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Global dynamics of soymeal production: Growth performance and instability with reference to India

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Abstract
This study assesses the growth performance and production instability of soymeal in India in comparison with leading global producers including China, the United States, Brazil, Argentina, and others. Using Compound Growth Rate (CGR), Coefficient of Variation (CV), and the Cuddy-Della Valle Instability Index (CDVI), the analysis offers a decade-long (2014-15 to 2023-24) cross-country perspective on soymeal production dynamics. The results reveal that while India achieved a statistically significant CAGR of 5.20 per cent with a CDVI of 0.12, global soymeal production grew at a comparatively lower CAGR of 2.33 per cent and exhibited more stability, reflected by a CDVI of 0.02. These findings highlight India's relatively stronger growth trajectory but also point to greater production volatility compared to mature producers such as the United States and China. The study underscores the need to stabilize domestic soymeal output through technological, climatic, and policy interventions to ensure global competitiveness.

Keywords: Soymeal production, Compound Growth Rate (CGR), production instability, comparative analysis

Introduction
Soymeal, the primary protein component derived from soybean processing, plays a crucial role in the global feed industry. In 2023-24, total world soymeal production reached 259.7 million metric tons, with China (78.4 MMT), the United States (49.1 MMT), and Brazil (42.1 MMT) being the leading producers. Collectively, these countries accounted for over 65 per cent of global soymeal output, supported by scale, infrastructure, and consistent soybean availability. In contrast, India produced 9.04 million metric tons of soymeal in 2023-24, with a decadal average of 7.06 million metric tons (2014-15 to 2023-24). Although this places India among the top six producers globally, its output remains considerably lower than that of dominant players. Nevertheless, India's production trajectory has shown a Compound Annual Growth Rate (CAGR) of 5.20 per cent, higher than the global average of 2.33 per cent, indicating a positive trend despite notable year-to-year fluctuations. This comparative assessment of production levels serves as the basis for evaluating India's position in the global soymeal sector and highlights the need to address volatility and enhance long-term sustainability.

Materials and Methods
The present study was conducted at the global level with a special focus on India. Ten major soymeal-producing countries China, United States, Brazil, Argentina, European Union, India, Mexico, Russia, Egypt, and Bolivia were selected based on their share in global soymeal production. The analysis aimed to compare India's performance against these countries in terms of growth and production stability over the last decade. The study relies entirely on secondary time-series data for the period 2014-15 to 2023-24. Country-wise soymeal production statistics were sourced from USDA Production Supply and Distribution Database. The dataset for each country includes annual soymeal production volume (in '000 metric tons) for the ten-year period.

Analytical Tools and Techniques

To fulfill the study's objectives, the following statistical tools were employed:

Compound Growth Rate (CGR)

$Y = a.b^t$

Where, Y = Depended variable for which growth rate is to be estimated (Soymeal Production)
a = Intercept
b = Regression Coefficient
t = Time Variable.

This equation was estimated after transforming (1) as follows,

Log Y = log a + t Log b

Then the percent compound growth rate (g) was computed using the relationship.

CAGR (g) = (antilog b -1) ×100

Instability Measures

Instability in soymeal production was assessed using two indicators:

Coefficient of variation (CV)

$$\text{Coefficient of variation (CV)} = \frac{\sigma}{\bar{x}} \text{ X } 100$$

Where, σ = Standard deviation

$$s = \sqrt{\frac{\Sigma(X-\bar{X})^2}{n}}$$

$\bar{X}$ = Arithmetic mean
X = Variable
n = Number of observations.

Cuddy-Della Valle's Instability Indices (CDVI)

$$\text{Instability Index} = CV\sqrt{(1 - R^2)}$$

Where, CV = coefficient of variation
adj R^2 = Coefficient of determination.

Results and Discussion

a) Soymeal Production by Country (2014-15 to 2023-24)

The yearly production of soymeal (in '000 metric tons) for India and other major producing nations is shown in table 1. India's production fluctuated between 4,400 thousand metric tons (2015-16) and 9,040 thousand metric tons (2023-24), averaging 7,057 thousand metric tons over the study period. In contrast, China consistently led with production rising from 59,004 thousand metric tons to 78,408 thousand metric tons, followed by the USA (from 40,880 thousand metric tons to 49,120 thousand metric tons) and Brazil (from 31,300 thousand metric tons to 42,119 thousand metric tons). Argentina, once a major producer, declined in later years. Emerging producers like Mexico, Russia, and Egypt showed gradual increases, while EU production remained relatively stable. The table highlights India's growing contribution but also its comparative lag in volume.

b) Compound Growth Rate (CGR) of Soymeal Production

Country-wise growth performance in soymeal production is shown in table 2. India recorded a mean production of 7,057 thousand metric tons with a significant CAGR of 5.20 per cent (SE: 0.007, t-value: 3.18), reflecting moderate and consistent growth. Brazil achieved a very high mean of 35,464.2 thousand metric tons and the highest CAGR of 44.54 per cent (SE: 0.002), with a strong t-value of 9.91, showing rapid expansion in its soymeal industry. The USA led in output with 44,695.1 thousand metric tons mean production and a CAGR of 25.89 per cent (SE: 0.001, t-value: 8.87), indicating stable and significant growth. China, though the top producer by volume (mean: 70,527.6 thousand metric tons), had a lower CAGR of 2.57 per cent (t-value: 5.31), suggesting a saturated market. Argentina saw a negative CAGR of -2.05 per cent (t-value: -2.31), indicating a declining trend. The EU maintained stable production (mean: 11,731.6 thousand metric tons) with a marginal growth of 0.23 per cent (t-value: 0.65). Mexico, Russia, and Egypt showed positive growth at 5.44 per cent, 4.23 per cent and 6.91 per cent respectively, supported by expanding feed demand. However, Egypt's higher SE (0.016) and lower t-value (1.84) signal lower statistical confidence. Bolivia registered a mean of 2,153 thousand metric tons and a CAGR of 3.75 per cent (t-value: 4.63), suggesting gradual improvement. The global average CAGR stood at 2.33 per cent, with a strong t-value of 9.97, reflecting overall steady growth across the world.

C) Instability in Soymeal Production

Using the Cuddy-Della Valle Instability Index (CDVI) and Coefficient of Variation (CV), table 3 illustrates the instability in soymeal production. India recorded a CV of 0.19 and CDVI of 0.12, indicating moderate instability. USA (CV: 0.07, CDVI: 0.02) and Brazil (0.12, 0.04) showed low variability, reflecting stable production systems. China and the EU also had low instability with CDVI values of 0.04 each. Moderate instability was observed in Mexico (0.06), Russia (0.06), and Bolivia (0.07). Argentina's CDVI of 0.08 suggests moderate fluctuation. The highest instability was found in Egypt, with a CV of 0.35 and CDVI of 0.32, indicating significant year-to-year variation. The global average CDVI was 0.02, showing overall production stability, while India remained more volatile than most major producers

Table 1: Soymeal Production by Country (2014-15 to 2023-24)

Year	India	China	USA	Brazil	Argentina	EU	Mexico	Russia	Egypt	Bolivia	Total World
2014-15	6160	59004	40880	31300	30928	11416	3300	2837	1540	1915	208500
2015-16	4400	64548	40525	30750	33500	11811	3480	3152	1279	1995	216400
2016-17	7200	69696	40630	31280	33600	11060	3790	3467	1659	1685	226400
2017-18	6160	71280	44657	34300	28750	11455	4300	3625	2530	1957	232900
2018-19	7680	67320	44283	32746	31500	11850	4860	3664	2767	2036	234000
2019-20	6890	72468	46358	35991	30241	12324	4740	3664	3715	2157	245400
2020-21	8000	75240	45872	35940	31318	12482	4900	3550	2923	2396	249600
2021-22	6800	71280	47005	39091	30287	12166	5020	3861	3555	2439	248300
2022-23	8240	76032	47621	41125	23648	11297	5255	4255	1738	2593	248400
2023-24	9040	78408	49120	42119	28535	11455	5159	4650	2469	2357	259700

(Production in '000 Metric Tons)
Source: United States Department of Agriculture (USDA)

Table 2: Compound Growth Rate (CGR) of Soymeal Production

Country	Mean Production	CAGR (%)	SE	t-Value
India	7057.0	5.2	0.007	3.18
Brazil	35464.2	44.54	0.002	9.91
USA	44695.1	25.89	0.001	8.87
China	70527.6	2.57	0.002	5.31
Argentina	30230.7	-2.05	0.004	-2.31
EU	11731.6	0.23	0.002	0.65
Mexico	4480.4	5.44	0.003	7.41
Russia	3672.5	4.23	0.003	7.02
Egypt	2417.5	6.91	0.016	1.84
Bolivia	2153.0	3.75	0.004	4.63
Total World	236960.0	2.33	0.001	9.97

(Mean Production in '000 Metric Tons)

Table 3: Instability in Soymeal Production

Country	CV	CDVI
India	0.19	0.12
Brazil	0.12	0.04
USA	0.07	0.02
China	0.08	0.04
Argentina	0.09	0.08
EU	0.04	0.04
Mexico	0.16	0.06
Russia	0.14	0.06
Egypt	0.35	0.32
Bolivia	0.13	0.07
Total World	0.07	0.02

Conclusion

The present study examined the growth performance and production instability of soymeal across major global producers, with a special focus on India, over the period 2014-15 to 2023-24. The findings reveal that while India exhibited a moderate and statistically significant growth rate of 5.20 per cent, it also faced higher production variability compared to more stable producers such as the United States, Brazil, and China. The analysis, based on Compound Growth Rate (CGR), Coefficient of Variation (CV), and Cuddy-Della Valle Instability Index (CDVI), indicates that global soymeal production has remained largely stable, with India showing potential but also vulnerability due to climatic and structural factors. The results underscore the need for targeted interventions in India to improve production stability through climate-resilient practices, supply chain modernization, and policy support. Strengthening domestic processing infrastructure and reducing volatility will be critical for enhancing India's competitiveness in the global soymeal market.

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