Preservatives (Antimicrobials, Antioxidants and Mold Inhibitors) Antimicrobials function in a food product just as the name implies. They prevent (anti) microbial growth throughout the life of the product. For clean-labeled products, alternative ingredients that can provide microbial protection include organic acids and plant-derived compounds. These alternative ingredients tend to function in one of two ways: 1) by lowering the pH or acidity of the product to make the food a less favorable environment for microbial growth or 2) altering the cell membranes of the microbes to prevent growth and proliferation in the food product. In addition, the hurdle concept implemented for food safety reasons within processing facilities works with these functional ingredients. Hurdle technology combines preservation techniques to establish a series of preservative factors (hurdles) that the microorganisms in question are unable to overcome (jump over). These hurdles may be temperature, water activity, acidity, preservatives and others. Similarly, when developing clean label products, the more that alternative ingredients are combined, each with their own specific function or multiple functions, the greater the chance of producing a very safe, high quality, and marketable product. Alternative antimicrobials include: • Organic acids (acetic and citric) o Vinegar o Lemon powder o Lemon juice solids • Plant-derived compounds o Essential oils of cinnamon and sage o Malic acid derived from dried plums o Celery extract Antioxidants serve as preservatives in food products by preventing lipid or fat oxidation. Antioxidants work by scavenging free radicals that react with fat. Traditionally, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) control the oxidation of animal fats. Therefore, meat products often include these ingredients as antioxidants. Alternative antioxidant ingredient options include: • Green tea extract • Vitamin E • Vinegar • Celery extract • Herb and spice extracts • Cultured sugar including rosemary extract with vinegar In bakery products, one of the main factors in extending product shelf life is controlling spoilage. The commonly used mold inhibitors in bakery products include propionates (calcium or sodium) and sorbates (sorbic acid or potassium sorbate). Alternative mold inhibitors are: • Vinegar • Prune-juice concentrate • Raisin juice concentrate • Paste and cultured whey No matter which alternative ingredients you choose in regards to preservatives, sensory attributes should always be a consideration. Will the alternative ingredient add a different flavor, odor or color to the product and will the consumer be accepting of these changes? Chemical Emulsifiers, Leavening Agents, Stabilizers, Thickeners Food products commonly use chemical emulsifiers, stabilizers, and texturizers to prevent separation or keep particles suspended, to provide thickness or mouthfeel or to delay staling or hardening. Commonly used emulsifiers include mono and diglycerides or polysorbate 80, while common texturizers include modified starch or gums. There are no readily available clean label substitutes for common chemical leavening agents such as baking soda (sodium bicarbonate) or baking powder (sodium bicarbonate plus one or more acid salts such as monocalcium phosphate, sodium acid pyrophosphate or sodium aluminum phosphate). However, since baking powders have been known since the mid 1800’s they are generally acceptable to consumers because they understand why they are used and are familiar with them. Organic acids such as malic or citric could be used but the leavening process may then need to be altered because these acids will react quickly during mixing. Leavening with yeast is another option for certain types of bakery products such as bread which would provide for a simpler ingredient declaration. Alternative emulsifiers: • Enzymes (amylase) • Lecithin (derived from soy) • Egg yolk • Mustard Alternative stabilizers and texturizers: • Functional native starches (corn, potato, tapioca etc.) for stabilizing or thickening • Enzymes (amylase) to modify texture in baked goods • Dried or concentrated fruit (apple flake powder or date paste) for thickening • Plum juice concentrate for moisture retention in processed meat • Natural gums (fruit pectin, guar gum or locust bean gum) for stabilizing or thickening • Fermented skim milk, buttermilk and acid whey to reduce staling in bread • Whey protein hydrolysate to delay hardening in protein fortified bar type products • Other proteins such as pea protein for thickening Learn More This overview report is a complimentary offering of the Agricultural Utilization Research Institute (AURI). To learn more about this subject, or how AURI can help you develop a clean label food product, visit auri.org, or call (507) 537-7440. ® CLEAN LABEL GUIDE ® The clean label trend started back in the 1990s with trans fatty acids (TFAs). Food producers traditionally used TFAs to replace the negatively perceived saturated fatty acids (SFAs) in foods. However, studies have shown that TFAs are more detrimental to heart health than natural SFAs. It was likely that at this point consumers became more conscious of highly processed ingredients in the food supply. More recently, consumers have developed a negative

perception of a plethora of other ingredients, including chemical sounding preservatives, high fructose corn syrup, chemical emulsifiers, stabilizers and thickeners, artificial colorants, artificial flavorings, and hydrogenated oils. It is worth noting that negative consumer perceptions of some of these ingredients are not science based, but many food producers are responding to consumer demand to remove or replace them nonetheless. Food producers use these ingredients for very specific functional purposes. In replacing them, one cannot expect food products to perform the same on either the retail shelf or the consumer's palate. Substitute ingredients may also increase cost, so one must consider the impact on the bottom line. Today's Consumer: A Changing Frontier Today's average consumer is more health-conscious than ever and desires an increasing amount of information around their food purchases. More than ever before, they scrutinize nutritional labels on foods to avoid artificial ingredients and foods containing ingredients with long, chemical sounding names. Consumers increasingly seek functional foods that provide sustenance and satiety, as well as perceived health benefits associated with ingredients such as antioxidants. Consumers view these functional foods as either containing components that have beneficial physiological effects or lacking components that could negatively impact their health. These are only a few of the reasons why cleaner labeled foods are oftentimes perceived as safer, higher quality and even healthier. However, is there a universal definition of a "clean label?" Clean-labeled foods have been associated with a plethora of food categories or phrases including "natural," "organic," or "minimally processed." Today, there is no industry-wide definition of the term or regulation of its use. Industry Challenge The food industry has a challenge ahead—providing cleaner labeled, highly demanded foods that perform the same as their existing counterparts in terms of taste, quality and price. To meet this changing demand, food processors are increasingly becoming more transparent with the ingredients and processes that they use. Additionally, food processors must find clean label alternatives for these negatively perceived ingredients. So, where do you start and what are your options? The food processors' number one goal should always be to create a safe product for human consumption. It is important to remember that taste trumps all else in terms of food products, especially as the main factor affecting repeat purchases. Therefore, it is very important to keep in mind the affect alternative ingredients have on both the safety and taste of the product. Targeted Ingredients In the clean-label-ingredient marketplace, many alternative options exist for processors. The alternatives listed in this report do not comprise an all-inclusive list and it is not AURI's intent to promote one ingredient over another, but simply to give an overview of available substitutes. 80% 75% 80% indicate that a short and simple ingredient listing is important or very important. 2 out of 3 indicate "no artificial ingredients" claim is important or very important. 75% usually or always read package claims and ingredient listings. 0% 23% 45% 68% 90% High Fructose Corn Syrup Artificial Colors Trans Fat Sodium Lauryl Sulfate Triclosan Caramel Coloring Percentage of Consumers Putting a High Priority on Avoiding Ingredients Nutrition Business Journal survey conducted Nov. 18-25th, 2014, 363 survey takers were asked: "Rate the degree in which you avoid the following ingredients." According to an online survey of US and UK customers conducted by Kalsec® (http://kalsec.com/news/cleaner-label-trends-1/) Additionally, the food industry commonly uses artificial sweeteners. These include synthetic substitutes, such as aspartame or saccharin, which give the product added sweetness, without the calories. Most notable for giving diet soft drinks their sweetness, artificial sweeteners, along with HFCS, have come under attack in recent years. The use of these sweeteners has seen a decline as consumers want cleaner labeled products, leading the industry to find alternative sweeteners to meet consumer demand. Alternative sweeteners: • Honey • Agave • Maple Syrup • Molasses • Tapioca Syrup • Brown Rice Syrup • Sweet Potato Juice • Apple Juice Concentrate • Pear Juice Concentrate • Other Fruit Juices, Juice Concentrates and blends • High Intensity Sweeteners: o Stevia Leaf Extract o Monk Fruit Extract Keep in mind that these alternative sweeteners may contribute some flavor, may be more or less sweet than sugar and will vary in the amount of solids or moisture they contribute to the end product. From a nutritional standpoint, these alternates will still count towards the overall sugar content of the product. The cost may also be an important consideration as some of these alternative ingredients could be considerably more expensive. CLEAN LABEL Organic acids (acetic acid), Plant-derived compounds (allicin in garlic, thymol in thyme, oregano and sage, rosemary extract, green-tea extract, Vitamin E) Natural colors and flavors from fruit, vegetable or spice origin Agave nectar, honey Potato starch, carrageenan, rice bran,

oat fiber, plum fiber Lecithin, amylase Different chlorides (potassium chloride), different forms of salt (flaked, coarse) TRADITIONAL Preservatives (BHA & BHT) Artificial Colorants & Flavorings Sweeteners Binders Chemical Emulsifiers Sodium Nearly 40% of all food product launches in the U.S. in 2013 were Clean Label* *According to data provided in Mintel GNPD, 2013-2014 40% INGREDIENTS: Whole Grain Rolled Oats, Brown Sugar, Butter (Cream, Salt), Raisins, Cassava Flour, Granulated Sugar, Tapioca Starch, High Oleic Sunflower Oil, Whole Eggs, Brown Rice Syrup, Potato Starch, Vanilla Extract, Baking Soda, Xanthan Gum, Salt. LABEL COMPARISON Grandma's® Oatmeal Raisin Cookie E&C;® Heavenly Hunks Oatmeal Raisin Artificial Colorants Artificial food dyes, otherwise known as certified colors (such as FD & C Red 40), have traditionally been used as they are an economical choice to produce intense colors within the products. In addition, certified colors are more able to withstand abuse from heat, light, pH and other factors during processing and storage. The ease of use, being either water-soluble or oil dispersible makes them a convenient choice for multiple food systems. Examples of natural color additives: • Annatto extract • Caramel • Grape seed extract • Fruit juice • Vegetable juice • Turmeric • Paprika • Beta carotene (non-synthetic version) One of the biggest challenges of natural colorants is their instability. Most are highly susceptible to oxidation. Heat and light exposure can also degrade color over time and shifts in the pH of the product can cause hue changes. Additionally, consideration of solubility is necessary, as some natural pigments are not water-soluble. Finally, the cost of some natural colorants is higher than their synthetic or artificial counterpart. This is most likely because the availability of natural colorants is limited and the process to grow and harvest the needed plant source is time consuming. Sugars/Artificial Sweeteners The food industry uses sweetening ingredients in food products of all types, including those with a sweet or savory profile. Foods include sweeteners for the obvious reason, to add sweetness, but can also add to the product stability, mouthfeel and color (for example, more browning in a baked good and cooked meat products). As noted in the previous section, consumers have even developed a negative perception of commonly used sweeteners such as high fructose corn syrup (HFCS). Literature Cited: 1. Aqualab, "Hurdle Technology Improves Food Preservation" www.aqualab.com/education/hurdle-technology-improves- food-preservation. 2. Bakingbusiness.com, "Leavening Agents Bring Lift to Baked Goods," October 1, 2015. 3. Food Product Design, "Clean Label Considerations," August 2013, page 21-22. 4. Food Product Design, "Clarifying Clean Labels," May 2011. 5. Food Product Design, "Antioxidant 'Meat' Needs," April 2005. 6. Food Product Design, Food Tech Toolbox: "Exploring Natural Ingredient Options," November 2013. 7. Meatingplace, "Uses of Synthetic and Natural antioxidants and antimicrobials to increase shelf-life, safety," January 20, 2014. 8. Meatingplace, "Researchers Highlight dozens of Natural Antioxidants for Meat Preservation," October 19, 2015. 9. Meat & Poultry, "Meat Ingredient Sourcebook," September 2012, page 12-13. 10. Technical Report: Dairy Solutions for Clean-Label Applications 11. 2016 Clean Label Conference Summary, "Sophisticated Solutions for Simplified Labels," Global Food Forums, Inc.