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Influence of heating and acidification on the flavor of whey protein isolate

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ABSTRACT

Previous studies have established that whey protein manufacture unit operations influence the flavor of dried whey proteins. Additionally, manufacturers generally instantize whey protein isolate (WPI; ≥90% protein) by agglomeration with lecithin to increase solubility and wettability. Whey protein isolate is often subjected to additional postprocessing steps in beverage manufacturing, including acidification and heat treatment. These postprocessing treatments may further influence formation or release of flavors. The objective of the first study was to characterize the effect of 2 processing steps inherent to manufacturing of acidic protein beverages (acidification and heat treatment) on the flavor of non-instant WPI. The second study sought to determine the effect of lecithin agglomeration, a common form of instantized (INST) WPI used in beverage manufacturing, on the flavor of WPI after acidification and heat treatment. In the first experiment, commercial non-instantized (NI) WPI were rehydrated and evaluated as is (control); acidified to pH 3.2; heated to 85°C for 5 min in a benchtop high temperature, short time (HTST) pasteurizer; or acidified to 3.2 and heated to 85°C for 30 s (AH-HTST). In the second experiment, INST and NI commercial WPI were subsequently evaluated as control, acidified, heated, or AH-HTST. All samples were evaluated by descriptive sensory analysis, solid-phase microextraction (SPME), and gas chromatography-mass spectrometry. Acidification of NI WPI produced higher concentrations of dimethyl disulfide (DMDS) and sensory detection of potato/brothy flavors, whereas heating increased cooked/sulfur flavors. Acidification and heating increased cardboard, potato/brothy, and malty flavors and produced higher concentrations of aldehydes, ketones, and sulfur compounds. Differences between INST and NI WPI existed before treatment; INST WPI displayed cucumber flavors not present in NI WPI. After acidification, INST WPI were distinguished by higher intensity of cucumber flavor and higher concentrations of E-2-nonenal. No perceivable differences were observed between INST and NI WPI after heating; sulfur and eggy flavors increased in both types of WPI. After treatment, AH-INST-HTST samples were differentiated from AH-NI-HTST by grassy/hay and grainy flavor and increased lipid oxidation products. Further processing of WPI in food applications has negative effects on the flavor contributions of WPI.

Key words: whey protein isolate, flavor, acidification/heat treatment, lecithin

INTRODUCTION

Whey protein and its derivatives have been added to a growing number of functional foods. Whey ingredients add not only protein to beverage applications, but provide essential amino acids and functional properties. For this reason, whey protein readily lends itself to sports drinks, infant formula, and meal replacement beverages. In ingredient applications, whey protein is expected to have a bland flavor; however, whey protein ingredients can display off-flavors such as cardboard, animal, soapy, cucumber, and brothy (Carunchia Whetstine et al., 2005; Drake, 2006; Wright et al., 2006, 2009). Research has associated these undesirable flavors with multiple variables along the whey manufacture process including milk type, cheese starter culture, processing conditions, and storage conditions (Carunchia Whetstine et al., 2003, 2005; Tomaino et al., 2004; Croissant et al., 2009; Gallardo-Escamilla et al., 2005; Wright et al., 2006, 2009; Whitson et al., 2011). The flavor variability of dried whey protein affects the flavor profile and consumer acceptance of products containing whey protein (Childs et al., 2007; Wright et al., 2009; Evans et al., 2010). Off-flavors may be successfully masked, depending on the perceived intensity of the off-flavor, the nature/description of the off-flavor, and characteristics of the product application. Alternatively, optimal process and storage conditions can be applied to reduce or eliminate off-flavors in the dried whey protein.

Whey protein isolate (**WPI**) is a value-added dried whey product that contains at least 90% protein. Whey

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protein isolate is typically added to functional beverages at levels of 3 to 8% protein (3 to 8 g per 100-mL serving; Hazen, 2003). In beverage manufacturing, dried whey protein is subjected to additional postprocessing steps; including acidification (pH <4.6) for clarity and heat treatment (typically 88°C for 120 s) for shelf stability (Prendergast, 1985; Rittmanic, 2006; LaClair and Etzel, 2010). In addition to stability concerns, flavor is an essential component in the consumer acceptance of whey protein beverages. Cardboard, soapy, cabbage, and potato are documented off-flavors associated with whey protein beverages, and postprocessing of the protein in the beverage may further affect the flavor and acceptance of the finished product (Childs et al., 2007; Wright et al., 2009; Evans et al., 2010).

Whey protein isolate for beverage manufacturing may also be agglomerated to increase wettability and solubility of the protein ingredient. In the process of agglomeration, the dried powder forms clumps and particles that create pores in the powder and increase dispersibility. Methods of instantization include rewet and single-pass agglomeration. In rewet agglomeration, dry product is placed on a fluidized bed and steam or lecithin is applied (Henning et al., 2006; Wright et al., 2009). The partial wetting allows sticking and particle formation. An alternate method is single-pass agglomeration. In this process, instantization occurs as the product is spray dried. A multi-nozzle system is used to redirect dry product into the path of wet product (Henning et al., 2006). A common form of agglomeration includes addition of soy lecithin to increase wettability and solubility. Soy lecithin is desired because it is classified as a nutraceutical food due to its phospholipid constituents (Colbert, 1998). However, lecithin-associated volatiles have been documented in instantized products and may contribute cucumber, fatty, and cardboard flavors (Mortenson et al., 2008; Wright et al., 2009). Wright et al. (2009) documented that WPI instantized with lecithin had decreased shelf stability due to increased lipid oxidation products. To our knowledge, no studies have documented the impact of instantization on the flavor of WPI and its possible role in the flavor of acidified whey protein beverages.

A better understanding of how postprocessing steps (heating and acidification) affect the flavor of WPI may lead to the identification of methods to reduce or minimize WPI flavor contributions in beverages or lead to the identification of key compounds that can be masked to produce a more palatable product. The objective of the first study was to characterize the effects of 2 beverage-processing steps (acidification and heating) on the flavor of WPI. The second study sought to investigate possible flavor contributions from agglomeration with lecithin. These objectives were achieved through sensory and instrumental analyses of WPI, with and without agglomeration, under various treatments [control (**CON**), acidified (**ACD**), heated (**H-batch**), and acidified and heated (**AH-HTST**).

MATERIALS AND METHODS

Sample Acquisition and Preliminary Assessments

Natural variance between commercial suppliers of WPI is common and expected due to processing variation and equipment differences (Carunchia Whetstine et al., 2005). To account for this variance, 5 different commercial suppliers from throughout the United States each provided 2 lots of non-instant WPI manufactured from Cheddar whey (experiment 1). To investigate the effect of instantization on WPI, 2 of these suppliers also provided an additional 2 lots of instantized (**INST**) and 2 lots of non-instantized (**NI**) WPI manufactured from Cheddar whey (experiment 2). These 2 suppliers were able to instantize samples using single-pass agglomeration. Single-pass agglomeration, as opposed to rewet agglomeration, was chosen to minimize extraneous variables, such as initial product age. All samples were stored at −20°C upon receipt.

Chemical standards were obtained from Sigma-Aldrich (St. Louis, MO) with some exceptions: dimethyl sulfide, Z-4-heptenal, phenylacetaldehyde, octanal, and *o*-aminoacetophenone were obtained from Acros Organics (Morris Plains, NJ); nonanal, 1-hexen-3-one, 2-pentyl furan, δ-decalactone, and δ-dodecalactone were obtained from Alfa Aesar (Ward Hill, MA); 2-acetyl-2-thiazoline was obtained from AstaTech Inc. (Bristol, PA); 2-acetyl-thiazole, 2-nonanone, and ethyl octanoate were obtained from SAFC Supply Solutions (St. Louis, MO); *p*-cresol, butyric acid, and benzaldehyde were obtained from Fluka Chemie GmbH (Buchs, Switzerland); and 2,5-octanedione was obtained from Frinton Laboratories Inc. (Vineland, NJ).

Proximate Analysis. All WPI obtained from each supplier were analyzed for protein, fat, moisture, ash, and mineral content in duplicate. Total protein was measured by the Kjeldahl method (AOAC International, 2000; method number 991.20; 33.2.11) and total nitrogen was multiplied by a 6.38 conversion factor. Total fat content was determined by Mojonnier extraction (AOAC International, 2000; method number 989.05; 33.2.26) and total moisture content by vacuum oven drying (AOAC International, 2000; method number 990.20; 33.2.44). Total ash and minerals were measured by North Carolina State University Analytical Services Laboratory (Raleigh, NC) using a dry ash method paired with inductively coupled plasma optical emission spectroscopy (Lloyd et al., 2009).