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# Draining and salting as responsible key steps in the generation of the acid-forming potential of cheese: Application to a soft blue-veined cheese

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## ABSTRACT

A disregarded nutritional feature of cheeses is their high acid-forming potential when ingested, which is associated with deleterious effects on consumers' health. This work aimed to characterize the acid-forming potential of a blue-veined cheese during manufacturing to identify the main steps of the process involved in this phenomenon. Sampling was performed on 3 batches at 10 steps of the cheese-making process: reception of raw milk, pasteurization, maturation of milk, coagulation, stirring, draining of the curds, and 4 ripening stages: 21, 28, 42, and 56 d. The acid-forming potential of each sample was evaluated by (1) the calculation of the potential renal acid load (PRAL) index (considering protein, Cl, P, Na, K, Mg, and Ca contents), and (2) its organic anion content (lactate and citrate), considered as alkalinizing elements. Draining and salting were identified as the main steps responsible for generation of the acid-forming potential of cheese. The draining process induced an increase in the PRAL index from 1.2 mEq/100 g in milk to 10.4 mEq/100 g in drained curds due to the increase in dry matter and the loss of alkaline minerals into the whey. The increase in PRAL value (20.3 mEq/100 g at d 56) following salting resulted from an imbalance between the strong acidogenic elements (Cl, P, and proteins) and the main alkalinizing ones (Na and Ca). Particularly, Cl had a major effect on the PRAL value. Regarding organic anions, draining induced a loss of 93% of the citrate content in initial milk. The lactate content increased as fermentation occurred (1,297.9 mg/100 g in drained curds), and then decreased during ripening (519.3 mg/100 g at d 56). This lactate level probably helps moderate the acidifying potential of end products. Technological strategies aimed at limiting the acid-forming potential of cheeses are proposed and deserve further research to evaluate their nutritional relevance.

**Key words:** acid-forming potential, cheese-making process, draining, salting, blue-veined cheese

## INTRODUCTION

A disregarded nutritional feature of cheeses is their high acid-forming potential. This means that their intake may potentially induce an acid load to the body (Remer and Manz, 1994). The substantial consumption of cheese in Western diets (more than 20 kg/yr per capita in France, Germany, Switzerland, and Italy; Fox and Guinee, 2013) justifies the study of this characteristic. Two dimensions should be considered for an extensive overview of the acid-forming or base-forming potential of a food product: (1) its potential renal acid load (**PRAL**) index, and (2) its organic anion content (Demigné et al., 2004a; Demigné, 2008; Gore et al., 2016).

The PRAL index was developed by Remer and Manz (1995) to evaluate the acid/alkaline load induced by foodstuffs when ingested. It is based on the nutrient composition of the product and is calculated as follows:

$$\begin{aligned}\text{PRAL (mEq/100 g)} &= 0.49 \times \text{protein (g/100 g)} \\ &+ 0.037 \times \text{P (mg/100 g)} + 0.027 \times \text{Cl (mg/100 g)} \\ &- 0.041 \times \text{Na (mg/100 g)} - 0.021 \times \text{K (mg/100 g)} \\ &- 0.026 \times \text{Mg (mg/100 g)} - 0.013 \times \text{Ca (mg/100 g)}.\end{aligned}$$

Diet influences the acid-base balance of the body. Fixed acids are produced as the result of (1) the oxidation of the absorbed sulfur-containing AA from dietary proteins, (2) the generation of phosphates from the metabolism of phosphoesters and phosphoproteins, and (3) the absorption of chloride (Oh, 2000; Poupin et al., 2012). In contrast, ingested cations (Na, Mg, K, and Ca), commonly assumed to be associated with metabolizable anions, have alkalinizing properties (Remer, 2001; Poupin et al., 2012). According to the calculation model, foods with positive PRAL denote an excess of acid-forming potential, whereas negative PRAL indicate an excess of alkaline-forming potential.

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Given their high positive PRAL values, cheeses may contribute to the development of low-grade metabolic acidosis (Remer and Manz, 1995; Cordain et al., 2005; Gore et al., 2016). In the long term, this state may have deleterious effects on renal function (Frassetto et al., 2007b; Fenton et al., 2011; Bonjour, 2013; Wang et al., 2015). Even if the hypothesis remains controversial because of the lack of well-designed clinical trials, bone and muscle tissues might be affected as well (New et al., 2004; Frassetto et al., 2008; Mardon et al., 2008; Pedone et al., 2010).

Citrate and lactate salt intakes may have an alkalinizing effect on the acid-base balance of the body (Demigné, 2008). When completely oxidized in the course of the metabolism, they are considered precursors of bicarbonate, an important alkalinizing component in the body (Oh, 2000; Poupin et al., 2012). Citrate is the most abundant organic anion in milk and lactate in cheese (Tormo and Izco, 2004). In cheeses, these organic anions result from biochemical changes during processing and ripening (Fox, 2004; McSweeney, 2004). Their contents depend on cheese type and on the existing microflora because lactate and citrate may follow different metabolic pathways (McSweeney and Sousa, 2000).

In their pioneering work, Remer and Manz (1995) found that milk and fresh cheeses were characterized by PRAL values around zero, whereas ripened cheeses exhibited high PRAL values. Demigné et al. (2004b) suggested that processing enhanced the acid-forming potential of cheese. This hypothesis was supported by Gore et al. (2016) who confirmed that different cheese-making technologies had strong effects on acid-forming potentials of end products. In particular, they reported that hard cheeses and blue-veined cheeses exhibited the strongest acidogenic character. This was the result of a great imbalance between acidifying elements (Cl, P, and proteins) and alkalinizing ones (Na and Ca) of PRAL index.

Therefore, it would be interesting to study the evolution of the acid-forming potential of cheeses during manufacturing to determine the technological steps responsible for this acid-forming potential generation. This would allow us to better understand this feature, and potentially to control it. Indeed, in cheese-making technology, different end products are obtained through the modulation of various technological steps: milk setting, coagulum cutting, stirring, heating, draining, pressing, curd salting, or cheese ripening (Fox et al., 2004). All of these steps affect, to a varying degree, the final concentrations of various nutrients and thus influence the acid-forming potential of final products. To our knowledge, no work addressing this issue is reported in the literature. Some studies have focused on the evolution of certain minerals during the cheese-making process (Moreno-Rojas et al., 1995; Cichoscki et al., 2002; González-Martín et al., 2011), but the lack of literature on this aspect is often criticized (Hickey et al., 2015) and these works do not allow evaluation of the PRAL index of intermediate and end products.

The aim of the present work was to determine the evolution of the acid-forming potential of cheese and its responsible key steps during the cheese-making process to characterize and better understand its generation. The study was based on the industrial cheese-making process (from raw milk to final stage of ripening) of a soft blue-veined cheese.

## MATERIALS AND METHODS

### Cheese Manufacture

Raw cow milk was pasteurized (72°C, 15 s) and standardized in fat content (3.8%), then cooled to 13°C (Figure 1). Calcium chloride (concentration = 520 g/L, volume = 15 mL/100 L) and fermented cocktail (starter culture and *Penicillium roqueforti*, volume = 0.6 L/100 L) were added for pre-maturation of milk for about 12 h. The milk was then heated to 32°C and moved to vats. Rennet extract (chymosin + pepsin, ≥160 international milk clotting units/mL, volume = 30 mL/100 L) was added. After 30 min of incubation, the coagulum was cut into cubes (1 × 2 × 2 cm) using an automated cutting grid, and a stirring process for 1 h was applied to form grains of curd. A draining conveyor was used before molding so the grain structure was not damaged. The syneresis was carried out in molds, with periodic turnarounds, at a temperature between 19 and 20°C. The curds were salted manually by rubbing dry salt on the surface and then pricked to allow the growth of *Penicillium*. Ripening was carried out at 8°C and 98% relative humidity until d 28 and thereafter at 0°C until d 56.

### Sampling

Three cheese-making batches were prepared and manufactured at 1-wk intervals. The sampling was done during different steps of the cheese-making process: reception of raw milk, pasteurization, maturation of milk, coagulation, stirring, draining, and ripening. The raw milk represented a mixed milk from about 20 local producers, sampled before standardization and pasteurization. Pasteurized milk was sampled before adding the $CaCl_2$ and the ferments and matured milk just before adding the rennet. One liter per batch was aliquoted