



An Assessment of Export Performance and Trade Competitiveness of Sorghum from India

Rohlupuii Ralte^{a*}

^a Punjab Agricultural University, Ludhiana, Punjab-141004, India.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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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 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 indicating high concentration. In the case of Indian *sorghum* exports, the HHI means that there is moderate

*Corresponding author: E-mail: ralteapuii11@gmail.com;

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. More research is recommended on the suitability of different varieties of *sorghum* to varying environmental conditions so that the best variety could be determined to further enhance production.

Keywords: *Sorghum*; comparative advantage; herfindahl-hirschman index; Markov chain analysis.

1. INTRODUCTION

In reference to the thousands of seed grains in a handful, the word millet is derived from the Latin word "mille". "Millets constitute one of the oldest crops known to humans, its cultivation has been estimated to be around since 800 BC. For those in the lower classes, millets serve both a basic diet and a source of income community residing in arid and semi-arid regions of the developing world especially in Africa and Asia. For 5,000 years ago, millet has been cultivated on the Indian subcontinent and is widely distributed throughout Southeast Asia and Africa. In the Indian states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand, millets are a staple food" [1]. The push for food security achieved in the 1960s by the Green Revolution decreased significantly from 40% to 20 %, making space for wheat and rice as the cultivator responded to market demand, rendering millets as 'orphan crops.

Recently, 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 year 2018 has been declared by the Indian government as the National Year of Millets, and the grain was rebranded as Nutri cereal. Further recognizing the importance of millets and to increase the domestic and global demand, The Indian government suggested to the UN that 2023 be designated as the International Year of Millets. 72 nations agreed with India's suggestion, and in March 2021 the UNGA proclaimed 2023 to be the International Year of Millets.

Major millets (*Sorghum*, Pearl Millet, Finger Millet) and minor millets (Little Millet, Foxtail Millet, Proso Millet, Barnyard Millet, and Kodo Millet) are the two main categories of millets. India's millet production in 2021–2022 jumped by 27% over the previous year's 15.92 MMT output. The majority of millets produced in India are

pearl millet (60%) followed by *sorghum* (27%), finger millet (11%) and small millets (2%).

Sorghum (*Sorghum bicolor* 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 southern states of Karnataka and Andhra Pradesh, along with Maharashtra are the main producers of the crop. These three states produce around 80% of the India production. Rajasthan, Gujarat, and Madhya Pradesh are the other states that produce *sorghum* [2]. India ranks among the world's top producers of *sorghum* with 4.03 million tonnes production during 2023-2024 [3]. Feed is the main purpose for *sorghum* in the importing countries, only *sorghum* harvested during the rainy season is exported; post-rainy season *sorghum*, which is of higher quality, is utilized for domestic food use [4]. Despite *sorghum* being a major millet, not many research has been done on the export potential of *sorghum*. Keeping this in view, this work has been carried out to study the trade performance, competitiveness and trade directions of *sorghum*.

2. METHODOLOGY

The secondary data was collected from ITC Trade Map during the period of 2012 to 2022, focusing on global and Indian *sorghum* exports and imports performance. 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 P_{ij} of this matrix indicates the probability that exports will switch from the country i to the country j with time. The diagonal element P_{ii} 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:

$$E_{jt} = \sum_{i=1}^r E_{jt} - 1P_{ij} + e_{jt}$$

Where,

E_{jt} = Exports from India to the j^{th} country during the year t ,

E_{it-1} = Exports to the i^{th} country during the year $t-1$,

e_{jt} = The error-term which is statistically independent of E_{it-1} , and

r = Number of importing countries.

The transitional probabilities P_{ij} , which can be arranged in a $(c \times r)$ matrix, have the following Properties

$$0 < P_{ij} < 1$$

$$\sum_{i=1}^r P_{ij} = 1 \text{ for all } i$$

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:

$$\text{Min } O'P^* + le$$

$$\text{Subject to, } XP^* + V = Y$$

$$GP^* = 1$$

$$P^* > 0$$

where, P^* is a vector of the probabilities P_{ij} , O is a vector of zeros, l 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 employed to distinguish between countries that export *sorghum* that are highly and poorly competitive. 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:

RCA₁: Balassa Index (BI)

$$RCA_{1it} = \frac{x_{it}/x_{ia}}{x_{wt}/x_{wa}}$$

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*.

RCA₂: 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].

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

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.

RCA₃: Additive Revealed Comparative Advantage (ARCA) and

RCA₄: 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.

$$RCA_{3it} = \left[\frac{X_{it}}{X_{ia}} \right] - \left[\frac{X_{wt}}{X_{wa}} \right]$$

$$RCA_3 = RCA_3 \times \left[\frac{X_{ia}}{X_{wa}} \right] \times 10000$$

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 determines how much a nation's actual exports deviate from its comparative advantage to neutral level in terms of their relative size in relation to the global export market, which accurately identifies the underlying comparative advantage [8].

2.3 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:

$$HHI = \sum_{i=1}^N S_i^2$$

Where;

S_i = 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 0 indicates 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 than 0.2" [10]. 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'.

3. RESULTS AND DISCUSSION

3.1 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 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 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).

Table 1. 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

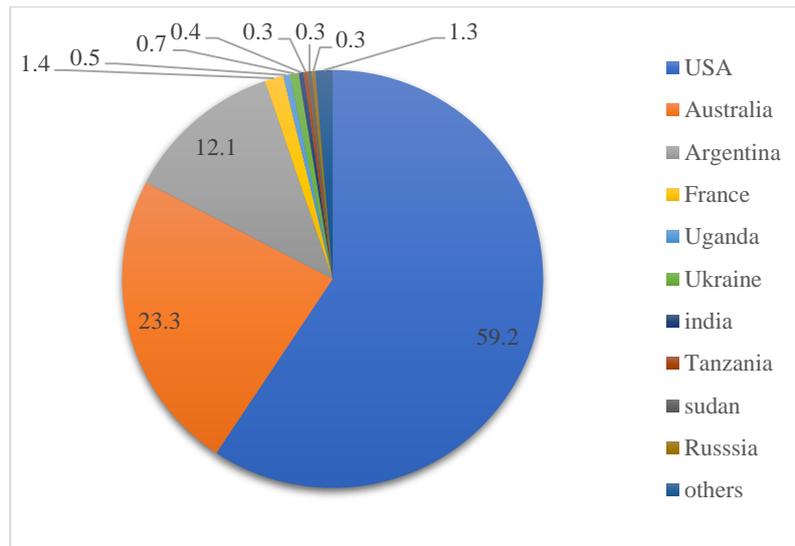


Fig. 1. Percentage share of major exporters of *sorghum* in the world (2022)

Table 2. 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

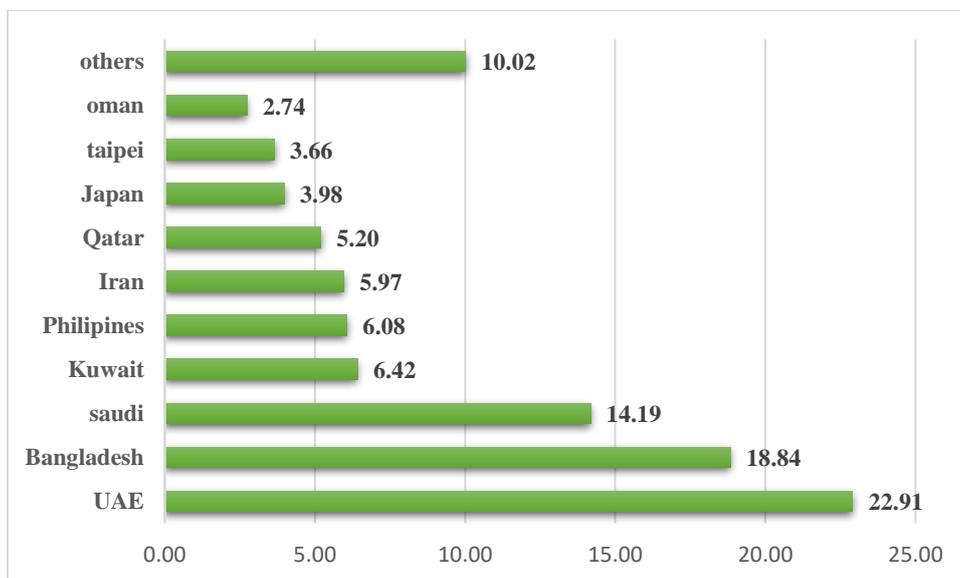


Fig. 2. Percentage share of major exporting destination for *sorghum* from India

3.2 Export Destinations for Sorghum

The major importing markets for *sorghum* exported by India during the year 2022, with 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.

3.3 Global Sorghum Imports

The global millets import scenario reveals in Table 3 that 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 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.

Table 3. 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

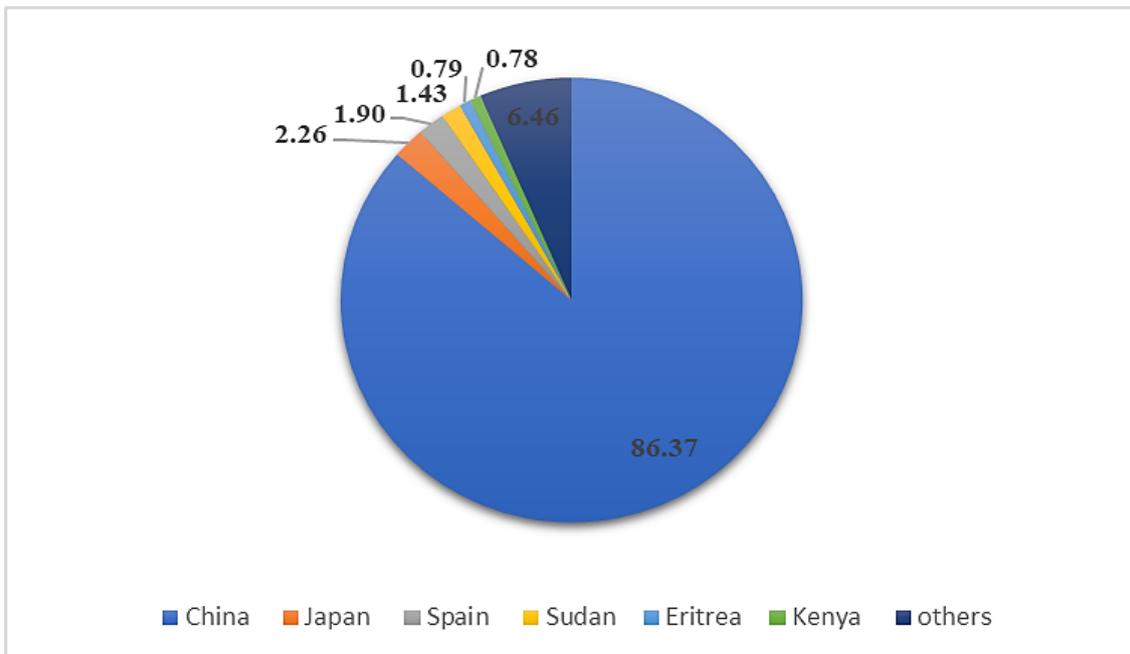


Fig. 3. Percentage share of major importers of *sorghum* in the world (2022)

Table 4. Transitional probability matrix of cumin exports from India: 2012 to 2022

	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

3.4 Trade Direction of Sorghum Export from India

By employing Markov chain analysis to estimate the transitional probability matrix, the direction of sorghum export trade was investigated. The results of this analysis are displayed in Table 4. Six countries—the United Arab Emirates, Saudi Arabia, Bangladesh, Kuwait, Egypt, and the Philippines—were taken into consideration for study in order to determine the direction of trade. The remaining countries were combined under the category of "others," as they were the top importers of Indian sorghum. In the TPM, the diagonal elements reflect the chance of trade retention while the row elements indicate the likelihood of trade loss as a result of competition. The columns' components indicate the possibility of establishing trade with adversarial 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 countries are reliable prospective markets for India in the future since they import sorghum. Concentrating on nations that presently import sorghum in small amounts and irregularly is advised because initiatives aimed at them may increase exports [11,12].

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.

Not only does it have a high retention rate, 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.

3.5 Global Export Competitiveness of Sorghum

Revealed Comparative Advantage 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 highest on the basis of different competitive indices for sorghum exports among 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.

3.6 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.

HHI of concentration of sorghum imports: 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. Strong competitive advantages, economies of scale, or a lack of diversification may be the cause of the high concentration, which could have an impact on price and market competitiveness as well as trade dynamics.

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)

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	$0.1 > \text{HHI} < 0.2$	$0.1 > \text{HHI} < 0.18$	
High concentration	≥ 0.2	≥ 0.18	

Table 7. 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	$0.1 > \text{HHI} < 0.2$	$0.1 > \text{HHI} < 0.18$	
High concentration	≥ 0.2	≥ 0.18	

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	$0.1 > \text{HHI} < 0.2$	$0.1 > \text{HHI} < 0.18$	
High concentration	≥ 0.2	≥ 0.18	

HHI of concentration of sorghum exports from India: 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. Even though they may have considerable price power, firms in a moderately concentrated market still have to fight with other businesses 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).

4. CONCLUSION AND POLICY IMPLICATION

The study of the dynamics of the sorghum trade offers important insights into the trends in

sorghum imports and exports as well as the competitiveness of the key market participants. 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. China has the top position in terms of imports, making up 86.37% of all imports worldwide. Based on various competitive indices for sorghum exports, the United States of America has the highest score among sorghum exporting countries, with Australia coming in second. Looking ahead, Argentina seems to be India's strongest rival. Bangladesh was the most stable market among sorghum importers, as indicated by the direction of sorghum exports from India, which also showed the highest chance of retention at 0.86. Conversely, Kuwait and Egypt have demonstrated a "zero" likelihood of retention, suggesting that they were sorghum importers that were unstable. 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 the dynamics in order to develop strategies that effectively enhance competitiveness *sorghum* market. There must be an increase in production since *sorghum* would continue to stay a crop with two purposes. More research on innovative food products and processing technologies of *sorghum* could be investigated to help meet food security.

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 manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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