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Comparative Analysis of Milk Production and Per Capita Availability in Gujarat and Maharashtra, India

Kripali Dave [a++] and Gurjar Mahendra [b#*]

[a] Virtual Heights IT Services, Ahmedabad and Ex-Postgraduate Student from College of FPTBE, Anand Agricultural University, Anand, India.
[b] SMC College of Dairy Science, Kamdhenu University, Anand, Gujarat, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

India is the world's largest milk producer, accounting for around 22% of global milk production, with significant contributions from cooperative dairy sectors. Among the leading milk-producing states are Gujarat and Maharashtra, which have witnessed distinct trajectories in milk production and per capita availability. This study aims to perform a comparative analysis of milk production and per capita milk availability between Gujarat and Maharashtra over the last two decades, shedding light on the factors driving these trends and the implications for the dairy sector.

Milk production in India has grown substantially, particularly due to the expansion of cooperative dairies like Amul in Gujarat. The dairy sector provides crucial entrepreneurial opportunities,

[++] Tech Consultant;
[#] Assistant Professor;
**Corresponding author: Email: mdgurjar247365@gmail.com;*

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contributing not only to the economy but also to nutritional security. The study reveals that Gujarat has consistently led in milk production, largely owing to its well-established cooperative model, particularly in districts like Banaskantha, Anand, and Mehsana. In contrast, Maharashtra, though initially lagging behind, has shown significant growth in recent years, closing the gap with Gujarat in milk production and per capita availability.

Between 2001-02 and 2022-23, Gujarat's milk production grew by approximately 194%, while Maharashtra's increased by 147%. Despite Gujarat's higher overall production, Maharashtra has witnessed a faster growth rate in recent years, especially in the 2020s. The study also examines per capita milk availability, where Gujarat consistently outperformed Maharashtra, but the latter's growth rate has outpaced Gujarat's in recent years, particularly after 2020-21.

Key contributing factors to these trends include infrastructure investments, the expansion of private dairy companies, technological advancements in dairy farming, and government support. Moreover, urbanization, rising incomes, and growing demand for dairy products have driven increased milk availability in both states. Statistical analyses of growth trends show that Gujarat's per capita availability of milk grew at a Compound Annual Growth Rate (CAGR) of 4.02%, while Maharashtra's CAGR was slightly higher at 4.32%.

This research underscores the significant strides made by both states in enhancing milk production and availability, highlighting the role of cooperative models in Gujarat and the recent acceleration of infrastructure development in Maharashtra. Continued investment in dairy infrastructure, sustainable practices, and rural market access will be crucial in meeting the future demand for milk and milk products in India.

Keywords: Dairy sector; milk production; per capita availability; Gujarat; Maharashtra; cooperative model; infrastructure; rural development.

1. INTRODUCTION

"India is the world's largest milk producing country. Its milk Production for the year 2022-23 stood at a mammoth 230.77 metric million tonnes which is around 22% of the world milk production. This growth is largely due to the growth of cooperative dairy sector. There are around 16.5 million dairy farmers registered with around 1,85,903 Village Dairy cooperatives in the country. Majority of the milk producers belong to small and marginal category with only 2 to 5 animal holding. The leading milk producing states are – Uttar Pradesh, Andhra Pradesh, Madhya Pradesh, Rajasthan and Gujarat" (Gurjar et. al. 2022). "The demand of milk and milk products in the country is also increasing and in order to meet the expected rise in demand, the NDDB has already implemented the National Dairy Plan (NDP-I). The entire dairy value chain provides excellent entrepreneurial opportunities for any potential dairy entrepreneur. Dairy is an important sector in the country. In the year 2020-21 the milk production reached to around 210 million tonnes and the per capita availability is more than 427 gm/day. With this achievements along with developments in modern dairy farming sector, the proliferation of ICT in the country and the growing demand of milk and milk products, the dairy sector seems to provide good lucrative opportunity for entrepreneurship" (Gurjar et. al. 2023).

According to the Annual report of NDDB (2024) , the milk production in the country continued to increase by about six per cent per annum, while the per capita availability registered a growth of above 4.5 per cent during the past five years. In 2022-23, milk production in the country is likely to be 230 million tonnes and per capita availability of milk is expected to be 455 grams per day. The year 2022-23 was marred with unfavourable climatic conditions such as long and intense heat spells, followed by unevenly distributed rainfall. Also, there were sporadic incidences of Lumpy Skin Disease (LSD) in cattle. The Government of India intervened to contain the disease through vaccination and provided financial & technical support to the affected states /Union Territories (UT).

2. LITERATURE REVIEW

"Gujarat is a leading milk producing state and has contributed significantly in the overall success of the dairy sector of the country. According to data available in the 19th livestock census -2012 All India Report, Gujarat had 9984 thousand cattle and 10386 thousand buffalo population, which comes to around 5.23% and

9.55% of cattle and buffalo population of the country" (Gurjar M.D., et. al., 2023).

According to DAHD's Annual Report (2023), "the contribution of milk production by Cow, Buffalo and Goat. The analysis shows nearly 45% of the milk production is contributed by Indigenous/ Non-Descript Buffaloes followed by 30% by crossbred cows. The Indigenous/Non-descript cows contribute 20% of the total milk production in the country. Goat milk shares a contribution of 3% in the total milk production across the country. The contribution of exotic cows in total milk production is 2%".

According to Gurjar M.D & Modi, Z. M (2024), Gujarat, with its significant dairy farming tradition, produced a total of 17.281 million metric tonnes of milk (in year 2022-23), is contributing substantially to India's milk output. Major districts such as Banaskantha, Sabarkantha, Mehsana, Anand, and Kheda were identified as key contributors. Banaskantha emerged as the leading district, particularly for crossbred cow and buffalo milk.Gujarat's dairy industry in 2022-23 was dominated by a few key districts, with Banaskantha leading in overall milk production. Crossbred cows were the primary contributors to cow milk, while buffaloes played a major role in several districts, especially in Banaskantha and Kheda. Goat milk production, although less significant, was concentrated in districts like Dahod and Kachchh. The success of these regions can be attributed to favorable climatic conditions, robust cooperative networks, and efficient animal husbandry practices. As Gujarat continues to be a central player in India's dairy sector, further strengthening of infrastructure, veterinary services, and sustainable practices will be crucial for maintaining and enhancing milk production capacity across the state. Cooperative dairies have contributed significantly in the development of the state's dairy sector. At village level 19505 Milk Co-operative Societies, 125 Chilling centres and 19 Dairy processing units at 22 district level (Dairy) are in functioning in the state. Total 12 Districts Co-operative Union have established.

Kaur and Singla (2018), in their study titled Growth and structural transformations in dairy sector of India, assert that Their study also shows that different states of India has responded differently to the structural changes such as rapid growth in contribution of milk by states like Andhra Pradesh, Gujarat and Rajasthan in national milk production, while traditionally green revolutionary states such as Punjab and Haryana along with Karnataka, Maharashtra, Tamil Nadu, Madhya Pradesh and West Bengal have registered a decline in milk contribution.

Further, Milk is a well-known source of essential nutrients that benefit various aspects of health. It is rich in Calcium: Supports strong bones and teeth, reducing the risk of osteoporosis, it is a valuable Protein Source: High-quality protein (casein and whey) helps with muscle growth, repair, and maintenance. It contains Vitamin D (Fortified milk contains vitamin D, which enhances calcium absorption and supports immune function). The Potassium in milk helps regulate blood pressure by counteracting the effects of sodium. Milk also serves as a hydrating beverage with electrolytes, particularly after physical activity. The synergistic relationship between yoga and dairy offers a comprehensive approach to enhancing digestive health across all age groups. By recognizing the specific digestive challenges faced at different life stages, targeted yoga practices and strategic dairy consumption can effectively alleviate discomfort, improve nutrient absorption, and promote holistic well-being (Modi Z.M. et.al 2024).

Animal husbandry and milk production also has an effect on environment. According to Gujar et. al. (2022), the Dairy sector affects the environment in terms of Animal husbandry activity mostly by production of methane, Dairy Processing operations, large Effluents, huge use of Electricity and fuel energy for Heating and Cooling Operations, Large use of Water in dairy operations, and so on and some of the solutions are - – Plantation, Rural Sanitation, Bio-CNG production, Use of Solar Energy, Innovations in the Energy efficient equipment and processes, Very recently one more sustainability issue linked to bovine colostrum has been highlighted. Bovine colostrum is a natural secretion from the mammary gland and the first milk produced after the birth of a calf. Large-scale milk production produces considerable volumes of colostrum, typically collected at farms, chilled, and transported to central processing facilities. At the processing facility, it undergoes pasteurization, cream separation, and lactose removal before drying. The required proteins and bioactive compounds are extracted from the bovine colostrum. However, during centrifugal separation, 28% of immunoglobulins are obtained in the lipid fraction. The colostrum cream obtained as a by-product is high in fat, containing 40–45% fat and concentrated further

to 70–80% fat. Currently, this cream is not effectively utilized and is often disposed of, resulting in sustainability concerns and economic problems (Modi, Zeel 2025).

Acording to Deshmuk (2014), Among various states, Uttar Pradesh ranks first in terms of number and capacity of milk plants operating under central registered authorities followed by Gujarat and Maharashtra. But Maharashtra rank first in terms of number and capacity of milk plants operating under state registered authorities followed by Utter Pradesh and Punjab. Several brands have been created by co-operatives like Amul (GCMMF), Vijaya (AP), Verka (Punjab), Saras (Rajasthan), Nandini (Karnataka), Milma (Kerala) and Gokul (Kolhapur).

Tanwar, Rashmi, and Sunil Kumar Singh (2024) analysed the instability in retail prices of milk in four selected markets namely- Delhi, Mumbai, Chennai and Kolkata for two periods (Sub period I 1975 – 1999; and sub period II 2000-2022) and concluded that the growth rate of production and per capita availability of milk had increased over time. The highest milk retail price was observed in Delhi markets during 2022. The CAGR of milk retail prices were increased in Delhi and Kolkata markets, while in Mumbai and Chennai markets, the growth rate was reduced from sub-period I to sub-period II. The variability in the retail prices of milk were reduced in the sub-period II in all the markets as compared to sub-period I. This reduction in price variability in sub-period II may be happened due to the increased production and per capita availability of milk, stable milk supply chain and other marketing infrastructures during sub-period II. The highest reduction in variability of milk retail prices were observed in the Mumbai market.

GN Narnaware et. Al. (2025) in their study titled Economics of milk production in Maharashtra: A case study, concluded that economic analysis of milk production, it was found that the overall cost of milk production decreased as the herd size increased, while the overall net returns per litre of milk increased with the herd size Negative net returns from local cow milk production do not mean milk production is unprofitable in the research area. Most of the milk production expenses in the study do not enter farmers' accounts because 60% of the resources are either farm-owned and have lower opportunity costs or communal and farmers do not pay directly. Farmers aren't losing much. However, improving milk yield and offering better health care and extension services can boost dairy profitability.

D.V Kolekar et. Al. (2015). Milk production parameters perceived by dairy farmers undercontract farming in Western Maharashtra there was more number of milking animalsin case of private as compared to cooperative dairy farmers.Due to which, total milk production per farm was more incase of private dairy farmers. But there was not muchdifference in total milk production per animal of both thedairy farmers. In case of feeding, on an average total dryfodder fed per animal in case of both the farmers was same.The same is true in case of health cost and labour cost peranimal. But in case of green fodder feeding, private dairyfarmers were feeding more green fodder than cooperativedairy farmers and vice versa in case of concentrate feedingper animal. Thus, total feed cost per animal was less in caseof private as compared to cooperative dairy farmers. Due towhich total expenditure per animal also was less in case ofprivate dairy farmers. Thus, gross return per animal, per farmand per liter was more in case of private dairy farmers as compared to cooperative dairy farmers.

2.1 Research Objectives

- To study and carry out the comparative analysis of Milk production and per capita availability of milk in two neighbouring states namely Gujarat and Maharashtra.

2.2 Research Methodology

The present research is based on secondary data. The data for the study was obtained from various websites and Annual reports of various organizations such as NDDB, Gujarat Government Animal Husbandry Department, DAHD, etc. Secondary data was also obtained from various research articles from reputed journals.

The data of milk production and per capita availability of milk were systematically analysed to find out the CAGR, growth rate, trends, etc. and a comparative analysis was done. The following formula were used

$$CAGR = [EV / BV]^{1/n} - 1$$

Where:

EV: Ending Value
BV: Beginning Value
N: Number of Compounding Periods

The results included comparative scenario, Notable growth periods, Notable trends, Identification of major districts which contribute around 50% of milk production to the Gujarat and Maharashtra states respectively. Appropriate interpretations of the findings was done and conclusions were drawn.

3. RESULTS AND DISCUSSION

3.1 Milk Production Over Last Two Decades in Gujarat and Maharashtra

The following Table 1 summarizes the milk production data (in thousand tonnes) for Gujarat and Maharashtra from 2001-02 to 2022-23.

3.2 Trend Analysis

(a) **Gujarat's Milk Production Growth**: From 2001-02 to 2022-23, Gujarat's milk production grew from **5,862 thousand tonnes** to **17,281 thousand tonnes**, representing an increase of approximately **194%.** The annual growth rate during this period averages around **7.4%.** Notable jumps in production occurred during the mid-2000s, likely driven by the expansion of cooperative dairy farming (especially by Amul) and increased investments in dairy infrastructure.

(b) **Maharashtra's Milk Production Growth**: Maharashtra's milk production grew from **6,094 thousand tonnes** in 2001-02 to **15,042 thousand tonnes** in 2022-23, reflecting a growth of about **147%.** The state has experienced steady growth over the years, with a slightly higher rate of growth in the 2020s compared to earlier periods. The average annual growth rate for Maharashtra is approximately **6.7%.**

3.2.1 Top milk producing districts of Gujarat and Maharashtra

The following table shows the milk top milk producing districts of Gujarat and Maharashtra and their contribution in respective state's total milk production.

Table 1. Milk Production of Gujarat and Maharashtra states (in thousand Tonnes)

Year	Gujarat	Maharashtra
2001-02	5,862	6,094
2002-03	6,089	6,238
2003-04	6,421	6,379
2004-05	6,745	6,567
2005-06	6,960	6,769
2006-07	7,533	6,978
2007-08	7,911	7,210
2008-09	8,386	7,455
2009-10	8,844	7,679
2010-11	9,321	8,044
2011-12	9,817	8,469
2012-13	10,315	8,734
2013-14	11,112	9,089
2014-15	11,691	9,542
2015-16	12,262	10,153
2016-17	12,784	10,402
2017-18	13,569	11,102
2018-19	14,493	11,655
2019-20	15,292	12,024
2020-21	15,853	13,703
2021-22	16,722	14,305
2022-23	17,281	15,042

Source: NDDB

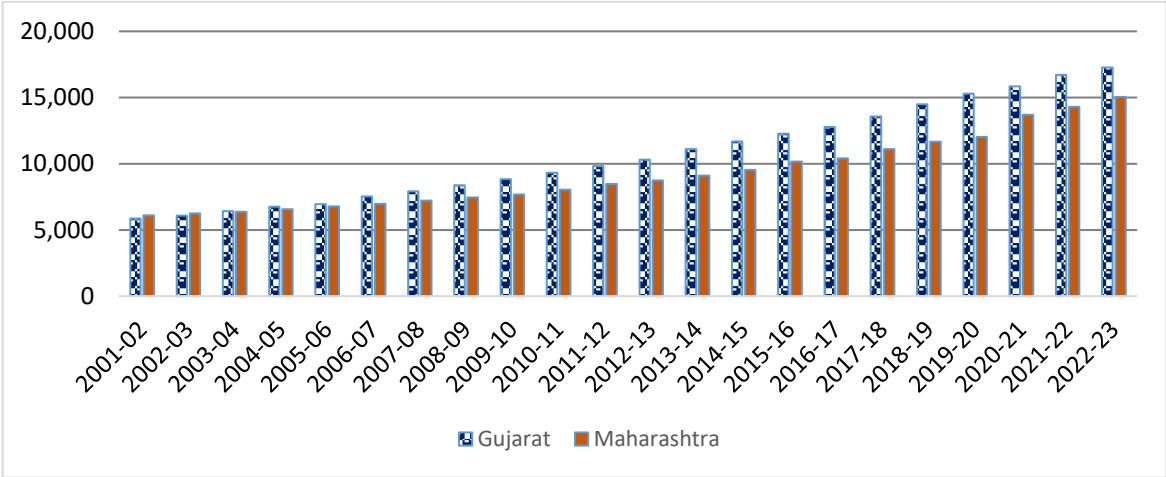

Fig. 1. Milk Production of Gujarat and Maharashtra States for last wo decades (in thousand tonnes)

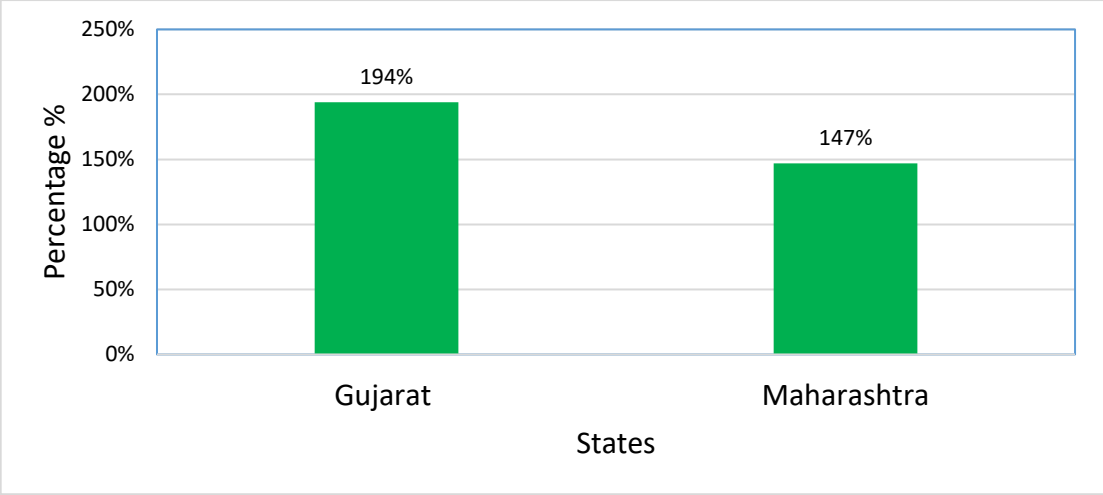

Fig. 2. Percent Increase in milk production From 2001-02 to 2022-23

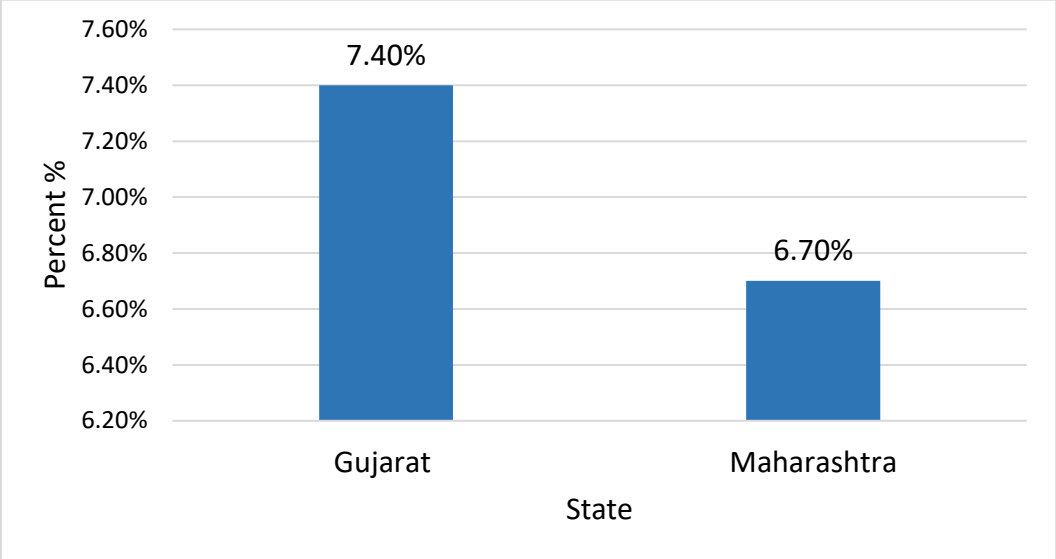

Fig. 3. Average Annual grwoth rate in milk production From 2001-02 to 2022-23

Table 2. Districts having Major contribution (around 50%) in Gujarat's Total Milk Production

District	Milk Production (Thousand Tonnes)	% Share of Total Milk Production
Banaskantha	3159.84	18.29%
Sabarkantha	957.99	5.54%
Mehsana	916.86	5.31%
Anand	876.13	5.07%
Kheda	862.44	4.99%
Arvalli	793.26	4.59%
Kachchh	727.58	4.21%
Mahisagar	604.48	3.50%
Total for Gujarat	17280.56	

year 2022-23

Table 3. Districts having Major contribution (around 50%) in Maharashtra'ss Total Milk Production

District	Milk Production (Thousand Tonnes)	% Share of Total Milk Production
Ahmadnagar	2073.27	15%
Pune	1769.2	13%
Solapur	1418.73	10%
Kolhapur	1167.49	9%
Sangli	1064.12	8%
Total for Maharashtra	13703.3	

year 2021-22

Out of total 33 districts only 8 districts of the state - Banaskantha, Sabarkantha, Mehsana, Anand, Kheda, Arvalli, Kachchh, and Mahisagar together contribute around 51% of the state's milk.

Out of around 35 districts only 5 districts of the Mahrashtra state – Ahmadnagr, Pune, Solapur, Kolhapur and Sangli together contribute around 55% of the state's milk.
So in both the states we can say that milk production there a few districts which have large contribution.

3.2.2 Key observations

(i) **Gujarat's Consistent Lead**: Gujarat has maintained a lead in milk production over Maharashtra for most of the period under study. In 2001-02, Gujarat's production was **232 thousand tonnes** less than Maharashtra's. However, Gujarat soon surpassed Maharashtra in 2004-05 and has consistently maintained a higher output since then.

(ii) **Maharashtra's Slower Growth Rate in Earlier Years**: While Gujarat's production outpaced Maharashtra's growth in the earlier years, Maharashtra started showing more significant growth in the 2020s. This trend became especially noticeable after 2019, likely due to increased dairy farming initiatives and an expansion of milk processing capacities.

(iii) **Recent Catch-up by Maharashtra**: Although Gujarat's milk production is higher, Maharashtra's production has increased at a faster rate in the latter part of the timeline. By 2022-23, Maharashtra's production came close to Gujarat's, with a difference of just **1,239 thousand tonnes**, down from **1,232 thousand tonnes** in 2019-20.

(iv) **Notable Growth Periods**:

a) **Year 2001-2010**: Gujarat showed consistent growth in milk production, with an average increase of around **7-8%** annually.

b) **Year 2011-2015**: Maharashtra's growth was more subdued during these years, while Gujarat experienced robust expansion.

c) **Year 2016-2022**: Maharashtra's growth rate picked up, reflecting investments in dairy farming infrastructure, private-sector involvement, and rising demand for milk and dairy products.

3.2.3 Economic and developmental factors

- **Gujarat's Dairy Sector**: Gujarat has benefitted from a well-established cooperative model, particularly through **Amul**, which has enabled efficient milk collection, processing, and distribution. The state's focus on dairy development policies, alongside the growth of dairy farming cooperatives, has contributed to its leadership in milk production.
- **Maharashtra's Dairy Sector:** The state of Maharashtra has maximum area under rainfed even though it is one of the leading states in terms of livestock population and milk production in the country. Dairy farming industry in Maharashtra has shown tremendous growth in terms of milk production from 6,002 MT (2001-02) to 11,655 MT (2018-19). Small and marginal farmers and landless laborer's, who derive a substantial part of their livelihood from sale of milk, own about 82 percent of cattle in the rural areas.

3.3 Per Capita Availability of Milk (grams per day) in Gujarat vs. Maharashtra (2009-10 to 2023-24)

Milk plays a crucial role in the nutritional diet of millions of people in India. The **per capita availability of milk** serves as a significant indicator of access to this essential commodity and reflects the overall health and productivity of the dairy sector in various regions. This section of the article focuses on the **per capita availability of milk** (measured in grams per day) in **Gujarat** and **Maharashtra** over the period **2009-10 to 2023-24**. It compares the trends in both states and analyses the key factors contributing to the growth or disparity in milk availability.

3.3.1 Per capita availability of milk in Gujarat and Maharashtra States

The following table presents the **per capita availability of milk (**in grams per day) for **Gujarat** and **Maharashtra** from **2009-10 to 2023-24.**

3.3.2 Descriptive statistics of per capita milk availability

To better understand the trends in per capita milk availability in both **Gujarat** and **Maharashtra**, we calculate key statistical measures such as **mean** and **standard deviation**.

- **Mean (Average) Per Capita Availability**:
  - **Gujarat**: Mean per capita availability = **548.5 grams/day**.
  - **Maharashtra**: Mean per capita availability = **261.6 grams/day**.
- **Standard Deviation**:
  - **Gujarat**: Standard deviation = **92.8 grams/day**, indicating a moderate level of variability in milk availability.
  - **Maharashtra**: Standard deviation = **51.8 grams/day**, showing relatively less variability in the data compared to Gujarat.

From these statistics, we can see that while **Gujarat** has consistently had higher per capita milk availability, **Maharashtra** has shown significant growth in recent years, narrowing the gap between the two states.

Table 4. Per capita availability of milk (in grams per day) for Gujarat and Maharashtra

Year	Gujarat	Maharashtra
2009-10	418	190
2010-11	435	197
2011-12	445	206
2012-13	476	213
2013-14	506	219
2014-15	506	225
2015-16	522	236
2016-17	538	240
2017-18	563	254
2018-19	593	264
2019-20	615	269
2020-21	631	305
2021-22	656	315
2022-23	670	329
2023-24	700	347

Source: NDDB

3.3.3 Growth analysis

To analyze the growth trends, we calculate the **Compound Annual Growth Rate (CAGR)** for both Gujarat and Maharashtra. The **CAGR for Gujarat was found to be** 4.02% and that of **Maharashtra** was 4.32%.

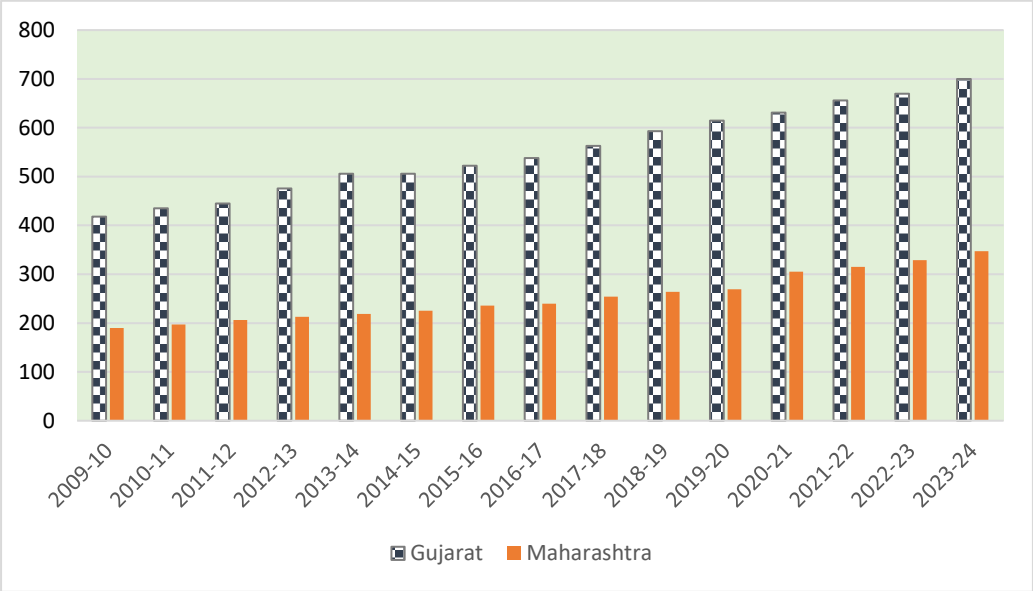

Fig. 4. Per capita Availability of milk (gms /day)- Gujarat and Mahrashtra States

4. TREND ANALYSIS AND KEY OBSERVATIONS

- **Gujarat's Growth**: Gujarat's per capita availability of milk has increased steadily from **418 grams/day** in 2009-10 to **700 grams/day** in 2023-24, reflecting a consistent growth trend with a **CAGR of 4.02%**. The state's well-established cooperative dairy model, particularly **Amul**, has been a significant driver of this growth, ensuring high production, efficient processing, and distribution of milk.
- **Maharashtra's Growth**: Maharashtra, on the other hand, has shown a **CAGR of 4.32%**, slightly outperforming Gujarat in terms of annual growth. The state's growth is especially notable in the later years, from 2020-21 onwards, when the per capita availability increased from **305 grams/day** to **347 grams/day**. This rapid growth can be attributed to several factors:

  - The expansion of **private dairy companies** and the **government's support** for the dairy sector in Maharashtra.
  - The establishment of more **milk processing units** and the adoption of modern technologies in dairy farming.
  - Increased investments in **rural infrastructure** and better market access for farmers.

- **Urbanization and Demand for Dairy Products**: Both Gujarat and Maharashtra are seeing an increasing demand for milk and milk products due to rising urbanization, higher disposable incomes, and a growing consumer preference for dairy products. This demand has contributed to the increased per capita availability in both states.

Further, K. Vykhaneswari and G. Sunil Kumar Babu (2021) studied the Performance of Dairy Sector in India and highlighted that there has been observed a positive and significant compound annual growth rate of 4.71 per cent to milk production and 3.26 per cent for per capita availability. Dairy cooperative societies, producer members, milk procurement and liquid milk marketing showed a positive and significant compound annual growth rate of 3.47, 2.31, 7.78 and 6.04 per cent respectively. The compound annual growth rate of exports in quantity showed a positive rate of 14.24 per cent and imports with a negative growth rate of 9.70 over the period which indicates that India is a net exporter of dairy products.

5. SUMMARY AND CONCLUSION

In conclusion, the comparative analysis of milk production and per capita availability in Gujarat and Maharashtra highlights significant progress in both states' dairy sectors, driven by distinct factors. Gujarat has consistently led in overall

milk production, supported by its robust cooperative model, particularly through Amul, which has facilitated steady growth in production and distribution. Meanwhile, Maharashtra has exhibited a more recent surge in milk production, with a higher Compound Annual Growth Rate (CAGR) in per capita availability, especially after 2020-21. The state's focus on expanding dairy infrastructure, including processing units and modern farming technologies, has contributed to this growth. Although Gujarat continues to have higher per capita milk availability, Maharashtra is closing the gap, indicating an overall positive trend in both states. This development reflects the increasing importance of the dairy sector in ensuring nutritional security and economic opportunities for rural communities, while also emphasizing the need for continued investment in infrastructure and sustainable practices to meet future demands.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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