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Robert M. Kerr Food & Agricultural Products Center

FOOD TECHNOLOGY FACT SHEET

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Clean Label Mold Inhibitors for Baking

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When warm and muggy weather arrives in Oklahoma, mold growth in bakery products becomes more of a concern. Bakery spoilage due to mold is always an issue worldwide. On an annual basis, approximately 4-5 percent of the bakery products produced in the world are lost to the presence of fungi. In fact, a staggering 600-million pounds of bread are lost each year due to stale and/or spoiled "unsellable" bread (Cook and Johnson, 2009). Combined with good sanitation, added preservatives can prevent many of these problems. With the popularity of clean-label products, some bakers are hesitant to add preservatives; the word "preservative" does not stir images or feelings of "homemade." Fortunately, clean-label preservatives for mold inhibition do exist and are becoming increasingly available.

Background

In the baking industry, the most commonly used chemical preservatives to prevent mold spoilage are the following: propionates (calcium or sodium propionate), sorbates (sorbic acid and potassium sorbate), benzoates, parabens (methyl and propyl) and acetic acid (Pyler and Gorton, 2008). Calcium and sodium propionate are the neutral salts of propionic acid, a naturally occurring by-product of the *Propionibacterium* found in swiss cheese. Due to their lack of activity against yeast, propionates are the most widely used antimicrobial in yeast-raised baked foods (Pyler and Gorton, 2008). Propionic acid is industrially produced by the hydrocarboxylation of ethylene and the aerobic oxidation of propionaldehyde (Samel, et al., 2005). Sorbic acid, and its sodium and potassium salts, are effective against yeasts and molds. Consequently, since these products can inhibit yeast fermentation, sorbates are applied to bakery products by encapsulation, spraying onto the product as an aerosol or incorporating it into the packaging material. Sorbic acid was first isolated from the berries of Mountain Ash (*Sorbus spp.*) trees (Bullerman, 2000) and is commercially prepared by synthetic procedures, such as the condensation of crotonaldehyde and ketene (Weissermel and Arpe, 2003). Benzoates (sodium benzoate) are inhibitory to yeast and most commonly used to delay spoilage of high acid fillings, fruits and jams (Pyler and Gorton, 2008). Sodium benzoate is manufactured by the neutralization of benzoic acid with sodium hydroxide (Wibbertman, et al., 2000). Benzoic acid is naturally occurring in cranberries, prunes and cinnamon. Parabens are related to benzoic acid – esters of para-hydroxybenzoic acid. Because they share benzoic acid's ability to inhibit yeast activity, parabens are typically used in cereal- and potato-based snacks (Pyler and Gorton, 2008).

Clean Label Mold Inhibitors

Breads, muffins, rolls, cookies, hamburger and hot-dog buns, bagels, etc. would all possibly benefit from the addition of a mold inhibitor, adding 1-4 more additional days (or more) of mold-free shelf life to these bakery products. Sour dough bread is an exception; the lactic- and acetic-acid-generating bacteria found in the starter create a low pH environment, hindering fungal growth.

Following are mold inhibitors, separated by mode-of-action. The amounts to use are given in Baker's Percentage. Baker's Percentage was developed because weight measurements are more consistently accurate than volume. With the availability and affordability of electronic balances, liquid and dry ingredients are now relatively

easy to weigh, and weights are readily expressed using a single unit of measure. When once understood, Baker's Percentage allows for the ease in scaling up or down a formula and quickly realizing the hydration of the flour (Baker's Percentage 2010). In Baker's Percentage, the flour weight is always expressed as 100 percent and each ingredient in the formula is expressed as a percentage of the flour weight.

Example of Baker's Percentage:

Ingredient	Weight (lbs)	Baker's Percent
Flour	60.0	100%
Water	37.2	62%
Yeast	1.8	
Salt	1.2	
Sugar	2.4	
Fat	1.8	
MSNF (milk solids nonfat)	1.2	
Total	**105.6**	

For the Baker's Percent of "water," divide the weight of water by the flour weight and multiple by 100. Continue for each ingredient (AIB International 2007).

REDUCE DOUGH pH

VINEGAR

Active Ingredient: (Gelroth et al., 2007)	Acetic acid Vinegar is a dilute solution of acetic acid. Strength (or concentration) of vinegar is measured in "grains." One grain is equal to one-tenth of one percent of acetic acid. The vinegar found at the grocery store is a 50-grain vinegar. A 100-grain vinegar is 10% acetic acid, and a 200-grain vinegar is 20% acetic acid. Using the 200-grain vinegar will obviously permit less vinegar to be used per batch of dough. Use different strengths of vinegars to determine baked product quality.
Amount to Use: (Bullerman, 2000) (Dubois, 1983)	0.5-2.0% of a 50-grain vinegar; Recommend 0.5-1.0%; add with liquids. 0.25-1.0% of a 100-grain vinegar; Recommend 0.25-0.4%; add with liquids. 0.125-0.5% of a 200-grain vinegar; Recommend 0.125-0.3%; add with liquids. During the winter months, when mold problems are not as likely to occur, use the lower end of the suggested ranges.
Associated Problems: (Williams and Pullen, 2007)	(1) too much could cause a vinegar odor (2) may need to slightly increase yeast levels – vinegar may affect yeast activity (3) may increase proof time.

PRUNE JUICE CONCENTRATE
(Sanders, 1990 and 1991)

Active Ingredient:	Predominately Malic acid but also Benzoic and Salicyclc acid.
Note:	FOR EVERY 10 LBS OF CONCENTRATE USED, REMOVE 3 LBS OF WATER.
Amount to Use:	Add at 9-12%; recommend beginning with 9%; add with liquids. During the winter months, when mold problems are not as likely to occur, use the lower end of the suggested range.
Associated Problems:	(1) may cause a darker and shinier crumb.
Additional Benefits:	(1) mainly used in whole grain breads to "round out" the grainy flavor (2) soften crumb – may need to eliminate emulsifiers (3) less crumbly crumb and aid in anti-staling (4) may reduce the amount of sugar in recipes – natural sweetener (5) may reduce mix time by 5 minutes (6) may slightly increase bread loaf volume (7) nutritional profile improvement of product (8) natural color enhancer.

RAISIN PASTE CONCENTRATE

Active Ingredient:	Predominately Propioninc acid for the mold inhibition but also Tartaric acid.
(Payne, 2004)	Raisin Paste is made from extruded raisins through a mesh screen. It comes in various degrees of consistency – from very fine grind to less fine.
Amount to Use: (Fagrell, 1992) (Labell, 2000)	5-10% [According to a 1992 AIB Technical Bulletin, at the 5% level, mold-free shelf life increased 3 days; at the 10% level, the shelf life increased up to 10 days.]; Use raisin paste instead of raisins or as a fat replacer. For example, raisin paste can be used to replace 50% of the fat in some cookie recipes. (Note that the Standard of Identity for raisin bread requires 50% whole raisins.)
Additional Benefits: (Manufacturing FAQs, 2010) (Payne, 2004)	(1) fat replacer (2) humectant, maintaining moisture (3) natural sweetener (4) flavor enhancer (5) nutritional profile improvement of product.

RAISIN JUICE CONCENTRATE

Active Ingredient: (Payne, 2004)	Predominately Propionic acid for the mold inhibition but also Tartaric acid. Raisin Juice Concentrate is made in a multi-stage process where pure raisin juice is extracted with water and then concentrated under vacuum to 70 Brix (70% soluble solids). It is very similar to molasses; however, it is less viscous.
Note: (Payne, 2004)	FOR EVERY 10 LBS OF CONCENTRATE USED, REDUCE THE AMOUNT OF WATER BY 3 LBS.
Amount to Use: (Bullerman, 2000)	Most effective usage level is 5-10%; add with liquids. During the winter months, when mold problems are not as concerning, use the lower end.
Additional Benefits: (Raisin Products, 2010)	(1) may reduce the amount of sugar in recipes - natural sweetener (2) natural coloring agent (3) flavor enhancer to "round out" a grainy taste in whole grain breads (4) soften crumb (5) maintains breakage in crisp cookies (6) maintains moisture in soft cookies (7) nutritional profile improvement of product (8) maintains softness in cakes (9) may need to reduce or eliminate use of oxidizers in bread formulations and increase mix time slightly.
Associated Problems: (Fagrell, 1992)	(1) may cause a darker and shinier crumb (2) at high usage levels, may impart the aroma of raisins (3) in yeast-raised goods, it may be necessary to increase the amount of yeast; raisin juice can inhibit yeast activity.

CULTURED WHEY PRODUCTS

Active Ingredient:	Acetic, Propionic and Lactic acids
(Pyler and Gorton, 2008)	Cultured Whey is usually a pasteurized product produced from food grade bacterial cultures grown on sweet whey. The production of organic acids during culturing provides the mold inhibition.
Amount to Use:	Follow supplier's instructions.

CULTURED WHEAT or CORN SYRUP PRODUCTS

Active Ingredient:	Citric, Acetic, Propionic and Lactic acids
(Cavanaugh, 2007)	A cultured wheat or corn syrup product is dairy free. It is made by a fermentation process similar to yogurt and cultured whey products but performed on wheat or corn syrup solids. Sometimes, spelt is used instead of wheat.
Amount of Use:	Follow supplier's instructions.

CELLULAR MEMBRANE DISRUPTION AND CELLULAR PROCESSES

(Gill and Holley, 2004)
(Thobunluepop, 2009)

CINNAMON

Active Ingredients:	Cinnamaldehyde, Eugenol, related Acids and Alcohols
Amount to Use: (Bullerman, 2000)	1-2% dry spice

CLOVE

Active Ingredient:	Eugenol
Amount to Use: (Bullerman, 2000)	about 1% dry spice

NATAMYCIN

Origin: (Fact Sheet Natamycin)	A substance produced by the bacterium *Streptomyces natalensis*.
Amount to Use: (Sprayable Antimicrobial)	After baking, spray a 7 to 20 ppm solution on baked foods immediately. Solution does not migrate into the food product but remains of the surface.

Summary

Usage of these clean label preservatives is fairly common. In a 1985-1986 survey, conducted by the American Institute of Baking (AIB), 26 percent of the responding larger baking companies in the U.S. used cultured whey, vinegar and raisin juice as mold inhibitors (Dubois and Vetter, 1987). Read the bread labels at the grocery store, and these ingredients will be present.

Cinnamon and clove have not found main-stream acceptance as mold inhibitors. Research to find alternative fungicides and antibiotics to control the increasing number of antibiotic-resistant microorganisms led to their discovery of new possible uses for these traditional flavorings.

Several other "natural preservatives" have been proven in the microbiology laboratory to be mold inhibitors, but their effective quantity in bakery products has not been fully determined (Pyler and Gorton, 2008). Examples are mustard seeds (isothiocyanates), oregano (thymol and carvacrol), thyme (thymol), byproducts of olive oil and wine production and the red-wine components (trans-resveratrol).

References

Baker's Percentage. Retrieved March 31, 2010, from http://www.kingarthurflour.com/professional/bakers-percentage.html.

Bullerman, L. (2000, May). Mold Growth in Bakery Products and Its Prevention. AIB Technical Bulletin. Volume XXII, Issue 6.

Cavanaugh, R. (2007, August). Natural Food Preservatives. Retrieved March 18, 2010 from http://www.ingredientexperts.com/content/view/44/76/.

Cook, F. and Johnson, B. (2009). Microbiological Spoilage of Cereal Products. In W. H. Sperber and M. P. Doyle (Eds.), Compendium of the Microbiological Spoilage of Foods and Beverages. (pp. 223-224). New York, New York: Springer Science+Business Media, LLC.

Dubois, D. 1983. Technical Assistance Industry Problems and Replies, III. AIB Technical Bulletin. Volume V, Issue 1. (pp 5).

Dubois, D. K. and Vetter, J. L. (1987). White, Whole Wheat, Wheat and Multigrain Bread A Survey of Formulas and Processes. AIB Technical Bulletin. Volume IX, Issue 2.

Fact Sheet Natamycin. Retrieved July 1, 2010, from http://www.dsm.com/en_US/downloads/dfs/Fact_sheet_Natamycin_v6.pdf.

Fagrell, E. (1992, April). Raisin Usage in Baked Goods. AIB Technical Bulletin. Volume XIV, Issue 4. (pp. 5-6).

Gelroth, J., Glaser, B. et al. (2007). Technical Assistance Industry Questions and Replies. AIB Technical Bulletin. Volume XXIX, Issue 6. p5.

Gill, A. and Holley, R. (2004). Mechanisms of Bactericidal Action of Cinnamaldehyde against Listeria monocytogenes and of Eugenol against L. monocytogenes and Lactobacillus sakei. Applied and Environmental Microbiology. Vol. 70, No. 10. (pp. 5750).

Labell, F. (2000, November). Raisins = Sweetn ess, Functionaliuty and Nutrition. Prepared Foods.

Module 1 AIB International Correspondence Course. 2007. Science of Baking Foundations. AIB International.

Payne, T. (2004). New Roles for Raisins in the Baking Industry. AIB Technical Bulletin. Volume XXVI, Issue 4. (pp. 2).

Pyler, E. J. and Gorton, L. A. (2008). Baking Science & Technology, 4th ed. Kansas City, MO: Sosland Publishing Company. (pp. 456-459).

Raisin Products. Retrieved January 28, 2010, from http://www.calraisins.org/professionals/processors-manufacturers/raisin-products/.

Samel, U., Kohler, W., Gamer, A. and Keuser, U. (2005). Propionic Acid and Derivatives. Ullmann's Encyclopedia of Industrial Chemistry. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA. Retrieved May 11, 2010 fromhttp://mrw.interscience.wiley.com/emrw/9783527306732/ueic/article/a22_223/current/pdf.

Sanders, S. (1990). Prunes in Bakery Products. AIB Technical Bulletin. Volume XII, Issue 3.

Sanders, S. (1991). Using Prune Juice Concentrate in Whole Wheat Bread and Other Bakery Products. Cereal Foods World. Vol. 36 (pp. 280-283).

Thobunluepop, P. (2009). Implementation of bio-fungicides and seed treatment in organic rice. Pak. J. Biol. Sci. Volume 12, (pp.1119-1126). Retrieved May 13, 2010 http://scialert.net/abstract/?doi=pjbs.2009.1119.1126.

Sprayable Antimicrobial. (June 2010). Baking and Snack. pp. 66.

Weissermel, K. and Arpe, H. (2003). Industrial Organic Chemistry, 4th ed. Weinheim, Germany: Wiley-VCH Verlag GMbH & Co. KGaA. (pp 187).

Wibbertmann, A., Kielhorn, J., Koennecker, G., Mangelsdorf, I. and Melber, C. (2000). Concise International Chemical Assessment Document No. 26 Benzoic Acid and Sodium Benzoate. International Programme on Chemical Safety. Retrieved March 13, 2010 from http://www.inchem.org/documents/cicads/cicads/cicad26.htm.

Williams, T. and Pullen, G. (2007). Functional Ingredients. In Stanley O. Cauvain and Linda S. Young (Eds.), Technology of Breadmaking. (pp. 86). New York, New York: Spring Science + Business Media, LLC.

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