Critical Limit Summary: Shelf-Stability of RTE Meat Products Based on pH and Water Activity

Background: Federal labeling standards exist for composition of many ready-to-eat (RTE) meat products; standards that have been assumed to define shelf-stability. The following data validate shelf stability of **fully cooked, shelf-stable meat products separate from the labeling standards**. In this regard, shelf-stable is defined as product that does not support growth of *L. monocytogenes* and *S. aureus* at room temperature.

The table gives combinations of pH and water activity scientifically supported as preventing growth of *S. aureus* and *L. monocytogenes* on fully-cooked meat products held at room temperature.* These combinations of pH and water activity may be used as critical limits in a HACCP plan. [These data are the foundation of the **Shelf Stability Predictor** on the University of Wisconsin-Madison website.]

*Evidence supports the use of these data for vacuum-packaged products, as well as for products stored under air: "The growth of *L. monocytogenes* is little affected by gaseous atmosphere (p.145)." "*S. aureus* grows both aerobically and anaerobically." Survival of *S. aureus* may be improved under anaerobic conditions, suggesting that aerobic storage is preferable for safety (p.302). See reference #5 in the list.

How to Use these Data:

1) Select the product category.
2) Determine product pH.
3) Note the water activity (maximum) that, combined with pH, is the limit for Shelf Stability.

For example, for **Beef Jerky** (Dried Product), set Critical Limits of pH 5.9 and Water Activity 0.85.
➔Product that is **fully cooked** with a pH 5.9 or below, and water activity 0.85 and below is **Shelf Stable**.

A **Summer Sausage** (Semi-dried, fermented, fully cooked) with pH 4.8 or lower is **shelf stable** as long as water activity is no more than 0.96.

Product Category	pH	Water Activity
Dried Product (e.g. beef jerky, beef strips, pemmican)	6.3	0.80
	6.2	0.80
	6.1	0.80
	6.0	0.80
	5.9	0.85
	5.8	0.85
	5.7	0.85
	5.6	0.85
	5.5	0.85
	5.4	0.85
	5.3 and lower	0.85
Semi-Dry and Dry Products (e.g. summer sausage, salami, snack sticks) with pH reduced through fermentation or use of encapsulated organic acids	5.3	0.91
	5.2	0.91
	5.1	0.92
	5.0	0.93
	4.9	0.96
	4.8	0.96
	4.7 or lower	0.96

REFERENCES:

1. Ingham, S.C., D.L. Borneman, C. Ané, and B.H. Ingham. 2010. Predicting growth-no growth of *Listeria monocytogenes* on vacuum-packaged ready-to-eat meats. J. Food Protection 73: 708-714.
2. Borneman, D.L., S.C. Ingham, and C. Ane. 2009. Predicting growth – no growth of *Staphylococcus aureus* on vacuum-packaged ready-to-eat meats. Journal of Food Protection 72: 539-548.
3. Ingham, S.C., G. Searls, S. Mohanan, and D.R. Buege. 2006. Survival of *Staphylococcus aureus* and *Listeria monocytogenes* on vacuum-packaged beef jerky and related products stored at21°C. Journal of Food Protection. 69: 2263-2267.
4. Ingham, S.C., D.R. Buege, B.K. Dropp, and J.A. Losinski. 2004. Survival of *Listeria monocytogenes* during storage of ready-to-eat meat products processed by drying, fermentation, and/or smoking. Journal of Food Protection. 67: 2698-2702.
5. Microorganisms in Food 5: Characteristics of Microbial Pathogens. 1996. ICMSF. Blackie Academic & Professional, New York.

NOTE: Copies of all references may be found in the reference list on the website: https://foodsafety.wisc.edu, see the Meat HACCP tab.

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