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Effect of enzymatic transglutaminase treatment on textural and sensory properties of low-fat UF-Feta cheese incorporated with whey proteins using response surface optimization

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Introduction: Scientific evidence has demonstrated that consumption of high-fat foods has direct connection with increasing incidences of various diseases such as obesity, diabetes, hardening of the artery walls and blood pressure. Thus, demand for low-fat foods has increasingly been promoted by health-conscious consumers. However, development of low-fat foods is challenging as fat makes a major contribution to sensory attributes of many foods. Low-fat cheeses are usually characterized as having a flat taste, more translucency and a rubbery and gummy texture. A common strategy for improving the properties of low-fat cheeses is to increase its moisture content sufficiently to provide moisture to protein ratio which is greater than or equal to its full-fat counterpart. The addition of denatured whey proteins, which are known for their high water-holding capacity, to cheese milk is one method used to achieve this objective. Likewise, transglutaminase treatment of cheeses milk has been shown to increase the moisture content of the resultant cheese. Enzyme transglutaminase (MTGase; protein-glutamine gamma glutamyl transferase, EC 2.3.2.13) catalyzes acyl transfer reactions between protein intra- or inter- chain glutamine (acyl donor) and lysine (acyl acceptor) peptide residues. UF-Feta cheese has the highest per capita consumption amongst cheese varieties in Iran. However, UF-Feta cheese is also perceived as being high in fat, discouraging some consumers from including it in their diets. The objective of this study was enzymatic incorporation of whey proteins into the formulation of UF-Feta cheese by TGase in order to obtain a low-fat product with desirable textural and sensory properties.

Materials and methods: The experiments were designed according to a 5-level-3-factor central composite design using response surface methodology (RSM). The independent variable were formulation ingredients including TGase enzyme (0-2 units/g protein), whey protein concentrate (WPC) (0-16 % w/w) and fat (0-10 % w/w) and the responses of interest were the physicochemical (moisture content and lightness (L*)), textural (hardness, adhesiveness, cohesiveness and springiness) and sensory properties (flavor and odor, color and appearance, texture and total acceptability) of UF-Feta cheese.

Results and discussion: The results indicated that fat reduction caused significant increment in the moisture content of UF-Feta cheese. The whey protein addition showed the same effect on moisture content as fat reduction whereas transglutaminase treatment decreased the moisture of UF-Feta cheese. As expected, fat reduction was accompanied by an increase in hardness and elasticity of UF-Feta cheese. Fat and moisture act as fillers in the casein matrix of cheese texture. When the fat content is decreased, the moisture does not replace the fat on an equal basis, so the total filler volume is decreased, resulting in lower moisture to protein ratio. This in turn increases possibilities of cross-linking between protein chains, resulting in a more compact cheese matrix with harder and chewier texture. Similarly, the increasing effect of TGase treatment on hardness and elasticity may be attributed to formation of a more compact protein matrix because of cross-linking action of enzyme on milk proteins. The whey proteins, however, decreased the hardness and elasticity of UF-Feta cheese. It seems that the added whey proteins increased the moisture content of cheese as sufficiently as to offset the decrease in the total filler volume caused by fat reduction, preventing the protein matrix to be more compact and elastic.

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Promoted protein-protein interactions of the cheese matrix resulting from fat reduction or TGase treatment might also account for our observation on decreased adhesiveness and increased cohesiveness. As the protein matrix becomes more compact, the cheese loses its adhesiveness. Conversely, as the number or strength of protein interactions increases, the structural integrity of cheese matrix called cohesiveness increases. Apart from fat, water can also create more open conformation for protein molecules, resulting in increased adhesiveness and decreased cohesiveness. This may justify our observation on higher adhesiveness and lower cohesiveness of whey protein-fortified low-fat cheeses with high moisture content. Not surprisingly, all the sensory attributes of UF-Feta cheese were adversely influenced by fat reduction. On the other hand, whey proteins improved the flavor and texture of low-fat UF-Feta cheeses. They, however, showed no effect on appearance score of cheese samples in spite of the fact that they somewhat compensated for lost lightness (L*) of low-fat cheeses. Similarly, TGase treatment did not affect the appearance acceptability of UF-Feta cheeses despite having significant effect on their L* value. The sensory panel did not appreciate the flavor of TGase-treated samples; however, they scored the samples treated with enzyme concentration lower than 1 U/g protein as having desirable texture. RSM suggested that the optimum formulation of 5.95% (w/w) fat, 0.56 unit TGase per gram protein and 8.79% (w/w) WPC could produce a low-fat cheese sample with desired textural (hardness 0.342 kg; elasticity 8.58 mm; adhesiveness -0.070 kg.s; cohesiveness 0.474) and sensory (overall sensory score 88.73 out of 100) attributes.

Keywords: Low fat ultra-filtrated cheese, Transglutaminase enzyme, Whey protein concentrate, Response surface method.