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Dairy Arithmetic of milk and milk products for sustainable Dairy Entrepreneuship

J BADSHAH[1*] AND SANJEEV KUMAR[2]

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ABSTRACT

The food quality and safety issues as well as sustainability of dairy entrepreneurship are integrated with accurate and rapid calculation for estimating the correct quantities of ingredients, resources requirements and corresponding resulting output of products and profits in the business. Arithmetic calculations in regards of market milk and frozen dairy products have been discussed in brief. The arithmetic calculation pertaining to milk producers, Pricing of milk, determination of amount of cream, Calculation of physical properties, problems related to market milk and Ice-Cream are described in for farmers engaged in dairy farming business as well as in dairy entrepreurship.

KEYWORD

Dairy, Milk, Entrepreurship

INTRODUCTION

Dairy arithmetic is an important aspect of sustainable dairy business. The correct amounts of ingredients in the final products are the result of accurate calculation of ingredients to be mixed before processing and conversion into final products. The important issues of quality, safety and economy in regards of costs of raw materials, energy, labour and processing operations are integral with arithmetical calculation related to dairy products handling, processing and marketing. It would not be wrong to say that the sustainability of dairy business for marginal farmers as well as big enterprisers solely depends on dairy arithmetic. In other words, the quality and safety issues are also integrated with accurate and rapid calculation as well as estimation of ingredients which needs proper programming and computerization of all arithmetic calculations and processing operations.

DAIRY ARITHMETIC

On the farms, the producers have interest to calculate the average daily and yearly milk production of his cows and the fat/SNF percentages for estimating the profit from the business annually. The manager of the dairy plant is interested to standardize their products so that it may be of uniform composition to compete in the market with the objectives of meeting quality, safety, cost, flexibility and delivery of the products.

The frozen dairy products manufacturers, particularly ice cream makers have their problems in preparing and calculating the composition of ice cream mix. Arithmetic calculations in regards of market milk and frozen dairy products have been discussed.

Milk, kg	Test, per cent	Fat, kg
200	5.0	10
600	3.0	18
100	4.0	4.0
Total 900		32.0

The true average fat test = (32 x 100)/900 = 3.5 %

Calculations pertaining to Milk Producers

Problem 1. The average fat percentage: The milk yield and fat percentage for a particular cow may be available by either milkings, days, or months, and it is desired to calculate the fat percentage for all the periods represented. In other cases, the milk yield and fat percentage for each cow in the herd are known and the average for the entire herd is wanted. In milk or cream receiving plants, the total milk or cream delivered from each farm is known, the test may be available, and the operator wishes to know the true average fat percentage of the mixed product. An example is illustrated as follows:

As the amounts of milk vary, never find the direct average of the fat tests otherwise the result will be inaccurate. Similarly to find true average fat percentage for the year, determine the amount of fat in each month separately, take a total of these to give the total fat in kg produced annually, then divide this fat total by the milk total, and multiply the result by 100. The figure obtained is true average fat test.

Problem 2. The Price of Milk :- The fat based pricing system or one axis pricing system was prevalent earlier. For example the milk is priced at a rate of Rs. 300 per

[1]University Professor-cum-Chief Scientist (Dairy Engineering), S.G. Institute of Dairy Technology, Jagdeopath, Patna-14. email- ejazbadshah@gmail.com
2 Assoc. Professor-cum-senior scientist (Dairy Technology), SGIDT, Patna. Email-sanju_kvk@yahoo.co.in
*Corresponding Author Email: ejazbadshah@gmail.com

kg fat in milk. If milk contains 6 % fat, the rate of milk is Rs. 300 x 6/100 = Rs. 18.00 per kg of milk weighed in weighing balance at reception section in dairy plant.

Secondly, if the payment is based on the basis of minimum fat percentage standard plus a premium for fat on pro-rata basis, the premium for above the standard fat percentage should be added at a decided flat rate of the premium and it should be subtracted for fat percentage below the standard fat percentage. If the premium for all milk testing above 6 % milk fat in above rate of Rs. 300 per kg fat is Rs. 0.20 for each 0.1 per cent fat increase, the price for milk testing 6.3 % fat to a milk plant will be Rs. 18.00 plus Rs. 0.20 x 3 i.e. Rs. Rs.18.60 per kg of milk.

Thirdly, on the basis of two axis pricing of milk, the rate of fat and SNF are decided by the organization depending upon the relative values of fat and SNF. If the rate of fat is Rs. 250 per kg and that of SNF is Rs 100 per kg SNF, the rate of milk of 6 % fat and 9 % SNF is calculated as Rs. (250 x 6 + 150 x 9)/100 = Rs. 28.50 per kg of milk. Generally the rate of SNF is accounted as 2/3 of the rate of fat in milk depending upon the trends in market. The incentives should be added for hygienic and clean milk production depending upon volume of milk supplied multiplied by the rate of incentives per litre of milk or based on the basis decided by the organization.

Problem 3. To determine the amount of cream :- In the separating milk on the farm a number of questions arises which can be answered by the application of simple mathematics. Assume that 800 kgs of milk containing 6 % fat is to be separated and the farmer desires to know how much cream containing 30 per cent of fat can be expected. The milk in this case will contain 48 kgs of milk fat (i.e. 800x0.06= 48) and the cream of 30 % fat expected will be approximately 160 kgs (i.e. 48 /0.30 =160). The loss of fat in skim milk is not considered due to practical importance. Approximately 640 kgs of skim milk (i.e. 800-160=640) may result.

Problem 4. Calculation of specific gravity, Total solids, SNF and acidity of milk:- To determine the specific gravity, bring the sample of milk to a temperature of very nearly 60° F (15.56°C). Mix the sample gently to avoid incorporating air and place the milk in a tall cylinder. Immediately lower the clean lactometer gently into it. When the lactometer reaches stationary position, take the reading at the top of meniscus on the stem and note the temperature of the milk immediately. It is necessary to correct the lactometer reading for a temperature higher or lower than 60°F (15.56°C). For each degree Fahrenheit above 60°F (or 1.8 degrees Centigrade above 15.56 °C), 0.1 must be added to the lactometer reading, while for each degree below 60°F (or 1.8 degrees below 15.56 °C), 0.1 must be subtracted from lactometer reading. If the corrected Lactometer reading (CLR) was 32.5, the specific gravity of milk = 1 + CLR/1000 = 1 + 32.5/1000 = 1.0325.
The following Babcock formula has been found to yield approximately correct results for estimating the percentage total solids (T.S.) :

$$T.S. = (CLR / 4) + (1.2 \times \text{per cent fat})$$

The formula for percentage of solid not fat (SNF) used is obviously as follows:

$$SNF = (CLR / 4) + (0.2 \times \text{per cent fat})$$

The percentage of total solids or SNF in milk can be calculated depending upon density (d) of milk sample at 20 °C using the following formulae (Aneja et., al.,2002):

$$\%\,TS = 0.25\,D + 1.22\,F + 0.72$$
$$\%SNF = 0.25\,D + 0.22\,F + 0.72$$

where,

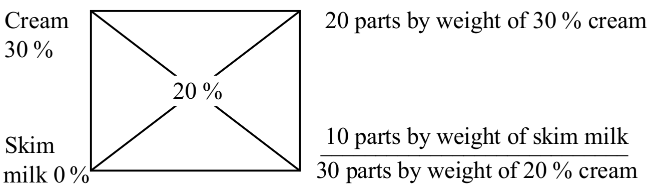
D = 1000 (d – 1)
D = density of sample of milk at 20°C in g/cm^3
F = fat percentage of sample

The calculation for milk acidity may be illustrated more clearly by the following formula:

$$\text{Per cent of lactic acid} = \frac{\text{milliliters of N / 10 alkali X 0.009 X 100}}{\text{grams of sample of milk}}$$

Problems pertaining to market milk:
In the market milk plants and composite milk plants, one of the most typical calculations in the handling of milk and cream is that of adjusting the percentage of fat and SNF to definite amount, commonly termed as "standardization". It is also used in connection with manufacture of such products as ice cream, cheese, condensed milk and dry milk to give a uniform quality of finished products.

Problem 1. Standardization by Pearson Square Method :-
Objective 1- 30 % cream is to be reduced to 20 % cream by adding skim milk assumed to be fat free.



Let us suppose a definite amount of desired product say 300 kg of 20 % cream is needed in the above case. Then proceed as :

30 parts of 20 % cream = 300 kg
1 part = 300/30 = 10 kg
Therefore 20 parts of 30 % cream = 20 x 10 = 200 kg
10 parts of skim milk = 10 x 10 = 100 kg

Therefore mixing 200 kg of 30 % cream and 100 kg of skim milk will result in 300 kg of 20 % cream.

Let us suppose all quantity of one of one of the resource material is to be changed to the desired test in the previous case. For example 8 cans of 30 % cream is to be standardized to 20 % cream using skim milk, when the capacity of each can is 40 kg cream holding.

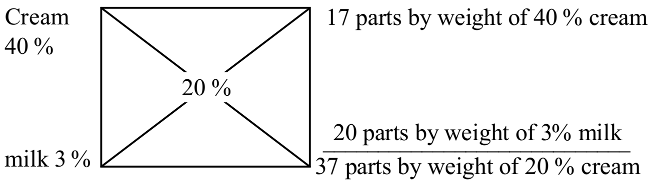
Weight of 30 % Cream in cans = 8x40 = 320 kg

The proportional parts will, of course, be the same as before in the Pearson Square.

Therefore, 20 parts = 320 kg
1 Part = 320/20 = 16 kg

Therefore, 10 part of skim milk = 10 x 16 = 160 kg
And weight of 30 parts of desired product i.e. 20 % cream = 30 x 16 = 480 kg.

Objective 2. 40 % cream is used to produce 500 kg of 20 % cream using milk containing 3 % fat.



As it is known in hand that the weight of 20 % cream to be made is 500 kg. Therefore 37 parts of 20 % cream will be equivalent to 500 kgs to start the problem
Therefore, 37 parts of 20 % cream = 500 kgs
1 part = 500/37 kgs

Therefore, 17 parts of 40 % cream = 17 x 500/37 = 229.7 kg
And, 20 parts of 3 % milk = 20 x 500/37 = 270.2 kg
Therefore by mixing 229.7 kg of 40 % cream with 270.2 kg of 3 % milk would result in 500 kg of 20 % cream.

Problem 2. Standardizing Milk and Cream using separation and hit and trial method:- Obviously this may be accomplished either by taking out some of the fat or by diluting the original lot by mixing with it a quantity of same class of material having a lower or higher fat content as desired. In the case of milk, the common procedure would be to separate a portion and add skim milk to the remainder if fat content is to decrease. For example: – For preparation of 10,000 litre of toned milk of 3.0 % fat and 8.5 % SNF from a lot of 10, 000 litre of whole milk of 6% fat and 9 % SNF, separate 5,000 litre of milk to cream of 40 % cream and skim milk. Amount of cream will be 750 kg (5000 x 0.06/0.40 = 750 litre) and skim milk will be 4250 litres (5000-750=4250 litres). Then calculate the fat needed in 10,000 Litre toned milk i.e. 300 kg which can be met by mixing 5,000 litre of whole milk with 4250 litre of skim milk. Mix rest amount i.e. 750 litre of pasteurized water to 5000 litre of whole milk and 4250 litre of skim milk and verify the fat and SNF per cent.

Per cent Fat in standardized toned milk = (5000 x 0.06) x 100/ 10,000 = 3. 0 per cent
Percent SNF in skim milk = (100 X per cent SNF in whole milk)/(100 – per cent fat in whole milk) = (100x 9)/(100-6) =9.57 = 9.6
Per cent SNF in standardized tone milk = (9 x5000 + 9.6 x 4250)/ 10,000 = 8.58).

By controlling the percent fat in cream during separation, the amount of water needed can be controlled and standardization can be accomplished by proper testing of percent fat and SNF before making up the volume of 10,000 litre using pasteurized water. Less amount of pasteurized make water can be added to increase the per cent fat and SNF at the last. Similar standardization are easy and handling for handling market milk production in Dairy Plant.

Per cent SNF in cream = (100- per cent fat in cream)x Per cent SNF in whole milk/ (100 – per cent fat in whole milk)
=(100 – 40)x 9/ (100- 6)= 5.75

The formulae for yield of cream and skim milk on separation of milk may be used for direct calculation:
Yield of cream $C = M \times (f_m - f_s)/(f_c - f_s)$
And Yield of skim milk $S = M \times (f_c - f_m)/(f_c - f_s)$
Where, f_m = % fat in milk, $f_{s=}$ % fat in cream, $f_{s=}$ % fat in skim milk
M = Raw milk in Kg, C = Cream in Kg and S = skim milk in Kg

Problem 3. Standardizing by forming equations : - It is necessary to know the composition of the ingredients to be mixed and the amount of at least any one product with composition of final products. Mass balance equations are formed on fat, total solid basis and total mass basis, and if required on the basis of other constituents. Then by solving the equations, the required quantities can be found out (De, 1982).

Objective 1. To prepare 10,000 litre market milk with 4.5 % fat and to estimate required quantities of raw milk and skim milk.

Source: - Raw milk of 6.5 % fat and skim milk of 0.01 % fat.
Assume the required quantities of raw milk (6.5 % fat) be A and skim milk be B.

Fat Balance : 6.5 A + 0.01 B = 4.5 x 10,000
Mass Balance : A + B = 10,000

On solution : 6.5 % fat milk required A = 6147.9 kg
0.01 % skim milk required B = 352.1 kg
The following formula can be directly used to estimate required quantities of kim milk and raw milk :
Skim milk , kg = Standard milk in kg x (% fat in Raw milk - % fat in standard milk)/(% fat in Raw milk - % fat in skim milk)
Raw milk, Kg = Standard milk in kg x (% fat in standard milk - % fat in skim milk)/ (% fat in Raw milk - % fat in skim milk)

Problems Pertaining to Ice cream
After the composition of the ice cream mix to be frozen has been decided upon, the next step is to calculate the amount of each ingredient to be used. This part of the work must be done with great care for two very important reasons. The first one is the uniform quality of ice cream of different varieties for consumer acceptability and second reason pertains to additional cost and loss to the concern due to excess amount of fat or other costly ingredients added due to mistake. The loss is accrued upon to a huge value when considering the annual losses. Technical skill is necessary because the raw products include cream, whole milk, condensed milk, skim milk, sugar, gelatin, and flavouring. Further more, the first three may vary in composition from day to day Almost any group of dairy products may be used as sources of fat and milk solids-not-fat If the fat s secured from one source for example cream, the problem is simplified. It is essential, however, in most instances that the milk solids-not-fat is secured from two or more sources.

Problem 1. Ice cream mix Balancing :-

Objective :-Prepare 100 kg of ice cream mix containing milk fat -14 per cent, total solids – 38 per cent, sugar – 15 per cent and gelatin- 0.5 per cent..

Sources :- Cream containing 40 per cent fat and 45.5 per cent total solids; plain condensed whole milk containing 11 per cent fat and 35 per cent Total solids; and skim milk containing 8.5 per cent total solids.

Algebraic Equation Method:-

First calculate the percentage of milk solids other than fat in the required mix.

Per cent milk solids other than fat = % Total solids – (% fat + % sugar + % gelatin)

$$= 38 - (14 + 15 + 0.5)$$
$$= 8.5$$

Let us suppose, Cream required in the mix = X kg
Plain condensed whole milk = Y kg
Skim milk required = Z kg

Total mass balance:

$$X + Y + Z + 15 + 0.5 = 100$$

Total fat balance :

$$0.40\,X + 0.11\,Y = 14$$

Total solids balance :

$$0.455\,X + 0.35\,Y + 0.085\,Z + 15 + 0.5 = 38$$

By solving the above three equations, it is found that 100 kg of mix is prepared using

Cream, X = 31.01 kg Plain condensed milk, Y = 14.51 kg
Skim milk, Z = 38.98 kg, Sugar = 15 kg, and Gelatin = 0.5 kg

In common practice, the calculation of the mix is often simplified by using milk products of uniform composition. As a general rule, the viscous fluids are placed in the vat first, followed by the less viscous fluids. Sugar and gelatin are added at the last. Flavouring is added to the mix at the freezer and generally is not included in the calculation (Eckles et. al., 1982).

Problem 2. Overrun in Ice cream :- The over run in ice cream is based upon the increased volume of ice cream over ice cream mix. The ice cream, however, owing to its physical nature, readily absorbs air in handling. This makes it difficult to secure an accurately measured over run in sample of ice cream. Instead of volume measurement, it is therefore more common to determine the overrun on the basis of weight of a given volume of ice cream mix as compared to the weight of the same volume of finished ice cream. To illustrate, assume that ten liter of ice-cream mix weighs 12 kg, and after freezing, 10 liters of the finished ice cream weighs 6 kg. The overrun secured in this case is 100 per cent.

Overrun = (weight of ice cream mix of a given volume – weight of finished ice cream of same given volume) x 100/ (weight of finished ice cream of a given volume)

Therefore, Overrun of ice cream = (12 –6) x100 /6 = 100 per cent.

CONCLUSION

The changing market profile due to increased urbanization and income growth, the marginal farmers must adopt dairy farming and processing business to meet sustainability. The changing scenario of globalization over localization calls for uniform quality and highly convenient dairy products of high nutritive values. The subject of dairy arithmetic has become highly significant and it should be given much care and importance at producer level as well as at production level. The softwares can be written to computerize the problems in different convenient languages to get the accurate solution through computers. The highly computerized milk analyzers have come in the market to measure fat, SNF, protein, density, added water etc. with high accuracy and resolution. It is the age of accuracy and automation, which can only be met through automatic instruments and computerization of all activities using dairy arithmetic as a base.

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