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Trend analysis trend analysis of milk production and milk products

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Abstract
Dairy production and processing certainly appear to be the most important industry in terms of contributing to the global challenge of food security today and in the future. Dairy is one of the largest agri-businesses in India and a significant contributor to the economy. India is the largest milk producer in the world and production increased by 6.2 percent and reach to mt worldwide. The contribution of agriculture and allied sectors is decreasing year by year, but during the pandemic situation, it was the only sector that had sustained. After consideration of the role of milk industry and positive contribution of dairy industry in India's Gross Domestic Product (GDP) in the pandemic situation, the research proposal come up with the investigation of the trend of milk procurement. This paper aimed to analyse the main trends in milk procurement and products production. It applied on secondary data of milk procurement on monthly basis from year 2013-2020 and milk products production from 2011-2020.The empirical data were collected from the Dharwad milk union limited (DMUL) and have been statistically processed using appropriate Polynomial fitting function model to provide analytical approach to describe trends of milk procurement and milk products production to identify the main trends. The study involved various polynomial degrees over the trend of milk procurement. From the study it was showed that 6^{th} degree polynomial is considered to be the best fit among all others as it showed highest R^2 value of and low RMSE value.

Keywords: Polynomial fitting function, R^2, RMSE, trend analysis

Introduction
Statistical analysis is a method of collecting and analysing data in order to discover patterns and trends. By modelling the current condition and offering a future scenario, it assists industries, policymakers, authorities, and others in making more accurate decisions, finding the best performance, discarding and developing products. For efficient practise in resolving the many difficulties that arise in many fields of agricultural businesses, statistical techniques and methodologies are required. Agriculture-based industries are critical components of any agriculture-based country's growth process. Agriculture supplies inputs to industry and the industry's output is employed in agriculture to boost output. There are numerous options.

The dairy sector is one of the crucial sectors in the Indian economy that not only provides employment to millions of rural households but also contributes to the economy. Among the livestock products, milk consists of the highest share. It being an important sector globally, dairying is equally important in developing economies like India, for providing nutrition support, reducing rural poverty, inequity, ensuring food security for millions of rural households, and enhancing economic growth, particularly in rural areas. Dairy production and processing looks to be the most important industry today and in the future in terms of contributing to the global challenge of food security. Milk is a common agricultural product produced by dairy animals in almost all countries, and dairy farms provide employment for many people. It's an important aspect of the global food chain, and it is especially important for rural communities' long-term survival.

The vast majority of milk production in the world is consumed in the region where it is produced, in the form of fresh dairy products, including pasteurized and fermented products. The global dairy sector is estimated to be worth over 720 billion US dollars (USD) (Anon., 2020) [1] Fluid milk is currently the most popular dairy product, accounting for the bulk of the total market share. Milk consumption is increasing year after year as the world's population continues to expand and people become more health conscious.

In the last three decades, world milk production has increased by more than 59 percent, from 530 million tonnes in 1988 to 843 million tonnes in 2018.

India is the world's largest milk producer, with 22 percent of global production, followed by the United States of America, China, Pakistan and Brazil. Since the 1970s, most of the expansion in milk production has been in South Asia, which is the main driver of milk production growth in the developing world. Milk production in Africa is growing more slowly than in other developing regions, because of poverty and – in some countries – adverse climatic conditions. The countries with the highest milk surpluses are New Zealand, the United States of America, Germany, France, Australia and Ireland. The countries with the highest milk deficits are China, Italy, the Russian Federation, Mexico, Algeria and Indonesia.

According to USDA data, world milk consumption was approximately 190 million tons in 2021. India ranks first in world milk consumption with 83 million tons. India is expected to consume around 83 million tons in 2021. India is followed by the European Union with 33.4 million tons, the US with 21.2 million tons, China with 12 million tons and Brazil with 11 million tons in terms of milk consumption in 2021, all of which are major dairy producers and have a direct impact on global dairy commerce. There is significant change is expected in the milk consumption of these countries in 2021. According to the latest forecasts for the main milk-producing regions, global production looks set to decline by 0.5% in 2022. This is down from the April forecast, in which the production remained stable in the year. In terms of volume, the projected decline in the EU will be the largest, with 838 million liters less than in 2021.

World milk production is expected to increase by 1.6 percent annually between 2020 and 2029 and reach 997 million tons in 2029, according to a report prepared by OECD-FAO. This report reveals that the increase in milk yield is highly related to the diet. In countries where grazing-based livestock breeding is carried out, milk production increases are mostly related to the number of herds, while in countries where special feeding is common, production increases due to productivity.

Uttar Pradesh, the state of the highest population, followed by Rajstan and Andrapradesh is the top most and highest milk producing state of the India. It holds a share of 17.22% in the total milk production of the country. It has the second largest population of cattle and the buffaloes are the primary source of milk in Uttar Pradesh. It produces 23.33 million tons of milk each year. The milk producing districts of U.P area are Meerut, Agra, Muzaffarnagar, Bijnore, Aligarh and Mathura.

Dharwad Milk Union Limited (DMUL)

Dharwad Co-operative milk producers Union Ltd., (DMUL) has been registered under Karnataka Co-operative Act in March 1986 covering Dharwad, Haveri, Gadag and Uttara Kannada Districts. DMUL has 995 number of Functional DCSs covering 28 taluks, of which DAMUL has infrastructure to handle 2.10 lakh litres of milk, produce 12 tons of milk powder, 9 tons of Butter and 6 tons of ghee and 600 kg of curd per day. DMU was Rs. 7 crore Projects of which Government has Rs. 1.2 crore of share capital and authorized capital of DMUL is Rs. 5 crores. DMUL formed 551 milk producer's co-operative societies in Dharwad (Gadag, Haveri and Uttar Kannada district). Further in 1988 the Raipur Dairy and Chilling Centre also came under the union. In 1959, the training canters which were controlled by KMF came under Dharwad Milk Union.

It has Chilling Centres at Haveri - 20 TLPD, Hirekerur - 20 TLPD, Gadag (Mallasandra)- 20 TLPD, Sirsi - 20 TLPD, Rona - 10 TLPD & Kumta - 2 TLPD with total capacity of 92 TLPD. There are 18 Bulk Milk Coolers and 351 Automatic Milk Collection units in the union. The union procures on an Average of 2.34 lakh kgs/day of milk, sells 0.96 lakh litres/day. Agriculture and related sectors' contribution is declining year by year, but it is the only sector that has remained stable during the pandemic. Due to the stop during the COVID-19 epidemic, the rest of the sectors crumbled. Crops and cattle make up a large portion of the agriculture sector, which has helped it to stay afloat in the face of the epidemic. The most important contributor to the livestock sub-sector is milk, which accounts for 66.2 percent of total output (22.2 percent). Though restaurant and hospital demand has slowed as a result of the declining economy, household consumption has remained consistent. Milk consumption losses are being mitigated by transforming extra milk into milk powder, which may then be sold.

Dairy production and processing certainly appear to be the most important industry in terms of contributing to the global challenge of food security today and in the future. Dairy is one of the largest agri-businesses in India and a significant contributor to the economy. The contribution of agriculture and allied sectors is decreasing year by year, but during the pandemic situation, it was the only sector that had sustained. After consideration of the role of milk industry and positive contribution of dairy industry in India's Gross Domestic Product (GDP) in the pandemic situation, the research proposal come up with the investigation of the trend of milk procurement and milk products production. the research proposal is covered under the heading of following objectives.

The specific objective of the study

1. To study the trend analysis of milk production and milk products.
2. Forecasting of milk procurement and production of milk and milk products.
3. To study the impact of Covid-19 on price and milk production.

Material and Methods

Description of the study area

Dharwad is located in the North-Western part of Karnataka state with coordinates 15˚27'30" North and 75˚00'30" East. Dharwad experiences tropical wet climate, which is 741m above sea level. The district encompasses an area of 4263 sq. kms. The district is bounded on the North by the district of Belgaum, on the East by the district of Gadag, on the South Haveri and on the West by Uttara Kannada district. All these districts, which surrounded Dharwad district, belong to Karnataka state itself. The district may be divided into 3 natural regions, viz., the Malnad, Semi-Malnad and Maidan.

Nature and sources of data

Dharwad Milk Union (DMU) was purposively selected for the presented study, since it handles large quantity of milk and milk products. The secondary data was collected from April, 2013 to December, 2020 of milk procurement on monthly basis and milk products (ghee, butter, and peda) production data i.e., from 2010 April to 2020 march on monthly basis.

Statistical tools and techniques employed

Polynomial function fitting Approach

Under the first approach polynomial functions of different degrees were fitted to the milk procurement and milk products

production data set using the method of least squares over a long period of time, the time series is very likely to show tendency to increase or decrease overtime. There are different types of trends. Some of them are linear and some of them are non-linear in their form. For shorter period of time, in most of the situation, the straight line provided the best description of trend and for longer period of time, the non-linear form generally provides a good description of trend.
The polynomial regression is used to determine the long-term behaviour, these polynomials are fitted by principal of least squares. The polynomials tried are shown below.

1st degree (straight line) $Yt = a_0 + a_1*X + \varepsilon$
2nd degree (straight line) $Yt = a_0 + a_1*X + a_2*X^2 +$
3rd degree (straight line) Yt
$= a_0 + a_1*X + a_2 * X^2 + a_3*X^3 + \varepsilon$
4th degree (straight line) $Yt = a_0 + a_1*X + a_2*X^2 + a_3* X^3 + a_4*X^4 + \varepsilon$
5th degree (straight line) $Yt = a_0 + a_1*X + a_2*X^2 + a_3*X^3 + a_4*X^4 + a_5*X^5 + \varepsilon$
6th degree (straight line) $Yt = a_0 + a_1*X + a_2* X^2 + a_3*X^3 + a_4*X^4 + a_5*X^5 + a_6*X^6 + \varepsilon$

The best fitting of the data with the polynomial function:
$Yt = a_0 + a_1*X + a_2*X^2 + a_3* X^3 + \ldots\ldots\ldots\ldots a_n*X^n + \varepsilon$ was found

Where,
Y_t = trend values at time t
ε = error term
a_1, a_2, a_3, a_4, a_5 and a_6 are coefficient to be estimated

The suitable model for data i.e., Goodness of fit of model was assessed by computing R^2 (co- efficient of determination) and RMSE (Root Mean Square error value).

Criteria to find best fit trend equation
a) Root Mean Square Error (RMSE)
The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between values (sample or population values) predicted by a model or an estimator and the values observed. The RMSD represents the square root of the second sample moment of the differences between predicted values and observed values or the quadratic mean of these differences. These deviations are called residuals when the calculations are performed over the data sample that was used for estimation and are called errors (or prediction errors) when computed out-of-sample.
RMSE is always non-negative, and a value of 0 (almost never achieved in practice) would indicate a perfect fit to the data. In general, a lower RMSE is better than a higher one. However, comparisons across different types of data would be invalid because the measure is dependent on the scale of the numbers used.

Formula for Root mean square error, RMSE is given by,

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(Oi - Pi)^2}{N}}$$

Where,
Oi = Observed value
Pi = Predicted value
N = Number of data points

Results and Discussion
Trend analysis of milk procurement and production of milk products
In this study for trend analysis, the polynomial function fitting was carried out with different degrees were tried for the period from 2013 to 2020 for milk procurement and 2010 to 2020 for milk products production and the selection of best model based on R^2 and RMSE value.

Milk procurement
The data was collected on monthly basis i.e., from April 2013 to March 2020. The estimates, R^2 and RMSE obtained by fitting various polynomial degree models over the trend of milk procurement was displayed in the Table 1. Which represent the annual milk procurement with different degrees of polynomial. Among all the degrees carried out 6th degree polynomial has shown the highest R^2 of 0.8134 with lowest RMSE value of 14659.35, and it could be seen that the above adverted equation from the graph in Fig 1. It clearly shown that increasing and decreasing trend in the milk procurement from year to year. Therefore, 6th degree polynomial was considered as best fit. Fig.1 represents the annual milk procurement showing both increasing and decreasing trend from year to year. In the year 2017 the milk procurement showing decreasing trend as compared to previous year due to occurrence of drought in the year 2017, union has taken a toll on milk production. Due to scarcity of natural fodder (green fodder) and drinking water, the procurement has come down and again it showed decreasing trend during the year 2020 due to the wake of COVID -19 pandemic, due to announcement of nation-wide lockdown from March 25, 2020, Supply chains are highly integrated and a minor effect on any one process significantly affects all the other processes and actors in the chain. This is why effect of movement restrictions during the lockdown is being felt along the entire supply chain. Dairy Production-Dairy farmers are facing problem in procuring milk as well as in disposing their output. Due to these reasons union had confronted low procurement of milk from former as compared to previous year. Hence, all milk unions under control of Karnataka Milk Federation have reduced the milk procurement during pandemic situation.

Peda production
The data was collected on monthly basis i.e., from April 2012 to march 2020. The estimates, R^2 and RMSE obtained by fitting various polynomial degrees over the trend of milk procurement was displayed in the Table 2. Among all the fitted polynomial degree the 6th degree polynomial with highest R^2 of 0.851and lowest RMSE of 2436.351 was considers to be best model for peda production. It could seen that above equation from graph in Fig 2. Clearly shows ups and downs in the trend of peda production.

Table 1: Polynomial function for milk procurement

Degree	Regression model equation of best fit	R^2	RMSE
2nd	$y = -12.952*x^2 + 2272.5*x + 136397$	0.798	14863.00
3rd	$y = -0.0835*x^3 - 0.8039*x^2 + 1798.7*x + 140326$	0.799	14797.46
4th	$Y = -0.0047*x^4 + 0.8282*x^3 - 57.85*x^2 + 3043.4*x + 134008$	0.803	14747.38
5th	$y = 0.0003*x^5 - 0.0687*x^4 + 6.3592*x^3 - 260.64*x^2 + 5912.7*x + 124057$	0.809	14708.06
6th	$y = 0.000009*x^6 - 0.0025*x^5 + 0.2328*x^4 - 9.3286*x^3 + 124.89*x^2 + 2053.7*x + 133897$	0.8134	14659.35

Note- * - Significant at 5 percent
** - Significant at 1 percent
*** - Significant at 0.01 percent
R^2 - coefficient of determination
RMSE – Root Mean Square Error

Table 2: Polynomial function for peda production

Degree	Regression model equation of best fit	R^2	RMSE
2nd	$y = -0.8237*x^2 - 86.818*x + 17042$	0.7803	2469.969
3rd	$y = 0.0443*x^3 - 7.2735*x^2 + 164.73*x + 14956$	0.801	2460.176
4th	$y = 0.0013*x^4 - 0.2135*x^3 + 8.8606*x^2 - 187.29*x + 16743$	0.8104	2443.151
5th	$y = 0.000004*x^5 + 0.0116*x^4 - 1.1036*x^3 + 41.495*x^2 - 649.03*x + 18344$	0.8165	2352.551
6th	$y = 0.000002*x^6 - 0.0025*x^5 + 0.2328*x^4 - 9.3286*x^3 + 124.89*x^2 + 2053.7*x + 133897$	0.851	2436.351

Note- * - Significant at 5 percent
** - Significant at 1 percent
*** - Significant at 0.01 percent
R^2 - coefficient of determination
RMSE – Root Mean Square Error

Ghee production

The data was collected on monthly basis i.e., from April 2012 to March 2020. The estimates, R^2 and RMSE obtained by fitting various polynomial degrees over the trend of milk procurement is displayed in the Table 3. Among all the fitted polynomial degree the 6th degree polynomial with highest R^2 of 0.2335 and lowest RMSE of 7106.115 was considers to be best model for ghee production. It could see that above equation from graph in Fig 3. It clearly shows ups and downs in the trend of ghee production.

Table 3: Polynomial function for ghee production

Degree	Regression model equation of best fit	R^2	RMSE
2nd	$y = -0.6731x^2 + 143.72x + 3788.2$	0.092^{NS}	7131.922
3rd	$y = -0.0188x^3 + 2.7472x^2 - 22.51x + 5499$	0.099^{NS}	7129.338
4th	$y = -0.0014x^4 + 0.3273x^3 - 24.254x^2 + 710.61x + 898.2$	0.135^{NS}	7121.019
5th	$y = 0.00006x^5 + 0.0159x^4 - 1.5386x^3 + 60.949x^2 - 786.97x + 7289.7$	0.1867^{NS}	7116.186
6th	$y = 0.000002x^6 + 0.0006x^5 - 0.0747x^4 + 4.3317x^3 - 118.52x^2 + 1439.8x + 340.11$	0.2335^{NS}	7106.115

Note- * - Significant at 5 percent
** - Significant at 1 percent
*** - Significant at 0.01 percent
R^2 - coefficient of determination
RMSE – Root Mean Square Error

Butter production

The data was collected on monthly basis i.e., from April 2012 to March 2020. The estimates, R^2 and RMSE obtained by fitting various degree polynomial over the trend of milk procurement was displayed in the Table 4. Among all the fitted polynomial degree the 6th degree polynomial with highest R^2 of 0.2207 and lowest RMSE of 14170.23 was considers to be best model for butter production. It could seen that above equation from graph in Fig 4. In the graph ups and downs in the trend of butter production.

Fig.2 to fig. 4. represents the peda, ghee, and butter production showing irregular trend from year to year. However, there was decreasing trend was observed in the year 2017 and 2020 due to low price of milk products in the national and global markets, the union was facing financial losses due to milk purchase price offered by the union. Also, in the year 2016-17 the profit received from the sale of wholesale milk to foreign states was negligible. Also, there was fierce competition from private milk seller in the area. The price of butter per kg in the wholesale market reduced from 280 per kg to 240 per kg in the month of Dec-17. The sale of milk products was not profitable as there was no demand and no price. Taking into account the milk storage volume, sales volume, price of milk products and other expenses of the union, the union had loss for the end of year 2017.

In 2020 milk products production showed decreasing trend due to consciousness of consumers during Covid-19 pandemic, the consumer preference was supplementary towards raw milk not for the milk products, there is lack transportation and restriction of public movements during pandemic situation. Hence the polynomial models represented for milk procurement and milk product production were insufficient to describe for the following data pattern, this seemed quite reasonable.

Table 4: Polynomial function for butter production

Degree	Regression model equation of best fit	R2	RMSE
2nd	$y = -2.0644x^2 + 173.45x + 21171$	0.0557 NS	14206.67
3rd	$y = -0.0128x^3 + 0.2595x^2 + 60.504x + 22333$	0.0565 NS	14216.05
4th	$y = -0.0055x^4 + 1.3281x^3 - 104.33x^2 + 2900.3x + 4512$	0.1963 NS	14143.353
5th	$y = 0.00003x^5 + 0.0032x^4 + 0.3875x^3 - 61.383x^2 + 2145.4x + 7733.8$	0.1997 NS	14146.181
6th	$y = 0.000002x^6 - 0.0009x^5 + 0.1217x^4 - 7.2992x^3 + 173.62x^2 - 770.49x + 16834$	0.2207 NS	14170.23

Note- * - Significant at 5 percent
** - Significant at 1 percent
*** - Significant at 0.01 percent
R^2 - coefficient of determination
RMSE – Root Mean Square Error

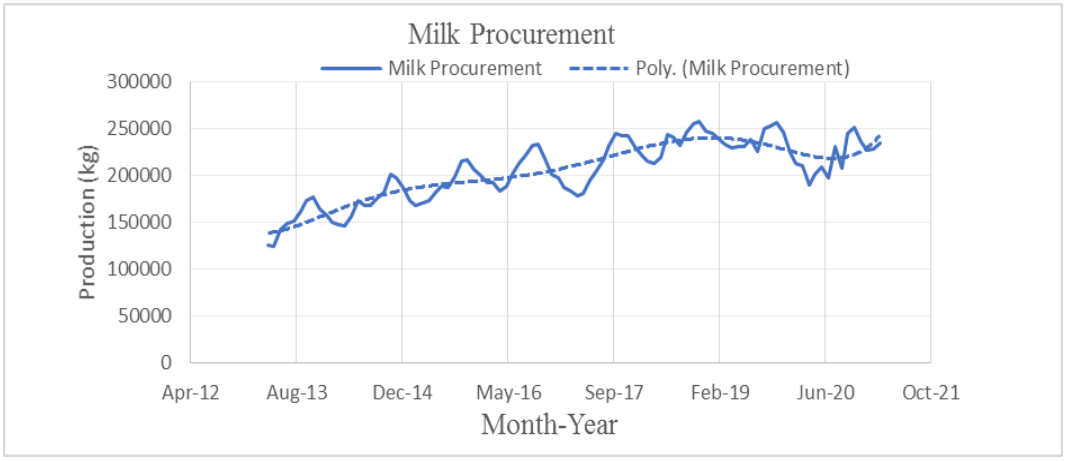

Fig 1: Trend in annual milk procurement

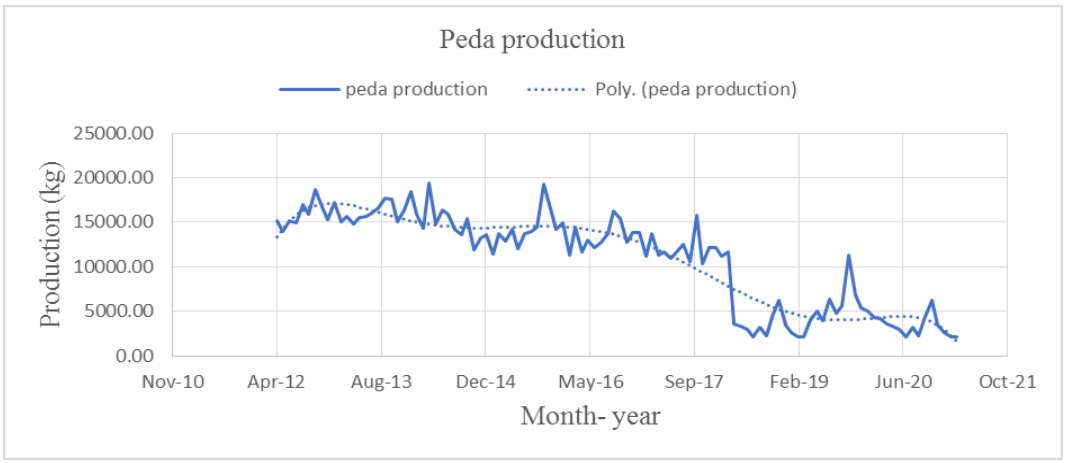

Fig 2: Trend in annual peda production

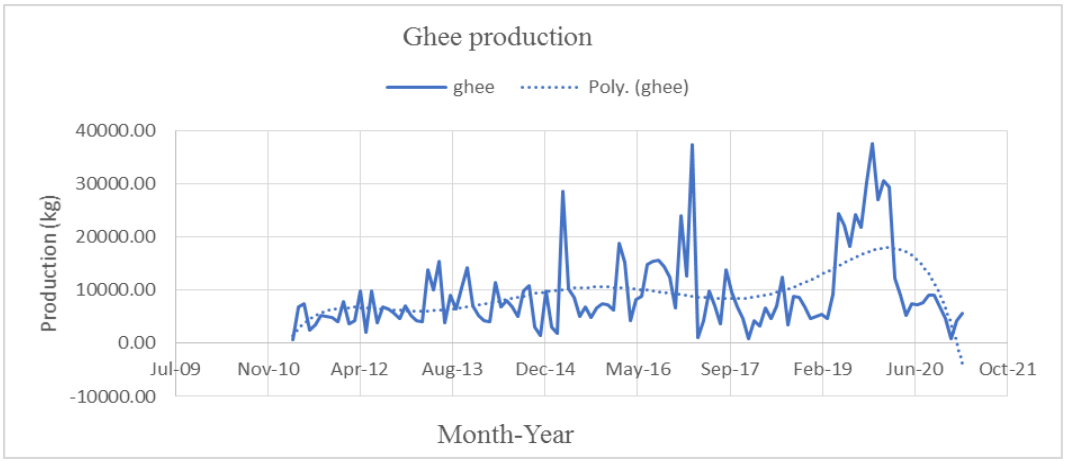

Fig 3: Trend in annual ghee production

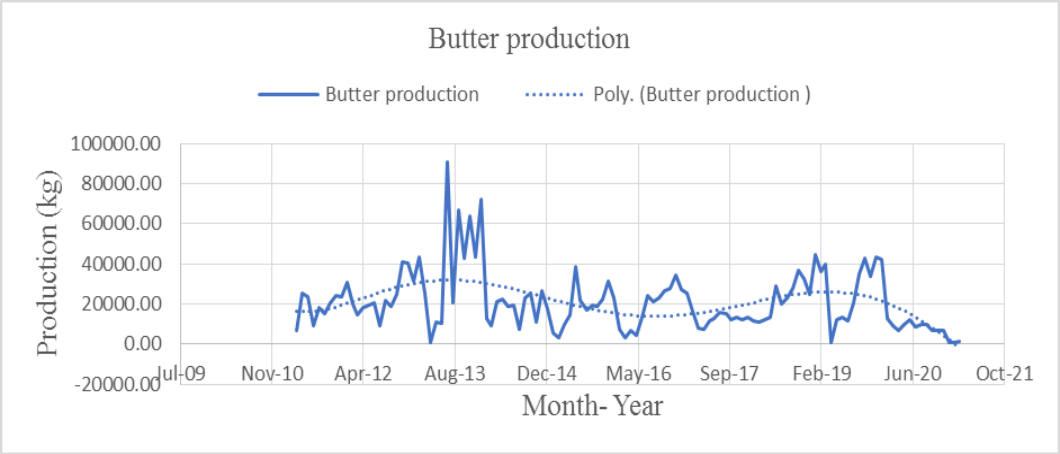

Fig 4: Trend in annual butter production

Conclusion

The present study was purposively undertaken in Dharwad milk union limited to analyses the growth pattern and the future condition of the same with impact of COVID pandemic. The secondary data was collected for milk procurement and milk products production of DMU for the period of 10 years. The polynomial models were employed over the trend of collected data to find out best curve of fit. The milk procurement and production of milk products, 6th degree polynomial found to best with highest R2 and lowest RMSE value. It was shows as irregular trend in milk procurement and milk products production. The graphical pattern of milk products like peda ghee and butter production under study not showing any constant trend.

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