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Short communication: Flavor and flavor stability of cheese, rennet, and acid wheys

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ABSTRACT

Dried whey ingredients are valuable food ingredients but potential whey sources are underutilized. Previous work has established flavor and flavor stability differences in Cheddar and Mozzarella wheys, but little work has compared these whey sources to acid or rennet wheys. The objective of this study was to characterize and compare flavor and flavor stability among cheese, rennet, and acid wheys. Full-fat and fat-free Cheddar, rennet and acid casein, cottage cheese, and Greek yogurt fluid wheys were manufactured in triplicate. Wheys were fat separated and pasteurized followed by compositional analyses and storage at 4°C for 48 h. Volatile compound analysis and descriptive sensory analysis were evaluated on all liquid wheys initially and after 24 and 48 h. Greek yogurt whey contained almost no true protein nitrogen (0.02% wt/vol) whereas other wheys contained 0.58% ± 0.4% (wt/vol) true protein nitrogen. Solids and fat content were not different between wheys, with the exception of Greek yogurt whey, which was also lower in solids content than the other wheys (5.6 vs. 6.5% wt/vol, respectively). Fresh wheys displayed sweet aromatic and cooked milk flavors. Cheddar wheys were distinguished by diacetyl/buttery flavors, and acid wheys (acid casein, cottage cheese, and Greek yogurt) by sour aromatic flavor. Acid casein whey had a distinct soapy flavor, and acid and Greek yogurt wheys had distinct potato flavor. Both cultured acid wheys contained acetaldehyde flavor. Cardboard flavor increased and sweet aromatic and buttery flavors decreased with storage in all wheys. Volatile compound profiles were also distinct among wheys and changed with storage, consistent with sensory results. Lipid oxidation aldehydes increased in all wheys with storage time. Fat-free Cheddar was more stable than full-fat Cheddar over 48 h of storage. Uncultured rennet casein whey was the most stable whey, as exhibited by the lowest increase in lipid oxidation products over time. These results provide baseline information for the viability of processing underutilized wheys into value-added ingredients.
Key words: acid whey, sweet whey, flavor, gas chromatography

Short Communication

When cheese or yogurt is produced by coagulating the casein from milk, the liquid byproduct is known as whey. Whey and whey protein powders are important ingredients but may contribute undesirable flavors to finished products (Wright et al., 2009; Evans et al., 2010; Oltman et al., 2015). The flavor of fluid whey changes based on cheese production parameters, including milk origin, heat treatment, bacterial starter cultures, coagulation method, and pH (Gallardo-Escamilla et al., 2005; Campbell et al., 2011a,b; Liaw et al., 2011). Pasteurization of fluid whey, storage, and fat removal also subsequently influence flavor (Liaw et al., 2010; Whitson et al., 2011). These effects on fluid whey flavor directly influence the flavor of any subsequent dried whey ingredient (Campbell et al., 2011b; Jervis et al., 2012, 2015). As such, flavor variability and flavor stability of fluid whey are important to maximize flavor quality of dried whey ingredients.

Whey is divided into 2 main categories: acid whey and sweet whey, although distinct differences also exist between cultured and rennet set wheys (Campbell et al., 2011b). Fresh sweet whey flavor has been characterized by the sensory terms sweet aromatic, cooked milky, and diacetyl/buttery (Gallardo-Escamilla et al., 2005; Liaw et al., 2010, 2011). Few studies have addressed the sensory properties of acid whey. Gallardo Escamilla et al. (2005) reported rancid and stale flavors in acid casein whey but the effect of storage time was not addressed so it is unclear if other confounding factors influenced the sensory properties reported. Storage of Cheddar and Mozzarella wheys increased cardboard flavor, which was directly sourced to increased volatile lipid oxidation compounds (Whitson et al., 2010;

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Campbell et al., 2011b; Liaw et al., 2011). Campbell et al. (2011b) demonstrated that these changes in lipid oxidation compounds were increased with cultured wheys compared with rennet set wheys and that differences documented among cultured wheys were attributed to differences with starter cultures.

Little work has addressed underutilized acid wheys such as cottage cheese and Greek yogurt wheys. A direct comparison of sweet and acid, and cultured and noncultured liquid wheys over storage time has yet to be studied and would facilitate additional applications for those products. The objective of this study was to evaluate the flavor and flavor stability of 6 different liquid wheys over 48 h of storage. The whey varieties evaluated were white Cheddar, fat-free white Cheddar, rennet casein (all sweet wheys), acid casein, Greek yogurt, and cottage cheese wheys (all acid wheys). This study serves as a baseline understanding of the sensory and stability characteristics of these 6 wheys and may determine potential uses for Greek yogurt whey.

The experiment was conducted over 2 d. On d 1, 3 of the wheys were manufactured and on d 2, the other 3 wheys were manufactured. One lot of milk was used for each replicate of all wheys. The order in which wheys were made on which days was randomized across all 3 replicates. Approximately 75 L of milk was used for each replicate of each whey. All wheys were manufactured in triplicate, and wheys were manufactured using standard procedures (Varnam and Sutherland, 1994; McAuliffe et al., 1999; Maragkoudakis et al., 2006; Campbell et al., 2011b). Raw bovine milk was obtained from the North Carolina State University Dairy Research and Education Unit (Raleigh). Wheys were manufactured from skim milk, except for Cheddar, which was made from whole milk. Skim milk was used because it is the milk source commonly used for these whey sources. Whey from regular (whole milk) uncolored Cheddar cheese milk has been previously characterized and served as a control (Liaw et al., 2010, 2011; Campbell et al., 2011b). Milk for wheys except Greek yogurt was HTST pasteurized at 72°C for 16 s using a plate heat exchanger (model T4 RGS-16/2; SPX Flow Technology, Greensboro, NC). For Greek yogurt whey, raw skim milk was heated to 95°C for 5 min in a water-jacketed pasteurization vat and then immediately cooled to 37°C using the same vat (model MPD1050, Micro Process Design, D&F Equipment Co., McLeansville, NC). All wheys were subjected to fat separation and pasteurization at 63°C for 30 min, followed by cooling to 10°C using a glycol bath. Cooled, pasteurized wheys were dispensed into autoclaved amber glass containers (VWR International, Radnor, PA) and stored at typical refrigeration temperatures (4°C). Wheys were sampled for immediate analysis and then after 24 and 48 h to determine the oxidative stability of each whey. These time points span the typical time that fluid product may be stored in whey processing (0 to 48 h).

Cheddar and fat-free Cheddar were produced in the same manner: milk was heated to 31°C and was inoculated with mesophilic starter culture (Choozit MA 11, Danisco, New Century, NJ) at a rate of 50 direct culture units/454 kg of milk. Calcium chloride was then added at 0.39 mL/kg of milk (50% wt/vol, Dairy Connection Inc., Madison, WI). The milk was ripened for 60 min under constant agitation. Milk was then coagulated for 30 min with double-strength recombinant rennet (Dairy Connection), which was added at a rate of 0.09 mL/kg of milk. The coagulum was cut into approximately 2.5-cm^3 cubes and allowed to rest for 5 min, followed by gradual heating to 39°C over the course of 30 min with gentle agitation. Cheddar and fat-free Cheddar wheys were then drained, fat separated, pasteurized, and held at 4°C.

For cottage cheese whey manufacture, pasteurized skim milk was heated to 21°C and inoculated with mesophilic starter culture (F-DVS Fresco 1000-21, Chr. Hansen, Milwaukee, WI) at a rate of 5 g/25 L of milk. After 30 min, double-strength recombinant rennet (Dairy Connection) was added at a rate of 0.2 mL/100 L of milk. The milk was then incubated for approximately 4 to 5 h, until a pH of 4.6 was reached. Afterward, the curd was cut into 2.5-cm^3 cubes and allowed to rest for 10 to 15 min. The curd was then heated gradually to 55°C over 90 min, drained through a sieve, separated, and pasteurized.

For Greek yogurt whey, raw skim bovine milk was heated to 95°C for 5 min in a vat pasteurizer (model MPD1050, Micro Process Design, D&F Equipment Co.), cooled to 40°C, and inoculated with thermophilic starter cultures (DVS YF-L702, Chr. Hansen) at a rate of 1 g/5 L of milk. The milk was then incubated at 40°C for 4 h until the pH reached 4.6. The coagulum and whey were then transferred to a plastic strainer lined with 2 layers of fine cheesecloth, and the whey was allowed to drain into a collection container for 16 h at 4°C followed by separation and pasteurization (Maragkoudakis et al., 2006).

Both acid and rennet casein were produced without the addition of starter culture. Acid casein whey was manufactured by addition of dilute (1 *N*) hydrochloric acid (Sigma Aldrich, St. Louis, MO) at a rate of approximately 3.75 L/75 L of skim milk to bring the pH to 4.6. The milk was then heated to 50°C. The whey was drained from the curd, fat separated, and pasteurized. Rennet casein whey was manufactured by heating skim