Original Research Article

An assessment of export performance and trade competitiveness of sorghum from India

ABSTRACT

The present study examines the trade performance, competitiveness and trade directions of sorghum. The secondary data was collected from ITC Trade Map, focusing on global and Indian sorghum exports and imports performance, the data spanning from 2012 to 2022. The analytical tools like Revealed Comparative Advantage (RCA), Markov Chain analysis, and Herfindahl-Hirschman Index (HHI) are employed. USA, Australia, and Argentina are major sorghum exporters, while China, Japan and Spain are importers in the world. UAE, Bangladesh and Saudi Arabia are prominent destinations for Indian sorghum exports. Among the top five sorghum exporting nations, USA ranks first in all the indices of relative competitiveness demonstrating country's potential to export sorghum in global market which is followed by Australia. Transitional probability matrix indicated that Bangladesh is the most stable market among the importers of sorghum followed by Saudi Arabia and UAE. On the other hand, Kuwait and Egypt has shown 'zero' probability of retention, indicating that these countries are unstable importers. The HHI for global sorghum exports and imports are 0.48 and 0.42 respectively, indicating high concentration. In the case of Indian sorghum exports, the HHI is 0.16, representing moderate concentration. To reduce reliance on a small number of nations and to take advantage of the possibilities of a variety of markets, efforts should be made to increase India's sorghum exports.

Keywords: Sorghum, comparative advantage, Herfindahl-Hirschman Index, Markov Chain analysis.

1.INTRODUCTION

The word millet has been taken from the Latin word 'mille' to represent thousands of seed grains in a handful. Millets constitute one of the oldest crops known to humans, its cultivation has been estimated to be around since 800 BC. Millets acts as staple food and a source of income for poorer section of the community residing in arid and semi-arid regions of the developing world especially in Africa and Asia. Millet has been grown on the Indian subcontinent for 5,000 years and is common all over Africa and Southeast Asia. In India, millets have been an integral part of tribal food in the states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand [1]. The push for food security through

Green Revolution in the 1960s its cultivation decreased significantly from 40% to 20 %, making space for wheat and rice as the cultivator responded to market demand, rendering millets as 'orphan crops'.

In recent past however owing to its nutritional benefits, climate resilience and disease and pest's resistant properties, millets have made a comeback with the government of India undertaking various initiatives to increase its cultivation and consumption. The Indian Government declared 2018 as the National Year of Millets and rebranding millets as Nutri cereals. Further recognizing the importance of millets and to increase the domestic and global demand, the Government of India, proposed to the United Nations for declaring the year 2023 as International Year of Millets. The proposal of India was supported by 72 countries, and UNGA declared 2023 as the International Year of Millets in March 2021.

Millets are broadly classified into major millets (Sorghum, Pearl Millet, Finger Millet) and minor millets (Little Millet, Foxtail Millet, Proso Millet, Barnyard Millet and Kodo Millet). India recorded 27 per cent growth in millet production in 2021-22 as compared to millet production in the previous year which was 15.92 MMT. Pearl millet (60%) followed by Sorghum (27%), Finger millet (11%) and small millets (2%) are the major millets produced in India.

Sorghum (Sorghum bicolour.L) also known as Jowar or great millet is a warm season crop and serves as a staple food for poorer sections of the community. The crop is primarily produced in Maharashtra and southern states of Karnataka and Andhra Pradesh. These three states together account for close to 80% of the all-India production. Madhya Pradesh, Gujarat and Rajasthan are the other states producing sorghum [2]. India is the one of the largest producers of sorghum in the world with 4.03 million tonnes production during 2023-2024 [3]. The demand for sorghum in the importing countries is primarily for feed use, and hence only sorghum produced during rainy season is exported as the sorghum produced during post rainy season is used for domestic food consumption as this is of good quality [4].

2.METHODOLOGY

The secondary data was collected from ITC Trade Map, focusing on global and Indian sorghum exports and imports performance, the data spanning from 2012 to 2022. The statistical techniques used were like Revealed Comparative Advantage (RCA), Markov Chain analysis, and Herfindahl-Hirschman Index (HHI) are employed.

2.1 Markov chain analysis

Markov chain analysis is primarily based on the estimation of the transitional probability matrix P. The element Pij of this matrix indicates the probability that exports will switch from the country i to the country j with time. The diagonal element Pii measures the probability that the export share of a country will be retained. Hence, examination of diagonal element indicates the loyalty of an importing country to a particular country's exports. In the context of the current application, the average exports to a

particular country were considered to be a random variable which depended only on its past exports to that country and which can be denoted as

$$Ejt = \sum_{i=1}^{r} Eit - 1Pij + ejt$$

Where,

Ejt = Exports from India to the jth country during the year t,

Eit-1= Exports to the ith country during the year t-1,

ejt = The error-term which is statistically independent of Eit-1, and

r = Number of importing countries.

The transitional probabilities Pij, which can be arranged in a (c×r) matrix, have the following properties

$$O < Pij < 1$$

$$\sum_{i=1}^{r} Pij = 1 \; for \; all \; i$$

Thus, the expected export shares of each country during period t were obtained by multiplying the exports to these countries in the previous period (t-1) with the transition probability matrix. The transition probability matrix was estimated in the linear programming (LP) framework by the method referred to as Minimization of Mean Absolute Deviation (MAD), the LP formulation is stated as:

Min O'P* + Ie

Subject to, XP* + V = Y

GP* = 1

P* > 0

where, P* is a vector of the probabilities Pij, O is a vector of zeros, I is an appropriately dimensional vector of areas, e is the vector of absolute errors (|U|), Y is the vector of exports to each country, X is a block diagonal matrix of lagged values of Y, V is the vector of errors, and G is a grouping matrix to add the row elements of P arranged in P*, to unity. Analysis was done by using LINGO software.

2.2 Competitiveness

Revealed comparative advantage (RCA) was introduced and popularized by [5] has been used to identify a weak and strong competitiveness between sorghum exporting countries. The data is collected

sorghum exports as well as total agricultural exports for the period of 2012 to 2022. RCA index is calculated in various methods and represented in four different representations such as:

RCA_1: Balassa Index (BI)

$$RCA_{1it} = \frac{x_{it}/x_{ia}}{x_{w_t}/x_{\omega a}}$$

Where,

RCA_{1it} = Balassa Revealed Comparative Advantage Index

X_{it} = The value of sorghum exports by country i

X_{ia} = Value of agricultural exports by country i

X_{wt} = Value of world sorghum exports

X_{wa} = Value of world agricultural exports

If the value of $RCA_{1it} > 1$ then the country is said to have a comparative advantage over other nations and if $RCA_{1it} < 1$ then the country is at disadvantage from exports of sorghum.

RCA_2: Revealed Symmetric Comparative Advantage (RSCA): Revealed symmetric comparative advantage was used to overcome the asymmetry problem i.e. the earlier RCA index ranges from '0' to '1' for no specialization and '1' to '∞' for specialization [6]. RSCA index provides symmetry as it is free from skewness and its value ranges from '+1' to '-1' [7].

$$RCA_{2it} = \frac{RCA1it-1}{RCA1it+1}$$

Where,

RCA_{2it} = Revealed symmetric comparative advantage

RCA_{1it} = Balassa Revealed Comparative Advantage Index

A country is at a comparative advantage for a specific commodity if the value of the index is positive and is at a disadvantage if the value is negative.

RCA_3: Additive Revealed Comparative Advantage (ARCA) and

RCA_4: Normalized Revealed Comparative Advantage (NRCA)

The Balassa RCA index was not appropriate for use in the long run as it possessed a few problems such as the index lacked symmetry and had dichotomous properties [6],[7] the index also lead to another drawback of double-counting as the world's exports double count the i^{th} country's exports. To overcome

these technical problems, experts presented the solution of normalizing Balassa's RCA Index by the cross-sectional mean method.

$RCA_{3it} = \left[\frac{Xit}{Xia}\right] - \left[\frac{Xwt}{Xwa}\right]$

$RCA_3 = RCA_3 \times \left[\frac{Xia}{Xwa}\right] \times 10000$

Where,

RCA_{3it} = Additive Revealed Comparative Advantage

RCA_{4it} = Normalized Revealed Comparative Advantage

X_{it} = The value of sorghum exports by country i

X_{wt} = Value of World sorghum exports

X_{ia} = Value of agricultural exports by country i

X_{wa} = Value of World agricultural exports

The scores of this index range between -1/4 and +1/4 with the neutral point at zero. As the value of NRCA index is very small, to get a clear picture the outcome value is multiplied by 10,000. NRCA index calculates the degree of deviation of a country's actual exports from its comparative-advantage-neutral level in terms of its relative scale with respect to the world exports market and thus provides a proper indication of the underlying comparative advantage [8].

Herfindahl-Hirschman Index of Concentration

Herfindahl-Hirschman Index (HHI) is a commonly used as measure of the degree of a country's export concentration [9]. It is calculated by squaring the market share of each commodity exported from India and then summing the resulting number. The HHI is expressed as:

$HHI = \sum_{i=1}^{N} Si2$

where Si = Is the market share of country i in the market, and

N = Is the number of countries.

The result is a weighted average of market shares, with values ranging from 0 to 1, where 0indicates no concentration and 1 full concentration in the market (this would be the case of a monopoly). The UK's Competition and Markets Authority (CMA) defines a market as 'concentrated' if the HHI is higher than 0.1 (or 10%) and as 'highly concentrated' if the HHI is higher than0.2. The US Federal Trade Commission (USFTC) defines a slightly different threshold with HHI values above 0.18 as a 'highly

concentrated market', and above 0.1 as 'moderately concentrated'. A market with a HHI below 0.1 is usually considered as 'non-concentrated'.

RESULTS AND DISCUSSION

Global sorghum Exports

The global sorghum export scenario revealed that the USA is the largest exporter of sorghum in 2022, accounting for 59.20 per cent of the total exports, followed by Australia with 23.27 per cent and Argentina with 12.11 per cent. France and Uganda for 1.43 per cent and 0.49 per cent, respectively, while Ukraine and India have contributed 0.69 per cent and 0.37 per cent of the exports. Tanzania and Sudan, have contributed the same with 0.30 per cent whereas Russia with 0.27. The total global millet exports in 2022 were 1,04,83,111 tonnes (Table 1 and Fig. 1).

Table1: Major exporters of sorghum in the world (2022)

Exporter	Quantities in (tonnes)	Percentage share
USA	62,06,367	59.20
Australia	24,39,445	23.27
Argentina	12,70,365	12.11
France	1,50,345	1.43
Uganda	51,840	0.49
Ukraine	72,422	0.69
India	39,831	0.37
Tanzania	32,257	0.30
Sudan	31,838	0.30
Russia	29,323	0.27
Others	1,37,865	1.31
world (2022)	1,04,83,111	100

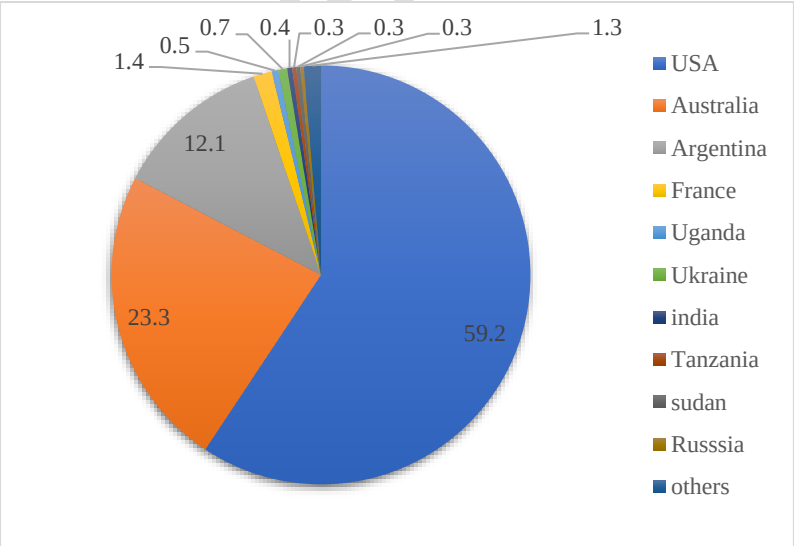

Fig. 1. Percentage share of major exporters of sorghum in the world (2022)

Export Destinations for sorghum

The major importing markets for sorghum exported by India during the year 2022, with a total exported quantity of 39,831 tonnes. The Table 2 and Fig 2, displays the top 10 importing markets for sorghum exported by India, along with the quantity of sorghum exported to each market and the percentage of the total exported quantity that each market represents.

Table2: Major export destinations for sorghum from India (2022)

Importers	Quantities (in tonnes)	Percentage share
UAE	9,126	22.91
Bangladesh	7,505	18.84
Saudi Arabia	5,651	14.18
Kuwait	2,558	6.42
Philippines	2,420	6.07
Iran	2,376	5.96
Qatar	2,071	5.19
Japan	1,587	3.98
taipei	1,456	3.65
oman	1,092	2.74
others	3990	10.01
World	39,831	100

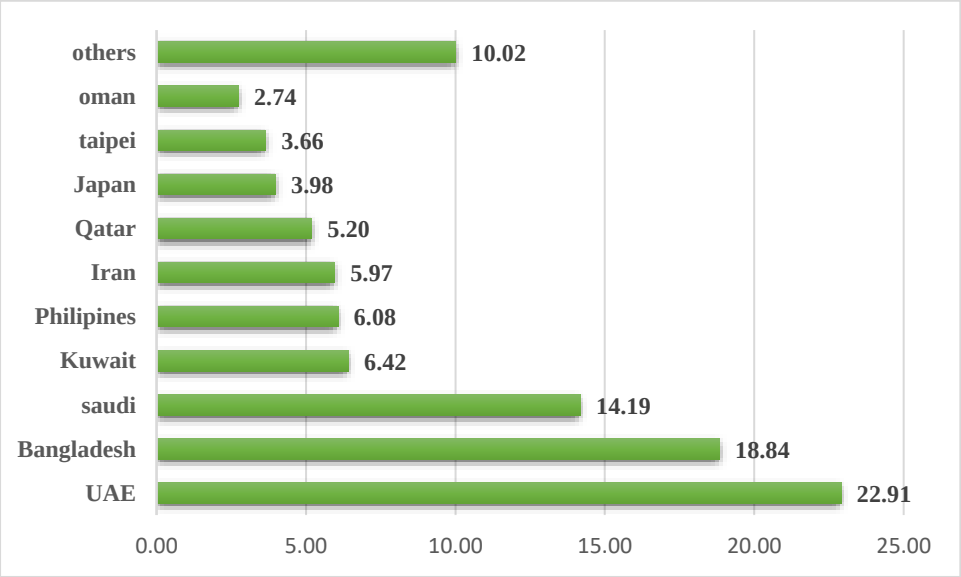

Fig. 2. Percentage share of major exporting destination for sorghum from India

Global sorghum Imports

The global millets import scenario reveals in Table 3 that the China is the largest importer of sorghum, accounting for 86.37 per cent of the total imports followed by Japan with 2.26 per cent and Spain with 1.90 per cent. Sudan and Eritrea Emirates account for 1.43 per cent and 0.79 per cent, respectively, while Kenya and Italy have contributed 0.78 per cent and 0.52 per cent of the imports. Taipei, Somalia,

and Djibouti have contributed 0.44 per cent, 0.37 per cent, and 0.36 per cent, respectively. The remaining 4.75 per cent of sorghum imports come from other countries. The total global millet imports in 2022 were 11740137 tonnes. In Fig 3 the importing countries which has minute share was pooled together as 'others' category.

Table3: Major importers of sorghum in the world (2022)

Importers	Quantities (in tonnes)	Percentage share
China	10140201	86.37
Japan	265411	2.26
Spain	223418	1.90
Sudan	168349	1.43
Eritrea	93000	0.79
Kenya	91909	0.78
Italy	61614	0.52
Taipei	51835	0.44
Somalia	43553	0.37
Djibouti	42400	0.36
others	558447	4.75
world (2022)	11740137	100

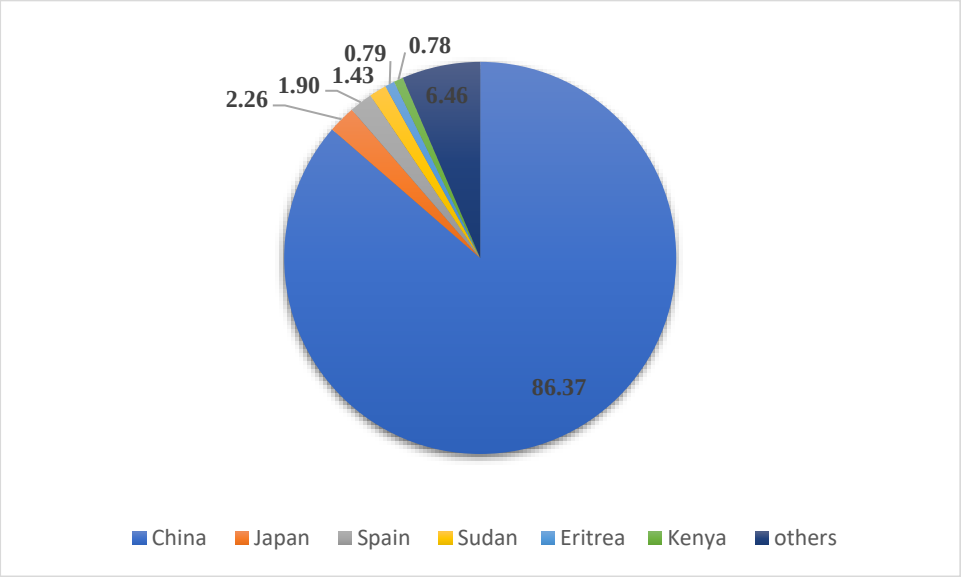

Fig 3 Percentage share of major importers of sorghum in the world (2022)

Trade direction of sorghum export from India

The direction of trade of sorghum export to different destinations was examined by estimating the transitional probability matrix using Markov chain analysis and the values of transitional probability matrix (TPM) is presented in Table 4. In order to analyse the direction of trade six countries viz., UAE, Saudi Arabia, Bangladesh, Kuwait, Egypt and Philippines were considered for the analysis as there were top importer countries of Indian sorghum and rest of the countries were pooled under 'others' category.

The diagonal elements in the TPM provide information on the probability of retention of trade, while row elements indicate the probability of loss in trade on account of competing countries. The column elements indicate the probability of gain in trade from the competing countries.

Among the selected countries, Bangladesh was the most stable market among the importers of sorghum, as exhibited by the highest probability of retention at 0.86, which means that Bangladesh had retained its original export share of 86.1 per cent during the period 2012 to 2022. Similarly, Saudi Arabia and UAE had retained its export share of 57.3 and 56.3 per cent respectively are reliable markets for sorghum exports from India. These nations import sorghum, establishing them as dependable potential markets for India in the future. It is advisable to focus on countries currently importing millets in limited quantities and at sporadic intervals, as efforts directed towards them could potentially enhance exports (Kumar, 2020).

On the contrary, Kuwait and Egypt have shown 'zero' probability of retention, indicating that these countries were unstable importers of sorghum. The major gainer among the importers of sorghum over the study period was Saudi Arabia which had a transfer probability of 0.20 from Philippines and 0.13 from Bangladesh, 0.11 from UAE and Kuwait. In a similar way, Bangladesh gained 16 per cent market share from Saudi Arabia.

In addition to having high probability of retention, Bangladesh was likely to gain 2 and 16 per cent of market share from Philippines and Saudi Arabia. On the other hand, Bangladesh was like to lose 13 per cent market share to Saudi Arabia.

	UAE	Saudi Arabia	Bangladesh	Kuwait	Egypt	Philippines	others
UAE	**0.563**	0.113	0.000	0.019	0.072	0.000	0.232
Saudi Arabia	0.000	**0.573**	0.167	0.157	0.103	0.000	0.000
Bangladesh	0.000	0.139	**0.861**	0.000	0.000	0.000	0.000
Kuwait	0.000	0.111	0.000	**0.000**	0.000	0.136	0.753
Egypt	0.000	0.000	0.000	0.000	**0.000**	0.000	1.000
Philippines	0.000	0.207	0.022	0.000	0.000	**0.079**	0.692
others	0.040	0.014	0.000	0.016	0.041	0.042	**0.847**

Table4: Transition probability matrix of cumin exports from India: 2012 to 2022

Global export competitiveness of sorghum

Revealed Comparative Advantage of sorghum exporting countries in world. RCA has been estimated for 5 exporting countries in the world. The major exporting countries viz., USA, Australia, Argentina, India and France for the period 2012 to 2022 (Table 5). USA's score the highest on the basis of different competitive indices for sorghum exports among the sorghum exporting nations followed by Australia.

Argentina appears to be the biggest competitor to India as it also scored the same rank in four competitiveness indices whereas France being the fifth largest exporter nation of sorghum.

Table 5: Ranking of countries on the basis of different competitive indices for sorghum exports

Rank	RCA1	RCA2	RCA3	RCA4
I	USA (6.25)	USA (0.71)	USA (0.01)	USA (7.20)
II	Australia (3.91)	Australia (0.49)	Australia (0.004)	Australia (1.13)
III	Argentina (1.79)	Argentina (-0.06)	India (-0.001)	India (-0.12)
IV	India (0.67)	India (-0.26)	Argentina (-0.002)	Argentina (-8.51)
V	France (0.20)	France (-0.72)	France (-0.008)	France (-35.87)

Herfindahl-Hirschman Index of Concentration (HHI)

HHI of concentration of sorghum exports

The HHI is used to estimate the concentration of global sorghum exports using the market share of more than 95 exporting countries as presented in Table 6. The estimates HHI values is 0.48 indicates that the sorghum exports market is highly concentrated.

Table 6: HHI reference thresholds and HHI of concentration of Global sorghum exports

Market characterization	**HHI Thresholds**		**HHI of Global sorghum Exports 2012- 2022**
	UK CMA	**US FTC**	
No concentration	<= 0.1	<= 0.1	0.48
Moderate concentration	0.1> HHI <0.2	0.1> HHI <0.18	
High concentration	>= 0.2	>= 0.18	

HHI of concentration of sorghum imports

The global sorghum imports, the estimated HHI value was 0.42 for the period 2012 to 2022, which also falls under 'High Concentration' according to the UK's CMA and USA's FTC as shown in Table 7. The high concentration may result from strong competitive advantages, economies of scale, or limited diversification, influencing trade dynamics and potentially impacting market competition and pricing

Table7: HHI reference thresholds and HHI of concentration of Global sorghum imports

Market characterization	HHI Thresholds		HHI of Global sorghum imports 2012- 2022
	UK CMA	US FTC	
No concentration	<= 0.1	<= 0.1	0.42
Moderate concentration	0.1> HHI <0.2	0.1> HHI <0.18	
High concentration	>= 0.2	>= 0.18	

HHI of concentration of sorghum exports from India

The sorghum exports from India as displayed in Table 8. The estimated HHI value was 0.16 for the period 2012 to 2022, which falls under 'Moderate Concentration' according to the UK's CMA and USA's FTC Firms in a moderately concentrated market may have some degree of pricing power, but they must still compete with other firms for customers. The top 6 sorghum export destination that are imported Indian sorghum during 2012 to 2022 those countries are UAE, Saudi Arabia, Bangladesh, Kuwait, Egypt and Philippines (Table 8).

Table 8: HHI reference thresholds and HHI of concentration of sorghum exports from India

Market characterization	HHI Thresholds		HHI of Global sorghum exports from India 2012- 2022
	UK CMA	US FTC	
No concentration	<= 0.1	<= 0.1	0.16
Moderate concentration	0.1> HHI <0.2	0.1> HHI <0.18	
High concentration	>= 0.2	>= 0.18	

CONCLUSION

The analysis of sorghum trade dynamics provides valuable insights into the patterns of sorghum exports and imports, as well as the competitiveness of major players in the market. USA as the leading millet exporter in 2022 contributing significantly to the global market with a share of 59.20 % followed by Australia and Argentina. On the import side, China emerges as the largest importer, accounting for 86.37 per cent of the total global imports. USA's score the highest on the basis of different competitive indices for sorghum exports among the sorghum exporting nations followed by Australia. Argentina appears to be the biggest competitor to India. The direction of sorghum exports from India highlights the most stable market among the importers of sorghum was Bangladesh, as exhibited by the highest probability of retention at 0.86. On the contrary, Kuwait and Egypt have shown 'zero' probability of retention, indicating that these countries were unstable importers of sorghum. The Herfindahl Hirschman Index analysis reveals that the global sorghum exports market is highly concentrated. Similarly, the HHI for

sorghum imports indicates a high concentration implying that a small number of nations control the majority of exports and imports. Policymakers, traders, and other stakeholders must comprehend these dynamics in order to develop strategies that effectively enhance competitiveness sorghum market.

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