# STANDARDISATION OF CULTURED BUTTER PROCESSING FOR SMALLSCALE PRODUCTION

A thesis submitted in partial fulfilment of the requirements

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# SUMMARY

Butter is one of the most popular dairy products that have been transformed from a cottage industry to successful large scale productions. In western countries, consumption of butter has slowly overtaken margarine as the most popular spread. Different kinds of butter are now available on the markets, of which sweet cream butter and salted butter constitute significant proportions. The popularity of cultured cream butter is mainly attributed to its unique flavour and nutritional properties. Butter contains large amounts of β-carotene (provitamin A carotenoid) and is characterised by the buttery flavour due to the presence of diacetyl as well as other organic aroma compounds. Although butter has been produced successfully in large scale commercial processing, small scale productions still exists in small communities and for use in specialised products. New Zealand, like in many other western countries, is dominated by small to medium scale food processing enterprises which produce speciality foods for discerning markets. The domestic market in New Zealand enjoys a variety of dairy products which includes cultured butter. Some small food processing enterprises in outlying areas of New Zealand produce their own cultured butter to cater for the local businesses and their inhabitants. Thus, the main objective of this project was to standardise small scale production of cultured butter using kitchen/domestic scale equipment.

Fresh cream (40% fat) used to produce cultured butter was fermented by a mixed lactic starter culture (*Lactococcus lactis* subsp. *lactis* biovar. *diacetylactis* and *Leuconostoc cremoris*) following a modified standard method. The cream was pasteurised at 95°C/5 min, rapidly cooled to 8°C, and then starter culture (2%) was added. The cream was held at 8°C/2 h to initiate the formation of low melting point fat crystals. The temperature of the cream was then increased to 20-21°C, and held at this temperature for further 2 h to melt fat crystals with high melting point and recrystallise the crystals. The temperature was then decreased to 16°C/2 h to form pure fat crystals. This was then followed by slightly decreasing the temperature to 15°C for butter churning in a K5SS KitchenAid Heavy Duty (USA) churning mixer.

Buttermilk (100 mL) was collected and stored at 4ºC for analysis and the remained buttermilk in the butter churn was drained. The butter grains were washed with distilled water to remove any residual buttermilk. Final cultured butter (product) was packed in heavy duty aluminium foil and stored at 4ºC for 21 days. Cultured butter was produced on three different occasions commencing in August 2014 (batch 1), September 2014 (batch 2), and October 2014 (batch 3). Various analyses and measurements were conducted during processing and storage to monitor the shelf life stability of the butter. Standard methods were used to measure chemical, physical, consumer sensory acceptance of the products and presence of coliforms were enumerated by Violet Red Bile Agar. Thus, fat content in buttermilk was determined by the Mojonnier test to calculate churning efficiency. Colour was measured by colourimetry, while texture analysis was determined by the TA.XT2 Texture Analyser. Water droplet size of butter was examined by confocal laser scanning microscope

after staining with Nile Red and Acridine Orange. The cultured butter samples were also evaluated by consumer sensory panellists using hedonic scaling of six sensory attributes (smoothness, hardness, spreadability, melting rate, buttery flavour, and overall acceptance). Data were plotted on graphs and also analysed by analysis of variance ($P<0.05$), linear regression and interaction plot.

There were significant differences ($P<0.05$) in moisture content of the three batches of butter which ranged from 13.90 to 19.19%. Although the moisture content of two batches (1 and 3) of butter was slightly higher than the standard (16%), it was within expected range. Manual washing butter grains after churning to remove water droplets may be inefficient to remove water droplets on the surface of butter. Most of the water droplets had a diameter of 5 μm which is desirable to inhibit the growth of spoilage microorganisms. No coliforms were detected in the cultured butter, indicating good hygiene standard during production. There were significant differences ($P<0.05$) in hardness of the three batches of cultured butter. Batch 2 had higher hardness than the other two batches, probably attributed to its low moisture content.

The fat content of cultured butter of the three batches ranged between 75% and 80%, which was slightly lower than the expected 80%. However, the results were reasonable, considering the higher moisture content of the butter. The cultured butter was well accepted by sensory panellists. Linear regression and interaction plot showed that spreadability and buttery flavour had significant effects ($P<0.05$) on the overall acceptance of the butter. The products were spreadable, presumably due to higher moisture content. The buttery flavour could be attributed to the aroma compounds produced by lactic acid bacteria through citrate metabolism during cream ripening. The dominant hue in the butter was yellowness, which slightly decreased during storage, presumably due to the loss of β-carotene. The pH of butter samples (5.3 to 5.8) during storage was slightly higher than in previous studies (4.7-5.2). The higher pH may be caused by poor acid production of the leuconostoc in the mixed culture.

Cultured butter was successfully processed using a kitchen/domestic churning mixer. The churning efficiency of the equipment was lower than the expected range. The butter had good keeping quality and was well accepted by sensory panellists. The quality of the butter during storage was probably attributed to the optimal size of water droplets, which were successfully measured by the confocal laser scanning microscope method modified in this study.

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| | | |
|---|---|---|
| A | = | Hamaker’s constant |
| ALA | = | α-linolenic |
| ANOVA | = | One-way Analysis of Variance |
| BC | = | Before Christ |
| biovar. | = | biovariance |
| BSG | = | Balangu seed gum |
| BT | = | Beef tallow |
| CB | = | Cocoa butter |
| CLA | = | Conjugated linoleic acid |
| CLSM | = | Confocal laser scanning microscope |
| cm | = | Centimetre |
| CNO | = | Coconut oil |
| $CO_2$ | = | Carbon dioxide |
| D | = | Particle diameter |
| ES | = | Electric sensing |
| FA | = | Fatty acid |
| g | = | Gramme |
| G | = | Shear modulus |
| G’ | = | Elastic modulus |
| G” | = | Viscous modulus |
| h | = | Hour |
| HDPE | = | High density polyethylene |
| $H_o$ | = | Interparticle distance |
| HPKO | = | Hardened palm kernel oil |
| HSBO | = | Hardened soyabean oil |
| k | = | Boltzmann's constant |
| kg | = | Kilogram |

| | | |
|---|---|---|
| L | = | Litre |
| *L.* | = | *Lactococcus* |
| LAB | = | Lactic acid bacteria |
| LD | = | Laser diffraction |
| *Leuc.* | = | *Leuconostoc* |
| m | = | Metre |
| M | = | Moles per litre |
| MA | = | Myristic acid |
| MF | = | Milkfat |
| MFGM | = | Milk fat globule membrane |
| min | = | Minute |
| mL | = | Millilitre |
| mm | = | Millimetre |
| MMIC | = | Microscopy and Imaging Facility Centre |
| mmol/L | = | Millimole per litre |
| MP | = | Melting point |
| n | = | Number |
| NMR | = | Nuclear magnetic resonance |
| OA | = | Oleic acid |
| P | = | P-value |
| PA | = | Palmitic acid |
| pfg-NMR | = | Pulsed field gradient nuclear magnetic resonance |
| PKO | = | Palm kernel oil |
| PN | = | Palmerston North |
| PO | = | Palm oil |
| PS | = | Polystyrene |
| PVC | = | Polyvinyl chloride |
| RSG | = | Reihan seed gum |
| s | = | Second |

| | | |
|---|---|---|
| SD | = | Standard deviation |
| SDL | = | Starter distillate |
| SFC | = | Solid fat content |
| SNF | = | Solids-not-fat |
| SPME | = | Solid phase microextraction |
| spp. | = | Species |
| subsp. | = | Subspecies |
| T | = | Absolute temperature |
| T.A. | = | Titratable acidity |
| TPA | = | Textural profile analysis |
| tr | = | Trace |
| TVA | = | Trans vaccenic acid |
| w/w | = | Weight/weight |
| XG | = | Xanthan gum |
| μm | = | Micrometre |
| ϕ | = | Volume fraction of solids |