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Milk quality from Processors' Perspective

Ranjan Sharma, PhD MBA

Processing of milk into value-added products & ingredients

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Raw Milk

Separation

Skim milk

Cream

Skim Milk Powder

Evaporation & Drying

Permeate

Membrane concentration

Retentate

Milk Protein Concentrate

Caseinate

Casein

Whey

Membrane concentration

Whey Protein Concentrate

Cheese

Processed Cheese

Evaporation & Drying

Whole Milk Powder

Standardised milk

Market Cream

Butter

Buttermilk

Butteroil

UHT Milk

Market Milk
No-, Low-, Full-fat

Additives

Evaporation & Drying

Infant Formula

Ice Cream

Yogurt

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Sources of milk for processors

- Fresh milk
  - Own farm milk (raw)
  - Raw milk from another farmer
  - Pasteurised milk from another supplier
- Other dairy Ingredients
  - Cream (raw/pasteurosed)
  - Skim concentrate
  - Skim/whole milk powder

Why quality of milk is important?

- Yogurt
  - Off-flavours/taints
  - Inhibition of the starter culture
  - Gel-strength
  - Syneresis
  - Ropiness/sliminess

- Cheese
  - Off-flavours/taints
  - Inhibition of the cheese starters
  - Affects rennet clotting time (RCT)
  - Cheese yield
  - Poor ripening

Why quality of milk is important?

- UHT Milk
  - Off-flavours/taints
  - Heat stability
  - Age-gelation/thickening

- WMP/SMP
  - Off-flavours/taints
  - Performance of the spray dryer
  - Functional properties

Composition of milk of different animals

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Species	Total solids %	Fat %	Protein %	Lactose %	Ash %
Cow	12.7	3.7	3.4	4.8	0.7
Goat	12.3	3.9	3.2	4.5	0.8
Camel	15.0	5.4	3.8	5.2	0.7
Buffalo	16.8	7.4	3.8	4.8	0.8
Sheep	19.3	7.4	4.5	4.8	1.0
Yak	19.3	7.9	5.3	5.2	1.0
Horse	11.2	1.9	2.5	6.2	0.5
Human	12.2	3.8	1.0	7.0	0.2
Blue whale	55.0	40.9	11.9	1.3	1.4

Source: Deeth, 2015

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Composition of milk of various breeds of cows

Breed	Fat	Protein	Lactose
Holstein/ Friesian	3.5	3.1	4.9
Ayrshire	4.1	3.6	4.7
Brown Swiss	4.0	3.6	5.0
Guernsey	5.0	3.8	4.9
Jersey	5.5	3.9	4.9

Source: Deeth, 2015

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Quality

- Quality is judged by a range of tests with varying degrees of objectivity, to ensure that a product
  - Is safe for human consumption with respect to both chemical or microbial contamination;
  - Conforms to food regulations such as those laid out by FSANZ, State or Council's Health and Environment Office
  - Is capable of achieving a specified shelf life without spoilage;
  - Has as high an organoleptic standard as can be achieved within the existing constraints of manufacture, transport or distribution

Milk Quality

- Organoleptic/Sensory
- Microbiological
- Physico-chemical
- Nutritional

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Bacterial aspects of pasteurisation

- Kills pathogenic bacteria (non-sporeformers)
- Kills most spoilage bacteria (non-sporeformers)
- Does **not** kill thermoduric bacteria, including sporeformers
  - thermodurics grow slowly at low temperature
  - pasteurised milk contains 1000 to 10,000 per mL thermodurics
- **Post-pasteurisation contamination is the major issue**
  - due to contamination from filling machine, air and packaging material
  - Post-pasteurisation contaminants are mostly psychrotrophs e.g. *Pseudomonas* – grow well at low temperature
- Shelf-life of pasteurised milk is 10-15 days
  - Much longer, if packaged aseptically

Spoilage of pasteurised milk

- Bacteria spoil milk through action of their enzymes on the milk components
- Off-flavours in spoiled pasteurised milk are:
  - Sour due to lactic acid
  - Bitter, putrid, sulfurous (due to protein breakdown)
  - Rancid due to breakdown of fat
- Skim milk spoils more quickly than whole (full fat) milk, mostly due to greater protein breakdown

Chemical aspects of pasteurisation

- Inactivation of alkaline phosphatase (used as a test for pasteurisation)
- Inactivation of milk lipase – otherwise all pasteurised homogenised milk would taste rancid
- Small changes to proteins & water-soluble vitamins (e.g. vitamin C)
- Little or no change to fats, lactose, minerals and fat-soluble vitamins (e.g. vitamin A)

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Sensory/organoleptic quality

- Colour
- Odour
- Taste
- Foreign objects

Organoleptic/Sensory

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Sensory quality – flavor defects in milk

Organoleptic/Sensory

- **A**bsorbed/Transmitted
- **B**acterial/Microbial
- **C**hemical/Enzymatic/Processing
  - A
    - Feedy, barny, cowy, weedy, unclean, lacks freshness, stale, refrigerator/cooler odors
  - B
    - Acid, bitter, malty, lacks freshness, unclean, fruity/fermented, putrid and rancid
  - C
    - Cowy (ketosis), salty, rancid, bitter, oxidized, sunlight, foreign, astringent, medicinal, flat, cooked

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Microbiological quality

- Total viable count
- Thermoduric count
- Psychrotrophic count

Microbiological

Important Types of Bacteria in Raw Milk

Cause Spoilage

- Fermentative/acid producers (LAB - lactic acid bacteria; coliforms)
- Proteolytic, lypolytic, etc, (breakdown proteins, fats, etc.)
- Gas producers (coliform bacteria; some LAB)

Grow under refrigeration

- Psychrotolerant (e.g., Pseudomonas)

Survive pasteurization

- Thermoduric or thermo-tolerant
- includes spore-formers, some psychrotolerant species and strains

Cause mastitis infections in cows - Staphylococcus, Streptococcus, coliforms, others

Cornell Uni

Microbiological quality of raw milk

- Sources of bacteria in raw milk include:
  - Natural flora of healthy udder
  - Flora of mastitic cows
  - Exterior of cow
  - Dairy barn environment, air, water
  - Equipment milk contact surfaces
- Bacterial growth in raw milk influence by:
  - Milk residue on equipment
  - Prolonged milking time
  - Milk storage time/temperature

Microbiological quality of raw milk

Example of count:

- Good milk has 1,000-10,000 colony forming units (cfu)/mL
- Poor quality milk has > 100,000 cfu/mL
- Spoiled milk has >1000,000 cfu/mL

Source: Deeth, 2015

Effect of milk storage time on total count

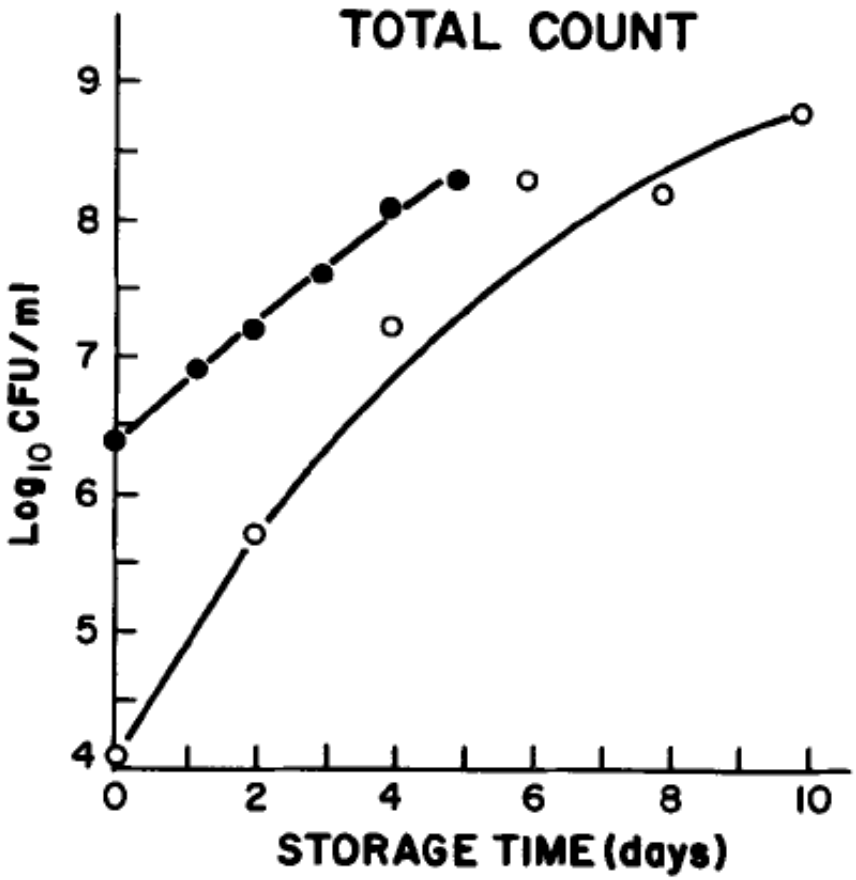

Figure 1. Effect of milk storage time on total aerobic count. (●—●) Manufacturing grade milk, (○—○) grade A milk. Each data point is an average of nine observations.

http://www.journalofdairyscience.org/article/S0022-0302%2886%2980452-0/abstract

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Physico-chemical quality

- Inhibitors e.g. Antibiotics
- Storage temperature (°C)
- Milk solids
- Fat
- Protein
- Titratable acidity (%)
- pH
- Specific gravity
- Heat stability (Clot on boiling/alcohol stability)

Physico-chemical

Inhibitors

- Growth and acid production by starter cultures in **yogurt** and **cheese** may be inhibited by
  - Bacterial viruses
  - Bacteriophages
  - Antibiotics, sterilant/sanitiser and detergent residues
  - Free fatty acids produced by or as a result of the growth of microorganisms
  - Natural often called indigenous antimicrobial proteins.

Inhibitors

- Antibiotics
  - Mainly through mastitis treatment
- Natural antibiotic - Nisin
  - Some *L.lactis* naturally present produce nisin (a natural antibiotic) – normally not a problem
- Sterilant and detergent residues
  - (a) farm, (b) during transport to the factory and (c) the factory due to careless use of sterilants or detergents, incomplete draining or inadequate rinsing of equipment
- Free fatty acids
  - Through lipolysis – large concentrations are required for inhibition of LAB (e.g. >0.1% butyric acid)
- Natural antimicrobial proteins
  - The lactoperoxidase-thiocyanate-hydrogen peroxide (LP) system, Immunoglobins, Lysozyme, Lactoferrin, Vitamin binding proteins.

Mullan, W.M.A. (2003) . Inhibitors in milk. [On-line]. Available from: https://www.dairyscience.info/index.php/inhibitors-in-milk/51-inhibitors-in-milk.html . Accessed: 12 August, 2015.

Antibiotics: Sensitivity of starter cultures to antibiotics

	Lactococcus lactis subsp. *cremoris*		*Lactococcus lactis*		Mixed or multi-strain	
	Partial inhibition	Marked inhibition(3)	Partial inhibition	Marked inhibition(3)	Partial inhibition	Marked inhibition(3)
Penicillin*	0.05-0.13	0.21-0.3	0.09-0.15	0.26-0.3	0.1-0.25	0.27-0.3
Tetracycline	0.11-0.16	0.3-0.4	0.09-0.21	0.28-0.65	0.09-0.20	0.29-0.35
Streptomycin	0.52-0.84	1.9-2.0	0.35-0.71	1.9-3.0	0.4-0.7	1.6-3.0
Erythromycin	-	2.0(1)	-	2.0(1)	0.05-0.10	-
Chloramphenicol	-	5.0(1)	-	5.0(1)	0.02-0.80	-
Chlortetracycline	0.015(1)	0.075(1)	-	5.0(1)	0.02-0.80	-
Neomycin	-	5.0(1)	5.0(1)	30.0(1)	2.5-3.5	-
Polymyxin B*	50(1)	300(1)(2)	300(2)	-	-	-
Ampicillin	-	2.0(1)	-	2.0(1)	-	-
Novobiocin	-	5.0(1)	-	5.0(1)	-	-
Cloxacillin	1.16-2.05	2.2-4.6	1.6-2.5	3.9-5.0	1.0-2.2	3.0-4.5
Bacitracin	-	-	-	-	0.3-0.5	2.0-3.0

* Concentration expressed in International units ml^{-1}. Concentration of other antibiotics in mg ml^{-1}.(1) Determined using an agar diffusion method.(2) Markedly strain dependent.(3) Ranging from a reduction in acid production of 80% to complete cessation of acid production except for (1).Table taken from Haverbeck et al. (1983)

https://www.dairyscience.info/index.php/inhibitors-in-milk/51-inhibitors-in-milk.html

Effect of milk storage temp on shelf life of raw milk

	Milk storage time before coagulation on pasteurisation occurred		
	5°C	7.5°C	10°C
Grade A Milk (Av 1300 cfu/ml)*	9	8	6
Manufacturing grade (>106 cfu/ml)*	5	4	3

*Initial aerobic plate count

Hicks etal, 1986; http://www.journalofdairyscience.org/article/S0022-0302%2886%2980452-0/abstract

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Quality analysis of milk

Test	Reason	Method	Typical values
Total solids	For standardisation Gel strength – yogurt Yield - cheese	Hydrometer Oven drying	11-14%
Fat	Legal or sensory requirement	Gerber Rose Gottlieb Light scatter	3.0-3.5%
Protein	Fortification requirement for gel strength (yogurt) Cheese yield	Infrared Dye binding Kjeldahl	3.0-3.5%
Antibiotics	Prevents starter growth	Delvotest P (DSM) Lec-Tek	<0.007IU per mL(<0.004ug/mL)
Taints	Present chemical taints in cheese or yogurt	Odour/sniff test	Absent

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Quality analysis of milk

Test	Reason	Method	Typical
Clot on boiling (COB)	Assess poor quality milk/Heat stability	Boil in test tube	No clotting
Alcohol stability (better than COB test)	Assess poor quality milk/Heat stability	Mix milk:ethanol (1:1)	No precipitation
Sometic cell count	Detection of mastitis (white blood cells)	Various test kits	<150,000 /mL*
Titratable acidity	Growth of unwanted bacteria Souring of milk	Titration with NaOH till pink colour of the phenolphthalein endpoint	<0.2% lactic acid
pH	Freshness of milk	pH meter	6.6-6.8

* Dairy Australia - http://www.dairyaustralia.com.au/Animal-management/Mastitis/What-is-Mastitis.aspx

Effect of milk on cheese quality

Quality attribute	Cheese quality
Milk from cows fed poor diet (low milk solids)	Lower cheese yield, softer & high moisture curd
Milk from heat–stressed cow (low milk solids)	Low cheese yield, inferior cheese
Mastitis milk	Low cheese yield, increased RCT, reduced starter activity, poor cheese flavour and texture
Autumn/Spring milk	Autumn milk – high solids and cheese yield Spring milk – low solids and low cheese yield
Late lactation milk	More yield due to high fat and protein in late lactation milk
Jersey/Holstein milk	Jersey milk has sorter RCT and firmer curd
Milk protein level	Milk with 0.1% more protein results in cheese yield by 0.13%
Casein content	More important than fat or whey protein – 0.1% reduction reduces cheese yield potential by 0.5%

Amenu & Deeth, 2007- Aus J Dairy Tech 62, 3, 171

Effect of milk on cheese quality

Quality attribute	Cheese quality
Fat	High fat – high moisture cheese
Casein/fat ratio	Complex relationship; ratio >0.64 – enhanced cheese yield High ratio – high coagulum strength
Casein/total protein ratio	Higher ratio – shorter RCT and firmer curd
Casein/WP ratio	Higher ratio – firmer curd with low moisture
Caseins	High K-casein - shorter RCT and more Syneresis high B-casein - shorter RCT, firmer curd firmness and more Syneresis high aS1-casein - shorter RCT and firmer curd
Casein micelle size	Small micelle - shorter RCT and tighter coagulum Large micelle - softer curd

Amenu & Deeth, 2007- Aus J Dairy Tech 62, 3, 171

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Effect of milk storage time on cheese moisture

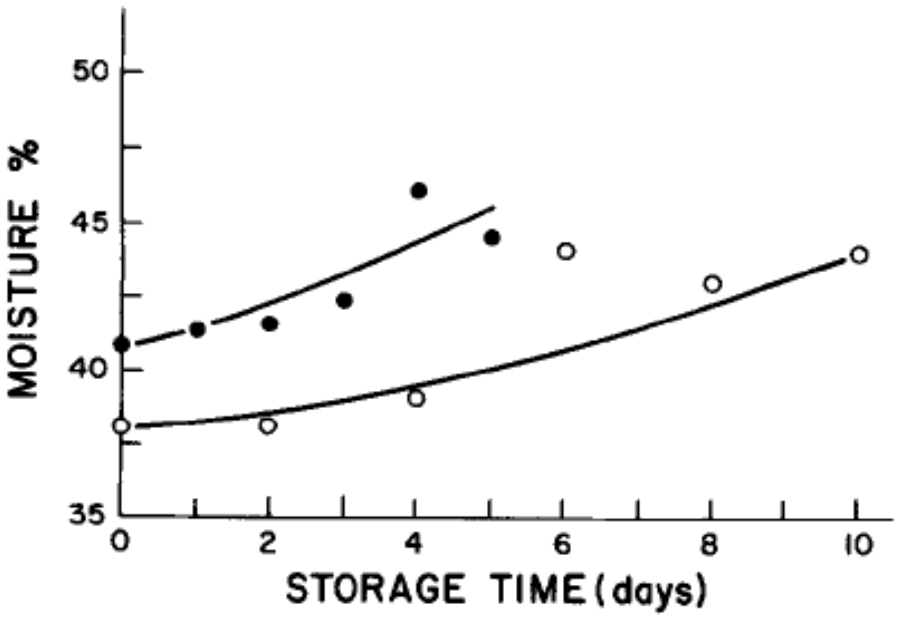

Figure 4. Cheese moisture as affected by milk storage time. (●—●) Manufacturing grade milk, (○—○) grade A milk. Each data point is an average of nine observations.

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Effect of milk storage time on cheese yield

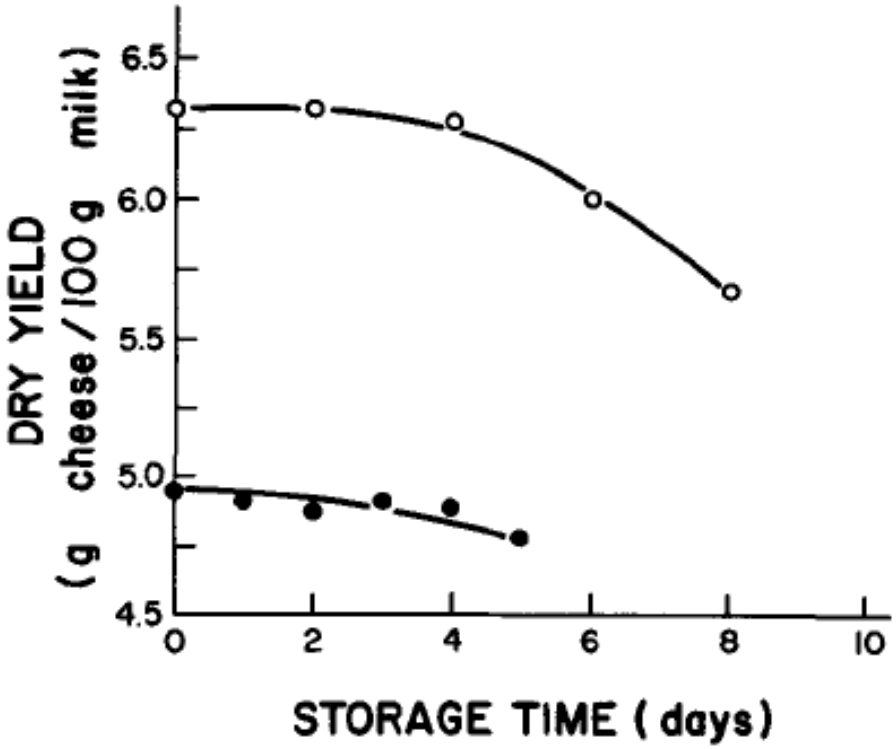

Figure 5. Effect of milk storage time on yield of cheese solids. (●—●) Manufacturing grade milk, (○—○) grade A milk. Initial yield differences are due to different total solid concentrations in the milk. Each data point is an average of nine observations.

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Effect of milk storage time on fat in cheese

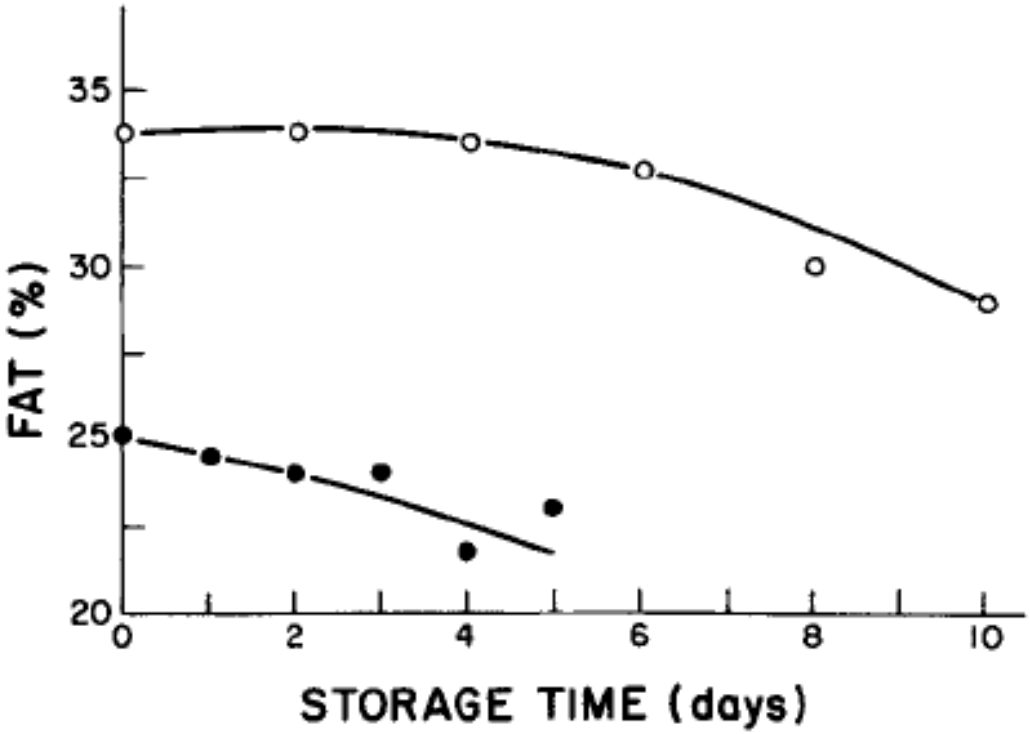

Figure 6. Effect of milk storage time on percent fat in cheese. (●—●) Manufacturing grade milk, (○—○) grade A milk. Each data point is an average of nine observations.

http://www.journalofdairyscience.org/article/S0022-0302%2886%2980452-0/abstract

Factors affecting quality of yogurt

- Raw materials
  - Raw milk, skim milk, cream, sugar, cultures, milk concentrate, milk powders, fruit/fruit conserves, stabilisers, flavours and colours
  - All can contribute micro-organisms and chemicals that affect the quality
  - Changes in the source and supply will cause variation in factors that can influence shelf life
  - Partnerships with approved suppliers and agreed specifications are recommended

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Factors affecting quality of yogurt

- Raw materials – Milk
  - Variability in protein, lactose, fat and microbial flora
  - Variability in breeds of cattle, season and region
  - Milking & storage conditions the farm
- Raw materials - cream
  - Depends on the quality of milk used for separation
  - Methods of handling before and after pasteurisation
  - Susceptibility to lipolysis due to high fat (potential for rancid taste)

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Summary - key quality criteria for milk

- Low natural microflora
- Free from inhibitors (antibiotics, sanitising chemicals etc)
- No contamination from mastitis milk and colostrums
- Free from rancidity
- Free from bacteriophages
- Free from hormones
- Stored below 5C

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Thank you!