MALAYSIAN FARM MANAGEMENT NOTE 6

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MANAGING MILK HARVESTING

Milk is the most perishable of all farm produce. Unlike other animal products such as meat, milk is frequently harvested in very unhygienic conditions, where all too frequently, the current practices of cleaning and sterilising the containers used for its collection and transportation, leave much to be desired. Not only is bacterial contamination in buckets and milk cans a major problem, but because the tropical environment encourages rapid growth of these bacteria, the prolonged time delays in cooling the milk to 4^{o}C, reduce its quality even further.

The government legislation controlling milk harvesting systems in countries with developed dairy industries, ensure a consistently superior milk quality that is just not currently possible in most of the farms throughout Asia. Good milk hygiene practices make it possible to produce clean, safe milk and dairy products with less than ideal equipment and facilities that are generally found on small holder farms in tropical environments.

Good milk hygiene produces dairy products that are safe for human consumption with good keeping quality. On the other hand, poor milk hygiene leads to spoiled products, product recalls (hence adverse publicity), food-borne diseases and unsatisfactory or declining product image. This all leads to reduced consumer confidence in the integrity of the dairy value chain.

This note discusses milk harvesting, either using hand or machine milking, and the key aspects to ensure the integrity of the raw milk is not compromised by poor management and milk harvesting practices.

Measures of milk composition and quality

Milk composition

This refers to the levels of total solids, milk fat and solids-non-fat or SNF (which include protein, lactose and minerals) in the milk. Milk hygiene on the other hand, refers to the levels of various contaminants in milk be they bacterial, chemical or any other adulterants that are detected. In many Asian countries, the term milk quality covers both composition and hygiene whereas in Australia, it refers specifically to milk hygiene.

Total solids (TS) content in raw milk is estimated from its specific gravity using a lactometer, after adjusting for milk temperature. The results are not very accurate because specific gravity is due to water, material less dense than water (milk fat) and material more dense than water (SNF). Therefore, milk with high fat and SNF content can have the same specific gravity as milk with low fat and SNF contents. Furthermore milk temperature is sometimes not measured meaning that cooler milk will have a higher specific gravity, hence a higher estimated TS content. If farmers leave their milk to cool before bringing it to the Milk Collection Centre, it may will a higher estimated (and non temperature adjusted) TS content, but will also have higher bacterial contamination. The alcohol test can indicate this, thus allowing the milk to be rejected for poor quality.

Milk fat has traditionally been measured in the laboratory using a centrifuge to separate out the milk fat which had been coagulated with a strong acid solution, although more modern techniques allow for rapid measurements. ***Solids-not-fat*** content is calculated as the difference between TS and milk fat. ***Milk lactose*** content is very consistent across all breeds and feeding management.

Milk quality

There are various ways and methods of monitoring milk quality, with the key ones described briefly below. Many of the methods are relatively inexpensive with little needed in the way of equipment. Other methods may require more expensive equipment but are more accurate and quicker.

Total Plate Count (TPC) measures the level of bacterial contamination that occurs after milking until the arrival at the Milk Collection Centre or milk processors. It is one of the most common milk hygiene tests performed in the world. A small sample of the milk is taken and is placed with an agar growth medium. This mixture is then incubated for several days and the number of bacterial colonies that grow are counted hence the name plate count. The greater the level of contamination, the poorer the keeping quality of the milk, and the less the farmer is paid for the milk.

***Methylene Blue Reduction Test (MBRT*)** is also a very common test for milk quality and is relatively easy to perform. It is similar to the TPC as it also measures the level of bacterial contamination in the milk. The initial mix of methylene blue and milk is blue in colour. As the level of oxygen diminishes in the milk due to bacterial activity, the blue colour changes to white. The time for this colour change indicates the level of bacterial contamination present in the milk sample. The shorter the time for milk to change colour, the more contaminated the milk.

***Resazurin test**:* This is a 10 minute test to assess bacterial contamination through colour change, which is not as accurate as the MBRT but is easier and quicker. The resazurin imparts a blue colour to the milk which changes to pink and then to white over time in a hot water bath. After 10 minutes, the colour is compared to standards to assess milk quality.

***Milk pH**:* The pH monitors whether compounds have been added to the milk to alter the specify gravity (and so falsely indicate higher levels of milk solids) or alcohol test, or mask the addition of water added to the milk to increase its volume. It should be 6.6 to 6.8. Lower values generally mean an acidification process due to bacterial growth while higher values can indicate the presence of mastitis.

Senses test (organoleptic) usually involves trained operators tasting, smelling and visually assessing the milk consignment. It does not require any expensive equipment to perform but is a subjective test. Any off-flavours, taints, smells and visible contaminants can be detected by a trained assessor.

***Milk temperature**:* This is recorded at the milk processors from each tanker as it delivers the milk to monitor the degree of warming since it was first cooled, to 4^{o}C, at the cooling plant.

Alcohol test: Milk is mixed with an equal volume of 68% ethanol and if it does not form floccules, the milk is normal. If abnormal, the type of flocculent can indicate the type of contamination. Milk that coagulates is likely to contain high levels of acid, calcium or magnesium contaminants.

Clot-on-boiling test: Milk is boiled for 5 minutes to assess its heat stability. If it clots it is likely to coagulate during processing (such as pasteurisation). It measures the same characteristics as the alcohol test but does not require the use of chemicals.

***Specific gravity**:* The lactometer is used to monitor both the milk composition (fat and SNF) and water adulteration. Milk density is 1.028 to 1.034 at 15 to 20 ^{o}C and values below 1.028 usually indicate the presence of added water.

When raw milk is delivered to Milk Collection Centres, it is routinely weighed then subjected to various "platform tests" for contaminants, using the senses and alcohol tests. It can then be sampled and tested for specific gravity and fat content to monitor solids not fat content. MBRT and TPC (and Resazurin) tests are generally measured in laboratories rather than on the platform.

The major influence of milk composition is nutrition, breed and stage of lactation. Milk quality is the result of both intrinsic factors, such as mastitis infections, and extrinsic factors:

- the animal shed; clean, good supply of clean water and of hot water
- the animal; clean and dried teats, check for subclinical mastitis
- the milker; human health, clean attire, no smoking while milking, correct milking techniques
- the milking equipment; clean and sterile metal buckets, storage upside down
- storage and transport; milk filtered prior to bulking, rapid delivery to Milk Collection Centre in covered containers

The principles of cleaning and sanitising dairy equipment

Cleaning and sanitising of milk harvesting equipment are two separate and distinct operations and must go together to ensure minimal bacterial contamination. Put simply, cleaning removes residual milk from surfaces whereas sanitising removes bacteria from cleaned surfaces. Basically detergents are chemical removers of surface deposits. The general guide to cleaning is to:

- Dry clean and remove all loose dirt and debris,
- Rinse or wet the surface, using cold or warm (not hot) water,
- Hot wash using detergent solution that hold contaminants (or soils) in suspension for a short time
- Rinse with cold water and drain,
- Apply sanitiser to contact surfaces and allow to dry.

The basics of good cleaning and sanitising dairy utensils can be summarised as ***WATCH*** as follows:

- **W**ater: Water quality, such as the level of sediment or bacteria, is very important
- **A**ction: This means using mechanical action (with pumps or vacuum) to encourage agitation, or manual cleaning, such as using a brush
- **T**ime: It should be long enough for the chemical to work but not too long for redepositing of soils. The longer a surface is manually cleaned, the better. Cleaning in place (CIP) systems are the best as they require the least physical effort.
- **C**hemicals: Match the chemicals for the job, use them at the recommended dilution rate and in the right sequence. Wear protective clothing if necessary.
- **H**eat: Chemical activity doubles for every 10^{o}C over 50^{o}C. Excess heat can denature some sanitisers.

Different types of detergents have different roles. Neutral detergents are the easiest to use as they require no skin protection. Alkali detergents remove protein, fats and carbohydrates, whereas acid detergents are best at removing milk stones and hard water scale. Good cleaning practices require regular use of both alkali and acid detergents. Their effectiveness is compromised when used in lower temperature water.

Milk stones are hardened deposits formed from residual milk, bonding to metal, rubber and plastic surfaces. Water high in dissolved minerals (hard water) will form a hard water scale. Both these residues provide a suitable environment for bacteria, which are released into any milk coming in contact with them. Milk stones will become more of an issue as hot water becomes more widely used.

To provide some guidelines on optimum water temperatures, Australian dairy cleaning standards are:

- Pre-rinse; not exceeding 50 ^{o}C,
- Flush cleaning; 80 ^{o}C,
- Acid cleaning; 80 ^{o}C minimum,
- Sterilising; 90 ^{o}C minimum.

Management practices for good milking hygiene

There are 20 key factors for small holders to produce clean milk. These are presented in the following Table together with the associated on-farm practices.

Key factors and on-farm practices to undertake to produce clean milk on small holder farms.

Key factors to produce clean milk	On-farm practices
Prepare the shed	Repair any holes in floor, clean the floor and wash with disinfectant
Personal hygiene	Use clean clothes, carefully wash hands, don't milk if you are sick
Prepare for milking	Have ready the udder cloths, buckets, stool, basket (for dirty udder cloths), strip cup, muslin cloth and milk can to save time; place milk can outside shed
Pre milking cleanliness	Do not use milk containers for any other purpose, all equipment must be clean, sanitised and dry
Cow comfort	Gentle handling of cows, maybe offer some concentrate, but not roughage
Cow cleanliness	Brush cow to remove dust, wash udder and teats, dry teats
Cow disinfection	Use one cleaning cloth per cow soaked in hypochlorite (1 teaspoon/5 L water)
Reduce disease transfer	Use one cloth per cow, put used udder cloths into separate basket, don't let milk drip/spill onto floor
Water quality	Only use good quality water for washing cows and containers
Pre milk each teat	Strip milk each teat into cup to check for mastitis and remove initial milk
Hand milking	Use fast steady speed, use "hand squeeze" not "hand strip" technique, don't use oil, water, milk or spittle as lubricant, use hand cream if necessary
Machine milking	Routinely replace rubber linings, sanitise after use, follow correct maintenance schedule, open tops of milk cans in cooling unit to facilitate heat dissipation
Timeliness of milking	Start milking within 30 sec of washing udder, cow's let down lasts 5 to 7 min
Teat dip	Dip each teat into iodine solution, can use all in cup if solution is still clean
Bulking milk	Quickly strain into milk can through muslin to remove contaminants, put lid on can
Cooling milk	Take milk to MCC for cooling as soon as possible, handle can gently
Post milking cleanliness	Rinse all milking utensils in cold water, wash them with detergent and brush in hot water, rinse again in cold water, then rinse in disinfection or very hot water and place upside to drain
Reusing disinfectant	Do not reuse rinsing disinfectant solution for next milking
Drying of equipment	Leave utensils to drain on racks in well ventilated, clean, tidy place
Disease treatment	Use indicator paper or California Mastitis Test to detect subclinical mastitis, treat on same day as detected
Clinical mastitis treatment	Empty inflamed teat out every 2 hr, leave antibiotic in teat for 8 hr

These management factors can be split up into various milk harvesting practices such as:

1. Health and personal hygiene
2. Environmental hygiene
3. Milking procedures and milk handling
4. Post milking

1. Health and personal hygiene

People suffering from contagious disease, respiratory problems (such as a cold) or intestinal problems (such as diarrhoea) shed bacteria at greater than normal rates. To guard against the spread of disease it must be assumed that everybody is potentially a disease carrier. People should not handle milk or hand milk cows if they have:

- sore throats or upset stomachs (diarrhoea and/or vomiting);
- skin infections (boils, septic pimples, rashes, etc);
- heavy colds or fever
- any disease which may be transmitted by contamination of milk and dairy products

To reduce the likelihood of contamination, anyone handling milk should be aware of bad or unconscious body habits and avoid the following:

- scratching any part of the body, face, nose, mouth, ears or hair
- coughing or sneezing directly onto milk or product
- touching, picking or squeezing pimples, boils or sores
- using spittle as a lubricant when hand milking (use hand cream if necessary)
- tasting milk or dairy product by using the fingers or a ladle that is returned to the product

The key to preventing bacterial contamination of milk and dairy products is to keep the hands clean as they are by far the most common mode of contamination.

Hand washing: The actual procedure for washing hands is simple yet is often not carried out correctly. Wash hands and forearms by:

- Pre-rinsing to remove dirt and grime,
- Washing in a rich lather using soap and water,
- Brushing under the nails,
- Rinsing then drying with disposable hand,
- Some western dairy farmers routinely use disposable gloves at each milking.

Smoking: Do not smoke tobacco or any other substance when handling milk
Smoking causes:

- Direct contamination of food by ash or cigarette butts,
- It encourages coughing,
- Contamination of food from fingers touching lips while smoking,
- Health issues for non-smokers (the effect of passive smoking is well documented).

Protective clothing: The use of hair coverings and gloves is recommended to keep hair and skin flakes out of milk and to prevent cross contamination occurring.

2. Environmental hygiene

Environmental hygiene relates to both internal and external environments. The external environment are those areas outside of the production area while the internal environment refers to areas where milk and dairy products are produced, packaged and stored.

Environs: Sealed, graded and drained roads and grassed areas around the dairy and cattle housing will cut down dust contamination of the dairy. Adequate drainage of the dairy and housing is essential. Effluent (manure, mud and cleaning water) must be disposed of effectively. Regular (once or twice per week) removal and spreading onto farm land or pasture areas should be undertaken.

Water supply: Sufficient quantities of clean drinkable water must be available for cleaning operations and a drinking supply for stock.

Rodents: Control can be a combination of the reduction of food and habitat, vermin proofing of structures, trapping and prudent use of chemical baits.

Flies, cockroaches and insects: Insect pests carry bacteria and are can transmit many diseases to humans. Control is the elimination of breeding and feeding places. Insect deterrent lighting, electrocutors and sticky pads also have their place. Reliance on insecticides alone should be avoided.

Birds: They carry salmonella and they will contaminate buildings, water supplies and surrounds with faeces. Birds are attracted to dairy premises by the presence of cattle feed.

Animals and housing: These can be a major source of contamination if not kept clean. Grooming and clipping is important in reducing contamination from hair and dust on the animals. This is particularly important when hand milking. Animals should always be handled quietly and gently to avoid upsetting them. Upset animals always result in more dust and manure. Calves, young heifers or other animals (ducks, chickens etc.) should not be housed in or have access to the dairy.

People: The potential for workers to bring contamination on clothing, footwear and on the person is always possible.

Internal environment: The dairy should be a dedicated building for milking. Cattle feedstuffs, chemicals or medications should not be stored in the dairy (except for cleansers and sanitisers). If feeding concentrates at milking, they should be stored outside the dairy and only brought in to feed cows at milking. Roughages should not be fed during milking. Dust and spillage of feedstuffs should be minimised.

The actual milking and milk handling areas of the dairy need special attention. The floor should be an impervious surface (such as concrete), and maintained in good repair. It should be kept clean both during and at completion of milking. Dairy equipment and facilities such as wash up troughs and drainage racks need to be constructed of non-absorbent, corrosion resistant materials, such as stainless steel.

3. Milking procedures and milk handling

Dairy/milking area: The milking area should be kept clean. Thorough cleaning following each milking session is essential. The floors should be swept and/or washed with water so as to be visibly clean.

Equipment: Teat cloths, buckets, stools, waste/dirties bucket, strip cups, teat-dip and milk storage all need to be clean and ready to use. Any milk contacting equipment such as buckets, milking machines and storage vessels should be sanitised and allowed to drain for at least 15 minutes prior to use.

Cow handling and preparation: Good cow handling and preparation should begin before she is brought to the milking area. Gentle handling at all times is essential and with some grooming, if hand milking, is necessary. Slapping or striking the cow with the hand or objects such as sticks or canes should be minimised. Consistent use of even moderate slapping or hitting will result in the cow becoming fearful and upset. This will negatively effect milking as it interferes with the “let-down” response.

Offering concentrate can be an excellent way to entice cows into the milking area, however it should be done consistently at every milking. Only give a set amount of concentrate at each milking. Offering cows more some days and less at others is likely to upset them.

Foremilk stripping: Teats should be striped into a strip cup to check for mastitis/abnormalities in the milk for at least a month (and preferably longer) into the lactation.

Teat preparation: Teat cleanliness is essential prior to milking. Dirty teats should be washed with clean running water (at low pressure) and then dried with clean, individual towels (paper or cloth). If the udder and teats are consistently dirty at each milking, the cows' environment requires closer attention.

Milking: Allow at least 30 seconds from the start of teat handling before hand milking. This provides adequate time for the "let-down" response to occur. Milking should be complete within five to seven minutes. Hand milking should be quick and gentle using a squeezing action rather than a pulling or stripping action. Do not use lubricants, milk or spittle when hand milking. If lubricant is needed then hand cream could be used.

Hand milking technique: The most common milking technique is "hand strip" milking for the entire milking cycle, rather than the accepted, and presumed better, alternative "hand squeeze" method. Udder and teats are washed with a cloth but left wet to facilitate lubrication for strip milking. The cow is strip milked either one quarter (one handed) or two quarters (two handed) at a time. The "hand squeeze" method more closely mimics the natural calf sucking reflex, which seals the top of teat with the lips and squeezes the teat with the tongue. The strip milking technique, combined with a non-dry udder, leads to additional bacterial loading to the milk in the bucket as the water on the teats acts as a vehicle and stripping helps push the water into the bucket.

Strip milking would also leave the teats moist, loosen the bacteria around the teat skin and provide a vehicle, via water and stripping, to bring bacteria close to the open teat orifice. The absence of teat dipping means there are always bacteria readily available to enter the teat post-milking. Strip milking is much more likely than squeeze milking to cause epidermal micro erosions that harbour mastitis bacteria.

4. Post milking

Milk filtering: Immediately following hand milking, the milk should be filtered into a clean, sterile storage container. The filter cloth should be thoroughly cleaned in detergent and sanitiser then dried in the sun.

Milk storage/cooling: It is vital that milk is chilled to below 3 to 4°C as soon as possible after milking.

Milk transport: For small holders without refrigeration, milk needs to be transported carefully and as soon as possible after the completion of milking and cooled immediately at the Milk Collection Centre. Heat, light, excessive movement and time all cause deterioration in warm milk. Transport containers should be clean, sanitised and able to be sealed with lids. They should be made of food grade materials, which are capable of being cleaned and sanitised properly.

Milking machine function and maintenance

Milking machine components

Vacuum pump: This is an air pump or air compressor which removes air entering the milking machine through the various components such as the teat cups and pulsators. The pump must have sufficient capacity to remove all this air as well as enough spare capacity (reserve or effective reserve) to maintain the vacuum at a preset level. It must also be able to return vacuum levels quickly to these levels following air admissions which occur for instance when cups are removed or fall off a cow.

Regulator: This simply regulates the vacuum level in the milking machine. Desirable features for a regulator are an ability to quickly regulate changes that occur in the vacuum levels of the milking machine during operation. Vacuum levels in milking machines are generally set between 40-50 kPa

depending on the type of machine and equipment set up. A good rule of thumb is that vacuum levels be set as low as possible. Cup slips indicate that the level is too low.

Pulsators: This is a valve mechanism which alternates vacuum and atmospheric pressure in the chamber between the teat cup liner and the shell of the teat cup. The cyclic pressure changes cause the liners to move within the teat cup.

Pulsation rate is the number of times the teat cup liners complete a pulsation cycle in one minute. An ideal range for the pulsation rate would be around 60 cycles/min ± 2 cycles. Rates can go to 50 cycles/min but should not exceed 62. Pulsation ratio refers to the portion of time of the vacuum phases that occur during each pulsation cycle. A pulsation cycle is divided into four main phases:

- Increasing vacuum phase (*a phase*) is when the vacuum level in the chamber between the liner and the shell is increasing from atmospheric pressure to machine vacuum level. Milk begins to flow from the teat end during this phase.
- Maximum vacuum phase (*b phase*) when full vacuum is achieved in the chamber. At this phase the liner is fully open and milk will be flowing from the teat end.
- Decreasing vacuum phase (*c phase*) occurs when the pulsator valve opens the chamber to atmospheric pressure causing the liner in the teat cup to begin collapsing under the vacuum within the liner. Milk flow will cease during this phase.
- Minimum vacuum phase (*d phase*) is when the chamber is at atmospheric pressure. The liner is fully collapsed and exerting maximum pressure on the teat.

Testing milking machines

With all types of machines, the pump should be run for 5 to 10 min before testing commences. This allows the pump and machine components to reach full operating efficiency.

Whilst the machines are warming up a visual inspection can be carried out.
Checks should be made on such things as:

- Guards over belts and pulleys;
- Electrical wiring and installation is not worn and cut out devices are operable;
- Vacuum pump oil feed and mounting are satisfactory with little vibration during operation;
- Vacuum regulator is mounted according to manufacturers recommendations and is subject to vibration;
- Vacuum gauge is fitted between the regulator and the first pulsator and were it can be read easily by the operators;
- Rubber ware should be in good condition and free from cracks and holes;
- Air admission holes on the claws are not blocked; and
- All air filters on regulators and pulsators are clean.

Pulsators: The important characteristics to test for and measure are the pulsation rate, ratio, and actual time of the *d phase*. Pulsation rate is generally acceptable in a range of 50 to 60 pulsations/minute.

Pulsation ratio characteristics that are monitored closely are the *d phase* and the *b phase*. The *d phase* should reach atmospheric pressure for at least 15% of the cycle and be not less than 0.15 seconds in duration. The *d phase*, also called the "squeeze phase", is very important in maintaining good teat health. The *b phase* should not be less than 30% to ensure an optimum milk removal rate from the teat.

If there is more than one pulsator, a tolerance of 5% difference should not be exceeded in pulsation characteristics between all pulsators on the plant.

Vacuum levels: Working vacuum level is controlled by the vacuum regulator. Whilst there is no formal specification for the working vacuum level for most systems, a level of between 40 to 50 kPa is acceptable. The capacity of a vacuum pump to maintain vacuum levels is critical. As a guide for bucket milking plants a basic allowance of 150L/min plus 60 L/min for each set of teat cup units is a standard pump capacity. This standard allows for all the consumption requirements of the milking machine as well as providing an allowance for an effective reserve. All effective reserve measurements at testing are recorded at a standard 50 kPa. The vacuum gauge can be checked for accuracy over a range of vacuum levels from 40-55 kPa and the working vacuum level set for the machine should be marked on the gauge.

Routine maintenance

Listed below are some basic maintenance requirements to keep a milking machine in sound operating condition.

Vacuum pump; Most pumps will have oil lubrication systems that need to be kept topped up. Manufacturer's recommendations should be followed. Check drive belts for wear and cracking and ensure that pulleys are aligned.

Pulsators; Most pulsators used on bucket milking plants are integral systems operated by vacuum and are mounted on the milking machine so as to access the vacuum. Once again manufacturer's recommendations should be followed as to maintenance needs. Generally this requires regular cleaning of air filters dependant on how dusty conditions are and regular maintenance of working components with in the pulsator.

Regulator: Once again large volumes of air flow through the air filter on the regulator and should be cleaned routinely. Manufacturer's guidelines need to be followed with regard to the maintenance requirements of the regulator.

Rubber ware: From the functional aspect of a milking machine the most important piece of equipment on the machine is the liner or inflation. The inflations are the only part of the machine that comes in contact with the cow. From the day they are fitted to the milking machine they begin to deteriorate and lose their flexibility. A good rule of thumb is to replace the inflations after 2500 milkings, using the following simple formula:

$$\text{Replacement age (d)} = \frac{2500 \times \text{number of claws}}{\text{herd size} \times \text{milkings/d}}$$

Therefore for a 40 cow farm milking twice daily, with one mobile milking machine with two claws, the rubber ware should be replaced every (2500 x 2)/(40 x 2) or every 62 d.

Apart from functional aspects of the inflation the other concerns are the milk quality problems caused by deteriorated rubber ware. Long milk rubbers should also be replaced regularly (usually every 9-12 months).