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RESEARCH PAPER

Optimization of milk procurement routes of FPO owned dairy unit

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ABSTRACT

Raw milk quality and quantity is the corner stone of excellent dairy products. Milk procurement guards this with an eagle eye and ensures that company's production needs are met. Milk procurement is the starting point of FPO's dairy supply chain. The FPO owned dairy unit has adopted a system of milk collection through village level milk pooling points (MPP's). MPP is a common place in villages where the farmers pool their milk. The person who collects the milk from the farmers is called as "Pala Mitra" / "MPP operator". The present study was carried out at the selected BMC centre of a FPO owned dairy unit in Chittoor district of Andhra Pradesh. The principal objective of the study was to optimize the milk procurement routes using travelling salesman model. The findings of the study show that in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 Rs. In route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 Rs. In route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 Rs.There was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. The total distance for travelling to procure the milk to BMC unit has been reduced to 186.8 kilometers per day from 194.6 kilometers per day. The total time of travelling to procure milk to BMC unit was reduced from 501 minutes per day to 461 minutes per day. The total cost incurred for transportation of raw milk to BMC unit has been reduced from 1391.4 Rs. to 1335.6 Rs. With route optimization in all routes of identified bulk milk cooling unit a total reduction in cost of transportation of 55.77 Rs. per day could be achieved. As these transportation operations are routine and need to be done throughout the year an annual cost saving of 20,356 Rs. per annum for the identified BMC unit could be achieved.

KEY WORDS : MPP (Milk pooling point), BMC (Bulk milk cooling) unit, Travelling salesman problem model (TSP), FPO, Milk procurement

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Milk is a highly perishable commodity, thus, proper procurement in the dairy industry has been a challenge and a permanent concern. To achieve this, it is essential to give importance to the route optimization and maintain time from primary production by keeping any possible disruption to a minimum. In India milking of animal is done either at community milking centre or at the houses of the farmers. In most of the areas milking is done at the farmers home and then delivered to the milk pooling points in the village. MPP is a common place in villages where the farmers pool their milk. The person who collects the milk from the farmers is called as "Pala Mitra" / "MPP operator". The "Pala Mitra" or "MPP operator" is a person from local community for sampling, testing and collecting the milk and is nominated by the registered milk pourers. The MPP operator is paid commission by the FPO, based on the quantity and quality of milk (in litres) collected by him/her. Each MPP is provided with all the essential utilities for the milk collection and also the testing equipment such as digital milk analyzers. Thus, at village level, milk is procured from member farmers at milk pooling points and the milk was tested for fat content. Milk is then collected into large stainless steel cans which are used for transport to bulk milk cooling units.

METHODOLOGY

Farmer Producer Organization (FPO) owned milk Producer Company in South India was selected purposively. The present study was undertaken in Chittoor district of Andhra Pradesh in view of presence of highest milk procuring bulk milk cooling units in the district. Primary data was collected from the selected BMC unit by using a well-defined schedule through personal interview and observation methods. To optimize the routes distance matrices were created in each route and then TSP model was employed in Python Software to get the optimized routes.

ANALYSIS AND DISCUSSION

The distances from one node to other node have been collected, distance matrix for each route have been prepared to optimize the routes using travelling salesman problem model.

Distance matrix of route-1:

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another were used to prepare the distance matrix of route-1 and presented in Table 1.

A perusal of Table 1 reveal that there was a maximum distance of 23.8 kilometers between BMC unit and MPP-02 and minimum distance of 2.2 between MPP-07 and MPP-08.

Distance matrix of route-2:

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling point to another were used to prepare the distance matrix of route-2 and presented in Table 2.

A perusal of Table 2 reveal that there was a maximum distance of 12 kilometers between MPP-10 and MPP-17 and minimum distance of 0.1 between MPP-17 and MPP-18.

Distance matrix of route-3:

The information on distance of milk pooling points from BMC unit and the distances from one milk pooling

Table 1: Distance matrix of route-1 (in km)

Locations	BMC unit	MPP-01	MPP-02	MPP-03	MPP-04	MPP-05	MPP-06	MPP-07	MPP-08	MPP-09
BMC unit	0.0	8.6	23.8	17.0	18.0	15.0	13.0	9.0	7.0	3.0
MPP-01	8.6	0.0	12.0	7.0	7.0	6.0	4.0	2.5	4.0	6.0
MPP-02	23.8	12.0	0.0	6.5	10.0	8.0	10.0	14.0	13.5	16.0
MPP-03	17.0	7.0	6.5	0.0	3.2	6.0	4.0	8.0	7.5	12.0
MPP-04	18.0	7.0	10.0	3.2	0.0	2.4	5.7	8.0	8.0	10.0
MPP-05	15.0	6.0	8.0	6.0	2.4	0.0	2.4	6.5	6.0	8.0
MPP-06	13.0	4.0	10.0	4.0	5.7	2.4	0.0	5.2	4.5	7.0
MPP-07	9.0	2.5	14.0	8.0	8.0	6.5	5.2	0.0	2.2	5.5
MPP-08	7.0	4.0	13.5	7.5	8.0	6.0	4.5	2.2	0.0	3.0
MPP-09	3.0	6.0	16.0	12.0	10.0	8.0	7.0	5.5	3.0	0.0

point to another were used to prepare the distance matrix of route-3 and presented in Table 3.

A perusal of Table 3 reveal that there was a maximum distance of 7.7 kilometers between MPP-22 and MPP-27 and minimum distance of 0.2 kilometers between BMC unit and MPP-30.

Optimization of route-1:

In route-1 distances were optimized by employing travelling salesman problem model and the results are presented in Table 4.

A look through Table 4 reveals that 09 milk pooling points were considered in the optimization of route-1. As a result in route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 Rs.

Optimization of route-2:

In route-2 distances were optimized by employing travelling salesman problem model and the results are presented in Table 5.

A look through Table 5 reveals that 11 milk pooling points were considered in the optimization of route-2. As a result in route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 Rs.

Optimization of route-3:

In route-3 distances were optimized by employing travelling sales man problem model and the results are

Table 2 : Distance matrix of route-2 (in km)

Locations	BMC unit	MPP-10	MPP-11	MPP-12	MPP-13	MPP-14	MPP-15	MPP-16	MPP-17	MPP-18	MPP-19	MPP-20
BMC unit	0.0	10.9	10.5	9.0	7.0	7.5	5.0	5.5	5.0	4.8	1.0	0.4
MPP-10	10.9	0.0	0.3	2.0	4.0	7.3	6.8	6.5	12.0	11.7	8.7	9.5
MPP-11	10.5	0.3	0.0	1.3	3.5	7.0	6.2	5.9	11.9	11.5	8.0	7.5
MPP-12	9.0	2.0	1.3	0.0	1.9	5.0	4.5	5.3	10.0	9.8	7.5	7.0
MPP-13	7.0	4.0	3.5	1.9	0.0	3.3	4.0	5.0	8.8	8.0	6.0	5.5
MPP-14	7.5	7.3	7.0	5.0	3.3	0.0	2.6	3.5	7.5	7.0	5.0	4.5
MPP-15	5.0	6.8	6.2	4.5	4.0	2.6	0.0	0.5	6.8	6.5	4.5	3.5
MPP-16	5.5	6.5	5.9	5.3	5.0	3.5	0.5	0.0	5.7	5.3	4.0	3.0
MPP-17	5.0	12.0	11.4	10.0	8.8	7.5	6.8	5.7	0.0	0.1	3.0	2.5
MPP-18	4.8	11.7	11.5	9.8	8.0	7.0	6.5	5.3	0.1	0.0	1.4	1.5
MPP-19	1.0	8.7	8.0	7.5	6.0	5.0	4.5	4.0	3.0	1.4	0.0	0.4
MPP-20	0.4	9.5	7.5	7.0	5.5	4.5	3.5	3.0	2.5	1.5	0.4	0.0

Table 3 : Distance matrix of route-3 (in km)

Locations	BMC unit	MPP-21	MPP-22	MPP-23	MPP-24	MPP-25	MPP-26	MPP-27	MPP-28	MPP-29	MPP-30
BMC unit	0.0	5.3	5.7	4.0	4.5	1.5	3.0	2.8	2.0	0.3	0.2
MPP-21	5.3	0.0	1.3	3.4	2.5	4.7	5.8	6.2	5.5	5.1	4.9
MPP-22	5.7	1.3	0.0	2.5	4.0	6.3	6.7	7.7	5.2	5.6	5.5
MPP-23	4.0	3.4	2.5	0.0	0.7	3.2	4.0	4.3	3.5	3.7	3.8
MPP-24	4.5	2.5	4.0	0.7	0.0	3.9	4.2	5.4	2.7	4.2	4.1
MPP-25	1.5	4.7	6.3	3.2	3.9	0.0	1.2	1.3	1.4	1.3	1.1
MPP-26	3.0	5.8	6.7	4.0	4.2	1.2	0.0	1.5	2.5	2.8	2.7
MPP-27	2.8	6.2	7.7	4.3	5.4	1.3	1.5	0.0	1.8	2.6	2.5
MPP-28	2.0	5.5	5.2	3.5	2.7	1.4	2.5	1.8	0.0	1.6	1.5
MPP-29	0.3	5.1	5.6	3.7	4.2	1.3	2.8	2.6	1.6	0.0	0.3
MPP-30	0.2	4.9	5.5	3.8	4.1	1.1	2.7	2.5	1.5	0.3	0.0

presented in Table 6.

A look through Table 6 reveals that 10 milk pooling points were considered in the optimization of route-3. As a result in route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 Rs.

Comparison of raw milk transportation before and after optimization of routes:

A comparison of the distance, time and cost in the optimized routes with existing routes are presented in Table 7.

A cursory of Table 7 shows that the distance of raw milk transportation in optimized route-1 has been reduced from 97 kilometers to 96.6 kilometers there by reducing the travelling time from 170 minutes to 167 minutes and reducing the cost from 693.55 Rs. to 690.69 Rs. The distance of raw milk transportation in optimized route-2 has been reduced from 57 kilometers to 53.4 kilometers thereby reducing the travelling time from 174 minutes to 152 minutes and reducing the cost from 407.55 Rs. to 381.81 Rs. The distance of raw milk transportation in optimized route-3 has been reduced from 40.6 kilometers to 36.8 kilometers thereby reducing the travelling time from 157 minutes to 142 minutes and reducing the cost from 290.29 Rs. to 263.12 Rs.

There was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was

Table 4 : Optimized route-1 summary

Sr. No.	Start node	End node	Distance from node to node (km)	Time taken (in minutes)	Cost (in Rs.)
1.	BMC unit	MPP-08	7.0	10.5	50.05
2.	MPP-08	MPP-07	2.2	5.0	15.73
3.	MPP-07	MPP-01	2.5	5.5	17.88
4.	MPP-01	MPP-02	12	18.5	85.8
5.	MPP-02	MPP-03	6.5	12.0	46.48
6.	MPP-03	MPP-04	3.2	6.0	22.88
7.	MPP-04	MPP-05	2.4	5.0	17.16
8.	MPP-05	MPP-06	2.4	5.5	17.16
9.	MPP-06	MPP-09	7.0	9.5	50.05
10.	MPP-09	BMC unit	3.0	6.0	21.45
11.	Total	09 MPPs	48.2	83.5	344.63

Table 5 : Optimized route-2 summary

Sr. No.	Start node	End node	Distance from node to node (km)	Time taken (in minutes)	Cost (in Rs.)
1.	BMC unit	MPP-20	0.4	2.0	2.86
2.	MPP-20	MPP-11	7.5	18.5	53.63
3.	MPP-11	MPP-10	0.3	3.0	2.15
4.	MPP-10	MPP-12	2.0	6.0	14.3
5.	MPP-12	MPP-13	1.9	6.0	13.59
6.	MPP-13	MPP-14	3.3	6.5	23.6
7.	MPP-14	MPP-15	2.6	6.0	18.59
8.	MPP-15	MPP-16	0.5	3.0	3.58
9.	MPP-16	MPP-17	5.7	14.5	40.76
10.	MPP-17	MPP-18	0.1	2.5	0.72
11.	MPP-18	MPP-19	1.4	5.5	10.01
12.	MPP-19	BMC unit	1.0	2.5	7.15
13.	Total	11 MPPs	26.7	76	190.91

Table 6 : Optimized route-3 summary

Sr. No.	Start node	End node	Distance from node to node (km)	Time taken (in minutes)	Cost (in Rs.)
1.	BMC unit	MPP-29	0.3	3.0	2.15
2.	MPP-29	MPP-25	1.3	6.0	9.3
3.	MPP-25	MPP-26	1.2	6.0	8.58
4.	MPP-26	MPP-27	1.5	8.0	10.73
5.	MPP-27	MPP-28	1.8	10.0	12.87
6.	MPP-28	MPP-24	2.7	13.0	19.31
7.	MPP-24	MPP-23	0.7	2.5	5.01
8.	MPP-23	MPP-22	2.5	6.0	17.88
9.	MPP-22	MPP-21	1.3	5.0	9.3
10.	MPP-21	MPP-30	4.9	10.0	35.04
11.	MPP-30	BMC unit	0.2	1.5	1.43
12.	Total	10 MPPs	18.4	71	131.56

Table 7 : Comparison of raw milk transportation before and after optimization of routes

Sr. No.	Routes	Distance per day (km)		Time per day (minutes)		Cost per day (Rs.)	
		Current design	Optimized design	Current design	Optimized design	Current design	Optimized design
1.	Route-1	97.0	96.6	170.0	167.0	693.55	690.69
2.	Route-2	57.0	53.4	174.0	152.0	407.55	381.81
3.	Route-3	40.6	36.8	157.0	142.0	290.29	263.12
Total for BMC		194.6	186.8	501.0	461.0	1391.4	1335.6

observed. The total distance for travelling to procure the milk has been reduced to 186.8 kilometers per day from 194.6 kilometers per day. The total time of travelling was reduced from 501 minutes per day to 461 minutes per day. The total cost incurred for transportation has reduced from 1391.4 Rs. to 1335.6 Rs. With route optimization in all routes of identified bulk milk cooling unit at total reduction in cost of transportation of 55.77 Rs. per day could be achieved. As these transportation operations are routine and need to be done throughout the year an annual cost saving of 20,356 Rs. per annum for the identified BMC unit could be achieved.

Conclusion:

The findings of the study show that in route-1, route-2 and route-3 the distances were optimized. In route-1 the optimized distance is 48.2 kilometers, time travelled to cover all the milk pooling points is 83.5 minutes and the total cost per trip is around 345 Rs. In route-2 optimized distance is 26.7 kilometers, time travelled to cover all the milk pooling points is 76 minutes and the total cost per trip is around 191 Rs. In route-3 optimized distance is 18.4 kilometers, time travelled to cover all the milk pooling points is 71 minutes and the total cost per trip is around 132 Rs.

There was a significance reduction of total distance, time and cost in raw milk transportation for the identified bulk milk cooling unit with the optimization of routes was observed. The total distance for travelling to procure the milk has been reduced to 186.8 kilometers per day from 194.6 kilometers per day. The total time of travelling was reduced from 501 minutes per day to 461 minutes per day. The total cost incurred for transportation has reduced from 1391.4 Rs. to 1335.6 Rs. With route optimization in all routes of identified bulk milk cooling unit at total reduction in cost of transportation of 55.77 Rs. per day could be achieved. As these transportation operations are routine and need to be done throughout the year an annual cost saving of 20,356 Rs. per annum for the identified BMC unit could be achieved.

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