Small Ruminant Research 112 (2013) 154–161

Contents lists available at SciVerse ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Research paper

The effect of transglutaminase concentration on the texture, syneresis and microstructure of set-type goat's milk yoghurt during the storage period

J. Domagała[a], M. Wszołek[a,*], A.Y. Tamime[b], B. Kupiec-Teahan[c]

[a] Department of Animal Products Technology, Faculty of Food Technology, University of Agriculture, Krakow, Poland
[b] Dairy Science & Technology Consultant, Ayr, Scotland, United Kingdom
[c] Scottish Agricultural College, Edinburgh, United Kingdom

ARTICLE INFO

Article history:
Received 13 August 2012
Received in revised form 3 December 2012
Accepted 4 December 2012
Available online 3 January 2013

Keywords:
Goat's milk yoghurt
Transglutaminase
Texture
Syneresis
Microstructure

ABSTRACT

Set-type yoghurts were produced from goat's milk cross-linked by microbial transglutaminase (TGase) using different amounts (1, 2 or 3 U/g protein), and the control yoghurt did not contain any TGase. Fresh and stored yoghurts (14 days) were examined for sensory profiling, instrumental texture analysis, syneresis and microstructure to study the influence of TGase concentration and storage time on the quality of the experimental products. TGase yoghurts (fresh and stored) had higher sensory scores, higher readings for texture measurements (i.e. firmness) and a lower volume of syneresis than the control product. In general, the higher the amount of added TGase used in the milk base the firmer the fresh yoghurt became, the lowest syneresis was observed and the highest sensory score was awarded by the taste panellist. Nevertheless, the best sensory score of fresh yoghurt was awarded to the product made with added 2 U TGase/g protein, and for stored yoghurts containing 2 and 3 U TGase/g protein, but syneresis of the product containing 3 U TGase/g protein was higher than the other experimental yoghurts. The firmness of the fresh experimental yoghurts (2 and 3 U TGase/g protein) was similar, and the stored products exhibited slight tendencies to syneresis and the firmness of the product was slightly higher, but the sensory score was lower. The protein matrix of the experimental yoghurts was more compact, and consisted of smaller casein micelles/aggregates than those of the control yoghurt. Modification of the goat's milk with microbial TGase improved the sensory quality, textural characteristic, and reduced syneresis of set-yoghurt when compared with the control product. Overall, the results suggest that best set-type goat's milk yoghurt was made using 2 U TGase/g protein.

1. Introduction

Rheological properties and texture characteristics of fermented milk products, including yoghurt, play a very important role in sensory evaluation and in consumer acceptability. In addition, the most typical defects of fermented milk products are low viscosity and reduced firmness, or these products have liquid consistency (Tamime and Robinson, 2007). In traditional yoghurt, the protein gel is mainly stabilised by weak non-covalent interactions (electrostatic, hydrogen bonding, hydrophobic bonds). The introduction of new covalent bonds leads to gel formation with different structure and properties, and the use of a specific enzyme, transglutaminase (TGase), offers such an opportunity (Schorsch et al., 2000a,b; Farnsworth et al., 2006).

* Corresponding author. Tel.: +48 12 6624788; fax: +48 12 6624810.
E-mail addresses: rtwszole@cyf-kr.edu.pl, monika@cyberia.pl (M. Wszołek).

0921-4488/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.smallrumres.2012.12.003

TGase (EC 2.3.2.13) catalyses the formation of covalent cross-links between glutamine and lysine residues in many food proteins including milk casein (Schorsch et al., 2000a; Jaros et al., 2006), Cross-linking of food proteins by TGase modifies their hydration ability, solubility, water holding capacity or emulsifying behaviour, foaming, viscosity, elasticity and their gelation properties and, thus, influences the techno-functional and physico-chemical properties of food products (Motoki and Seguro, 1998; Jaros et al., 2006). In the early 1980s, the possibility of modification of the functional properties of the casein micelles in milk and soybean globulins using TGase derived from guinea pig liver or bovine plasma was investigated by Motoki and Seguro (1998). Due to cost-effective production of TGase by microorganisms (e.g. *Streptoverticilium* spp.) and their Ca^{2+} – independent catalytic actions, applications of the enzyme in industrial food production became possible (Farnsworth et al., 2006).

Potential fields of application of TGase preparations in dairy processing were reviewed by Lorenzen and Schlimme (1998). Treatment of milk with TGase affects its heat stability (O'Sullivan et al., 2002), changes the properties of rennet milk gel, modifies functional properties of milk proteins and improves rheological properties of yoghurt (Lorenzen and Schlimme, 1998; Lorenzen, 2000). According to Lauber et al. (2000) and Lorenzen et al. (2002), cross-linking of casein in milk by microbial TGase increases the apparent viscosity of cow's milk yoghurt gel. Faergemand et al. (1999) reported that the addition of TGase to cow's milk enabled the production of yoghurt with proper rheological properties without fortifying the milk base with skimmed milk powder (SMP). According to Guyot and Kulozik (2011), stirred skimmed milk yoghurt fortified with TGase-modified SMP had higher viscosity readings and lower serum loss than yoghurt produced with the addition of untreated SMP. Jaros et al. (2010) reported that mainly dimer and trimer casein particles successfully enhanced the properties of milk protein gels modified by TGase. Generally, the influence of TGase on cow's milk yoghurt properties has been extensively studied by many researchers (Faergemand et al., 1999; Lauber et al., 2000; Lorenzen, 2000; Lorenzen et al., 2002, 2005; Abou El-Nour et al., 2004; Bonisch et al., 2007; Ozer et al., 2007; Oner et al., 2008; Jaros et al., 2010; Guyot and Kulozik, 2011). TGase can be also used to improve the rheological properties of goat's milk yoghurt, which is generally characterised by lower viscosity and firmness when compared with cow's milk yoghurt. However, very limited studies have been conducted on the use of TGase during the manufacture of goat's milk yoghurt and, according to Farnsworth et al. (2002, 2003, 2006), the use of this enzyme may be an effective means for improving the functional properties of goat's milk probiotic yoghurt and enhances the survival rate of probiotic microorganisms in the product. More recently, Rodriquez-Nogales (2006) investigated the susceptibility of goat's milk protein with or without preheating to cross-linking with microbial TGase, and reported that heating the milk prior to enzyme addition enhanced the subsequent cross-linking of milk proteins. Ardelean et al. (2012) concluded that combined fortification of the dry matter content of goat's milk base and TGase treatment resulted in the production of the gel of the fermentate that had similar properties to those of cow's milk gel, and such an approach appeared as a promising tool for manufacturing goat's milk yoghurt with satisfying texture properties.

The cross-linking and gelation process induced by TGase depends on enzyme concentration, protein concentration, pH, method and rate of acidification, and temperature (Schorsch et al., 2000a; Jacob et al., 2011). The same parameters can also influence the textural and rheological properties of yoghurt modified by TGase. In a separate study, Domagała et al. (2007) reported that the pH of the milk in the range of 6.4–6.1 incubated with TGase had no influence on the viscosity and texture properties of goat's milk yoghurt; however, higher viscosity and firmness of the gel from milk modified by TGase were observed.

The aims of this paper were to study the influence of enzyme concentration and time of storage on textural properties, syneresis and microstructure of yoghurt prepared from goat's milk treated with microbial TGase.

2. Materials and methods

2.1. Materials

The research work was carried out in the middle of the lactation period of goats (i.e. 4–5 months after kidding) in Poland. Goat's milk was obtained directly from a farm in village Modlnica near Krakow for the manufacture of yoghurt (control and experimental). The cold milk, consisted of morning milk blended with the evening milk, without and was transported directly to the laboratory. Chemical analysis of the milk was carried out before the manufacture of yoghurt.

2.2. Chemical analysis of the milk

The total solids, protein, casein, non-protein nitrogen, fat, lactose and ash contents of milk, including the density, viscosity, acidity and pH level were measured according to the methods reported by the AOAC (1995). Whey protein content was calculated by difference, i.e. summation of the casein and non-protein nitrogen contents subtracted from the protein content.

Cross-linking the milk for yoghurt making by TGase was prepared by heating the milk to 85 °C for 15 min, cooled to 5 °C, and microbial TGase ACTIVA MP (manufactured by Ajinomoto Foods Europe S.A.S., France, obtained from Barentz, Poland) was added to the milk at different amounts (1, 2 and 3 U/g protein). Enzyme dose was based on the manufacturer's suggestions (Ajinomoto, 2000), and our own preliminary studies (data unpublished). The milk containing the enzyme was incubated at 5 °C for 16 h. For the control yoghurt, the milk was not treated with TGase.

2.3. Manufacture of yoghurt

Milk for yoghurt making was heated to 80 °C for 1 min to inactivate the enzyme, cooled to 44 °C and inoculated with a yoghurt starter culture YC-180 (Chr. Hansen, Denmark) at a rate of 2% (w/w). The homogenisation of goat's milk was omitted because of the fat globules being small, and it seemed most likely that the fat in goat's milk might be susceptible to lipolysis.

The milk was thoroughly mixed, poured into containers and incubated at 44 °C for 4–5 h until the pH reached ~4.8. At this pH, the incubation was stopped, in order to avoid excessive acidification of the products during the cooling stage and storage of the yoghurts at 5–8 °C. All the yoghurts (control and experimental) were examined when fresh (i.e. one day old) and after 14 days of storage for sensory evaluation, instrumental texture analysis, syneresis and microstructure. The experiment was replicated on five different days of production.

2.4. Sensory evaluation

Sensory profiling of the yoghurts (control and experimental) was done using a 5 point scale (1 – least; 5 – best). The sensory attributes assessed