Ron Hull and Associates

Food Industry Consultants
8 Park Road, Mount Waverley, Vic 3149, Australia
Phone/fax +61 (03)9807 5011 Mobile 0428 319063
ABN: 58 401 320 504

Standards Management Officer
Food Standards Australia New Zealand
at submissions@foodstandards.gov.au.
Wednesday, 17 September 2008

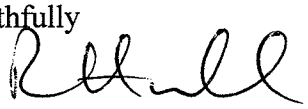
RE: **Submission on FSANZ document P1007: Primary Production and processing Requirements for raw milk products (Australia only)**

Dear Sir,
Please find attached our submission to the Proposal P1007. The file is *Submission to FSANZ P1007 Final 080917 Hull & Hammond.doc.*
Our submission refers to attachments which will be mailed separately along with a hard copy to

Food Standards Australia New Zealand
PO Box 7186
Canberra BC ACT 2610
AUSTRALIA
Tel (02) 6271 2222

Please acknowledge receipt of this correspondence.

Yours faithfully



Ron Hull
Principal Consultant Microbiologist

SUBMISSION *Wednesday, September 17, 2008*

Submission on FSANZ document P1007: Primary Production and processing Requirements for raw milk products (Australia only)

Executive Summary

We support changes to the Australian food regulations to allow the manufacture of cheese without mandatory pasteurisation of the cheese milk - that is to manufacture raw milk cheese. The proposed change will bring consistency within the recently deregulated Australian Dairy industry, manufacturers will be able to compete on an equal footing with imported raw milk cheese and consumers will be offered choice to consume imported and locally made raw milk cheese. And in our opinion raw milk cheese does not pose a public health risk of any greater magnitude than cheese made from pasteurised milk.

However, we disagree with the proposed regulatory framework for raw milk cheese as set out in P1007, because the key assumptions about pathogen control in cheese are incorrect. We are of the opinion that any cheese fitting the proposed class 2 and class 3 categories are a significant public health hazard and should not be an approved for legal sale whether made from raw milk or pasteurised milk. Correctly made and matured cheese of any variety, will not allow pathogens to survive or grow. We provide examples in this document.

We put forward an alternate framework for regulation of raw milk cheese based on the science and technology of cheese manufacture and pathogen control. The key elements of this proposal are:

- That legal **Chemical Standards of Identity** for each cheese variety be a key feature of the regulations for raw milk cheese. These were decommissioned in Australia about 20 years ago in response to the emergence of low fat and other perceived healthier variants of cheese. Standards of Identity can be found in Australian Department of Primary Industry and State Department of Agriculture records and in the USA FDA regulations. We will show that the chemical composition of cheese can be effectively used as a monitor of the microbiological safety of cheese. This is the same principle used in selective and differential microbiological media, where small variations in chemical composition of microbiological media are used to control microbial survival and growth. Variants to the composition of traditional cheese such as reduced salt, reduced fat and the addition of non traditional cheese ingredients would not be permitted under this proposal without prior scientific studies to validate equivalent safety as found in the traditional cheese variety.
- The second element to ensure public health and safety of raw milk cheese is the legal requirement of manufacturers of raw milk cheese to maintain appropriate records. This will be in the form of a **Food Safety Plan** based on HACCP principles (FSP). The plan will cover raw milk production and supply as well as key steps in manufacture. Examples of plans for 3 cheese varieties, Cheddar, Mozzarella and camembert are attached. These plans briefly describe the key steps in manufacture in relation to pathogen control.

The authors have a combined 84 years experience in the science and technology, and international marketing of cheese.

Address for correspondence, Ron Hull & Associates, 8 Park Road, Mount Waverley, VIC 3149.

Submission on FSANZ document P1007: Primary Production and processing Requirements for raw milk products (Australia only)

CONTENTS

1. Scientific control of food borne disease

Three conditions must be met for food borne disease to occur. The microbe (or toxin) must be present in pathogenic form, the food chemistry must provide conditions that allow the pathogen to grow and infect the host, and finally the host must lack immunity to infection by the pathogen. All of these conditions must be aligned for disease to occur. Scientific control of food borne disease can target any one or all **three** areas.

a. Test **for pathogens** in foods. Target as near zero as commercially practical. This is the least effective measure because testing is slow and inaccurate because of sampling errors and false positives, and the absence of pathogens at the time of testing does not ensure food safety because contamination can occur post testing. This approach of controlling disease has failed many times including control of virus infection of cheese starter cultures, whereas increasing host immunity (see (c) below) has yielded positive results (Hull, 1984; 2007). This has been the focus of the Australian and the USA regulatory systems over the past decade and is the focus of P1007. This approach has not reduced the incidence of food borne illness over the decade (see various USA Centre for Disease Control reports over the last decade) and promotes the activity of adding more preservatives to foods in order to pass the regulatory tests. This approach is not in the long term interest of consumers.

b. Control the **chemistry** both physical and biochemical so that pathogens cannot survive or grow in the food particularly after they are eaten by the consumer. This is known as chemical standard of identity of foods and is the second most effective control measure for manufacturers and regulators. It is fast and accurate to measure and limits for foods can easily be monitored by both manufacturers and regulators. All microbes have boundaries for growth and in the case of pathogens the chemical boundaries for growth and infection are known. These boundaries are known in food science as the intrinsic and extrinsic properties of foods. The main ones are pH, moisture content (water activity), oxidation-

Address for correspondence, Ron Hull & Associates, 8 Park Road, Mount Waverley, VIC 3149.

reduction potential (redox), available nutrient content (eg available energy and nitrogen sources), anti-microbial compounds, and biological structures (Jay, 1996). Thus **chemical standards of identity** for food are an excellent regulatory tool for microbiological foods safety (Keating and Dennien, 1983; FDA 1988), and provide good consumer protection.

And

c. Use the food to increase the consumer's **gut immunity**. This is done by the chemistry of the food (**prebiotics**) and biology by adding live **probiotic** microbes. This combination known as synbiotics is the most effective measure to control food borne diseases, and best protects consumers. It is equivalent to immunization used to control infectious viral and bacterial diseases. Yoghurt and cheeses are examples of **symbiotic** foods. Prebiotics are food components (chemical or biochemical) that specifically enhance the growth and survival of probiotic microbes in foods and in the gastro-intestinal tract. They have the opposite effect on pathogens. Examples can be found amongst carbohydrates, fats and proteins in milk. In cheese examples are short and long chain fatty acids (Dillon Board, 1994; Gibson Robertfroid, 1999; Mitsuoka, 1980; Robinson, 1991; Salminen and Wright, 1993).

Rationally up until a decade ago all cheese varieties were assigned a legal chemical standard of identity. THIS WAS AN EXTREMELY EFFECTIVE REGULATORY TOOL. This was deregulated because of pressure form nutrition science promoting themes such as low fat and low salt foods. These components, fat and salt, are important regulators the microbiology of foods. The dairy industry initially resisted but by the mid 1980's went along with this movement because it was profitable to remove fat from dairy products and replace it with less expensive fat replacers. Reducing the level of salt in cheese speeds up ripening and flavour development but at the increased risk of spoilage and production of toxic biogenic amines.

2. **How should raw milk cheeses be regulated to ensure public health and safety?**
   a. **Manufactures to use a HACCP based food safety plan** AS IS CURRENT LAW
      i. The plan to include relevant CCPs for each variety and importantly
         1. use only milk from disease free cows.
         2. Starter activity both primary and secondary starter microbes to be monitored within limits for each variety, and
   b. **Chemical composition of the mature cheese**. That is **standard of identity**. These are published for all varieties of cheese and can be found in historical legal standards in Australia, USA and EU countries. Only cheeses conforming to the known chemical standard should be legal.
      i. Variants such as low fat and low salt varieties should not be legalized for raw milk cheeses unless validation studies confirm equivalent food safety to the traditional variety. It is known that

Address for correspondence, Ron Hull & Associates, 8 Park Road, Mount Waverley, VIC 3149.

these chemically varied products are more susceptible to spoilage and to allow the growth pathogens. This is because they lack key preservatives that also act as prebiotics. This was established for pasteurised milk products conducted in Australia by CSIRO in the period 1987 to 1990 and in conjunction with the Victorian Dairy industry Authority. Additional CSIRO and ADC studies on low fat and low salt cheese produced in Australia in the 1990's showed these products were also more susceptible to spoilage and allowed production of toxic biogenic amines.

In conclusion regulations for food safety of raw milk cheese should not focus on testing for pathogens; rather it should focus on chemical standards of identity for each cheese variety and recognize the key role played by starter cultures in the safety of these foods by way of the current audited food safety plan system.

3. Microbiology and Food Safety of Natural Cheese.

Natural cheeses are live foods just like whole fruits and vegetables. And just like fruit and vegetables, cheeses have complex natural preservative systems that prevent spoilage and growth of pathogens. So in handling, storage and selling of natural cheeses we need to apply similar principles to those used in handling fresh ripe fruit and vegetable produce.

Temperature. As with fruits and vegetables the natural preservative systems of cheese do not require refrigeration to be effective. In fact they are more effective at temperatures above refrigeration and closer to body temperatures of 37°C. However cheeses ripen too quickly at these temperatures, and often become unbalanced in flavours. For these reasons intermediate temperatures of between 10 and 20°C are best for cheese. The exact temperature range depends on the variety of cheese and its age or stage of maturation. When we want to temporarily stop or slow the rate of cheese ripening very low temperatures around 2-4°C are used. In some cases we may freeze the cheese to completely stop the ripening process and greatly extend shelf life. The temperature and systems of storage vary for each cheese variety. Remember to control relative humidity to around 85 to 90% when storing cheese at low temperatures, as most refrigeration systems dry the air. Condition for storage of individual varieties of cheese, such as relative humidity and maturation temperatures, can be found in cheese reference texts.

What are the preservative systems in natural cheeses? The preservative systems of cheese are derived from two sources; the raw milk and the cheese starter cultures. The cheese starter culture is a mixture of lactic-acid bacteria, yeasts and moulds. These microbes are never pathogenic, quite the opposite, they are beneficial to the digestive tract by assisting digestion, by providing essential nutrients, and by stimulating innate immunity. They act as a natural biological barrier to spoilage and pathogenic microbes.

This natural barrier is seen in the outer rind of hard and smear ripened cheeses and in the mould growth (mycelium) covering mould ripened cheese. When natural cheeses are cut the surface smear culture is transferred to the newly cut surfaces. Provided the

cheese is stored under the correct conditions of maturation temperature (10 to 15°C) and humidity (85 to 95%) then the rind will quickly seal and protect the new surface.

All of the preservative systems of cheese work together as multiple hurdles to the survival of spoilage and pathogenic microbes. The key classes of chemical preservatives in cheeses and the microbes affected are;

(1) **Redox Potential.** Internally cheese contains very high levels of carbon dioxide and no oxygen, caused by starter metabolism. These conditions of redox potential are inhibitory or kill all bacteria except lactic acid bacteria, some yeasts and Clostridia;

(2) **Organic Acids** produced by starter from the fermentation of sugars kill all gram-negative bacteria, such as **Escherichia coli** and **Salmonellae** by disrupting their outer membrane or permeability barrier, independently of pH. The killing kinetics are rapid at temperatures above 10°C and the die of rate is more rapid the higher the storage temperature. Freshly made cheese or other fermented dairy products should be held warm (15 -20°C) for a few days to ensure that any coliform or other gram-negative bacteria in the product are killed. They will not be killed if the young cheese is rapidly cooled and stored refrigerated below 4°C.

(3) **Diacetyl and Long-chain Fatty Acids,** produced by starter and cheese ripening enzymes (lipases), that, in addition to acting in the same way as organic acids, also inhibit gram positive bacteria such as **Staphylococcus aureus** and spoilage yeasts;

(4) **Peroxides** produced by starter (and white cells in raw milk cheeses) that are toxic to gram-negative bacteria;

(5) **Bacteriocin** proteins produced by starter bacteria that kill other gram positive bacteria such as Staphylococci, Clostridia, and **Listeria monocytogenes** by disrupting their energy metabolism;

(6) the **absence of an energy source** (carbon-source or sugar) brought about by starter and ripening microbes. All spoilage and pathogenic microbes need an energy source to grow, or repair damage caused by any of the above preservatives.

(7) the absence of **free Iron(Fe)** which is needed for energy metabolism by all gram negative bacteria and by Listeria.

(8) Salt in moisture called brine concentration in cheese. Brine levels vary with cheese variety. **Brine** concentration is an important parameter in the chemical standards for each cheese variety. Brine is an important control of cheese microbiology, in ripening, control of spoilage and pathogens. Low brine levels are a common cause of microbiological defects in cheese; for example bio-active amines produced by de-carboxylation of aromatic amino acids. Cheeses can be dry-salted or brine salted. The length of time and the temperature in the brine bath control the rate of salt uptake in the cheese. The surface of a brine-salted cheese will contain greater than 10% brine, sufficient to inhibit all known spoilage and pathogenic microbes. A level of 6.5% brine (NaCl) will inhibit production of toxins by Staphylococcus.

(9) **Water activity** is not a controlling factor in cheese, except at the outer surface of traditional rinded cheeses, where oxygen is present and reduced water activity control the microbiology.

(10) **Raw milk enzymes** that kill spoilage and pathogenic microbes. These enzyme systems are listed below along with their anti-microbial activity spectrum.

Enzyme	Temperature of inactivation	Spectrum of anti-microbial activity
1. Complement	56°C	A complex set of 10 enzymes that can destroy all bacteria. It is a key component of both the innate and acquired immunity systems of animals.
2. Lactoperoxidase	80°C	Gram negative bacteria are killed
3. Lysozyme	>90°C	Dissolves growing gram positive spoilage bacteria and germinating spores of bacteria. Examples of affected bacteria are *Staphylococcus aureus*, Clostridia and bacillus.
4. Lactoferrin	>90°C	Two actions. As a dimer it withholds essential iron (Fe) from gram negative bacteria and Listeria. As a monomer it kills coliform bacteria and other gram negative bacteria.
Note that raw milk cheese will contain active Complement, the most potent bactericide known to science. Cheeses made from pasteurised milk will lack this important preservative.		

These preservative systems work together in what is known to science as the "hurdle concept", to prevent spoilage, kill pathogenic microbes, whilst allowing the continued growth and metabolism of the secondary or ripening flora that brings the complex and delicate flavour to cheeses. The secondary flora is made up of bacteria, yeasts and fungi that metabolise organic acids, milk fat and milk proteins. This secondary flora which covers the surface as a rind, smear or mould culture depending on the cheese variety acts as a natural biological barrier to contamination by other microbes.

(11) The amount and relative importance of each class of preservative varies with cheese variety. Each natural cheese variety is made using a unique protocol of starter and manufacturing systems that includes Good Manufacturing Practice and appropriate critical-control-points. This ensures the quality and food-safety of each cheese variety.

4. Key assumptions underlying P1007

We disagree with the key assumptions underlying P1007, namely that

a. **That natural cheeses can be classified into 3 classes based upon growth and survival of pathogens, namely,**

i. Class 1. Pathogens cannot grow or survive.
ii. Class 2. pathogens survive but do not grow, and
iii. Class 3. Pathogens survive and grow.

All cheese varieties made from raw milk or pasteurised milk belong to class 1. Any cheese that belongs to class 2 or 3 has been incorrectly made or ripened and poses a public health risk.

b. That raw milk is a major source of pathogens

i. Pathogens are not present in fresh raw milk drawn from healthy (disease free) cows on a balanced diet. There are a number of situations where pathogens are present. These situations are well understood in science and technology, and adequate monitors and controls are available through veterinary checks to ensure that such milk is not used for human consumption. (see California Fresh Raw milk Act 2008, SB201)
ii. Adulteration of milk is mainly by addition of water, deliberate or otherwise, is a major source of pathogen contamination of raw milk. The pathogens in water are the gram negative group of bacteria, Ecoli, salmonellas, campylobacter, etc. adulteration of milk is centuries old (R Tannahill, 1975), continues today (the Age 16/9/08 page 8, 'China-NZ contaminated baby milk powder'). Water adulteration of milk is readily detected by the freezing point test and by monitoring milk solids levels. It is financially counter-productive in cheese manufacture.
iii. Raw milk contains biological systems that actively kill pathogens in milk (Hull, 2007). This is nature's way of protecting the new born from infection. Any microbiologist that has tried to grow micro-organism other than starter cultures in raw milk will know of the natural inhibition present in raw milk. The main antimicrobial systems in milk are. Lactose is the only carbon source in milk limiting microbial growth to Lac+ organisms. Fresh raw milk contains no oxygen and 8% dissolved carbon dioxide. This level is maintained by the white cells present and creates anaerobic conditions. Only anaerobes and micro-aerophilic microbes can grow. It contains inhibitory levels of hydrogen peroxide produced by white cells. Fresh raw milk contains several biological antimicrobial systems, including white cells with phagocytic activity, the bactericidal complement system, lactoperoxidase system, lactoferrin, lysozyme and bactericidal fats and fatty acids.
iv. The milking operation. Milk contains relatively few bacteria when it leaves the udder of a healthy cow, and generally these do not grow in milk under the usual conditions of handling. Aseptically drawn milk contains between 500-1,000 bacteria per ml (by standard plate count) and these are mainly micrococci and streptococci (lactic streptococci and Lactococcus). The most

significant source of contamination is milk contact surfaces including milking machines, rubbers, strainers, pipelines, coolers pumps and storage vats and valves. However where adequate maintenance, including cleaning and sanitation, microbial contamination can be averted (Frazier & Westhoff, 1988).

v. Bulk collection of raw milk and storage at the central factory greatly increases this problem. This is seen in the incremental increase in microbial numbers in raw milk from farm to factory. Bulk milk contains milk from numerous farms each with differing quality comingled before it reaches the factory. This variation in milk quality is reflected in current Australian farm gate milk pricing with typically four levels of penalty applied by creameries. On farm storage of raw milk is known to be the better option to preserve milk quality during periods of excess milk to factory capacity. Direct off farm bulk milk is also preferred by specialty cheese manufactures for its superior quality. Raw bulk milk adequately cooled will remain of good quality for several days with a low microbial count. This has been demonstrated commercially over a number of years by routine shipping in insulated non-refrigerated tankers from Townsville to Darwin (2 days) and from Tasmania to the mainland with destinations as far as Sydney (2 days).

vi. *Listeria monocytogenes* is a pathogen found predominately in liquid milk plants and infrequently in cheese plants (Sutherland and Porritt, 1995). This same observation was made in Europe in 1988 and led to the isolation from cheese factory environments lactic starter strains that produce bacteriocins that kill Listeria. These are currently used as adjunct starters for the biological control of Listeria in cheese and other foods manufacture. Listeria is found in rotting food soil in drains of cold rooms and in cooling systems of milk plants. Its source is rarely raw milk, because it does not grow well in raw milk when compared to lactic acid bacteria, (Pitt et al, 2000).

c. That pasteurisation is the single and most important critical control point (CCP) in cheese manufacture.

This is not correct as the most important critical control point in cheese manufacture is starter activity, both primary fermentation of lactose and the various secondary fermentations carried out by bacteria, yeasts and fungi and specific to each variety of cheese. If starter activity fails then the cheese is potentially hazardous independently of whether or not the milk was pasteurised. Pasteurisation is effective in the production of standardized cheese in terms of flavour and keeping qualities (long shelf life). This is important to the production of bulk cheese such as Cheddar because it is the world's most traded cheese commodity. And Australia has been until recently one of the major international traders. New Zealand is the number one trader in Cheddar. It is also true for soft

cheese varieties. According to Czulak, 1959, the founder of modern cheese making in Australia, '*although the best cheese from the flavour point of view is made from raw milk, some large factories in Europe make some soft cheese varieties from pasteurised milk. Their cheese is milder in flavour, but its quality is more uniform and the percentage of low grade is much smaller'.*

5. **Chemical Standards of Identity of cheese**

Examples of legal standards for cheese are found in Keating and Dennien, 1983, Cheese Assessment Manual, Queensland Department of Primary Industries Information Series Q183024. This document lists the "typical chemical composition" and the Legal Standards (Qld) for forty four varieties of cheese manufactured and/or sold in Queensland in 1983. Similar legal standards were in place for the other states of Australia.

A second reference to Standards of Identity for cheese can be found in the USDA document, Food and Drug Administration,

Code of Federal Regulations TITLE 21 FOOD and DRUGS; PARTS 100 to 199

Part 133 - Cheeses and Related Products

Chemical standard of identity for cheese from hard, semi-hard and soft categories

	% Moisture	% Fat	% MFFS	%FDM	% salt	% SM (brine)	pH
Hard							
Cheddar Typical	35-37	32-33	52-54	50-54	1.5-2	4.5-5	5.1-5.3
Legal std local	<38			>50			
Legal std export	<37			>50			
Semi-hard							
Mozzarella typical	46-48	20-24	61-63	39-45	1.3-1.5	3.0-3.5	5.1-5.3
Legal std local	<50			>40			
Soft							
Camembert typical	43-55	22-28	69-72.5	46-58	2-2.5	4.6-5.5	6-7
Legal std local	<60			>40			
Blue typical-immature	45-47	28-29	66-68	54-56	3.0-3.5	6.5-7.5	4.5-4.7
-matured	42-44	30-31	62-64	54-56	4-4.8	10-11	6-7
Legal std local	<47			>50			

The legal standards quoted here are from Keating and Dennien 1983. MFFS is moisture in fat free substance. This is the microbial environment. FDM is fat in the dry matter. SM is the salt in moisture (brine).

Examples of where chemical composition excludes pathogens.

i. *E.coli* in Cheddar. pH knife edge is 5.4, above which they survive. ADC- CSIRO Japanese export experience of thousands of tons over 30+ years

ii. E coli and most gram negatives inhibited by cheese brine of greater than 5% and are killed by 9% or above (eg Blue cheeses, feta). Brine is the salt in moisture content of cheese.
iii. Toxin production by Staphylococcus spp is inhibited at brine concentrations above 6.5%.
iv. Many of these killing effects are temperature dependent and/or may require actively growing cells.
v. The role of maturing temperatures in killing actions against gram negative bacteria in cheese and yoghurt is documented commercially and examples can be found in the scientific literature. This becomes an issue when delaying cheese ripening by refrigeration as for example in international shipping of short shelf life products like Camembert and Brie.
vi. Increasing the moisture content of any type of cheese by as little as 1% without a corresponding increase in salting rate will reduce the brine level and change the secondary micro flora of the cheese, significantly affecting its quality and increasing the possibility of spoilage.

6. Examples of cheese making protocols

a. Cheddar. This is the grandfather of the internationally traded cheeses. The science and technology of this variety has been well understood for decades and this includes the control of pathogens. When Australia lost the export market to the UK in the mid 1960's the Australian industry looked to Japan and other markets to take its export production of hard cheeses mainly Cheddar. State Departments of Agriculture and CSIRO provided were well equipped with dedicated dairy scientists to meet the challenges. One of the first hurdles was to comply with the stringent requirements for absence of E.coli and Coagulase positive staphylococcus in the exports. Another requirement was for the cheese to be consistently slightly-sweet and non-bitter, both atypical for traditional Cheddar. These required the cheese to be of a higher pH than traditional Cheddar and this in turn created problems with a trade off between starter activity and E.coli surviving in the cheese. This era led to greatly improved starter culture systems (Hull, 1983) and a detailed understanding of the conditions under which pathogens like E.coli and staphylococcus survive and grow in Cheddar cheese. A key control is starter activity and the complete fermentation of milk sugar lactose to organic acids in the first 7-10 days of maturation. Checking residual lactose in cheese early in maturation is an important control point (Radford and Hull, 1982). Simple and effective monitors of cheese starter activity are available to cheese makers including farmhouse operators (Hull, 1978). Hygiene procedures used to maintain consistent starter activity against virus infection and other inhibitors in the cheese milk minimizes the possibility of co-growth of spoilage and pathogenic microbes. In cheese making deviations from established procedures are likely to cause an increased risk of; poor or

defective flavor, body and texture; less than optimum yield of cheese; possible total loss of some product or at least less than best financial return; and growth of spoilage and pathogenic organisms. A diagrammatic protocol for Cheddar cheese manufacture is attached, attachment 1.

b. **Mozzarella.** The method of manufacture of Mozzarella (starter-type) cheese follows that of Cheddar excepting that the milled curd at a pH of 5.1 is not salted but instead is cooked and stretched in hot water and molded into loaves which are then cooled and brine salted. The food safety issues are similar to those described for Cheddar. Australian manufacturers have been supplying cheese to the major Pizza chains, local and international for more than three decades. A diagrammatic protocol for Mozzarella cheese manufacture is attached, attachment 2.

c. **Camembert.** Ripened (slightly acid) raw milk is inoculated with starter (1% equivalent) and set at about 35C with sufficient rennet to coagulate within .5 to 1.5 hours. When firm, the curd is not cut but carefully transferred to hoops and allowed to drain at about 30C overnight. At this time the pH is about 4.6 an important acidity level to kill gram negative bacteria that may be present. In production of extended shelf life Camembert (known as stabilized Camembert) starter activity is deliberately curtailed so that the pH does not go below 5. This product has a significant risk of harboring gram negative bacteria such as *E.coli* because it has not transited the low pH of 4.6. The contracted curd, now in its final shape, is cooled (20C) and salted by brining and/or dry salting and then inoculated with lactic yeasts and moulds to perform the secondary ripening. These secondary ripening microbes form metabolites of lactic acid which are bactericidal to Listeria. Staphylococcus toxin production is inhibited by the anaerobic conditions of the surface growth and the high surface brine concentration. In recent times anti-Listeria starter strains that produce bacteriocins active against Listeria monocytogenes are incorporated into the primary lactic starter as an additional precaution. These details would be contained in the Food Safety Plan. It is important to note that the preservative action of brine is dependent on the final composition of the cheese emphasizing the importance of the legal Chemical Standard of identity to food safety. A diagrammatic protocol for Camembert cheese manufacture is attached, attachment 3.

Similar detail is available for all other varieties of cheese, eg, Eck, 1987; Kosikowski. 1989.

7. About the Authors

Les Hammond (Diploma of Dairy technology, GCIDT, Werribee) was one of the founding staff members of CSIRO's Division of Dairy Science in 1952 and worked on cheese starter microbiology, cheese technology and Cheddar cheese mechanization systems developed by CSIRO over a 25 year period. He participated in the development in 1956 of the CSIRO freeze dried starter cultures for distribution to factories around Australia. He was supervisor of the CSIRO dairy pilot plant and industry extension

officer. From 1977-1989 he was a member of the Technical Division at the Australian Dairy Corporation(ADC) responsible for export quality of cheese traded to Asia, the EU and USA. He gained extensive experience in dairy technology and the technical aspects of international trade in dairy products. From 1989 to 2006 he was principal consultant at Les Hammond and Associates Pty Ltd, cheese consultants where he participated in a number of significant developments in the Australian cheese industry. He is currently a member of the publications committee for the Australian Journal of Dairy Technology.
Ron Hull, BSc PhD (Adelaide) has extensive experience in cheese microbiology and technology. He was a staff member at CSIRO's dairy section from 1974 to 1994, where he was curator of the CSIRO Starter Culture Collection, Australia's primary reserve of dairy starter cultures and was head of the dairy microbiology section. He developed the starter technology for control of viruses attack on cheese starter cultures. Virus attach on cheese starters is the major cause of defects in cheese including the presence of pathogens. The technology was widely adopted by the Australian cheese industry in 1978 and moved to international use in 1984. The starter technology was the foundation for the formation of a dairy industry association, the Australian Starter Culture Association Inc, which founded in 1989 the Australian Starter Culture Research Centre in Werribee. Since 1994 he has been Principal Consultant at Ron Hull & Associates, a technical consulting service to the Australian and International dairy industries. Clients include medium and large size cheese and yoghurt producers in Australia and raw milk producers and retailers in the USA. Recently he served as a committee member for the drafting of California Senate Bill SB201 The Fresh Raw Milk Act 2008. He has taught Food Microbiology and Food Safety at undergraduate and postgraduate levels at Victoria University of Technology since 1994 and was a member of the Reference Group of the Victorian Food Standards Sub-Committee (1999-2005).

8. References.

1. Bodyfelt FV, J Tobias & GM Trout. 1988. The sensory evaluation of dairy products. Van Nostrand Reinhold, New York. ISBN 0-442-22685-3

2. Czulak, J. 1959. Some notes on Soft Cheese Varieties. Australian Journal of Dairy Technology, Suppl. September 1959, p19-21.

3. Dillon VM and RG Board. 1994. Natural antimicrobial systems and food preservation. CAB International, Wallingford, Oxon, UK. ISBN 0 85198 878 4

4. Eck, A. 1987. Cheesemaking: Science and Technology; English translation. Lavoisier Publications Inc. NY. ISBN 2-85206 398-0

5. FDA Code of Federal Regulations, Title 21 Food and Drugs; Parts 100 to 199; Part 133 – Cheeses and Related Products, 1988.

6. Frazier WC and DC Westhoff. 1988. Contamination, preservation and spoilage of milk and milk products. In, Food Microbiology, McGraw-Hill, NY.

7. Gibson GR and MR Robertfroid. 1999. Colonic Microbiota, Nutrition and Health. Kluver Academic Publishers, Netherlands. ISBN 0-4127-9880-8

8. Hocking, AD. 1997. Foodborne microorganisms of public health significance. 5th edition. Australian Institute of Food Science and Technology, Inc. PO Box 1493, North Sydney, NSW 2059. ISBN 0 9587 5155 05

9. Hull, R.R. ed. (1978) *Factory-derived Cheese Starters*; proceedings of a meeting organised by Dairy Research Laboratory, CSIRO Division of Food Research and the Australian Dairy Corporation, edited by R.R. Hull. Highett, CSIRO Dairy Res. Lab. 60pp.

10. Hull, R.R. 1983. Factory-derived starter cultures for the control of bacteriophage in cheese manufacture. *Aust. J. Dairy Technol.* 38: 149-54

11. Hull, R.R. 2007. Challenging current concepts in dairy food safety. *Aust. J Dairy technology. 62:100-103.*

12. Jay JM. 1998. Modern Food Microbiology, 5th edition. Aspen Publishers, Inc, Maryland, USA. ISBN 0 8342 1230 7

6 Keating, DC and GJ Dennien. 1983. Cheese Assessment Manual. Queensland Department of Primary industries, Information Series Q183024, 90 pages.

7 Kosikowski. C. 1989. Cheese and Fermented Milk Products.

8 Mitsuoka, T. 1980. Intestinal Bacteria and Health. Harcourt Brace Jovanovich . Japan. ISBN 4-8337- 6507-4

9 Naidu AS. 2000. Natural Food Antimicrobial Systems. CRC Press, UK. ISBN 0-8493 2047 X

10 Pitt, W.M., Harden, T.J. and Hull, R.R. 2000. Behaviour of Listeria monocytogenes in pasteurised milk during fermentation with lactic acid bacteria. *J. Food Protection*,63: 916-920.

11 Pitt, W.M., Harden, T.J. and Hull, R.R. 2000. Investigation of the antimicrobial activity of raw milk against several foodborne pathogens. *Milchwissenchaft* 55: 249-252

12 Radford, D.R. and Hull, R.R. (1982) Utilization of carbohydrate in "short method" Cheddar cheese by mesophilic starters. *Aust. J. Dairy Technol.* 37: 104-6

13 Robinson R.K. 1991. Therapeutic Properties of Fermented Milks. Elsevier Science Publishers. ISBN 1-85166-552-8

14 Salminen, S. and Wright A. 1993. Lactic Acid Bacteria. Marcel Dekker Inc. New York.

15 Sutherland P and R Porritt. 1995. Mechanisms of dissemination of Listeria monocytogenes in dairy factories. Report to Dairy Research and Development Corporation, NDC 1.

Attachment 1

Ron Hull and Associates
8 Park Road, Mount Waverley
Australia 3149
Ph. & Fax (+61) 03 9807 5011

CHEDDAR

The time from cut to dry is the most important stage in the schedule. To a large extent procedures before and after are tailored to fit the necessary constraints of the period. It is at this stage the conditions are set which influence the final composition, flavour and body characteristics of the cheese.

The curd particles are kept separate by agitation. Moisture expulsion from curd is assisted by more vigorous agitation as the curd firms and the controlled rise in temperature. The temperature of the curd directly affects the contraction of the curd and expels more whey. Temperatures within the 30-38°C range foster the growth of mesophilic starters and production of lactic acid. As the starer bacteria are trapped in the curd , that is where most acid is produced. As more acid is formed in and around the curd, so is shrinkage of the curd increased.

Lactose and some minerals, as well as lactic acid, are released into the whey. The rise in acidity (or fall in pH) of the whey is measured and used as an indication of what is happening in the curd. As production of acid in the curd continues, the imbalance

between lactose content of curd and whey causes a migration of lactose back into the curd, thereby providing more 'fuel' for the starter.

As all lactose present will eventually be converted to lactic acid, the ultimate pH of the cheese will depend on the levels of lactic acid and lactose in the curd at 'dry' almost independently of subsequent treatment of the curd.

While lactose continues to diffuse back into the curd and more acid is produced in the curd, the greater will be the loss of calcium and phosphorus into the whey

Excessive loss of phosphorus diminishes the buffering capacity of the curd, consequently the pH of the cheese will eventually be lower after all of the residual lactose is fermented. The loss of calcium reduces the ability of curd particles to bond and form cohesive blocks. When curd is held for extended times in the whey the cheese is likely to develop sour and bitter flavours, the colour will be bleached and the body is likely to be crumbly.

When the period between 'cut' and 'dry' is unduly short (ie under two hours) similar conditions for excess acid production and high moisture levels in the curd result. This situation is less likely to occur in today's cheesemaking except where the starter is racing (usually because the rate of addition to the vats is too high).

Ideally the time in the whey should be 140 minutes ± 20 minutes coupled with the required increase in acidity in that period. The time can be extended by up to 30 minutes in emergencies such as when the starters are slow, but not when acid production is normal, without the consequences previously described. If the starter is racing the vat should be heated to 42-43°C to slow the starter down and to firm the curd more quickly so that the whey can be taken off as soon as possible.

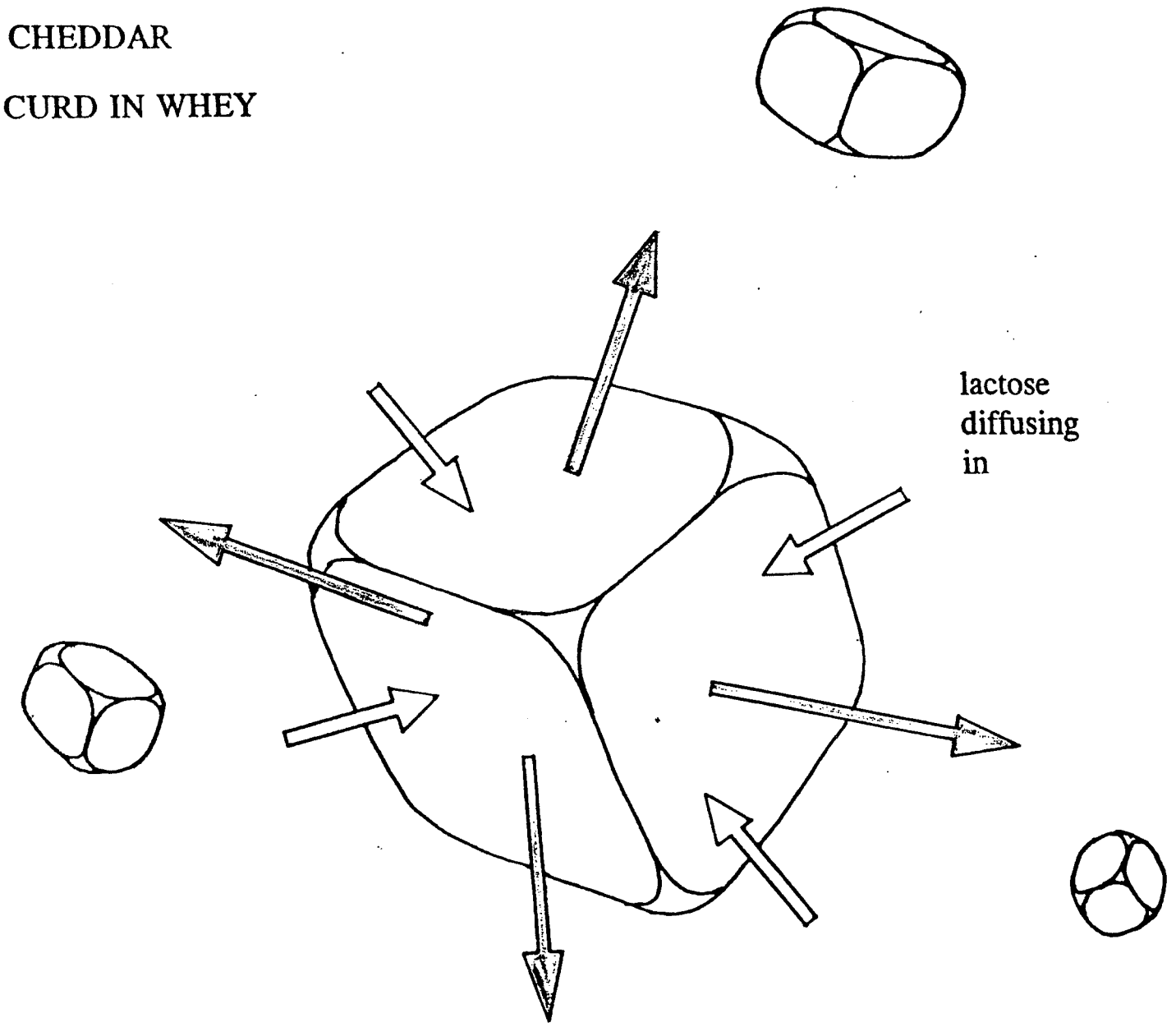
When the curd is cut the titratable acidity (TA) of the whey is measured and this figure becomes the zero reference point for movements in acidity during the time the curd is in the whey. The commended increases in acidity up to the point of running (all whey off), or in the case of mechanised manufacture, start of pumping are given in the following table. The approximate pH values at the same points are also given.

With full whey in vat		**With half whey off**	
		At ½ whey off increase in TA	0.02%
		pH of whey	6.25
		pH of curd	6.35
Increase of TA of whey	0.025%	Total increase in TA	0.04%
pH of whey approx.	6.2	pH of whey approx.	6.0
pH of curd approx.	6.25	pH of curd approx.	6.2

In practice a compromise has to be reached, the cheesemaker has to 'straddle the target' of the ideal time for 'dry'. Pumping has to be started early enough that all of the curd is dry within the 140±20 minutes stated previously.

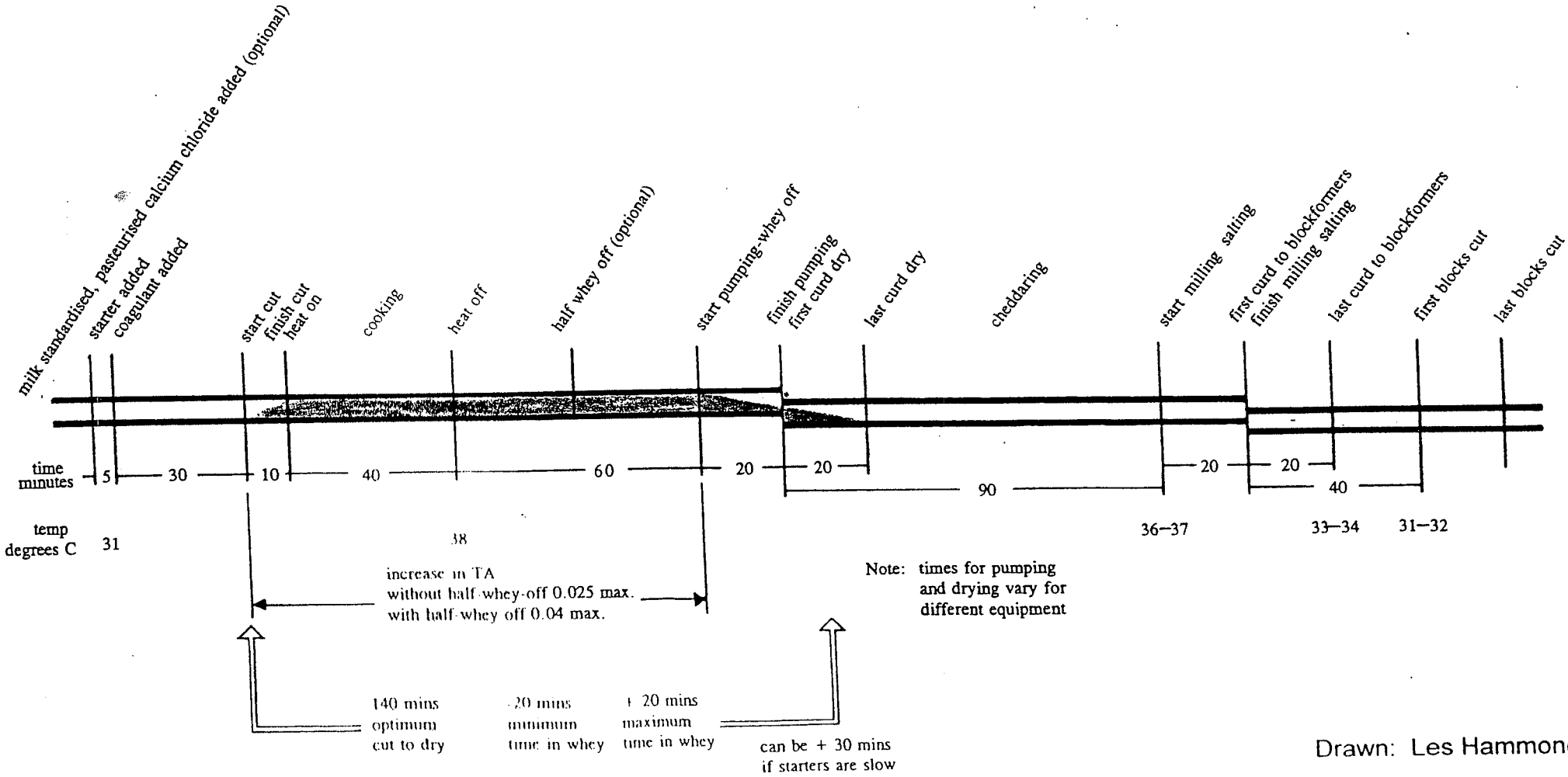
CHEDDAR

CURD IN WHEY



Drawn: Les Hammond

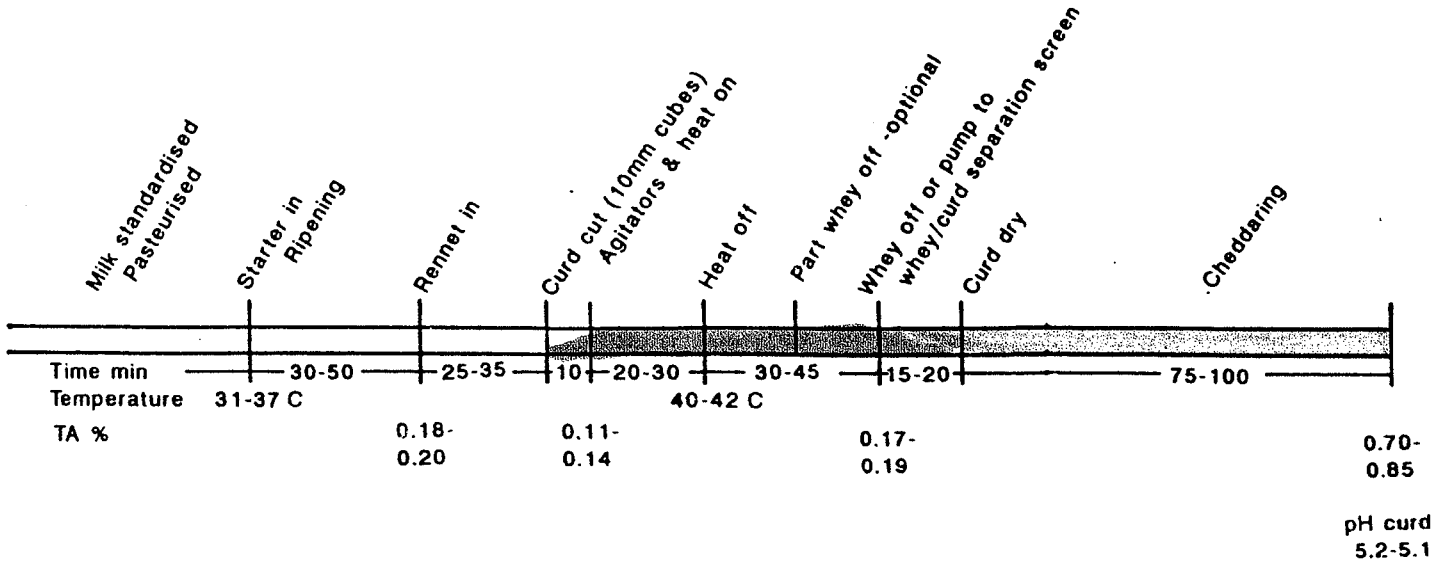
CHEDDAR — MECHANISED (CONTINUOUS) MANUFACTURE

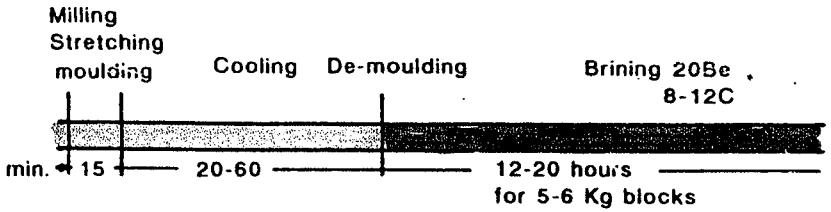


Drawn: Les Hammond

Attachment 2

Ron Hull and Associates
8 Park Road, Mount Waverley
Australia 3149
Ph. & Fax (+61) 03 9807 5011





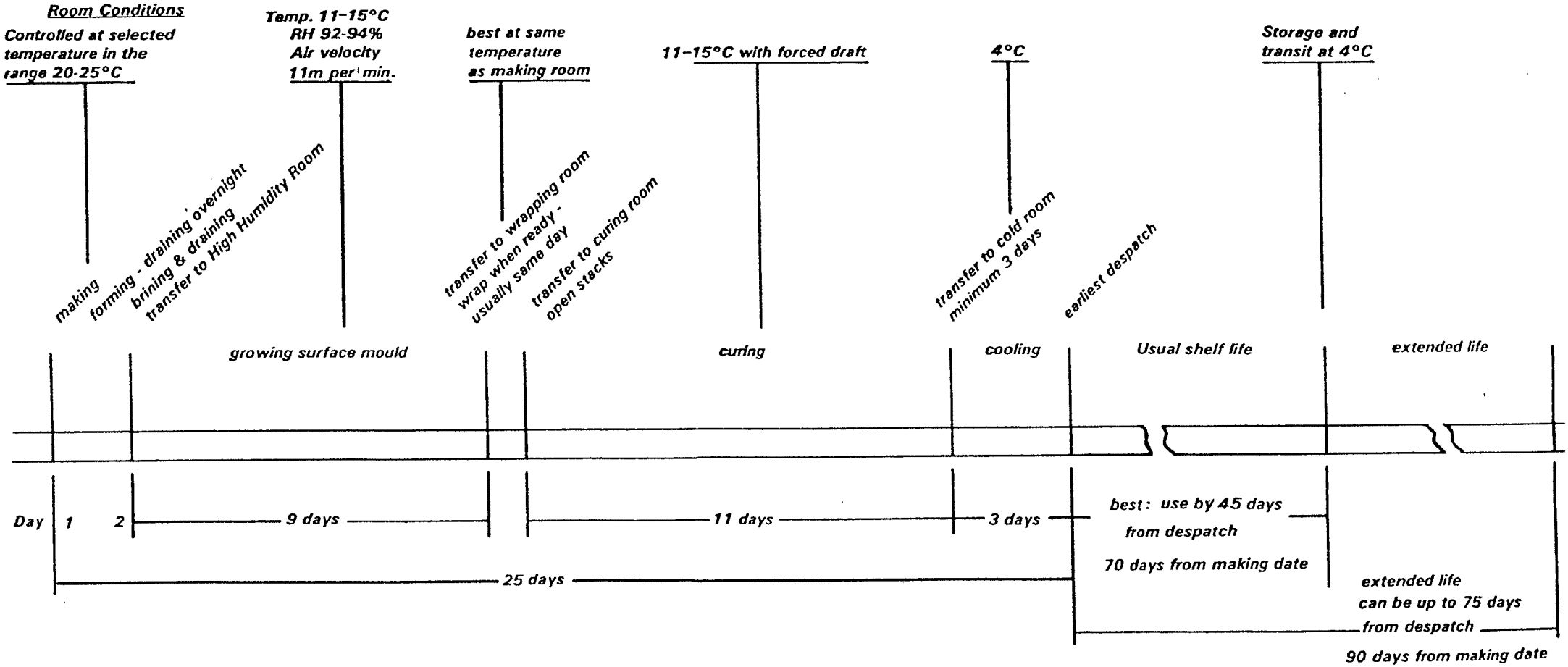
Times, temperatures and procedures illustrated are varied to suit particular manufacturing conditions, customer requirements and variations in the milk supply.

Mozzarella flow sheet	
Drawn	Les Hammond
Date	3 March 04

Attachment 3

FRESH CAMEMBERT - NORMANDIE STYLE

Ron Hull and Associates
8 Park Road, Mount Waverley
Australia 3149
Ph. & Fax (+61) 03 9807 5011

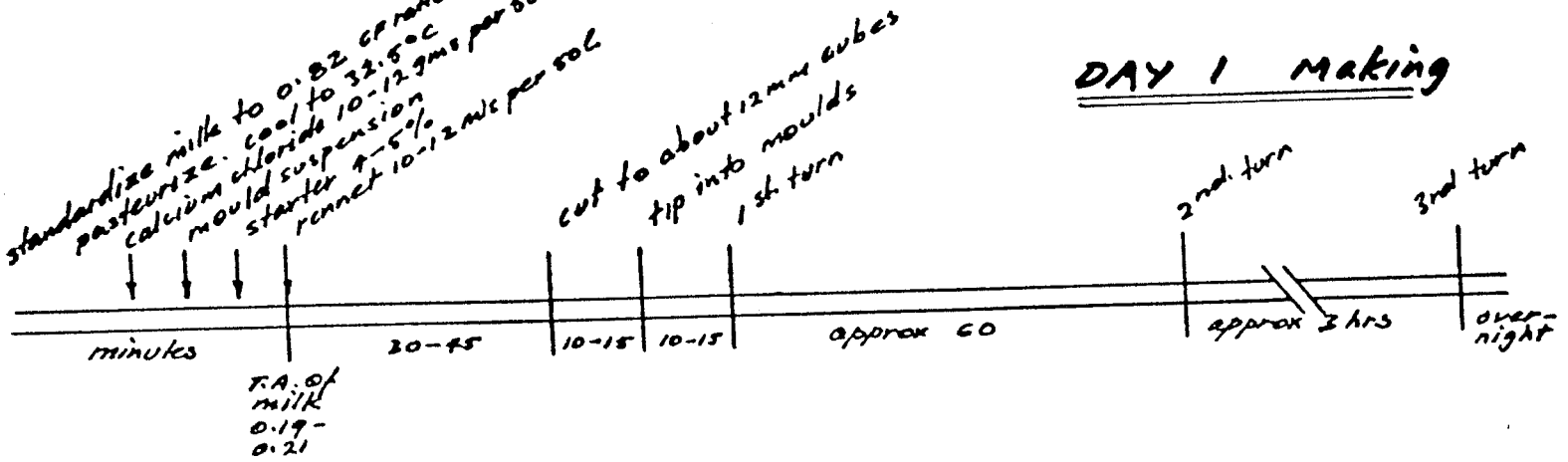


Times, temperatures and procedures illustrated are varied to suit particular manufacturing conditions, customer requirements and variations in the milk supply.

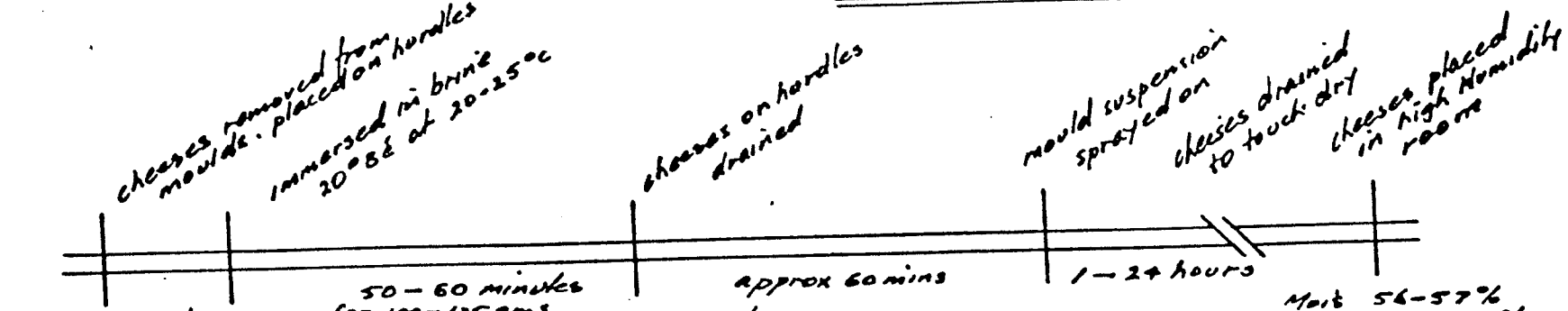
Drawn: *Les Hammond*

CAMEMBERT Part I

DAY 1 Making

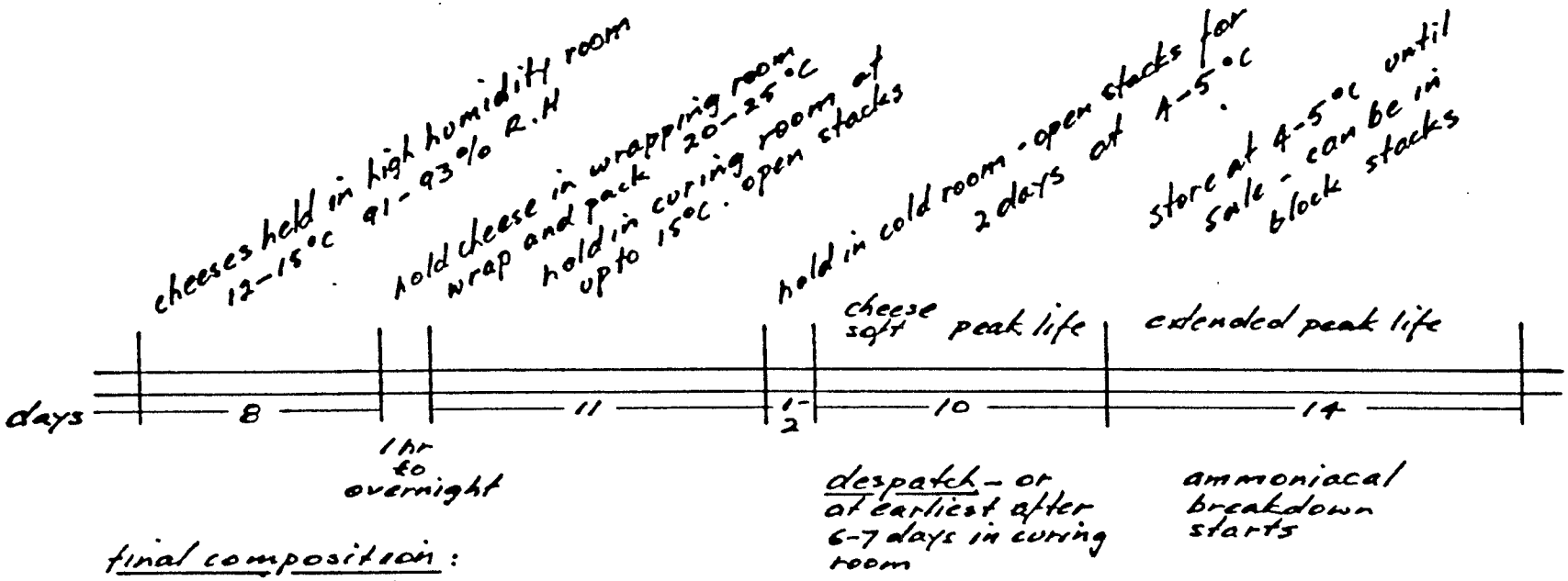


DAY 2 Salting, draining



Drawn: L.A. Hammond
A.D.C. April 1981

CAMEMBERT Part ii curing and handling



final composition:

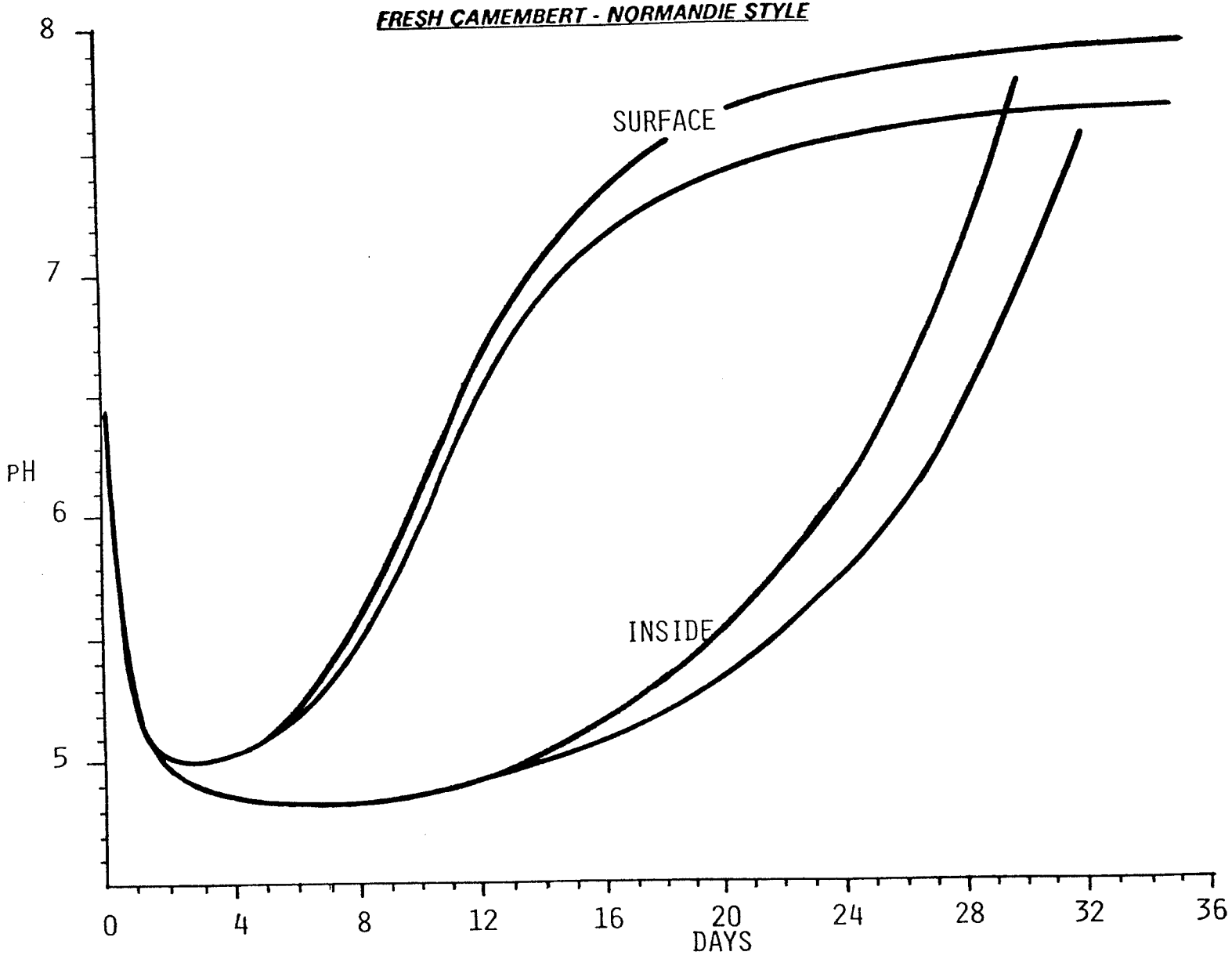
Mois 54-55 %
FDM 45-45.5 %
Salt 2.5-2.6 %
wt of cheeses 115 gms

date stamp: wrap date + 14 days (earliest date for consumption

Drawn: L.A. Hammond A.D.C. Apr 81

PH OF WHITE SURFACE MOULD CHEESE

FRESH CAMEMBERT - NORMANDIE STYLE



L.A. HAMMOND
Cheese Consultant

SEPTEMBER 1994

LES HAMMOND AND ASSOCIATES PTY LTD

Cheese Consultants *ACN 007 282 108*

6A Crawford Street, Cheltenham, Victoria, 3192, Australia

Ripening of White Mould Cheeses. Temperature Increases in Confined Enclosures

Les Hammond - Cheese Consultant

It has been known for some time that white surface mould ripened cheeses, at a predictable stage in their curing, generate heat. The intensive degradation of protein, which results in softening the body of the cheese to a smooth gelatinous consistency, is an exothermic process which, in turn, is accelerated unless the heat can escape and the temperature controlled.

An extract from *Cheesemaking - Science and Technology,* Edited by A. Eck, 1986 summarises the phenomenon as follows:

> It must be emphasized that any uncontrolled temperature variation in the factory or in the course of distribution increases the risk of changes in the kinetics of ripening and in the organoleptic qualities of the product.
>
> It must also be borne in mind that in many cheeses undergoing rapid and extensive transformation by fermentative processes, heat energy is released. When these cheeses are confined within an insulated enclosure, the increase in temperature may produce their rapid degradation.

Fresh soft cheeses of these types imported from Europe, mostly from France and Denmark, used to arrive by air freight in about three days from their point of departure. Air freight containers are relatively small with little insulation, consequently heat was not likely to be retained in the cheese. It is also probable that the cheese had already been through the critical period before despatch.

In the late 1980's the combined influences of increased air freight costs and the gradual lessening of subsidies for export of marginal cost surplus cheese resulted in a shift from air to sea transport. Often shipping containers had more than one variety of cheese to make up full loads. It is likely that the exporters, realising that the cheese would be in transit for 4-6 weeks and likely to arrive in Melbourne with little remaining safe storage life, took delivery early in its life without an awareness of its stage of curing or the possibility of later heat generation.

Telephone: (03) 9583 0069 *Home (03) 9584 8464* *Int. (61) 39583 0069*

Fax: (03) 9583 0660

At least five claims for losses involved due to spoilage of white mould cheese - and sometimes others in the container resulted.

To explain the situation and learn the lesson that some major French companies learned the hard way, I include the following extract from my statement, which was aired in an open court. The shipping company's position was successfully defended.

Les Hammond

9 September 1997

Conditions in the container

The temperature in the container was about 9°C at the time of loading as mentioned in the telex of 21.2.86 but it is unlikely the cheese was held in a store room at a temperature high enough to result in the damage described. Had this been so the air temperature in the container would have been much higher than the 9°C indicated in the chart.

Although the ambient temperature was lower than inside the container its insulation would prevent rapid heat loss. Had the refrigeration unit been operating in transit and for the three days over the weekend, the air temperature inside the container would have come down more quickly, however, the temperature inside the stack could well have remained the same. Cheese, cardboard and wrapping material are effective insulators, particularly in a closed stack.

The practice of transporting without cooling at that time of year is reasonable and even delays over weekends without power on would not normally be a problem.

In paragraph 2 of Scancarriers letter RD/MO of June 18th '86 it states ".... there is no other plausible explanation to high inside temperature (+9C) than the cheese having been stuffed into the container without pre-cooling in a warm storeroom with the result that the insulated reefer unit has preserved these high temperatures ...."

To take up the point about no other "plausible explanation", the bulk of the cheese may have started to generate its own heat from about the time it was close stacked for transportation by road and subsequently containerised.

Paragraph 2 also states ".... Had the cheese to the contrary been properly pre-cooled and the container been placed in a cooled storeroom during stuffing, the insulated unit would have preserved the cool air and pre-cooled temperature of the cheese ...."

This may not have been the situation at all, the major damage would have occurred in the container where the temperature inside the stack would have risen to well above 10°C for several days at least. More thermal energy was released in the course of the biochemical processes than could be disposed of by the containers refrigeration system under the conditions.

The Partlow chart indicates air temperature rises in the container at fairly regular intervals of about 8 hours each, the peaks varying between 5 and 9°C. The regularity of these rises may be due to some mechanical intervention such as periodical defrosting of refrigeration coils or they indicate rises in temperature due to heat generation by the cheese. It is unlikely they would be due to external heating of the container.

A possible scenario is:-

1. The air temperature rises to slightly above 1°C.

2. The refrigeration unit and fan comes on and the "mixed" air temperature rises to the peak.

3. The relatively small volume of air is quickly cooled back to 1°C and the cycle repeats at the intervals illustrated.

This can be taken to indicate the cheese is continuously generating heat which bleeds out of the load gradually. Internally the load would change very little in response to the periodical operation of the refrigeration system.

If the peaks are due to intermittent defrosting then it may have been necessitated by continued evaporation loss from the overhot cheese.

Related experiences

In one scientific study of the effects of ripening conditions on surface ripened cheeses translated from the original German, the following observations were made:-

"Elsewhere, after storage for 24 hours of 1 tonne of packaged Camembert without cooling and without intermediate spaces a temperature of 40°C was measured inside the stack. After a further 24 hours the cheeses were so severely liquefied that the cheese body ran out of the foils."

In my own experience:-

(a) A load of packaged Camembert was inadvertently block stacked on pallets in a ripening room maintained at 15°C. After 4 days the temperature at the centre of the stack was 44°C. Heat damage was similar to that suffered by the Brie as described in the Caleb Brett report.

(b) Several pallet loads of Camembert were block stacked immediately after packaging and held together with shrunk-on plastic overwraps. The cheese was transported interstate in a refrigerated van maintained at 3-5°C. On arrival at the destination 4 days later the cheeses on the extreme outsides of the load were unripened and those inside had varying degrees of heat damage. Most were discoloured and very runny. The temperature inside the stack was between 34 and 37°C.

Conclusion

Within the limitations mentioned earlier I believe:-

- The cheese was close packed at about the start of what should have been a temperature controlled ripening period.
- Loading (stuffing) the container in colder conditions, ensuring pre-cooling of the cheese, expediting the road transportation and connecting power to the container earlier would have made little if any difference to the cheese and would not have avoided the subsequent damage.
- The temperature of at least some zones in the interior of the stack probably reached about 43°C.
- Marcillat Brie made up most of the total shipment and would have produced most of the thermal energy released. The other white mould cheeses could have contributed or just been affected by the heat within the stack.
- Transporting fresh sensitive short-life cheeses by ship to distant ports is ill-advised.
- Packaged cheese should be held in controlled conditions to complete the ripening and cooled to refrigeration temperature before close stacking or containerisation.

L. A. Hammond