Impacts of Removing Functional Non-Meat Ingredients in Processed Meat Products and Exploring Possible Alternatives

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INTRODUCTION

Functional ingredients are not only important but in many cases essential for the success of further processed meat and poultry products. The act of removal or replacement of certain functional ingredients can have adverse consequences impacting quality, safety, and profit. Functional ingredients are added for very specific reasons as they provide tangible "function" or desired outcomes regarding quality, safety, and economical aspects of meat production. Thus, removal and/or replacement with alternative versions can provide manufacturing challenges and a number of concerns regarding the impact this could have compared to when using traditional versions.

It should be noted, however, that of all the functional ingredients available for meat processing, historically speaking, only a few would be considered essential for the successful manufacture of processed meats: salt and curing ingredients (i.e. sodium nitrite). All others, and many being extremely important as used today, have really evolved as functional ingredients allowing the ability to improve quality, safety, and economic attributes. Beyond the need to extract salt-soluble proteins and stabilize meat color, providing processed meats their basic composition, nearly all other ingredients provide contributory (not critical) benefits.

Decades ago, processed meats were made with relatively high quality (and today expensive) raw materials, a short list of ingredients (namely salt, cure, and spices), and during a time when a lesser need to address food safety (compared to today) existed. As the meat and poultry industry has since evolved, the availability, opportunity, and in some cases need to incorporate functional ingredients to address raw material/finished products costs, manufacturing/finished product performance (e.g. machinability, slicing, sensory properties, etc.), food safety, and consumer demands/expectations has created the need for increasead functional ingredient utilization.

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As the meat and poultry has since continued to evolve, in recent years, a new wave of consumer interests and demands have driven a new approach to processed meat manufacturing…natural, organic, and clean label. As such, many of the traditional functional ingredients used in conventional production have been prohibited by labeling restrictions or removed due to customer friendly labeling approaches. Fortunately, for most of the functional ingredients commonly used today in processed meat and poultry production, alternative versions do exist. However, most have been found to be less functional while their true functionality is not always as scientifically well understood. This discussion will provide examples of alternative ingredients and their utilization including efficacy and considerations.

REMOVING FUNCTIONAL INGREDIENTS

Besides the critical, functional ingredients (salt and curing agents) already mentioned, all other ingredients can technically be removed to result in an acceptable processed meat or poultry product. However; consequences of this action will certainly exist. What impact the removal of a particular ingredient has is dependent on the original reason for including that ingredient which is often product specific and product dependent. Manufacturing a high quality processed meat product with only salt and curing ingredients (and of course appropriate spices) is not only possible but was the primary approach before the discovery and widespread availability and utilization of many of today's popular functional ingredients. Focusing on high quality extractile protein for bind and using manufacturing systems to ensure finished product goals were achieved has since been replaced with lower-cost formulations and faster production systems with interests in achieving the same product goals as with earlier processes. These goals are met by incorporating efficiencies to maintain costs as well as dealing with both cost and variability of raw materials. As such, the meat and poultry industry has become accustomed to using all the "tools' available to achieve desired process and product goals. Functional ingredients significantly help with this effort.

Today, removing and/or replacing functional ingredients can impact the ability to successfully achieve finished product and production goals as well as address raw material, production, or finished product related variation and uniformity. Thus, an understanding of what function specific ingredients provide, what comparable replacements are available, and what impact the removal or replacement of these ingredients might have is important to consider.

SALT (SODIUM CHLORIDE)

Salt (sodium chloride) is still universally used for natural, organic, and clean label processed meat and poultry products and is still important for its functional properties. In some cases, sea salt it used to replace regular salt in formulations and is acceptable to do so as long as considerations are made regarding the differences between the two. Sea salt has less functionality compared to a regular salt as it has less sodium and chloride by volume than regular salt. Further, sea salt has less surface area (until dissolved) which can impact functionality. Finally, sea salt commonly contains impurities such as minerals which can impact flavor and color of products in which it is used.

SWEETENERS

Dextrose and corn syrup are the most common sweeteners used and their primary functions are to offset the saltiness as a result of adding salt and provide some water binding function. Sugar, is used in certain products where browning needs to be minimized or additional sweetness is desired. Common replacements for dextrose and corn syrup include evaporated cane sugar, honey, Turbinado sugar (minimally refined sugar), and an increased utilization of sugar. As long as products aren't dependent on water binding, the need for available carbohydrate for microbial fermentation, or control of browning during cooking, sweeteners can fairly easily be interchanged with little impact. It should be noted that Turbinado sugar can contribute to trace amounts calcium, potassium, magnesium, and even iron but likely at levels with minimal to no impact on processed meat quality.

CURING AGENTS

In the past decade, we have seen the emergence of replacing purified (chemical) sources of nitrite with natural sources…namely from celery powder high in naturally occurring nitrate.

Consumer perceptions of the human health related safety risks associated with consuming nitrite and nitrate have led to in increased interest in selecting "no-nitrate/nitrite-added" products, with expectations that they are safer or healthier choices than traditional, conventionally produced cured meats. The increase in demand for no-nitrate/nitrite-added products has led to the development of alternative curing methods that do not utilize the direct addition of purified sodium nitrite, yet result in a "cured" product for consumers. To date, there is still a great deal of confusion surrounding these products, from labeling and ingredients to questions regarding food safety (Sebranek and Bacus, 2007; Sebranek et al., 2012).

The technology of alternative curing has advanced from using a vegetable-based natural source of nitrate in combination with nitrate reducing bacteria to facilitate *in situ* generation of nitrite during the manufacturing process to the more direct and standardized pre-converted nitrite offerings available today. A wealth of research has been conducted in the past decade to better understand quality and more recently focused safety impacts of using these ingredients with an underlying interest to also understand whether natural sources of nitrite provide equivalent quality and food safety outcomes if formulated to similar concentrations.

There have also been advances in alternative options to serve as reducing agents, such as cherry powder (ascorbic acid), to provide natural forms of cure accelerators. Specifically, cherry powder has been shown to function similarly to ascorbate or erythorbate and decrease residual nitrite in alternatively cured products (Terns et al., 2011). When a natural cure accelerator is used, greater depletion of nitrite, improved cured color, and longer color shelf life has been found (Terns et al., 2011). As a result of this and other academic and industry research, it has been generally accepted that a minimum of 75 ppm nitrite (on a sodium nitrite equivalence) and 250 ppm ascorbate from natural sources are important to achieve suitable cured properties such as an acceptable cured color shelf life.

PHOSPHATES AND BINDERS/EXTENDERS

Phosphates and binders/extenders are widely used in processed meats with a greater utilization of phosphates observed. To date, no direct replacement for phosphates has been discovered making this a challenging functional ingredient to remove and/or replace. However, many commonly utilized binders and extenders can also be replaced with alternative versions and provide reasonably similar outcomes. So, removal of phosphates can be partially remedied by inclusion of alternative binding/extending ingredients. Due to the unique ability that only phosphates provide in mimicking ATP in the muscle and allowing for dissociation of actomyosin to create "space" for water binding which also exposes additional binding sites, some manufacturers have opted to not remove this functional ingredient from their formulations. However, removal is not impossible and several options exist to partially replace the function provided by phosphates.

Phosphate & binder/extender replacement ingredients follow two primary pathways for their function. The first is to mimic the biochemical action of phosphates by increasing the meat system pH and thus increasing water binding by creating a higher concentration of negative polar protein charges. Ingredients with a relatively high pH such as sodium carbonate and sodium bicarbonate can used for this purpose. However, their impact is not equivalent to phosphates since they have no ability to mimic ATP and provide dissociation of actomyosin. The second approach is to replace common binders and extenders with less "processed" and "purified" versions such as starches (e.g. potato, rice), fibers (e.g. carrot) and even hydrocolloids (i.e. carrageenan). Because these ingredients are not significantly modified from their native state and can resonate with a consumer's "kitchen cabinet" vocabulary, that are viable alternatives for replacing many of the more traditionally used ingredients. However, it's important to remember that the modification to the ingredient, such as a modified food starch, takes place to increase the functionality of that starch. Thus native versions of water binding/extending ingredients do offer functionality but not typically at the equivalency of the modified/altered versions.

One of the approaches to address the "lack of function" is to understand the amount of functionality that is still missing and determine what adjustments or modifications in the formulation and/or process are needed and can take place to compensate for this. A common approach in addressing this type of scenario is to provide additional focus on extractive protein via adjustments in raw materials or processing methods (e.g. longer mixing or tumbling times for hams), utilization of one or more alternative water binding/functional ingredient(s), or a combination of both. Depending on the product this approach may be easily achievable or it could be challenging at best.

ANTIMICROBIALS

Due to a large number of highly effective and functional antimicrobials, excluding nitrite, the meat and poultry industry has enjoyed an array of highly beneficial ingredient options for improving and maintaining the safety of conventional processed meats. With the advent and growth of natural, organic and "clean" labeled products, this all changed creating potential food safety vulnerabilities and concerns. As such, the past 6-8 years have brought about much research focus investigating and understanding functional alternative antimicrobial ingredients. Since a wealth of previous research has shown the importance and synergistic activity of nitrite in combination with antimicrobial ingredients, much of these work has also incorporated alternative curing concepts and the impact natural sources of nitrite have on the efficacy of different alternative antimicrobial ingredients as well as food safety as a whole.

Several traditionally used antimicrobials such as organic acids with chemical names such as sodium lactate or sodium diacetate, classified by USDA as preservatives, are either prohibited for natural or organic formulations via labeling regulations or aren't often included in "clean" labeling ingredient decks due to negative consumer connotations. Fortunately, many weak organic acids and other antimicrobial compounds are naturally occurring or can be generated and concentrated using naturally occurring ingredients and processes. For example, acetic acid is a primary component of vinegar, lactic acid is naturally produced by bacterial fermentation of sugars, and citric acid can be found in high concentrations in many fruits.

Functional antimicrobial ingredient research has spanned across a number of different products and has addressed a number of different pathogens to better determine true expected antimicrobial effects when using these alternative antimicrobial ingredients. While the use of antimicrobials has been extensively studied, both in uncured products and those cured with direct addition of nitrite, the same level of confidence and in-depth understanding remains to be determined when referring to natural or clean-label antimicrobials and alternatively cured meat products.

In alternative cured frankfurters, blends of cultured sugar and vinegar as well as cherry, lemon, and vinegar have been shown to effectively inhibit *Listeria monocytogenes* (Schrader, 2010). Similar results have been observed for preventing *Clostridium botulinum* toxin production using the same antimicrobials and model system (Wanless, 2010). McDonnell et al., screening a number of ingredients for antimicrobial properties in uncured and alternative cured model systems, found a 1.5% vinegar/lemon/cherry powder blend, 2.0% buffered vinegar, 2.5% vinegar/lemon juice blend, 0.05% tea tree oil, or 3.0% cultured sugar/vinegar inhibited *L. monocytogenes* outgrowth at 4°C for 4 weeks in an uncured turkey system (McDonnell et al., 2013). In a system containing nitrite from purified or natural sources, these researchers also noted the antimicrobial impact of nitrite was enhanced by the use of 0.03% grapeseed extract, 1.0% liquid smoke extract, or 0.5% cherry powder during the same storage period. After alternative ingredient validation in commercial deli-style turkey breast, roast beef, and ham, the study concluded that natural antimicrobial alternatives are available and can be effective in inhibiting *L. monocytogenes* growth during refrigerated storage. The synergistic impact with nitrite has further been shown by other researchers. Golden et al. (2014) observed turkey breast products supplemented with 1.0% cultured sugar/vinegar blend and 80 ppm nitrite from celery powder prevented *L. monocytogenes* growth through 12 weeks at 4°C. Lavieri et al. (2014) reported that 1.0% dried vinegar or 2.5% lemon/vinegar blend in alternative cured frankfurters containing 50 ppm ingoing nitrite from celery powder prevented *L. monocytogenes* growth through 98 days at 4°C, while a control with nitrite but no antimicrobials allowed for populations to reach approximately 8 log.

Due to processing challenges related to the post-thermal processing cooling of larger diameter/greater mass products normally allowed extended chilling (15 vs 6.5 hours) if containing an ingoing minimum of 100 ppm nitrite, alternative antimicrobial ingredients have also been evaluated for their efficacy to control *Clostridium perfringens*. Lemon juice and vinegar, natural sources of citric and acetic acids, respectively, were shown to inhibit the outgrowth of *C. perfringens* in uncured turkey and roast beef during chilling (Li et al., 2012; Valenzuela-Martinez, 2010). This study found a 2.0% lemon juice and vinegar blend minimized outgrowth of *C. perfringens* spores to less than 1 log during cooling of roast beef, even when cooling took as long as 21 hours to cool from 54.4 to 4.4°C (Li et al., 2012). In turkey breast, 3.5% of the lemon and vinegar blend was required to limit outgrowth to less than 1 log during 21 h of chilling, and 2.5% buffered vinegar also provided similar inhibition (Valenzuela-Martinez, 2010). This research provides valuable insight on the effectiveness and limitations of different alternative antimicrobial ingredients.

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