to acidify the product. Ingredients used for their seasoning properties included soy sauce (62%), vinegar (8%), worcestershire sauce (16%) and tabasco sauce (5%). Lesser used ingredients included pineapple juice, teriyaki sauce, apple cider, garlic salt, and char oil (3% each).

Respondents indicated a variety of packaging methods were employed including vacuum (78%), no vacuum (32%), and gas flush (14%). Storage, distribution, and marketing were variable as well, with 32% reporting refrigerated storage, 3% frozen and 5 of 13 (38%) reported shelf-stable storage and distribution. However, examination of package markings upon receipt of samples indicated that 12 of 13 (92%) of sample packages lack any precautionary handling markings, and may be interpreted as shelf-stable.

Conclusions

In the Midwest, slightly more than half of the jerky produced by small and very small facilities that responded to the survey was whole muscle, while slightly less than half was ground and formed or chunked and formed. Jerky a_w and pH among different species was similar. NaCl levels among species may be similar, however an insufficient number of turkey samples were tested to conclude this similarity. This data provides sufficient correlation to proceed with lethality studies around a_w 0.74, NaCl 6.85% and pH 5.85,

with additional study around upper and lower limits of each parameter in combination to determine any synergistic affect between parameters.

Survey results confirmed the hypothesis that there is widespread variability in thermal processing and most other production methods from one manufacturer to another. Variables included processing time and temperature, processing environment relative humidity and method employed to control humidity. Extremes in thermal processing provide useful baselines under which to proceed with lethality studies. Challenge studies at thermal extremes, in the presence of mean product characteristics, can provide inactivation or protective effects for targeted microorganisms.

The survey revealed that, while a significant proportion of the industry has instituted the use of sodium nitrite into their product, many manufacturers may not be realizing any functional properties of this ingredient. Fifty-three percent of those using nitrite are not using a cure accelerator to speed the curing process. Among this group of products, product is allowed a lower limit of 45 minutes for the curing reaction to occur. With 86% of the industry using cure, challenge studies should be conducted with cure for most iterations, and without cure in a comparative study at the mean level of product and thermal processing conditions.

Slightly less widespread use of acidic ingredients are used in jerky production. Ingredients such as vinegar (pH 2.41), worcestershire sauce (pH 3.50), soy sauce (pH 4.83) and tabasco sauce (pH 3.20) are used by some manufacturers as flavor additives, primarily as a constituent of a wet marinade process. The pH of a marinade mixture and length of time held in marinade prior to thermal processing should be considered in a challenge study.

Packaging methods employed throughout the industry varied slightly with most manufacturers using vacuum packs or modified atmosphere packaging to extend shelf-life by preventing oxidation or mold growth. The use of potassium sorbate as a mold inhibitor was limited. One consideration in a challenge study would be the impact of packaging and subsequent shelf life on pathogen lethality during storage.

References

USDA, FSIS. Compliance guideline for meat and poultry jerky produced by small and very small plants. 2004. Available at http://www.fsis.usda.gov/pdf/compliance_guideline_jerky.pdf, accessed on 15 Feb 05.

Tables and Figures

Table 1. Mean NaCl content, a_{w}_ and pH of whole muscle, ground and formed, and chunked and formed jerky by species from 33 primarily Midwestern companies.

Species	% NaCl	SD[1]	A_w	SD	pH	SD
Beef	6.90% (n=28)	2.54%	0.74 (n=49)	0.10	5.86 (n=49)	0.32
Pork	7.58% (n=5)	2.42%	0.71 (n=6)	0.09	5.87 (n=6)	0.35
Turkey	3.73% *(n=1)*	-	0.77 (n=4)	0.09	5.82 (n=4)	0.46
Buffalo	4.95% *(n=1)*	-	0.79 (n=2)	0.08	5.52 (n=2)	0.16
Maximum for all Products	11.54%		0.90			6.60
Minimum for all Products	2.10%		0.51			5.00

[1]SD=Standard deviation.