MILK MARKETING IN THE ORGANISED SECTOR- A PROGRAMMING APPROACH TO OPTIMISATION OF COLLECTION AND DISTRIBUTION

BY

ASOKAN M. V.

THESIS

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Department of Statistics

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DECLARATION

I hereby declare that this thesis entitled "MILK MARKETING IN THE ORGANISED SECTOR - A PROGRAMMING APPROACH TO OPTIMISATION OF COLLECTION AND DISTRIBUTION" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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ASOKAN.M.V.

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Mannuthy
19-6-87

N. RAVINDRANATHAN
(Chairman, Advisory Board)
Associate Professor of Statistics
College of Co-operation and Banking
Mannuthy

19/6/87
(Dr T P Gangadharan)
External Examiner

K C George
19/6/87
(Dr K C George)
Member

T Prabhakaran
(Dr T Prabhakaran)
Member

19 6 87
(N Narayanan Nair)
Member

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INTRODUCTION

INTRODUCTION

India is a developing country with 69 percent of its population still engaged in agriculture. Milk production stands second only to rice in terms of gross value among edible national products. The productivity of our agriculture heavily depends on organic manure and draft motive power from livestock.

The percapita availablity of arable land in Kerala being lower than one third of the national average, mixed farming of either cash or cereal crops with livestock production is necessary to maximise the net returns for an average farmer. Since dairy cattle has the ability to convert higher proportion of atmospheric nitrogen into edible milk solids, dairy farming offers better scope in the production of much needed animal protein.

Out of the total annual milk production of 38.4 million metric tonne, 60 percent is concentrated in the villages that too from animals which yield an average one to two litres per day. On account of this 10 percent of the total production alone is coming into the organised sector. Milk being an easily perishable commodity, its organised marketing has great importance in maintaining the dairy economy.

Marketing will include not merely purchase and sale of goods, but also the various business activities and process involved in bringing the goods from producer to consumer. Beginning from farmers' field, marketing has to cover a network of services, viz, collection of marketed surplus quantity from producers, transport to assembling centres, grading and standardisation, pooling, processing, warehousing, packing, transport to consuming centres and ultimately sale of produce to consumers. The American Marketing Association defines marketing as 'the performance of business activities that direct the flow of goods and services from producer to consumer or user'.

The co-operative marketing is a part of the integrated system of co-operative economic activities. The basic concept of the co-operative marketing of agricultural produce is to minimise the price spread between the producer and consumer and to ensure the benefit of the maximum price to the producer and the minimum to the consumer.

Functional marketing of milk depends on the efficiency and economy in the procurement, processing and distribution. It has been well recognised that procurement of milk for the organised dairy sector is best done through dairy co-operative societies at the village level. In Kerala 1800 number of dairy co-operative societies are engaged in the collection and distribution of milk to the eight dairy plants and 28 chilling plants functioning in the state. Though there is uniformity in the rates for milk solids purchased under the two axis pricing followed in the dairies and chilling plants, this constitute only 60 to 65 percent of the price realised from the consumers. Thus the marketing costs and margins of the dairies take up 35 to 40 percent. One of the major components of marketing expenditure has been identified as the transportation expenses in both procurement and distribution of milk. For better efficiency and administrative convenience, milk transportation in majority of cases is entrusted to private contractors on an yearly basis. Differences in the density of milk production, road facilities, type of vehicles used, milk yield, density of house-hold, hygiene etc. greatly contribute to the procurement and distribution expenses. Scientific attempts to rationalize the expenditure is necessary to have a check on the above factors.

Much thought has not been given so far for formulating a scientific model in the procurement and distribution stages of milk in dairy plants with a view to minimising costs. At present the procurement of milk in dairy plants is through co-operative societies situated within the milkshed area of 60 to 100 square Kilometers. The distributin of milk is made through booths located at different consuming centres and routes are formed by linking these centres. Milk is collected twice in a day and different kinds of vehicles are used for quick transportation. Normally conventional workable methods are used and milk is being procured from dairy co-operative societies and transported either direct to dairy plant or through chilling plants located en-route. In this context, it is much useful to have a scientific plan which serves quick transportation at minimum cost.

A common procedure for finding a route from a plant to a number of societies / customers is to locate each stop with the aid of a road map. Clusters of stops to be included in a route are then rearranged logically by matching the quantities to be collected / delivered together with the capcities of the available vehicles. Even the most knowledgable and experienced person is not in a position to guarantee that the route system made by him is the best and the cheapest. The use of analytical tools in general is lacking and only a few have attempted to apply them in the actual operations to identify the best among possible alteranative routes. Recently scientific operation research methods have become available in solving this type of problem.

The first optimising model applied was based on the principles of linear programming and transportation algorithems. Routes are obtained by applying transportation techniques, viz, North - West Corner method, Least Cost method and Vogel's Approximation method. The routes obtained by these methods are connecting one origin to one or more destinations. In the case of milk transportation, two or more destinations / origins are procurement and distribution.

The identificaton and encouragement of the reliable and consistent dairy co-operative societies are absolutely essential for the smooth running of dairy plants. In our country, no attempts have been made by the dairy plant to fix up a criterion for the performance rating and grading of dairy co-operative societies. A modified performance rating and grading of dairy co-operative societies based on the different parameters as criteria for selection is very important. The scientific selection thus helps to identify the societies in an objective manner for the satisfactory working of the dairy plants.

Based on the above, the objectives of the present investigation are as follows:

(1) To workout a model for optimising the cost of procurement and distribution of milk.

(2) To identify the potentiality of the dairy co-operative societies and fix up a criterion for performance rating.

(3) To isolate the constraints influencing efficient milk transportation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In earlier days, for route transportation problems, routes were formed by the visual inspection of customer locations on a road map. The routes obtained by this visual inspection method were optimum for smaller problems. But for larger problems, the routes were not found to be optimum. Considerable effort and time would normally be required to find solutions under this method. Even now, some of the route planners use this method for route formation in the fields such as collection and distribution of milk, physical distribution systems etc.

With the advent of linear programming techniques, more and more investigations on its practical application were studied by different researchers. Literature pertaining to route transportation, economic parameters in the efficient transportation of milk and performance rating and grading technique have been reviewed in the various sections as follows:

1. General transportation problem.
2. Travelling Salesman Problem.
3. Vehicle Scheduling Problem.
4. Economic parameters in the transportation of milk.
5. Performance rating and grading.

2.1. General transportation problem.

Transportation probelms has its origin in devising a schedule for shipping products from origins to destinations where unit cost for shipping the product from any origin to any destination is known. Also the quantity available at each origin and quantity required at each destination should be known.

Wagner (1973) illustrated an example of transportation problem in a large dairy farm, the Saur milk company, U.S.A., which involved a number of daily plants and distribution centres. This problem was analysed by means of transportation algorithem.

Gupta and Mathur (1979) conducted a study for the optimum location of warehouses in a physical distribution system in a sector of giant public sector undertaking engaged in a mass movement of passenger and goods traffic. To decide optimum number and location of 18 main depots/ warehouses, a linear programming model was used. The results arrived at by the above model clearly identified warehouses and their corresponding area to be served, considering minimum distance and minimum cost as major criteria.

Singh et al (1984) conducted a study on the wheat movement in different markets in the Punjab state. A mathematical linear model was used for the optimal movement of wheat from various markets of Punjab to 12 exporting points and to five receiving points in India was developed. Optimal movement of wheat in order to minimise the transportation cost could be worked out.

2.2. Travelling Salesman Problem.

A Travelling Salesman Problem (TSP) is defined as a method to select a route from a salesman's homecity which passes through all cities to be visited once and only once and returning to his homecity covering the shortest distance. Different approaches have been suggested to solve TSP and they differ on the size and nature of the problem.

Little et al (1963) developed a branch and bound algorithem for solving TSP which guaranteed the optimality of the solution. By this method, the space of all feasible solutions is repeatedly partitioned into smaller and smaller subsets (branching) and a lower bound is calculated for the cost of solutions within each subsets (bounding). After each partitioning, those subsets that exceed the cost of a known feasible solution are excluded from all further partitioning. Partitioning is continued until a feasible solution is found such that its cost is not greater than the bound of any subsets. The algorithem could be extended to the size of the problem that could be reasonably solved without using special methods to a perticular problem.

In a survey on branch and bound methods Lawler and

Wood (1966) compared the procedure suggested by Little *et al* (1963) with dynamic programming approaches in solving TSP. They concluded that computational time was less for larger problems in case of using the procedure suggested by Little *et al* (1963) than dynamic programming approach.

Ackoff and Sesieni (1968) explained the computational steps for the procedure suggested by Little *et al* (1963) with a suitable example. They suggested that it was the best method for solving larger TSPs.

Bellmore and Nehauser(1968) compared the three methods, viz, dynamic programming, linear programming and branch and bound technique for solving TSP. They recommended dynamic programming for smaller problems over branch and bound techinque, eventhough expected time for solving the problem was too high and for larger problems, branch and bound techinque was suggested.

Narang and Pandit (1984) analysed salesman routing problem as an integer programming problem using branch and bound algorithem and studied the routing problem of products of a private undertaking company in India. The objective of their problem was to minimise the total distance travelled of sales engnieers with a view to minimising the journey cycle.

Gupta and Gupta (1984) presented a case study which was conducted in Eastern Railways, India to determine minimum time consuming van routes for distribution of the items stocked at a depot to various demand centres, which engaged in the maintanence of the rolling stock.

2.3. Vehicle Scheduling Problem

The Vehicle Scheduling Problem (VSP) can be defined as the problem of designing routes for delivery/ collection vehicles of known capacities operating from a central / single depot to supply /collect one type of goods to a set of customers with known locations and known demand / availability. Routes for vehicles are designed in such a way as to minimise the total distance travelled. VSP is similar to that of TSP if there is one vehicle and no constraints.

The first published attempt to obtain a sound basis of this problem was developed by Dantzig and Ramser (1959). They gave more emphasis for filling the vehicle to near capacity than to minimising the distance covered.

Balinski and Quant (1964) observed the actual truck dispatching delivery problem of general applicability as an integer programming problem. The structure of the general problem was shown to be natural generalisation of the covering problem of the graph theory.

Clarke and Wright (1964) developed an iterative procedure for optimum or near optimum routes to a fleet of vehicles of varying capacities from a central depot to a number of delivery points. Linking the delivery points into a route was based on the saving in distance,

$$S_{ij} = d_{0i} + d_{0j} - d_{ij}$$

where d_{0i} is the distance between depot and i^{th} demand point, d_{0j} is the distance between depot and the j^{th} demand point and d_{ij} is the distance between i^{th} and j^{th} demand points. The results obtained by using this method were found to be better than the method suggested by Dantzig and Ramser (1959).

Gaskel (1967) discussed the bases for the allocation of customers to various routes. Five methods, viz, saving multiple, saving sequential, λ multiple, π multiple and visual were considered and applied in six cases. Except visual method, other methods were extensions of the method suggested by Clarke and Wright (1964). The results indicated that no basis was found superior to the others in all cases and the method suggested by Clarke and Wright (1964) was found to be reasonable one to use in all aspects.

Schrubein and Cliffon (1968) illustrated the computational steps for the method suggested by Clarke and Wright (1964) taking three theoitical problems which were constrained, non-constrained and general problem.

Christofides and Eilon (1969) compared three methods of VSP, viz, branch and bound technique, saving method suggested by Clarke and Wright (1964) and 3-optimal method. From this study they concluded that the 3-optimal method was better than other methods, eventhough computational time was very high. Computational time for saving method was found to be the least.

Wren and Holliday (1972) developed a heuristic method for solving VSP for one or more depots. In this method the routes obtained in the initial solution / random solution were refinedby seven procedures such as Inspect, Single, Pair, Complain, Delete, Combine and Desentangle until no improvement in results could be obtained. By comparing with other methods, this method gave better results for larger problems eventhough the method was complicated and time taken for analysis was too large.

Webb (1972) tested the relative performance of several sequential methods of planning VSP and concluded that the method suggested by Clarke and Wright (1964) perform better than other methods.

Mc Donald (1972) used the method suggested by Gaskel (1967) for the introductin and maintanence of a medical specimen collection service.

Gillet and Miller (1974) introduced and illustrated an efficient heuristic algorithem which is known as sweep algorithem. Eventhough the method gave better results than other methods, it was found to be computationally not efficient.

A computerised routing algorithem was developed by

Grisson and Hardy Jr. (1976) based on the method suggested by Clarke and Wright (1964) for collecting and disposing of solid waste materials. Choosing this method by arguing that it would perform better than any other alternative.

Foster and Ryan (1976) developed an integer programming formulation for VSP and solved by revised simplex method. The results generally showed an improvement on previously published methods especially for larger problems. Although the approach retained the property of optimality, the rate of convergence was found to be poor and it would be seen that such a method was impractical for all but small problems.

Mole and Jameson (1976) developed a sequential route building algorithem which was the generalisation of the saving method suggested by Clarke and Wright (1964). This method was found to be computationally efficient as evidenced by a study of sensitivity with respect to fleet size, changes in vehicle capacity and a given distance constraint for a single depot problem with 225 customers.

Holmes and Parker (1976) developed an extension of the saving method for VSP and detailed algorithem was presented. Saving method was modified by supressing the selected pair of customers for joining route one by one if it would make any saving in total distance travelled. This method can be applied for both symmetric and non-symmetric VSPs. This method was found to be more efficient than saving method suggested by Clarke and Wright (1964).

In a survey of local delevery routing methodology, Mole (1979) concluded that the systematic construction of efficient vehicle route structures for local delivery operations provided an important tool for control of costs. The design of 'flexible fixed routes' was the real target of the algorithem.

Hardy Jr. (1980) introduced the "Districting Analysis" for VSP, which was grouping the delivery points into groups for making the routes with different constraints. For this cluster analysis is used which is an application of the Lagrangian relation. By taking an urban delivery network of whole sale milk processor problem, he compared the Districting analysis with saving method suggested by Clarke and Wright (1964) and concluded that saving method gave better results.

Finney Jr. (1981) recommanded the method suggested by Clarke and Wright (1964) for scheduling of vehicles in a scientific manner. He concluded that if more constraints were imposed in the problem, then the routing system developed would be apt to deviate from a true optimum result.

Karla and Singh (1984) formulated an optimum milk pick up routes system based on the saving method subject to various conditions and restrictions in National Dairy Research Institute, Karnal. They pointed out that this method does not gaurentee an optimum solution, but it out perform any known alternative.

Beasley (1984) compared three methods for fixed routes, viz, reduction to a single day probelm, adopted saving criterion (saving method) and "r-optimal" algorithem and found that no method was efficient in all problems. But comparatively r-optimal method was found to be better than other methods.

2.4. Economic parameters in the transportation of milk.

The economic parameters depending on the collection and distribution of milk were idenitfied by various researchers.

Madhavan (1978) suggested that a number of societies could be grouped under a milk route depending on

(a) total quantity of milk expected

(b) time taken

(c) total distance to be travelled

and (d) size of the transport vehicle.

He also suggested that flush seasons milk collection should be taken as a criterion and the maximum time permitted was four hours from milking to pasteurisation.

Rao et. al. (1979) concluded in their study on milk transportation that the economic milk transportation depended on

(a) frequency of pick up

(b) load capacity of collection routes

(c) point of pick up

(d) percentage variation between maximum and minimum quantities

(e) the distance of milk collection route

(f) topography of milk shed area

(g) percentage capacity of vehicle used

(h) network and condition of road

and (i) density of milk production.

In this study it was identified that 1/4th cost of procurement of milk was due to transportation cost for transporting milk from collection centre to chilling plant.

Rawat (1979) suggested to re-aligin the collection route in order to reduce the collection costs possibly also by organising a two way traffic, viz, milk to dairy and input to milk producer.

Sandhu (1979) suggested to organise a route in such a way that each vehicle could carry themaximum permissible load and the distance in each trip should not exceed 60 Km.

The economic parameters considered by Rao (1983) for milk transportation are

(a) average milk procurement

(b) sourage

(c) saving through reversion of losses due to sourages

(d) total number of routes

(e) total kilometers saving per day

(f) yearly saving in transportation cost

(g) depreciated value assets of 1000 liters per day milk cooling unit

and (h) cost of the project, i.e, capital recurring.

Kalra (1984) in his study on milk transportation mentioned that cost of procurement was governed by milk prices, size of the milk shed area, milk density and seasonality of milk supply and the saving in distance.

2.5. Performance rating and grading.

Performance rating is the systematic evaluation of individual / firm with respect to his / its performance on the job and its potential for development.

Evaluation methods were suggested by using vendor analysis by Kotler (1972) as a guideline for marketing of products in an industry. A ranking method was suggested for evaluation purposes in these guideline which is of ascending scores.

Khanna (1977) explained the ABC analysis as an inventory control technique for segregating the items from one another and find its worthness in the interest of the organisation. In the ABC analysis, the items are classified into A, B and C classes where A items are high valued, B items are medium valued and C items are low valued.

Kanthiswarup *et al* (1978) explained three techniques of inventory control with selective control. They were

(a) ABC analysis

ABC analysis helps to concentrate efforts in areas which need it most. It gives the most effective and rewarding control with the least amount of controlling.

(b) Usage rate

Here the items were categorised into classes according to the descending order of their usage rate as (1) fast moving items, (2) normal moving items, (3) slow moving items and (4) dead items.

(c) Criticality

When the items are classifed in the descending order of their criticality, namely (1) vital items (2) essential items and (3) desirable items, then a close attention is paid to vital items.

Danyer (1980) explained the job evaluation and grading techniques. The jobs cans be grouped, classified or graded according to their importance and performance. Three methods, viz,the ranking method, the classification method and point system method were generally used in this context depending on the number of jobs graded.

Cunningham and Cunningham (1981) explained five important elements for vendor analysis as

(a) technical and production capacity

(b) financial strength

(c) production reliability

help the manager to apply selection control and focus his attention only on few items. Detailed computational procedure of ABC analysis for performance rating was presented.

(d) delivery reliability

and (e) service capability.

A rating scale was constructed for evaluation of vendors in this context such that the scores alloted to each category were added and finally total ranking were compared.

Ahuja (1983) discussed the performance rating techniques in detail. The traditional performance appraisal systems considered are

(1) Unstructured appraisal

(2) Employees ranking

(3) Graphic rating scales

(4) Check list

(5) Critical incident

and (6) Field review

Because of the judgement role of superiors under traditional system, performance rating are frequently subject to a number of errors and weakness. The advantage of performance rating of individuals are

(a) It helps the supervisors to evaluate the performance and to know potentials of their subordinates systematically and periodically .

(b) Performance rating help in guiding and correcting the employees / firms.

(c) Ability of the personnel is recognised.

Gopalakrishnan and Sundaresan (1984) considered ABC analysis as a basic analytical management tool. This will

MATERIALS AND METHODS

MATERIALS AND METHODS

Materials.

The materials for the study were the data of collection of milk by Pattikad chilling plant and distribution of milk by Thirur - Palghat distribution route of Palghat Dairy and data from the collection routes of Chalakudy chilling plant of Ernakulam Dairy, both units functioning under Kerala Co-operative Milk Marketing Federation (Milma). The milk collection routes of Pattikad chilling plant organised through 11 dairy co-operative societies in morning and evening and that of Chalakudy chilling plant organised through 47 dairy co-operative societies in the morning. Four months data, relating to April, May, October and November 1986, on daily supply of milk for all societies were collected. Since evening milk collection of the Chalakudy chilling plant became operational from December 1986, the maximum quantity of milk supplied in December by all 24 societies in the evening collection were collected. The quantity of milk to be supplied to 14 booths in Thirur- Palghat route was collected. The distance between societies / booths in each route were collected from dairy records, road maps and other sources of information.

Six months data, viz, June, July, August, September, October and November 1986, on daily supply of milk to chilling plant, total production of milk, Fat, SNF and number of producers of 44 dairy co-operative societies were collected for the analysis of performance rating and grading of dairy co-operative societies.

Methods

3.1. Identification of major constraints.

The major factors affecting the routes for the transportation of milk from dairy co-operative societies to chilling plants / dairy plant are the capacity of the vehicle used for transportation, total distance / time taken for transportation in a route and the season of the year.

3.1.1. Determination of the capacity of the vehicle.

Milk is transported by trucks in cans usually of 40 litres capacity. The number of cans that can be accomodated in a truck was taken as the capacity of the truck.

3.1.2. Determination of maximum distance allowed in a route.

Since milk is highly perishable, it should be transported to the chilling plant/ dairy plant within 4 1/2 hrs. after milking. Therefore the maximum route time for transportation of milk is taken as 4 hrs. The maximum time taken for loading and unloading a can is 1/2 minute. For each vehicle, maximum loading and unloading time is calculated as N/120 hrs, where N is the capacity of the vehicle in terms of number of cans. Giving a small time allowance of d hrs., the maximum time that can be taken for the vehicle in a route is,

$$K = 4 - N/120 - d \text{ hrs.}$$

Depending on the condition of the roads, the maximum distance that can be travelled by trucks within K hrs.was computed. It ia considered as the distance and time constraint value.

3.1.3. Determination of expected availability of milk per day for each dairy co-operative society.

For the construction of milk routes, the expected availability of milk for each society was taken as the maximum milk supplied per day by the society in the previous year. This is an over estimate because all the societies cannot supply maximum quantity of milk on the same day and in all days. So in order to estimate the expected availability of milk, the year was divided into two seasons, viz, Flush Season (June, July, October, November, December and January) and Lean Season (August, September, February, March, April and May). From the flush season two months were selected based on the highest supply of milk per day and median and third quartile values of the daily supply of milk was computed. Similarly, based on the least supply of milk, two months were selected from lean season and median and third quartile values computed. Expected availability of milk lies between the median value of the lean season and third quartile value of the flush season. Therefore two milk routes were considered seperately for each season with median and third quartile values as expected availability. Usually milk was transported by trucks in cans. Therefore the availability of milk is expressed in terms of number of cans. Since 40 kg of milk can be filled in a can, expected availability of milk is divided by 40 to get the number of cans. If this value is not an integer, the next integer value is taken as the number of cans.

In the case of distribution routes, the quantity required in each booth is known and fixed. This value is expressed in terms of number of cans.

3.2. Vehicle Scheduling Models.

A number of trucks of capacity C and number of cans q_i for i^{th} society are available, where $i = 1,2,3,\ldots\ldots,n$. Construct the distance matrix $D = (d_{ij})$, $i,j = 0, 1,2,3,\ldots\ldots,n$, where d_{ij} is the distance between i^{th} and j^{th} points where 0 is the dairy / chilling plant and $1,2,3,\ldots\ldots,n$ are the societies. It is required to minimise the total distance covered by the trucks.

It is assumed that the value of q_i's are such that an initial allocation of one vehicle to each society is possible. If this is not true, it is assumed that an allocation can be made by splitting load into two or more full trucks of highest capacities available and only considering the reminder of that load, an amount less than a truck load of highest capacity.

Three models were considered for the construction of routes. They are,

3.2.1. Model I

Clarke and Wright (1964) suggested the model,

$$S_{AB} = d_{OA} + d_{OB} - d_{AB}$$

where d_{AB} is the distance between A^{th} and B^{th} society, d_{OA} is the distance between origin and A^{th} society and d_{OB} is the distance between origin and B^{th} society. S_{AB} is a suitable measure of priority of the linkage A and B. The mileage saved is S_{AB} if a route previously ending at A is extended by the addition of B as a new end point and simple route involving B alone is avoided.

The measure S_{AB} has the following properties.

(i) If a route consists of points A, B, C,......,P in the order stated, then the total saving, when the alternative is a series of simple routes, is the sum of the saving S_{AB} + S_{BC} + ...+ S_{OP} .

(ii) The added mileage to a route when B is added to end points is $2(d_{OB} - S_{AB})$

(iii) The saving is a symmetrical function of the two points A and B relative to the dairy / chilling plant.

3.2.2. Model II

Gaskel (1967) suggested the model,

$$\lambda_{AB} = S_{AB} \left(\bar{d} + \left| d_{OA} - d_{OB} \right| - d_{AB} \right)$$

where $S_{AB} = d_{OA} + d_{OB} - d_{AB}$

$\bar{d}$ = average d_{Oi}

λ_{AB} has a variable search pattern depending on the relative magnitude of $\bar{d}$ and d_{OA} . If $d_{OA} > d_{OB}$, then the term in brackets is $\bar{d}$ less distance added to the route by the introduction of Bas a new end point. λ_{AB} is a symmetrical function.

3.2.3. Model III

Gaskel (1967) suggested the model,

$$\pi_{AB} = 2\, d_{OB} - (d_{OB} + d_{AB} - d_{OA}) - d_{AB}$$

$$= d_{OA} + d_{OB} - 2\, d_{AB}$$

$$= S_{AB} - d_{AB}$$

π_{AB} is given greater emphasis to the distance apart. This is also a symmetrical function.

Both λ_{AB} and π_{AB} give greater priority to points on the dairy / chilling plant side of the end point of A.

3.3. Construction of Route.

Let C be the capacity of the vehicle and D be the maximum distance that can be travelled by the truck in a route.

For each model, routes were constructed as follows:

Step I.

Considering all the societies are in simple routes, compute the distance T of the initial solution as

$$T = \sum_i d_{0i} + \sum_j d_{0j}$$

Step II.

Determination of the candidate pairs.

Model value is computed for all pairs of societies except the origin (dairy / chilling plant) and values are arranged in decending order of magnitude. If two values are equal, priority is given to the pair which has least distance apart.

Step III.

Starting from the top of the list of the model values, choose the pair of points (i, j) which has maximum model value. Join the points on a route,

III.1 If neither of the points is an end point of a route and are unassigned, construct a new route Z and compute the expected number of cans in that route Q_Z such that

$Q_Z = q_i + q_j$ and route Z as

0 - i - j - 0 with end points i and j and distance travelled D_Z as

$$D_Z = d_{0i} + d_{ij} + d_{0j}$$

Go to step III.5.

III.2. If one of the point j is currently an end point of a route, say Z, and the other point i is an unassigned point, attempt to join the unassigned point i to the route Z.

Compute total expected number of cans, Q_Z such that

$Q_Z = Q_Z + q_i$

Now route Z as

$0 - i - Z$ with new end point i in place of j and distance travelled D_Z as

$D_Z = D_Z - d_{0j} + d_{0i} + d_{ij}$

Go to step III.5

III.3. If both points i and j are the end points of the two routes say U and V, attempt to join both routes U and V into a single route say Z.

Compute total expected number of cans as

$Q_Z = Q_U + Q_V$

Route as U - V with end points as the end points of U and V other than i and j and the total distance travelled as

$D_Z = D_U + D_V - d_{0i} + d_{ij} - d_{j0}$

Go to step III.5

III.4. If the pair (i,j) does not satisfy steps III.1, III.2 and III.3 it is removed and next pair of points which has next maximum model value is taken from the list and proceed step III.1 until all the pairs of points are exhausted.

III.5. Check the capacity and distance restrictions. If both restrictions are satisfied, the pair (i,j) is accepted and assign the points as joined, otherwise remove the pair. Then next pair of points is taken from the list and same procedure is repeated starting from step III.1. until the list is exhausted.

Step IV. The total distance travelled is computed as the sum of the distance travelled for all routes as $\sum_i D_i$. This is compared with initial distance and less distance routes are accepted. Let the total distance travelled in the selected routes be T.

Routes were formed for each season with median and third quartile values as expected availa bility of milk.

Gaskel (1967) suggeted to apply Travelling Salesman Problem technique in the routes obtained by the models II and III because the routes need not be optimum. Here Travelling Salesman Problem techinique was applied to the routes obtained by all the models.

3.4. Travelling Salesman Problem (TSP).

The TSP is stated as follows. A salesman has a number of cities that he must visit. He knows the diatance or time or cost of travel between every pair of cities. His problem is to select a route that starts from his nome city, passes through each city once and only once and returns to home city in the shortest possible distance.

TSP is a linear programming problem, which is an extension of the transportation problem. Mathematically TSP is defined as,

$$\text{Minimise} \sum_i \sum_j d_{ij} x_{ij} \qquad i,j = 1,2,3,\ldots\ldots.n.$$

Subject to

$$\sum_j x_{ij} = 1 \quad \text{for all } i$$

$$\sum_i x_{ij} = 1 \quad \text{for all } j$$

$$x_{ij} = 0 \text{ or } 1 \quad \text{for all } i \text{ and } j$$

and $$d_{ii} = \infty \quad \text{for all } i$$

where $X = (x_{ij})$ is the tour assignment

$D = (d_{ij})$ is the distance or cost or time matrix.

If only two cities are involved, there is no other choice of the route. If three cities are involved, one of which, A, is the home base, there are two possible routes ABC and ACB. Similarly for 4 cities, 6 possible routes exist. In general, if there are n cities, there are (n-1)! possible routes. The problem is to select the best route without trying each one.

If the distance or cost or time between every pair of cities is independent of the direction of travel, the problem is said to be symmetrical. If for one or more cities, the distance or cost or time varies depending on the direction, the problem is said to be assymmetrical.

An iterative procedure, which is an extension of the branch and bound techinique developed by Little et. al.(1963) was used for solving the TSP. The algorithem is given as follows.

Let S(0) be the set of all possible tour to an n X n

TSP with distance matrix (d_{ij}). There are (n-1)! tours in S(0).

Step.I.

Reduce the distance matrix until there is a zero in every row and column by subracting the smallest element in each row from every element in the row and then subtracting the smallest element in each column of the remaining matrix from each element in the column. The total reduction, r, is the sum of the amounts subracted. Let the resulting matrix be (d_{ij}^1).

Step. II.

For each zero element in (d_{ij}^1), record the penalty (p_{ij}) for nonuse. If the link (h,k) is not used, then some element in row h and some element in column k is used. Thus cost of not using (h,k) is atleast the sum of the smallest elements in row h and in column k, excluding d_{hk}^1 itself. Thus,

$$p_{ij} = \mathrm{Min}_{j \neq k} (d_{hj}^1) + \mathrm{Min}_{i \neq h} (d_{ik}^1)$$

Step III.

Let (h,k) be the zero entry with largest penalty. In the case of a tie, select arbitararily. Then partition the set S(0) of all possible routes into those that contain the link (h,k) and those that do not. Let these subsets be S(h,k) and $\overline{S(h,k)}$.

Step IV.

Computation of lower bounds on the distance of all routes in each subset.

IV.1. The lower bound $\overline{Q(h,k)}$ of $\overline{S(h,k)}$ is given by

$$\overline{Q(h,k)} = r + p_{hk}$$

IV.2. To compute a lower bound for S(h,k), it is observed that if the link (h,k) is used, the link (k,h) cannot be used. If both (k,h) and (h,k) is used, it would gofrom h to k and back again to h without visiting the other cities. To avoid this subtour, set the distance $d_{kh}{}^{1} = \infty$, if the link (h,k) is used. Once the link (h,k) is used, any other link in row h and column k is not used. Hence delete the row h and column k. In the remaining martix select an element from each row and column sothat the distance will be atleast the amount by which the remaining matrix can be reduced. Let this be r_{hk}. Then the lower bound Q(h,k) for S(h,k) is given by

$$Q(h,k) = r + r_{hk}$$

Step.V.

Select S(h,k) or $\overline{S(h,k)}$ for further partitioning according as Q(h,k) or $\overline{Q(h,k)}$ is smaller. If S(h,k) is selected, return to step II using the reduced matrix obtained in step IV.2. If $\overline{S(h,k)}$ is selected,return to the matrix (d'_{ij}),set $d'_{ij} = \infty$ and reduce the resulting matrix. Return to step II,using the matrix obtained.

Step VI.

Let (u,v) be the cell that has the largest penalty p_{uv}. Partition again into sets that contain (u,v) and those that do not.

Step VII.

Compute the lower bound for the new sets. Let Q^1 be the lower bound on the set to be partitioned.

VII.1. For the set excluding (u,v) the lower bound is Q, where $Q = Q^1 + p_{uv}$

VII.2. For the set including (u,v), delete row u and column v. Find the element (x,y) that together with (u,v) and the element previously included would make a subtour.

(To find the link that would complete a subtour, it is useful to introduce the concept of a chain. A single link is a chain of length k when there are links of the form (a,b), (b,c), (c,d),........., (g,h), (h,j) comprising k links. When an additional link (j,l) to be added, exclude the link (l,a) to avoid the subtour. Similarly a link to be added which joins two chains, for example, add (h,u) to the chains (a,b), (b,c),........., (g,h) and (u,v), (v,w),............, (y,z). In this case delete the link (z,a).). Set the distance (x,y) equal to infinity. Reduce the matrix. Let r_{uv} be the reduction, then $Q = Q^1 + r_{uv}$.

Go to the step V until all the points taken into the tour. The subset of S(0) obtained have least lower bound. The subset contained a single tour whose distance equal to the lower bound and all other tours belong to subsets whose lower bounds are greater than the one obtained. Hence the tour obtained is optimal.

The routes obtained by the models after applying Travelling Salesman Problem algorithem for each route, were compared and the best model is selected on the basis of total distance travelled.

3.5. Refinement method.

The best model selected for each case were refined by the refinement method suggested by Holmes and Parker(1976). In this method, each pair of points selected for route building were supressed in the order they were obtained for joining. The steps involved in this method are given as follows.

Step I.

Initilise the supression counter L at 1 and maximum number of pairs of points selected for the construction of routes as L^1. Let $T^1 = T$ be the total distance travelled in the initial solution. Maintain all routes and the order in which points were joined. Then go to step III.

Step II.

II.1. If $T <= T^1$, set $T^1 = T$, $L = 1$, L^1 = the number of pairs of points in the current solution and supress the pair of points (i,j) permanently in all subsequent solutions. Maintain the routes formed and the order in which points were joined. Go to step III.

II.2. If $T > T^1$, then $L = L + 1$

Step III.

III.1. If $L = 1$, supress the pair of points joined first say (i,j) in the current solution temperarily and form new routes by method presented in 3.3 and return to step II.

III.2. If $L < L^1$, supress the pair of points joined next in the current solution temperarily and form new route by the method presented in 3.3 and return to step II.

III.3. If $L = L^1$ or if all joined pairs in the current solution have been supressed, terminate the procedure and save the best solution.

Apply the TSP technique to the best routes obtained by the refinement method to check whether any improvement is possible within the selected routes.

3.6. Performance rating and grading the co-operative societies.

A modified vendor rating method was used for the analysis of performance rating and grading of dairy co-operative societies. This method discussed about different parameters and corresponding subjective ratings and rankings. Important parameters were given higher weight and total scores for each society were worked out.

The seven parameters used for this analysis for each society were, (1) the quantity of milk supplied to dairy in Kg/day, (2) consistency in supply expressed in terms of coefficient of variation, (3) percentage of supply based on total production, (4) number of producers, (5) distance to chilling plant in Kilometers, (6) milk fat in percentage weight and (7) SNF in percentage weight. Societies were ranked based on the these parameter values & subjective weight was given based on its importance. The total rating for each society was calculated as follows:

No.	Parameter	Index	Weight		Rating
1.	Quantity	Q_1	Q		Q_1 X Q
2.	Consistancy	C_1	C		C_1 X C
3.	%age of supply	P_1	P		P_1 X P
4.	Fat	F_1	F		F_1 X F
5.	SNF	S_1	S		S_1 X S
6.	No. of producers	N_1	N		N_1 X N
7.	Distance	D_1	D		D_1 X D
				Total score	A_1

Total score alloted by the above method determined the performance of each society. Based on the total score, societies were classified and graded as A, B, C and D.

RESULTS

RESULTS

The collection and distribution arrangements of Palghat and Ernakulum dairies of Kerala Co-operative Milk Marketing Federation formed the material for this study. Two milk collection routes and one milk distribution route were taken to workout optimised routes in the present study. The results obtained in each case are given as follows.

4.1. Milk collection routes.

(a) Pattikad chilling plant.

The milk procurement of Pattikad chilling plant is organised by 11 co-operative societies giving milk both in the morning and the evening. The procurement is arranged at 14 collection centres. The routes thus formed for both morning and evening procurement connected all these collection centres. These centres are numbered for identification and given in appendix A. The road map and distance matrix are also shown in appendix A.

The vehicle used for transportation of milk from the collection centre to the chilling plant had the capacity to accomodate 50 cans of 40 litres each.

Time taken for loading and unloading 50 cans was 25 minutes. Giving a time allowance of 15 minutes, the maximum time taken for a vehicle transporting milk in one route was restricted to 3 hours and 20 minutes. Taking an average speed of the vehicle as 30 Km./hr., the maximum distance that can be travelled in one route by the vehicle within 3 hours and 20 minutes was taken as 100 Km.

Two months, October and November, were selected from flush season, being maximum supply in the flush season months during previous year. Similarly the months April and May were selected from lean season because of lowest supply of milk by each society. Median and third quartile values of the daily milk supply of the two selected months of each society were computed for each season. These values in terms of number of cans are given in appendix A.

Morning routes.

Routes were formed by the three models with median and third quartile values of daily supply of milk as expected availability for each society sepeartely for each season.

Flush season

The routes formed with median value as expected availability by each model are given in table 1.

An attempt was made using Travelling Salesman Problem technique to find out whether any rearrangement within routes for reducing the distance travelled is possible. This technique did not yield any improvement in the

Table 1. Morning routes of the Pattikad chilling plant in the flush season - Median value as expected availability

Model	No.	Route	Distance (Km.)	Load (cans)
I	1	0-9-12-11-10-13-14-0	30	49
	2	0-1-2-3-4-5-8-6-7-0	35	44
		Total	65	93
II	1	0-8-13-14-10-11-12-6-0	25	45
	2	0-1-2-3-4-5-9-7-0	41	48
		Total	66	93
III	1	0-14-13-10-11-12-6-7-0	30	45
	2	0-1-2-3-4-5-8-9-0	36	48
		Total	66	93

arrangement of routes. Since the routes obtained by the model I had least distance, it was selected for applying refinement method. There was no reduction in total distance travelled by using refinement method in this model.

Routes obtained by all the models when third quartile value as expected availability of milk for each society in the flush season are given in table 2.

There was no reduction in distance travelled within routes by applying TSP technique. Model I was selected for applying refinement method because the routes obtained by the model I had least total distance. No reduction in total distance travelled was found possible.

Table 2. Morning routes of the Pattikad chilling plant in the flush season - Third quartile value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)
I	1	0-7-6-12-11-10-13-14-0	30	47
	2	0-1-2-3-4-5-8-9-0	36	50
		Total	66	97
II	1	0-8-13-14-10-11-12-6-0	25	47
	2	0-1-2-34-5-9-7-0	41	50
		Total	56	97
III	1	0-14-13-10-11-12-6-7-0	30	47
	2	0-1-2-3-4-5-8-9-0	36	50
		Total	66	97

Lean season.

In this season, the total number of cans expected from all societies were 38 and 45 for median and third quartile values respectively as expected availability of milk. The routes obtained with median and third quartile values for each model were same. The routes obtained by each model are given in table 3.

By applying TSP technique within routes for checking the possible reduction in distance travelled, routes formed by the model II and III were subjected to reduction in

Table 3. Morning routes of the Pattikad chilling plant in the lean season.

Model	No.	Route	Distance (Km.)
I	1	0-1-2-3-4-5-8-9-12-11-10-13-14-6-7-0	57
II	1	0-7-6-9-8-13-14-10-11-12-5-4-3-2-1-0	58
III	1	0-1-2-3-4-5-6-7-9-8-12-11-10-12-14-0	62

distance travelled. The routes obtained in the lean season after applying TSP technique are given in table 4.

Table 4. Morning routes of the Pattikad chilling plant in the lean season - After applying TSP technique.

Model	No.	Route	Distance (Km.)
I	1	0-1-2-3-4-5-8-9-12-11-10-13-14-6-7-0	57
II	1	0-1-2-3-4-5-8-9-12-11-10-13-14-6-7-0	57
III	1	0-1-2-3-4-5-8-9-12-11-10-13-14-6-7-0	57

No reduction in distance travelled was found by applying refinement method in model 1.

<u>Evening routes.</u>

The total number of cans expected from all societies in the evening collection are as follows:

Season	Total no. of cans
Flush season	
(1) Median value as availability	33
(2) Third quartile value as availability	33
Lean season	
(1) Median value as availability	15
(2) Third quartile value as availability	17

The total number of cans in each case was less than the capacity of the vehicle used for transportation. The routes obtained in all cases were same as shown in the table 3. The routes obtained by applying TSP technique was same as given in table 4 and no reduction in total distance travelled was found in the routes obtained by the model I after applying refinement method.

The routes obtained by model I is suggested for the transportation of milk in this plant for each season depending on the availability of milk.

No fixed routes were arranged in this plant for the transportation of milk. The routes, which were used depending on the availability of the milk are same as the routes suggested.

(b) Chalakudy chilling plant.

Milk procurement at Chalakudy chilling plant was organised by 47 diary co-operative societies to give milk in the morning. Out of the 47 societies, evening collection was confined to only 24 societies. All these societies have been numbered and given in appendix B. Road map and distance matrix of these societies are also shown in appendix B.

Only one type of vehicle is available for the transportation of milk in this plant. The capacity of the vehicle determined in terms of number of cans, was 54. As in the case of Pattikad chilling plant, average speed of the vehicle was taken as 30 Km./hr. and the maximum distance that can be travelled in a route by the vehicle as 100 Km.

The months, October and Novemeber, were selected from flush season and April and May, were selected from lean season and the median and third quartile values of daily supply of milk were taken as expected availability similar to that of Pattikad chilling plant. These values are given in appendix B.

Morning routes.

Routes were formed by the three models with median and third quartile values as expected availability of milk for each season seperately.

Flush season

(1) Median value as expected availability of milk.

The routes formed in this case by the three models are given in table 5.

There was reduction in the distance travelled in routes by applying TSP technique. The routes after applying TSP technique are given in table 6.

Model I was selected for applying refinement method. The routes obtained by applying refinement method are given in table 7. These routes were again rearranged by applying TSP technique but no reduction in distance was noticed.

(2) Third quartile value as expected availability of milk.

The routes obtained in this case for each model are given in table 8 and routes obtained after applying TSP technique to each route are given in table 9.

Model I was selected for applying refinement method. No reduction in total distance was noticed in this case.

Lean season.

(1) Median value as expected availability of milk.

The routes obtained in this case by the three models are given in table 10. Applying TSP technique for each route, the resultant routes are given in table 11.

Model I was selected for applying refinement method. Routes obtained after applying refinement method are given in table 12. By applying TSP technique to these routes no reduction in distance was noticed.

Table 5. Morning routes of the Chalakudy chilling plant in the flush season - Median value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)
I	1	0-46-45-43-44-42-41-40-39-37-36-38-0	92.5	39
	2	0-19-18-17-15-16-6-7-5-4-3-2-1-8-9-0	95.5	54
	3	0-22-23-24-25-26-10-11-12-13-14-20-21-47-0	83.5	41
	4	0-35-27-28-29-30-31-32-33-34-0	44	42
		Total	315.5	176
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	39
	2	0-12-8-9-1-2-3-4-5-6-7-15-16-0	89	48
	3	0-22-23-24-25-26-10-11-13-14-20-19-18-17-21-47-0	99.5	47
	4	0-34-33-31-32-29-30-28-27-35-0	49	42
		Total	328	176
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	31
	2	0-12-9-8-4-5-6-7-15-16-17-18-19-20-0	71	52
	3	0-1-2-3-11-10-26-25-24-23-22-0	99.5	29
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0	24	52
	5	0-13-14-21-0	24	12
		Total	349	176

Table 6. Morning routes of the Chalakudy chilling plant in the flush season after applying TSP technique - Median value as expected availability.

Model	No	Route	Distance (Km.)	Load (cans)	Distance reduced. (Km.)
I	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	39	2
	2	0-19-18-17-15-16-6-7-5-4-3-2-1-8-9-0	95.5	54	0
	3	0-22-23-24-25-26-10-11-12-13-14-20-21-47-0	83.5	41	0
	4	0-35-27-28-29-30-31-32-33-34-0	44	42	0
		Total	313.5	176	2
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	39	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-0	83.5	48	5.5
	3	0-22-23-24-25-26-10-11-13-14-20-19-18-17-21-47-0	99.5	47	0
	4	0-34-33-32-31-30-29-28-27-35-0	44	42	5
		Total	317.5	176	10.5
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	31	0
	2	0-12-9-8-4-5-6-7-16-15-17-18-19-20-0	70.5	52	0.5
	3	0-1-2-3-11-10-26-25-24-23-22-0	99.5	29	0
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0	64	52	0
	5	0-13-14-21-0	24	12	0
		Total	348.5	176	0.5

Table 7. Morning routes of the Chalakudy chilling plant in the flush season after applying refinement method - Median value as expected availability

Supression levels	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
(37,39)	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	39	2
	2	0-19-18-17-15-16-6-7-5-4-3-2-1-8-9-0	95.5	54	
	3	0-22-23-24-25-26-10-11-12-13-14-20-21-47-0	83.5	41	
	4	0-35-27-28-29-30-31-32-33-34-0	44	42	
		Total	313.5	176	

Table 8. Morning routes of the Chalakudy chilling plant in the flush season - Third quartile value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)
I	1	0-46-45-43-44-42-41-40-39-38-37-36-0	92.5	42
	2	0-15-16-6-7-5-4-3-2-1-8-9-12-0	82.5	53
	3	0-22-23-24-25-26-10-11-13-14-17-18-19-20-21-47-0	99.5	53
	4	0-35-27-28-29-30-31-32-33-34-0	44	46
		Total	319.5	194
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	42
	2	0-12-8-9-1-2-3-4-5-6-7-15-16-0	89	53
	3	0-22-23-24-25-26-10-11-13-14-20-19-18-17-21-47-0	99.5	53
	4	0-34-33-31-32-29-30-28-27-35-0	49	46
		Total	328	194
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	34
	2	0-9-8-4-5-6-7-15-16-17-18-19-20-0	77	54
	3	0-1-2-3-0	58	10
	4	0-22-23-24-25-26-10-11-12-13-14-21-47-46-45-0	96.5	50
	5	0-35-27-28-29-30-31-32-33-34-0	44	46
		Total	360	194

Table 9. Morning routes of the Chalakudy chilling plant in the flush season after applying TSP technique - Third quartile value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)	Distance reduced. (Km.)
I	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	42	2
	2	0-15-16-6-7-5-4-3-2-1-8-9-12-0	83.5	53	0
	3	0-22-23-24-25-26-10-11-13-14-17-18-19-20-21-47-0	99.5	53	0
	4	0-35-27-28-29-30-31-32-33-34-0	44	46	0
		Total	317.5	194	2
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	42	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-0	83.5	53	5.5
	3	0-22-23-24-25-26-10-11-13-14-20-19-18-17-21-47-0	99.5	53	0
	4	0-34-33-32-31-30-29-28-27-35-0	44	46	5
		Total	317.5	194	10.5
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	34	0
	2	0-9-8-4-5-6-7-16-15-17-18-19-20-0	70.5	54	0.5
	3	0-1-2-3-0	58	10	0
	4	0-22-23-24-25-26-10-11-12-13-14-21-47-46-45-0	96.5	50	0
	5	0-35-27-28-29-30-31-32-33-34-0	44	46	0
		Total	359.5	194	0.5

Table 10. Morning routes of the Chalakudy chilling plant in the lean season - Median value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)
I	1	0-46-45-43-44-42-41-40-39-37-36-38-0	92.5	41
	2	0-47-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8-9-12-0	98.5	50
	3	0-22-23-24-25-26-10-11-13-14-0	68.5	18
	4	0-35-27-28-29-30-31-32-33-34-0	44	35
		Total	303.5	144
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	41
	2	0-12-8-9-1-2-3-4-5-6-7-15-16-11-10-0	91.5	39
	3	0-22-23-24-25-26-35-27-28-30-29-32-31-33-34-0	94	41
	4	0-47-21-17-18-19-20-14-13-0	47	23
		Total	323	144
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	34
	2	0-12-9-1-2-3-8-4-5-6-7-15-16-17-18-19-20-14-13-0	97	51
	3	0-22-23-24-25-26-10-11-21-0	73.5	14
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0	64	45
		Total	325	144

Table 11. Morning routes of the Chalakudy chilling plant in the lean season after applying TSP technique - Median value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
I	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	41	2
	2	0-47-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8-9-12-0	98.5	50	0
	3	0-22-23-24-25-26-10-11-13-14-0	68.5	18	0
	4	0-35-27-28-29-30-31-32-33-34-0	44	35	0
		Total	301.5	144	2
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	41	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-11-10-0	86	39	5.5
	3	0-22-23-24-25-26-35-27-28-29-30-31-32-33-34-0	89	41	5
	4	0-47-21-17-18-19-20-14-13-0	47	23	0
		Total	312.5	144	10.5
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	34	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-17-18-19-20-14-13-0	95.5	51	1.5
	3	0-22-23-24-25-26-10-11-21-0	73.5	14	0
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0	64	45	0
		Total	323.5	144	1.5

Table12. Morning routes of the Chalakudy chilling plant in the lean season after applying refinement method - Median value as expected availability

Supression levels	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	41	
(37,39) & (8,12)	2	0-47-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8--9-11-10-0	99	54	3
	3	0-22-23-24-25-26-36-27-28-29-30-31-32-33-34-0	89	41	
	4	0-12-13-14-0	22	8	
		Total	300.5	144	

(2) Third quartile value as expected availability of milk.

The routes obtained in this case by each model are given in table 13. The routes obtained after applying TSP technique for each route are given in table 14.

Model I was selected for applying refinement method. Routes obtained in this case are given in table 15. By applying TSP technique for each route in this case, routes obtained were same as in table 15.

The existing routes in the plant are given in table 16. There is a saving of 6 Km./day if the routes obtained by the model I when third quartile value as expected availability of milk in the flush season was used. Depending on the availability of milk, routes can be changed to those obtained by the model I with median and third quartile values as availability in two seasons, more savings in transportation cost can be effected.

Evening routes.

Evening milk collection from 24 societies has became operational from December 1986. Since only one month data of daily supply of milk was available and the quantity of milk available in each society is expected to increase, the maximum quantity supplied by each society in this month was taken as the expected availability of milk. These values are given in appendix B. Capacity of the vehicle was 54 cans and distance constraint was 100 Km.

Table 13. Morning routes of the Chalakudy chilling plant in the lean season - Third quartile value as expected availability.

Model	No.	Route		Distance (Km.)	Load (cans)
I	1	0-46-45-43-44-42-41-40-39-37-36-38-0		92.5	47
	2	0-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8-9-12-0		98.5	54
	3	0-22-23-24-25-26-10-11-13-14-0		68.5	21
	4	0-35-27-28-29-30-31-32-33-34-47-0		44	40
			Total	303.5	162
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0		90.5	47
	2	0-12-8-9-1-2-3-4-5-6-7-15-16-11-10-0		91.5	47
	3	0-22-23-24-25-26-35-27-28-30-29-32-31-33-34-0		94	43
	4	0-47-21-17-18-19-20-14-13-0		47	25
			Total	323	162
III	1	0-43-44-42-41-40-39-38-37-36-0		90.5	39
	2	0-12-9-1-2-3-8-4-5-6-7-15-16-17-18-19-20-0		97	52
	3	0-22-23-24-25-26-10-11-13-14-21-0		76.5	23
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0		64	48
			Total	328	162

Table 14. Morning routes of the Chalakudy chilling plant in the lean season after applying TSP technique - Third quartile value as expected availability.

Model	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
I	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	47	2
	2	0-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8-9-12-0	98.5	54	0
	3	0-22-23-24-25-26-10-11-13-14-0	68.5	21	0
	4	0-35-27-28-29-30-31-32-33-34-47-0	44	40	0
		Total	301.5	162	2
II	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	47	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-11-10-0	86	47	5.5
	3	0-22-23-24-25-26-35-27-28-29-30-31-32-33-34-0	89	43	5
	4	0-47-21-17-18-19-20-14-13-0	47	25	0
		Total	312.5	162	10.5
III	1	0-43-44-42-41-40-39-38-37-36-0	90.5	39	0
	2	0-12-9-8-1-2-3-4-5-6-7-16-15-17-18-19-20-0	95.5	52	1.5
	3	0-22-23-24-25-26-10-11-13-14-21-0	76.5	23	0
	4	0-35-27-28-29-30-31-32-33-34-47-46-45-0	64	48	0
		Total	326.5	162	1.5

Table 15. Morning routes of the Chalakudy chilling plant in the lean season after applying refinement method - Third quartile value as expected availability

Supression levels	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
	1	0-46-45-43-44-42-41-40-39-38-37-36-0	90.5	47	
(37,39)	2	0-21-20-19-18-17-15-16-6-7-5-4-3-2-1-8-9-12-0	98.5	54	2
	3	0-22-23-24-25-26-10-11-13-14-0	68.5	21	
	4	0-35-27-28-29-30-31-32-33-34-47-0	44	40	
		Total	301.5	162	

Table 16. Existing morning routes of the Chalakudy chilling plant.

No.	Route	Distance (Km.)
1	0-1-2-3-4-7-6-5-8-9-10-11-12-13-0	86
2	0-14-15-16-17-18-19-20-21-0	57
3	0-22-23-24-25-26-35-27-28-29-30-31-32-33-34-0	90
4	0-36-37-38-39-40-43-44-42-41-45-46-47-0	90.5
	Total	323.5

The routes formed by the three models are given in table 17. Applying TSP technique to each routes, the new routes obtained were as given in table 18.

Model I was selected for applying refinement method and routes obtained are given in table 19. In these routes TSP technique was applied and no change was noticed.

The routes now existing in this plant for evening collection are given in table 20.

Table 20. Existing evening routes of the Chalakudy chilling plant.

No.	Route	Distance (Km.)
1	0-1-2-3-4-7-6-8-9-10-11-12-13-0	86
2	0-14-15-16-17-18-19-21-0	57
3	0-27-30-31-32-33-0	38
	Total	181

There is a saving of 27.5 Km./day in distance travelled if the routes obtained by the model 1 is used.

4.2. Distribution route.

Thirur - Palgnat route.

Milk is distributed to 14 booths through this route. These booths were numbered and the quantity of milk supplied to these booths were as shown in appendix C. The

Table 17. Evening routes of the Chalakudy chilling plant.

Model	No.	Route		Distance (Km.)	Load (cans)
I	1	0-21-19-18-17-15-16-6-7-4-3-2-1-8-9-12-0		98.5	18
	2	0-14-13-11-10-27-30-31-32-33-0		59.5	12
			Total	158	30
II	1	0-19-18-17-16-15-6-7-8-4-3-2-1-9-12-13-14-0		100	19
	2	0-21-11-10-27-30-31-32-33-0		64.5	11
			Total	164.5	30
III	1	0-10-11-16-15-6-7-4-3-2-1-9-8-12-0		91.5	15
	2	0-21-17-18-19-14-13-27-30-32-31-33-0		85	15
			Total	176.5	30

Table 18. Evening routes of the Chalakudy chilling plant after applying TSP technique.

Model	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
I	1	0-21-19-18-17-15-16-6-7-4-3-2-1-8-9-12-0	98.5	18	0
	2	0-14-13-11-10-27-30-31-32-33-0	59.5	12	0
		Total	158	30	0
II	1	0-19-18-17-15-16-6-7-4-3-2-1-8-9-12-13-14-0	99.5	19	0.5
	2	0-21-11-10-27-30-31-32-33-0	64.5	11	0
		Total	164	30	0.5
III	1	0-10-11-15-16-6-7-4-3-2-1-8-9-12-0	86	15	5.5
	2	0-21-17-18-19-14-13-27-30-31-32-33-0	80.5	15	4.5
		Total	166.5	30	10

Table 19. Evening routes of the Chalakudy chilling plant after applying refinement method in model I.

Supression levels	No.	Route	Distance (Km.)	Load (cans)	Distance reduced (Km.)
(9,12)	1	0-21-19-18-17-15-16-6-7-4-3-2-1-8-9-11-10-0	99	19	4.5
	2	0-14-13-12-27-30-31-32-33-0	54.5	11	
		Total	153.5	30	

distance matrix is also given in appendix C.

The vehicle used in the distribution of milk has a capacity of 75 cans of 40 litres each. Since chilled milk was delivered, distance and time constraints were not imposed.

Packet milk and bulk milk were delivered in this route. Twenty packets of milk can be filled in a tray and two trays are considered equivalent to one can.

The routes formed by the three models are given in table 21.

Table 21. Thrissur - Palghat distribution route.

Model	No.	Route	Distance (Km.)
I	1	0-1-2-3-4-5-6-7-8-9-10-12-11-13-14-0	236
II	1	0-2-4-6-8-10-13-14-12-11-9-7-5-3-1-0	238
III	1	0-1-2-3-4-5-6-7-8-9-10-11-12-13-14-0	238

An attempt was made to check the optimality of the solution obtained in each model by applying TSP technique. There was no change in the route in the case of model I. But in the case of model II and III the routes obtained were same as the routes obtained by the model I in table 21. No reduction in total distance travelled was found while applying refinement method in model I.

The existing routes of the distribution of milk was the same as the route obtained by the model I.

4.3. Performance rating and grading the diary co-operative societies.

Forty four dairy co-operative societies were selected for this analysis. The values of each parameter for each society have been calculated and presented in appendix D. The societies were ranked using the parameter values based on the following criteria.

1. The quantity of milk.

The average quantity of milk supplied by the societies were calculated based on six month data. The maximum quantity of milk was supplied by Vilanganoor society (528.61 Kg.) and minimum by Pullur society (20.1 Kg.). Ranking was done as follows.

Average quantity of milk(Kg/day)	Index
$\geq$ 400	5
400 - 300	4
300 - 200	3
200 - 100	2
< 100	1

2. Consistency in supply to chilling plant.

The varience of daily milk supply for the selected six months was calculated and the coefficient of variation was worked out. Most consistent society was Marakkal with least coefficient of variation 3.63 and the most inconsistent society was Pullur with high coefficient of variation 45.23. Ranking was done as follows.

Coefficient of variation	Index
≥ 40	5
40 - 30	4
30 - 20	3
20 - 10	2
< 10	1

3. Fat %.

The average daily fat percent was calculated based on six months data. Vadakkekara society has maximum fat value (5.62) and least for Nanthipulam society (3.8). Ranking was done as follows.

Fat (in percentage weight)	Index
≥ 5	5
5 - 4.7	4
4.7 - 4.4	3
4.4 - 4.1	2
< 4.1	1

4. SNF %.

The average SNF value computed based on six month data. Pullur society has maximum SNF value (8.48) and least for Nanthikara society (7.72). Societies were ranked as follows.

SNF(in percentage weight)		Index
≥	8.45	5
8.45 -	8.30	4
8.30 -	8.15	3
8.15 -	8.00	2
<	8.00	1

5. Percentage of supply of daily production.

Considering the total milk production in each society, the average percentage of supply was calculated based on six months data. Maximum percentage of supply was done by Kormala society (97.33%) and least by Panancherry society (44%). Ranking was done as follows.

Percentage of supply per day		Index
≥	90	5
90 -	80	4
80 -	70	3
70 -	60	2
<	60	1

6. Distance from chilling centre.

Vallivattom society was found to be placed at maximum distance from chilling plant (23 Km.) and Panancherry society was closed to the chilling plant (1 Km.). Ranking was done as follows.

Distance			Index
	≥	20	5
20	-	15	4
15	-	10	3
10	-	5	2
	<	5	1

7. Number of producers.

Average number of producers supplying milk to the each society was calculated based on the six months data. Vilanganoor society had maximum number of producers (225) and minimum for Pullur society (28). Societies were ranked as follows.

No. of producers			Index
	≥	125	5
125	-	100	4
100	-	75	3
75	-	50	2
	<	50	1

A subjective weightage was given for each parameter value by considerng the importance of the each of them. Distant and inconsistent societies normally reduce the profit margin of dairies. So negative weight was assigned to the parameters distance and consistency. The weight given to each parameter was as follows.

Parameter	Weight
1. Fat	5
2. SNF	5

3.	Quantity of milk supplied	4
4.	Percentage of supply	3
5.	No. of producers	1
6.	Consistency in supply	-1
7.	Distance to chilling plant	-2

All societies were ranked and total score for each society was calculated.

Fixing the minimum standard of the parameter values as follows.

Parameter	Value	Score
1. Fat	4.1	10
2. SNF	8	10
3. Quantity of milk supplied	100	8
4. Percentage of supply	50	3
5. No. of producers	50	2
6. Coefficient of variation	<10	-1
7. Distance to chilling centre	< 5	-2
	Total	30

Each society was graded as A, B, C and D based on the total score as follows.

Total score	Grade
≥ 60	A
60 - 45	B
45 - 30	C
< 30	D

Out of the 44 societies, 5 societies graded as A, 12 societies graded as B, 17 societies graded as C and 10 societies graded as D. The list of the graded societies with total score and grade are given as follows.

Name of society	Total score
Grade A	
1. Kormala	65
2. Marakkal	63
3. Vaniyampara	61
4. Munoorpilly	60
5. Vilanganoor	60
Grade B	
1. Cherumkuzhy	59
2. Vadakkekara	59
3. Malamukku	59
4. Vazhakkumpara	58
5. Kuttichira	56
6. Palissery	54
7. Mechira	54
8. Panancherry	54
9. Chettikulum	52
10. Vallivattom	52
11. Puthenchira	50
12. Vellur	45
Grade C	
1. Mambra	41
2. Pulani	40
3. Pullur	40
4. Thazhekad	40

5.	Thuruthiparamb	39
6.	Meloor	39
7.	Aloor	39
8.	Palayamparamb	36
9.	Vellikulangara	34
10.	Edakulum	34
11.	Ananthapuram	34
12.	Nanthikara	33
13.	Ashtamichira	33
14.	Moonumury	31
15.	Nadavaramb	31
16.	Vennur	31
17.	Alpara	31

<u>Grade D</u>

1.	Cheruvaloor	29
2.	Konathukunnu	28
3.	Edathirinji	27
4.	Pudukad	22
5.	Kalparamb	22
6.	Muriyad	22
7.	Mattathur	19
8.	Mala	18
9.	Mullakara	16
10.	Nanthipulam	12

DISCUSSION

DISCUSSION

Three Vehicle Scheduling Models were considered for suggesting a suitable model for optimising the transportation cost in the collection and distribution of milk by dairy plants. Two collection routes and one distribution route were selected for this study to find out the efficient model. The models used in this studywere, (1) saving model (model I) suggested by Clarke and Wright (1964), (2) λ model (model II) and (3) π model (model III), which were suggested by Gaskel (1967).

Usually collection / distribution routes are formed with known availability / demand in each of the centres. But in the case of milk collection, due to high variation in production, fixing a quantity as availability in a centre for the whole year was meaningless. The data of daily supply of milk in various months of each society indicated that there were variation in supply by each society in each season. The maximum quantity supplied by each society was found to be overestimated value for expected availability of milk. Therefore the availability of milk was taken based on the probability sense. The total number of cans available in different days indicated that it did not exceed the total number of cans when third quartile value was taken as expected availability of the flush season. So for this study the upper limit of the expected availability of milk was fixed as the third quartile value of the daily supply of milk of the two selected months of the flush season. This is in agreement with the findings of Dooernbos (1976) who suggested that the expected availability of rainfall should be taken in the probability sense because of high variation.

In the case of collection routes, routes were formed with median and third quartile values of the daily supply of milk as expected availability for each season. In the case of the morning routes of the Pattikad chilling plant results indicated that (Table.1) two routes obtained by the model I required 65 Km. for transporting 93 cans and routes obtained by the models II and III required 66 Km. for the same purpose, while taking median value as expected availability in the flush season. Taking third quartile value as expected availability in the same season, routes obtained by all the models require 66 Km. for transporting 97 cans. The number of routes in each season for all models were same.

Routes obtained in the lean season's morning and for all season's evening collection of the Pattikad chilling plant were same for each model. This is probably because the total number of cans available in all societies were less than the capacity of the vehicle. In these cases, routes obtained by the model I required 57 Km. for transportation of milk from all societies where as 58 and 62 Km. were required for models II and III.

In the case of morning routes of the Chalakudy chilling plant, four routes obtained by the model I took 315.5 Km. for the transportation of 176 cans when median value was taken as the expected availability of milk in the flush season. Routes formed by the model II and III required 328 and 349 Km. The number of routes was found to be five by model III, where as by models I and II, the number of routes was four. While taking third quartile value as expected availability of milk in the flush season, routes obtained by the model I required 319.5 Km. where as 328 and 360 Km.for the routes obtained by the models II and III for transporting 196 cans. The number of routes was four for both models I and II and for model III, five routes were necessary.

Routes obtained by the model I required 303 Km. for transporting 144 cans in the lean season where median value was taken as expected availability. For the routes obtained by the models II and III, 323 and 325 Km. were required. The number of routes obtained by all the models were same. While taking third quartile value as expected availability of milk, routes obtained by the model I took 303.5 Km. for transporting 162 cans, where as 323 and 328 Km. were taken by the routes obtained by the models II and III. Four routes were required for each models in this context.

In the case of evening routes of the Chalakudy chilling plant, routes obtained by the model I required 158 Km. for transporting 30 cans, where as 164.5 and 176.5 Km. were required for routes obtained by the models II and III. The number of routes in each model were found to be two.

In the case of milk distribution, routes obtained by the model I required 236 Km. where as 238 Km. was required for the route obtained by the model II and III.

Considering all the cases seperately, in 13 cases out of 14, routes obtained by model I were found to be the best by comparing with routes obtained by the models II and III. In one case, Pattikad chilling plant's morning routes where third quartile value as expected availability in the flush season (Table.3), total distance travelled by all the routes obtained in each model were same. So from this, it is concluded that routes obtained by the model I were better than the routes obtained by the models II and III. This is a contridiction to the conclusion of Gaskel's(1967) study, stating that none of the models is considered uniformly better than any others.

Applying Travelling Salesman Problem (TSP) techniques to understand the validity of the optimisation gained in each of the route obtained by the all models, results revealed that there was no reduction in distance travelled in Pattikad chilling plant's flush season morning routes. But in the case of lean season's routes, routes obtained by the model II and III had reduced distance by applying

TSP technique in each route. Distance reduced in model I is one Km. and in model III 5 Kms.

In the case of Chalakudy chilling plant, route 1 obtained by the model I reduced 2 Kms. while applying TSP, where median value was taken as expected availability in the flush season. For the model II, routes 2 and 3 reduced 10.5 Kms. and route 2 in the model III reduced 0.5 Kms. In the same season when third quartile value was taken as expected availability of milk, route 1 in the model I reduced a distance of 2 Kms., where as routes 2 and 3 of the model II reduced a distance 10.5 Kms. and route 2 in the model III reduced 0.5 Kms., by applying TSP technique. When median value was taken as expected availability in the lean season, route 1 of the model I reduced a distance of 2 Kms., routes 2 and 3 of the model II reduced a distance of 10.5 Kms. and route 3 of the model III reduced a distance of 1.5 Kms. In the same season where third quartile value was taken as expected availability of milk, route 1 of the model I reduced a distance of 2 Kms. where as routes 2 and 3 of the model II reduced a distance of 10.5 Kms. and route 2 of the model III reduced a distance of 1.5 Kms.

While applying TSP technique in evening routes of the Chalakudy chilling plant , there was no reduction in distance travelled in the routes obtained in the model I. But in the case of model II, route 1 reduced a distance of 0.5 Kms. and routes 1 and 2 reduced a distance of 10 Kms. of the model III.

Applying TSP technique in the distribution routes obtained, there was no reduction in distance in the routes obtained by model I. But a distance of 2 Km. was reduced in the routes obtained by the models II and III.

From the above discussion, it is concluded that the routes obtained by the all models need not be optimum. So TSP technique should be applied to each route obtained by all the models. This supports the recommandation of Clarke and Wright (1964) to apply TSP technique to the routes obtained by the model I. But Gaskel (1967) commented in his study that no improvement is possible by reording the collection points (ie, apply TSP technique) when model I is used.

Since routes obtained by the model I was found to be the best by comparing with routes obtained by the models II and III, model I was selected for applying refinement method in all the cases. In the case of Pattikad chilling plant's routes, no improvemnt in routes was noticed while applying refinement method. But in the case of Chalakudy chilling plant's morning routes, by supressing the pair of centres (37,39) and (9,12) a reduction of 3 Kms. in distance was noticed, with median value as expected availability in lean season. When third quartile value was taken as expected availability by supressing (37,39) 2 Kms. could be saved. A reduction of 2 Kms. was also noticed by supressing (37,39) when median value was taken as expected availability value in the flush season. There was no reduction in distance in the flush season routes when third quartile value was taken as expected availability by applying refinement method.

In the evening route of the Chalakudy chilling plant, supressing (9,12), 4.5 Kms. was reduced in distance. By applying refinement method in the distribution route obtained by the model I, no improvement was noticed.

From these, it is clear that the refinement method is a reasonable one to use. Better routes could be obtained by applying refinement method. Holmes and Parker (1976), who suggested this method, had applied this method in an generated problem. Hence the results of this study is a clear indication of the efficiency of this method.

The parameters considered for the performance rating and grading of 44 societies under consideration were (1) quanitty of milk supplied to the dairy plant per day (2) percentage of supply of total production (3) Fat% (4) SNF% (5) consistency in supply in terms of coefficient of variation (6) distance to chilling plant and (7) number of producers supplying milk to each society. For each parameter, a subjective weightage was given based on its importance. The most important parameters considered in this study were chemical quality. For these parameters, high weightage was given. Since high value of distance and coefficient of variation was not desirable from the economic point of view, the weight for these parameters was assigned to negative sign Total score for each society was calculated and graded these societies based on these total score Out of the 44 societies 5 societies were graded as A, 12 societies graded as B, 17 societies graded as C and 10 societies graded as D

It is noted here that voluminous data from individual societies had to be processed, as a result of perishable nature of milk and seasonal fluctuation Non availability of data relating to distance among societies also posed a major problem in the formulation of models

Conventional transportation algorithm could not be made use of in the formulation of routes in the present study because of the existence of only one destination and different origins in each case The three models attempted in this study could give a programming approach to optimisation in the transportation of milk However it is stated here that under different situation these models can be used with necessary modifications The routes formed by model I in this study was found to be better than the existing routes eventhough no theoritical proof could be established Further study in this aspect will throw light in getting theoritical background

SUMMARY

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Milk collection routes of Pattikad and Chalakudy chilling plants and milk distribution route Thirur - Palghat of Palghat and Ernakulum dairies were used for this study with the following objectives.

1. To work out a model for optimising the cost of procurement and distribution of milk.
2. To identify the potentiality of dairy co-operatve societies and to fix up a criterion for performance rating.
3. To isolate the constraints influencing efficient milk transportation.

Three Vehicle Scheduling Models, viz, saving model (model I) suggested by Clarke and Wright (1964), λ model (model II) and π model (model III) suggested by Gaskel (1967) were used for this study.

The major constraints affecting the milk transportation were taken as the capacity of the vehicle used for transportation, maximum distance and time that can be allowed in a route and the season of the year. Since there was high variation in supply of milk by each society to chilling plant, two months, viz, October and November were selected from flush season based on the maximum supply of milk and April and May were selected from lean season based on the least supply of milk. Median and third

quartile values of daily supply of milk for each society was calculated for each season. These values were considered as the expected availability of milk for each society. These values were expressed in terms of number of cans since milk is transported in cans by trucks.

Routes were formed in each season with median and third quartile values as expected availability of milk seperately for both morning and evening. Routes formed for Pattikad chilling plant indicated that model I was the best in all cases except one. In one case all the models were found to be equally good. Routes formed in the case of Chalakudy chilling plant indicated that in all cases routes formed by model I was found to the best. Routes obtained by model I was found to be the best in the milk distribution case also. The number of routes for model I and model II were equal in all cases and for model III, more routes were necessary than other models.

An attempt was made to check the optimality of the routes obtained by applying Travelling Salesman Problem technique in each route obtained by each model. In many of the cases, routes obtained by all models were found to be not optimum. The routes obtained by model III were found to be far from optimum in most of the cases and routes obtained by model I were optimum in many cases.

Refinement method, which was suggested by Holmes and Parker (1976) was used to find any reduction in distance travelled is possible or not. The method is simply supressing the pair of points (centres) one at a time in the order they are selected for joining for routes and form new routes by considering other points. Model I was selected for applying the refinement method because it was found to be the best in each case. In four cases this method is found to be effective. In two cases out of the four cases, the method gave better results than a combined application of model I and Travelling Salesman Problem technique.

From this study it is concluded that refinement method was a resonable one to use. It is also suggested that for the route formation in dairy plants for collection and distribution of milk, the three methods, viz, Clarke and Wright method (model I), Refinement method and Travelling Salesman Problem techinique are to be used in the order stated to get optimum or near optimum routes.

Forty four dairy co-operative societies were selected for performance rating and grading of societies. The seven parameters taken for each society in this analysis were (1) the quantity of milk supplied to dairy per day, (2) the consistency in supply, (3) percentage of supply based on total production, (4) number of producers, (5) distance to chilling plant, (6) Fat% and (7) SNF%. The societies were ranked based on the parameter values a subjective weight was given to each parameter based on its importance.

Total score for each society was calculated and based on it the societies were graded as A, B, C and D. Out of 44 dairy co-operative societies, five societies graded as A, 12 societies graded as B, 17 societies graded as C and 10 societies graded as D.

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APPENDICES

APPENDIX A

1. Expected daily supply of milk in terms of number of cans in the Pattikad chilling plant (morning).

Code No.	Name of the Collection Centre	Flush Season Median	Flush Season Third quartile	Lean Season Median	Lean Season Third quartile
1	Vaniyampara	13	13	5	6
2	Vazhakkumpara	9	10	2	3
3	Chuvannamannu	3	3	3	3
4	Thanipadam	2	2	2	2
5	Pattikad	4	4	2	3
6	Panancherry	7	8	2	3
7	Mullakkara	3	3	1	1
8	Alpara	3	3	1	2
9	Vilanganoor	14	15	7	8
10	Malamukku	7	7	3	4
11	Marakkal	5	5	3	3
12	Chalambadam	8	8	5	5
13	Cherumkuzhy	10	10	1	1
14	Asarikad	5	6	1	1

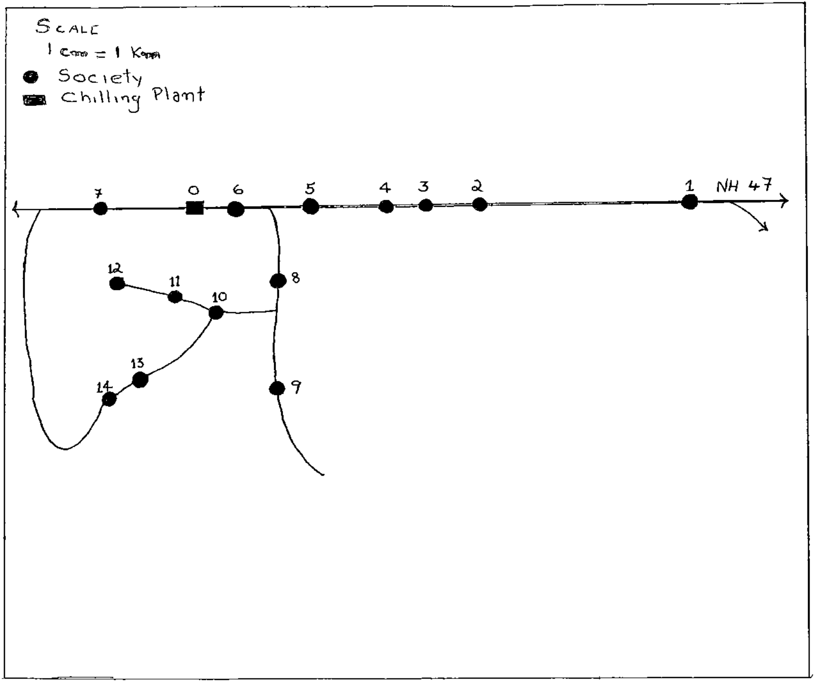
2. Expected daily supply of milk in terms of number of cans in the Pattikad chilling plant (Evening).

Code No.	Name of the Collection Centre	Flush Season Median	Flush Season Third quartile	Lean Season Median	Lean Season Third quartile
1	Vaniyampara	5	5	1	1
2	Vazhakkumpara	4	4	1	2
3	Chuvannamannu	2	2	1	1
4	Thanipadam	1	1	1	1
5	Pattikad	1	2	1	1
6	Panancherry	2	2	1	1
7	Mullakkara	1	1	1	1
8	Alpara	1	1	1	1
9	Vilanganoor	3	3	1	2
10	Malamukku	3	3	1	1
11	Marakkal	2	2	1	1
12	Chalambadam	2	2	1	1
13	Cherumkuzhy	4	4	2	2
14	Asarikad	2	2	1	1

3. Distance matrix : Pattikad chilling plant.

0	1	2	3	4	5	6	7	8	9	10	11	12	13
13													
7.5	5.5												
6	7	1.5											
5	8	2.5	1										
3	10	4.5	3	2									
1	12	6.5	5	4	2								
2.5	15.5	10	8.5	7.5	5.5	3.5							
4	13	7.5	6	5	3	3	6.5						
7	16	10.5	9	8	6	6	9.5	3					
6	15	9.5	8	7	5	5	8.5	2	4				
7	16	10.5	9	8	6	6	9.5	3	5	1			
8.5	17.5	12	10.5	9.5	7.5	7.5	11	4.5	6.5	2.5	1.5		
9	18	12.5	11	10	8	8	11.5	5	7	3	4	5.5	
10	19	13.5	12	11	9	9	12.5	6	8	4	5	6.5	1

4 ROAD MAP - PATTIKAD MILK SHED AREA



APPENDIX B

1. Expected daily supply of milk in terms of number of cans in the Chalakudy chilling plant.

Code No.	Name of the Society	Morning: Flush season Median	Morning: Flush season third quartile	Morning: Lean season Median	Morning: Lean season Third quartile	Evening
1	Edathuruthy	2	2	2	2	1
2	Edathirnji	4	5	4	5	1
3	Edakulam	3	3	2	3	1
4	Kalparamb	3	3	1	2	1
5	Vellangallor	3	3	1	1	0
6	Konthukunnu	3	4	4	4	1
7	Vallivattom	7	7	3	4	2
8	Nadavaramb	3	3	2	2	1
9	Pullur	1	1	1	1	1
10	Ananthapuram	7	7	5	6	1
11	Muriyad	3	3	1	2	1
12	Kallettumkara	4	5	2	2	1
13	Aloor	4	5	4	4	1
14	Thazhekad	5	6	2	2	1
15	Puthenchira	10	11	6	7	1
16	Vellur	5	6	5	6	2
17	Mala	3	3	2	3	1
18	Vennur	3	4	2	2	1
19	Palayamparamb	4	5	5	5	1
20	Ashtamichira	3	4	3	3	0

Contd.....

21	Thuruthiparamb	3	3	2	2	1
22	Nanthipulam	1	1	1	1	0
23	Velupadam	2	2	1	2	1
24	Pookode	3	3	2	2	0
25	Pudukad	2	2	1	1	0
26	Nanthikara	2	2	1	1	0
27	Moonumuri	1	2	2	2	1
28	Mattathur	2	3	2	2	0
29	Vellikulangara	4	4	4	4	0
30	Kormala	9	9	5	5	2
31	Kuttichira	10	11	9	9	2
32	Chettikulam	4	4	3	3	1
33	Mechira	7	7	4	5	2
34	Pariyaram	4	4	5	5	0
35	Kodakara	1	2	1	1	0
36	Cheruvaloor	2	2	2	2	0
37	Mambra	2	2	2	2	0
38	Chirangara	2	2	2	3	0
39	Vadakkekara	4	4	3	4	0
40	Palissery	6	7	6	6	0
41	Munoorpilly	7	8	8	9	0
42	Vettilapara	5	5	5	5	0
43	Kallala	1	1	2	3	0
44	Athirapilly	2	3	4	5	0
45	Pulani	6	6	6	7	0
46	Meloor	2	2	1	1	0
47	Chalakudy	2	3	3	4	0

2. Distance matrix - Chalakudy chilling plant

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	25															
2	22	7														
3	21	8	5													
4	18	13	10	5												
5	17	14	11	6	1											
6	20	17	14	9	4	3										
7	23	20	17	12	7	6	3									
8	18.5	11.5	8.5	7.5	3.5	2.5	5.5	8.5								
9	13.5	11.5	8.5	7.5	8.5	7.5	10.5	13.5	5							
10	7	18.5	15.5	14.5	13.5	12.5	15.5	18.5	12	7						
11	9	16.5	13.5	12.5	11.5	10.5	13.5	16.5	10	5	2					
12	9	16	13	12	11	10	13	16	9.5	4.5	7.5	5.5				
13	6	19	16	15	12	11	14	17	12.5	7.5	8.5	8.5	3			
14	8	21	18	17	10	9	12	15	11.5	9.5	10.5	10.5	5	2		
15	19	19	15	12	7	6	4	7	8.5	7.5	14.5	12.5	12	13	11	
16	21	21	17	14	9	7	5.5	8.5	10.5	9.5	16.5	14.5	14	15	13	2

Contd......

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
17	18	24	20	17	12	11	9	12	13.5	12.5	19.5	17.5	15	12	10	5
18	21	28	25	21	16	15	13	16	17.5	16.5	23.5	21.5	19	16	14	9
19	17	25	22	20	15	14	16	19	16.5	13.5	18.5	16.5	14	11	9	12
20	14	22	19	17	12	11	13	16	13.5	10.5	15.5	13.5	11	8	6	9
21	10	22	19	17	12	11	14	17	13.5	10.5	15.5	13.5	12	9	6	13
22	20.5	31	28	27	28	27	29	33	34.5	24.5	17.5	19.5	24	22	24	35
23	24.5	35	32	31	32	31	34	37	28.5	28.5	21.5	23.5	28	26	28	39
24	16.5	27	24	23	24	23	26	29	20.5	20.5	13.5	15.5	20	18	20	31
25	11.5	22	19	18	19	18	21	24	15.5	15.5	8.5	10.5	15	13	15	26
26	9	21	18	17	17.5	16.5	21.5	24.5	14.5	13	6	8	12.5	10.5	12.5	23.5
27	7	26.5	23.5	22.5	21.5	20.5	23.5	26.5	20	15	8	10	10.5	8.5	10.5	21.5
28	11	30.5	27.5	26.5	25.5	24.5	27.5	30.5	24	19	12	14	14.5	12.5	14.5	25.5
29	15	34.5	31.5	30.5	29.5	28.5	31.5	34.5	28	23	16	18	18.5	16.5	18.5	29.5
30	17	37	34	33	32	31	34	37	30.5	25.5	18.5	20.5	21	19	21	32
31	15	37	34	33	32	31	34	37	30.5	25.5	22	24	23	20	22	31
32	11	33	30	29	28	27	30	33	26.5	21.5	18	20	19	16	18	27

Contd......

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
33	8	30	27	26	25	24	27	30	23.5	18.5	15	17	16	13	15	24
34	9	30	27	26	24	23	26	29	23.5	18.5	16	18	14	11	13	21
35	3	22.5	19.5	18.5	17.5	16.5	19.5	22.5	16	11	4	6	7.5	4.5	6.5	17.5
36	13	34	31	30	25	24	22	25	26.5	20.5	20	22	18	15	17	18
37	15	34	31	27	22	21	19	22	23.5	22.5	22	24	21	18	20	15
38	11	32	29	28	26	25	23	26	25.5	20.5	18	20	16	13	15	19
39	15	36	33	32	28	27	25	28	29.5	24.5	22	24	20	17	19	21
40	20	41	38	37	33	32	30	33	34.5	29.5	27	29	25	22	24	26
41	19	40	37	36	35	34	32.5	35.5	33.5	28.5	26	28	24	21	23	28.5
42	28	49	46	45	44	43	41.5	44.5	42.5	37.5	35	37	33	30	32	37.5
43	39	60	57	56	55	54	52.5	55.5	53.5	48.5	46	48	44	41	43	48.5
44	34	55	52	51	50	49	47.5	50.5	48.5	43.5	41	43	39	36	38	43.5
45	14	35	32	31	30	29	32	35	28.5	23.5	21	23	19	16	18	26
46	9	30	27	26	25	24	27	30	23.5	18.5	16	18	14	11	13	21
47	4	25	22	21	20	19	23	25	18.5	13.5	11	13	9	6	8	16

Contd......

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
17	7															
18	11	4														
19	14	7	5													
20	11	4	8	3												
21	15	11	15	10	7											
22	37	34	38	33	30	30.5										
23	41	30	42	37	34	34.5	6									
24	33	30	34	29	26	26.5	10	8								
25	28	25	29	24	21	21.5	9	13	5							
26	25.5	22.5	26.5	[illegible]	18.5	19	11.5	15.5	7.5	2.5						
27	23.5	20.5	24.5	19.5	16.5	17	21.5	25.5	17.5	12.5	10					
28	27.5	24.5	28.5	23.5	20.5	21	25.5	29.5	21.5	16.5	14	4				
29	31.5	28.5	32.5	27.5	24.5	22	29.5	33.5	25.5	20.5	18	8	4			
30	34	31	34.5	29.5	27	24	32	36	28	22.5	20.5	10.5	6.5	2.5		
31	33	30	33	29	26	22	35.5	39.5	31.5	26.5	24	14	10	6	5.5	
32	29	26	29	25	22	18	31.5	35.5	27.5	22.5	20	12	8	4	6	4

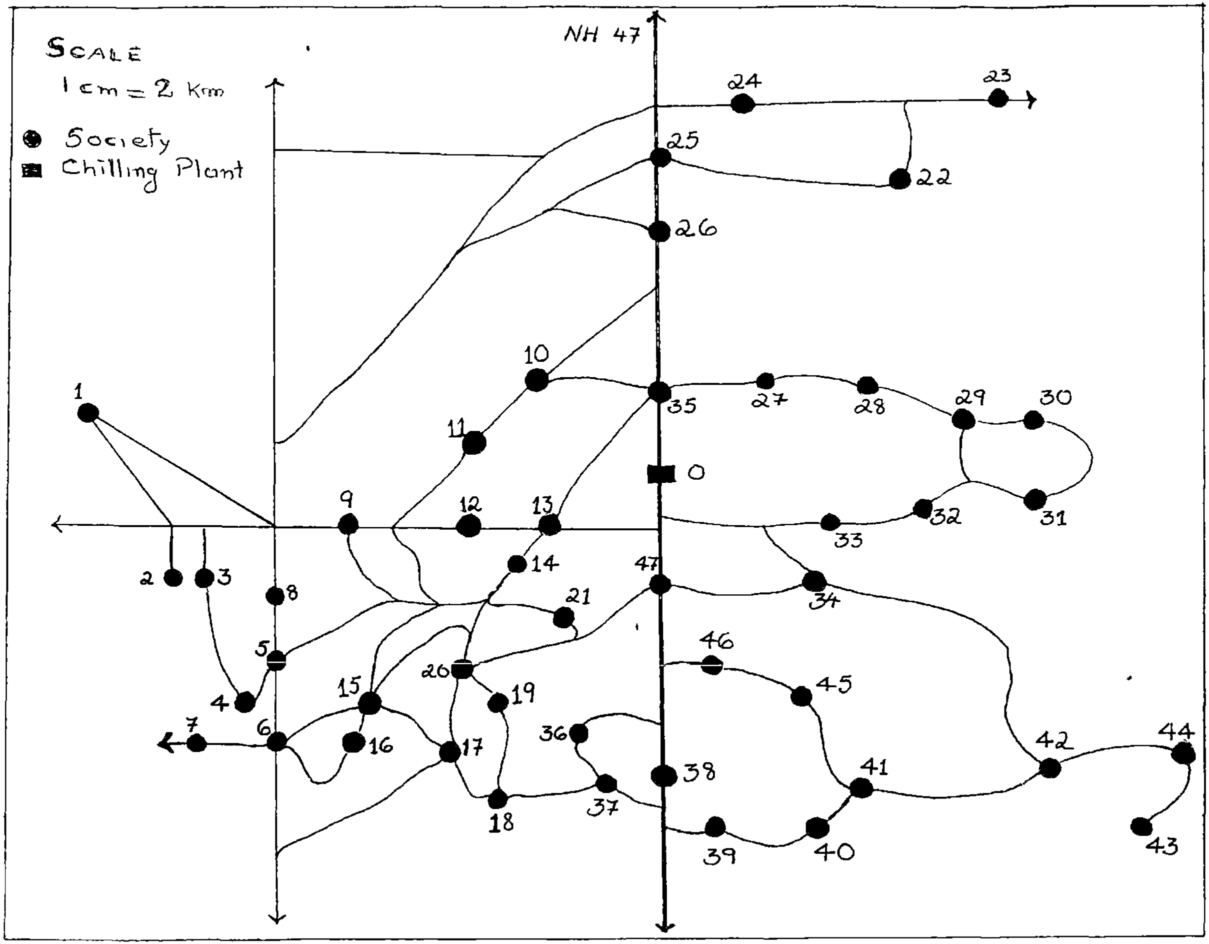
Contd......

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
33	26	23	26	22	19	15	28.5	32.5	24.5	19.5	17	15	11	7	9	7
34	23	20	22	19	16	11	29.5	33.5	25.5	20.5	18	16	16	12	14	12
35	19.5	16.5	20.5	15.5	12.5	12.5	17.5	21.5	13.5	8.5	6	4	8	12	14.5	18
36	20	13	9	14	17	15	33.5	37.5	29.5	24.5	22	20	24	25	27	25
37	17	10	6	11	14	17	35.5	39.5	31.5	26.5	24	22	26	27	29	27
38	21	14	10	15	18	15	31.5	35.5	27.5	22.5	20	18	22	23	25	23
39	23	16	12	17	20	17	35.5	39.5	31.5	26.5	24	22	26	27	29	27
40	28	21	17	22	25	22	40.5	44.5	36.5	31.5	29	27	31	32	34	32
41	30.5	23.5	19.5	24.5	26	21	39	43.5	35.5	30.5	28	26	30	31	33	31
42	39.5	32.5	28.5	33.5	35	30	48.5	52.5	44.5	39.5	37	35	36	32	34	32
43	50.5	43.5	39.5	44.5	46	41	59.5	63.5	55.5	50.5	48	46	47	43	45	43
44	45.5	38.5	34.5	39.5	41	36	54.5	58.5	50.5	45.5	43	41	42	38	40	38
45	28	25	24	24	21	16	34.5	38.5	30.5	25.5	23	21	25	26	28	26
46	23	20	19	19	16	11	29.5	23.5	25.5	20.5	18	16	20	21	23	21
47	18	15	14	14	11	6	24.5	28.5	20.5	15.5	13	11	15	16	18	16

Contd......

	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
33	3														
34	8	5													
35	14	11	12												
36	21	18	14	16											
37	23	20	16	18	3										
38	19	16	12	14	6	4									
39	23	20	16	18	9	6	4								
40	28	25	21	23	14	11	9	5							
41	27	24	20	22	16.5	13.5	11.5	7.5	2.5						
42	28	25	20	31	25.5	22.5	20.5	16.5	11.5	9					
43	39	36	31	42	36.5	33.5	31.5	27.5	22.5	20	11				
44	34	31	26	37	31.5	28.5	26.5	22.5	17.5	15	6	5			
45	22	19	15	17	13	15	11	12.5	7.5	5	14	25	20		
46	17	14	10	12	8	10	6	10	12.5	10	19	30	25	5	
47	12	9	5	7	9	11	7	11	16	15	24	35	30	10	5

3 ROAD MAP - CHALAKUDY MILK SHED AREA



APPENDIX C

1. The quantity of milk to be supplied in the Thirur-Palghat distribution route.

Code No.	Name of the booth	Bulk milk (cans)	Packet milk (Nos.)
1	Edathara	1	30
2	Pathiripala	0	55
3	Lakkidi	0	60
4	Ottapalam	0	610
5	Vaniyamkulam	0	40
6	Shornur - I	2	200
7	Shornur - II	0	280
8	Pattambi	3	290
9	Koottanad	0	65
10	Ponnani	0	120
11	Edappal	1	270
12	Kuttipuram	0	235
13	Thirur	0	275
14	Kolappully	0	50
	Total	7	2580

Total number of cans = 72

2.Distance matrix: Thirur - Palghat distribution route

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	13													
2	26	13												
3	31	18	5											
4	37	24	11	6										
5	43	30	17	12	6									
6	47	34	21	16	10	4								
7	51	38	25	20	14	8	4							
8	55	42	29	24	18	12	8	4						
9	67	54	41	36	30	24	20	16	12					
10	75	62	49	44	38	32	28	24	20	8				
11	92	79	66	61	55	49	45	41	37	25	17			
12	82	69	56	51	45	39	35	31	27	15	7	8		
13	90	77	64	59	53	47	43	39	25	23	15	18	10	
14	109	96	83	78	72	66	62	58	54	42	34	37	29	19

APPENDIX D

Values of the parameters for performance rating and grading

No.	Name ofthe Society	Average daily colle-cion(Kg)	%age of supply	C.V.	Average Fat	Average SNF	Noof Produ-cers	Distance (Km.)
1	Vaniyampara	455.56	73.78	18.64	5.02	8.12	150	13
2	Vazhakkumpara	351.18	75.83	10.78	4.92	8.24	102	7.5
3	Vilanganoor	528.61	66.21	17.55	4.7	8.22	225	7
4	Panancherry	389.70	44.26	26.04	4.76	8.2	202	1
5	Cherumkuzhy	511.01	87.97	38.87	4.98	8.1	171	9
6	Mullakara	87.07	61.06	21.04	4	7.88	45	2.5
7	Marakkal	166.40	93.18	3.63	5.02	8.2	131	7
8	Malamukku	237.44	93.03	7.54	4.82	8.22	56	6
9	Alpara	89.38	77.63	35.93	4.2	8.06	112	4
10	Ananthapuram	230.26	68.27	26.37	4.24	8.14	98	7
11	Vellur	187.92	88.31	20.82	4.46	8.32	88	21
12	Muriyad	86.61	75.89	26.82	3.94	8	37	9

Contd......

13	Ashtamichira	109.9	81.76	29.27	4	8.24	56	14
14	Vennur	104.67	94.37	23.96	4	8.2	42	21
15	Aloor	125.51	86.91	31.51	4.08	8.3	66	6
16	Mala	90.26	58.44	28.13	4.04	8.26	55	18
17	Konathukunnu	102.61	80.68	38.26	4	8.18	65	20
18	Kalparamb	76.2	79.11	33.63	4.04	8.22	39	18
19	Vallivattom	240.72	90.2	20.76	4.4	8.34	81	23
20	Edakulam	84.03	86.96	34.04	4.18	8.32	59	21
21	Edathirinji	124.79	86.03	41.78	4	8.22	69	22
22	Thazhekad	185.02	87.94	26.85	4.34	8.28	64	8
23	Nadavaramb	83.18	81.5	28.42	3.84	8.32	44	18.5
24	Puthenchira	367.93	93.44	21.8	4	8.32	144	19
25	Pullur	20.1	64.34	45.23	4.5	8.48	28	13.5
26	Mechira	240.8	91.38	16.32	4.3	8.44	82	8
27	Kuttichira	382.88	91.15	17.88	4.5	8.28	136	15
28	Cheruvaloor	48.02	76.86	34.59	4.08	8.44	31	13

Contd......

29	Chettikulam	140.57	90.79	14.79	4.6	8.4	54	11
30	Meloor	66.41	83.43	32.54	4.28	8.36	39	9
31	Thuruthiparamb	86.08	86.05	18.31	4.2	8.34	34	11
32	Pulani	203.88	94.82	30.26	4.1	8.26	87	14
33	Kormala	323.23	97.33	13.75	5	8.28	114	17
34	Pudukad	53.77	80.6	32.42	3.8	8.12	34	11.5
35	Mattathur	71.74	57.98	27.53	4.2	8.06	48	11
36	Palayamparamb	145.06	90.73	17.76	4.1	8.12	80	17
37	Nanthipulam	31.84	64.03	37.62	3.8	8.02	17	20.5
38	Nanthikara	53.43	61.08	39.06	5	7.72	43	9
39	Mambra	59.39	88.34	33.19	4.48	8.32	50	15
40	Moonumuri	39	73.2	31.29	4.18	8.2	38	7
41	Vellikulangara	120.43	78.24	20.54	4.52	8.12	84	15
42	Palissery	237.46	96.06	9.23	4.84	8.28	83	20
43	Munoorpilly	285.61	97.32	15.56	4.9	8.36	90	19
44	Vadakkekara	127.72	91.56	22.5	5.62	8.36	50	15

MILK MARKETING IN THE ORGANISED SECTOR- A PROGRAMMING APPROACH TO OPTIMISATION OF COLLECTION AND DISTRIBUTION

BY

ASOKAN M. V.

ABSTRACT OF A THESIS

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Kerala Agricultural University

Department of Statistics

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ABSTRACT

Two milk collection and one distribution route were taken for suggesting a suitable transportation model for optimising the cost of collection and distribution of milk in dairy plants. Three Vehicle Scheduling Models, viz, saving model (model I) suggested by Clarke and Wright (1964), λ model (model II) and π model (model III) suggested by Gaskel (1967) were used in this study.

Since there was high variation in supply of milk by each society to chilling plant, median and third quartile values of daily supply of milk of two selected months for each season was taken as expected availability of milk. Maximum distance that can be travelled by a truck in a route was calculated by considering the time .

Morning and evening routes were formed with median and third quartile values as expected availability of milk in each season. Routes obtained in all cases indicated that routes formed by model I were the best. In the case of distribution of milk routes obtained by the model I was found to be the best. Using Travelling Salesman Problem technique, an attempt was made to check the optimality of the routes obtained by each model and found that the routes were not optimum in most of the cases. Refinement method suggested by Holmes and Parker (1976) was tried out for knowing whether any further improvement is possible in model I. In certain cases better routes could be achieved.

From this study, it is suggested that for the route formation in dairy plants for collection and distribution of milk, three techniques, viz, Clarke and Wright method (model I), Refinement method and Travelling Salesman Problem technique should be used in the order stated.

Forty four dairy co-operative societies were considered in the analysis of performance rating and grading of societies. Seven parameters were taken and subjective weights were given to each of them. Total score for each society was calculated and based on it the societies were graded as A, B, C and D.