UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

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INTRODUCTION

1.1 Considerations of food healthiness

Access to safe and nutritious food is essential for good health and is linked to Universal Health Coverage (UHC) and the United Nations Sustainable Development Goals (SDGs), particularly SDG 2: Zero Hunger and SDG 3: Good Health and Well-being. Recognizing the pivotal role of access to adequate, safe, and nutritious food in achieving these goals highlights the critical interconnectedness between food access, health, and international development objectives. (United Nations, 2023a; World Health Organization, 2023; United Nations, 2015)

While a universally accepted definition of 'healthy foods' is lacking, it can be generally understood as foods which positively contribute to overall health and well-being. In this technical paper, the United Nations Conference on Trade and Development (UNCTAD) when addressing the healthiness of food relies on expertise of the World Health Organization (WHO), which takes a holistic approach, emphasizing the importance of an overall healthy diet rather than focusing on individual foods. The WHO general dietary guidelines consider essential nutrient intake and are developed to be flexible and adapt to evolving scientific evidence, accommodating diverse dietary needs and cultural approaches.

To understand the complex environment around the question of health, food, and nutrient intake, UNCTAD paired with WHO to undertake the study on trade in healthy food. Initially, this project aimed to identify trade patterns in the import and export of “healthy” foods by economy by correlating food healthiness with the classification of commodities used to monitor international trade, i.e., the Harmonized Commodity Description and Coding System (HS). However, in the absence of a globally recognized classification for "healthy” or “nutritious foods," and in alignment with WHO's emphasis on overall diet, the approach was extended to also explore the utility of food processing classifications. This led to the development of a novel two-part approach, where HS categories are grouped into similar categories based on both processing and food groups.

The objective of the project is therefore to identify trends in global food trade, examining contributions to food markets and access at the economy level by level of processing and food group. Importantly, this work avoids inherently framing processing as detrimental. This acknowledges the challenge posed by the lack of a universal definition for 'healthy foods' and underscores the commitment to understanding imported/exported food dynamics without making sweeping judgments about the merits or drawbacks of food processing. Such conceptual work and debate are outside the scope of this technical paper and work at hand and are referred to here merely as providing a background information to understand and support the approach taken in linking processing of food to international trade of these commodities.

1.2 Trade in processed food items

The food supply chain, from origin to consumer, encompasses a complex journey involving harvest, farming, production, transportation, storage, processing, packaging, wholesaling, retailing, and eventual consumption. It also extends to international trade.

The term "nutrition transition" describes the shift in population dietary patterns and nutritional profiles that commonly occurs alongside economic development (Popkin, 2001). This transition involves a move from traditional diets, primarily based on whole foods, to diets characterized by high consumption of processed foods, sugars, and fats, contributing to the rise in diet-related non-communicable diseases such as obesity and diabetes. Nutrient-rich foods often originate as raw commodities in low-income countries, only to return later as highly processed items with potentially reduced nutritional value (Popkin, 2006).

This technical paper aims to quantify and elucidate trends in the imports and exports of whole or unprocessed foods and more processed alternatives. The primary objective of this work is to augment available information by creating a global dataset of bilateral food trade flows, building on UNCTAD’s expertise in the field. This matrix will facilitate new analyses on processed food consumption, supporting the WHO and other entities in understanding and addressing nutrition-related diseases. It serves as a valuable policy tool for member States, by contributing to a comprehensive understanding of food markets and nutritional access and informing nutrition-related trade policies.

Robust data and statistics are crucial for informing WHO policies and guidance on food safety, nutrition, and food access. Within this policy space, an often-overlooked aspect is understanding how and from where countries source their food. This new trade data matrix, a product of this project contributes to addressing this gap, supporting analyses and guidance developed by the WHO Department of Nutrition and Food Safety and other stakeholders. In a similar vein, trade itself complements this area-specific analysis by offering a mechanism to analyse trade flows of food by different levels of processing. This can provide economic and developmental insights into our understanding of patterns of domestic consumption and production, when coupled with relevant national information. Combined, these different views picture a comprehensive status linked to the questions of health and well-being.

1.3 Structure of the paper

This technical paper focuses on efforts by UNCTAD Statistics to define and measure international trade flows in food items according to various levels of processing, building on expertise by WHO. It reviews and assesses development of concepts related to the question of healthiness and links to level of food processing, itself a basis for providing a trade matrix of bilateral trade flow of processed food groups. This serves as a stepping stone into further analysis and methodological, as well as conceptual, work. The aim of the paper is therefore to outline the conceptual and methodological backbone of the trade matrix of food categories by processing level and provide initial analysis of how existing data sets could potentially be used for informing research and relevant policy. It does not, however, strive to provide a comprehensive analytical framework, as this would need to be user-defined and -driven to be effective.

The technical paper is structured as follows: Chapter 2 reviews the conceptual elements of defining processed food, outlining how various classification systems have already been used, and offering a new approach to processed food trade in an attempt to link two distinct areas, namely processed food (with potential link to health spectrum of the analysis) and international trade; Chapter 3 details the methodological aspects of measuring trade flows of processed food items, focusing on the critical work on corresponding HS-based food commodities to their level of processing; In Chapter 4, results of this work are presented by a brief overview of the trade matrix, and, based on it, an overview of some of the findings; Chapter 5 concludes; and Annexes offers additional relevant material, such as the correspondence table of different versions of HS to the processed food categories as developed for and used in this research. Due to practical reasons, the majority of these tables are posted as on-line annexes to be downloaded and used directly by the users of the trade matrix of processed food categories. These annexes are found at the dedicated website at: https://unctadstat.unctad.org/EN/ProcessedFood.html (UNCTAD, 2023a).

2

DEFINING PROCESSED FOOD

2.1 Raw food to processed food

Food processing involves the intentional transformation of any food item (or items) from its raw or natural state into a consumable or more durable form. This process spans simple tasks like washing or cutting to a series of chemical, physical, and biological processes that modify the form or structure of the raw food item. The ultimate objectives include preparing foods for consumption, preservation by slowing or stopping decay to extend shelf life, ensuring safety, and enhancing taste and nutritional profiles. (FAO et al., 2023)

Not all food processing adversely affects nutritional quality; processing technologies like pasteurization and refrigeration, have played essential roles in ensuring food safety, nutrition, and accessibility, including conversion of inedible to edible foods (FAO et al., 2023). Additionally, the positive implementation of food fortification and supplementation has contributed significantly to both individual and population health (World Health Organization, 2018). Therefore, the type or extent of processing alone does not determine whether a food can be considered 'good' or 'bad' within the context of overall diet. This notion is also central to the conceptual as well as analytical considerations of this technical paper. Any inference on how the trade of specific processed food category impacts health at national, regional, or global levels is left to subject-matter experts by coupling preliminary and descriptive analysis presented in this technical paper with subject-specific expertise.

Nevertheless, a growing focus among public health agencies and researchers is on extensively processed foods, often containing additives, preservatives, and flavourings. These foods are recognized for their convenience, prolonged shelf life, and appealing taste. Researchers aim to understand potential health implications of added sugars, sodium, and unhealthy fats (Jones, 2019; Gibney et al., 2017; Capozzi et al., 2021; Fardet, 2018; Weaver et al., 2014). At the global level, the World Health Assembly approved the 13th General Programme of Work (GPW13), emphasizing the reduction of salt/sodium intake and elimination of industrially-produced trans-fats as crucial actions aligned with WHO's goal of ensuring healthy lives and promoting overall well-being.

As noted, such expertise of public health experts is crucial in providing substantive interpretation of the work conducted within this project and presented in this technical paper. While such a substantive interpretation goes beyond the scope of this technical paper, researchers require tools to observe and classify different food items according to their potential impacts on public health. This has led to the development and refinement of other processed food classifications to inform consumer choices, support research, inform and influence policy, and guide dietary recommendations. This paper offers a tool to link such food categories from an international trade perspective to their processing level.

2.2 Classifying processed food

Various classifications have been created with the aim of categorizing food by the extent of processing to inform health research or consumer guidance. However, caution is warranted in equating processing to the healthiness of items, as it oversimplifies and can be misleading. While research indicates that high consumption of extremely processed foods may correlate with negative health outcomes and an increased risk of chronic diseases, many processed foods offer benefits to an overall diet, by extending shelf life, availability or as result of nutrient fortification.

A literature review revealed numerous food processing classifications categorizing foods based on assigned degrees of processing. These classifications exhibit variations in perspectives, applications, definitions, and limitations. While the literature clearly reveals an interest and research need for food processing classifications, the lack of international definitions or consensus on what features determine the degree of food processing poses challenges (Sadler et al., 2021).

De Araújo et al. (2022) compared and assessed five notable classification systems:

- IARC-EPIC - International Agency for Research on Cancer, (Europe),
- “Nova” - named by researchers who created it, University of Sao Paulo in 2009 (Brazil),
- International Food Policy Research Institute – IFPRI (Guatemala),
- International Food Information Council – IFIC (USA), and

- University of North Carolina – UNC (USA).

While the overall classification narrative of these systems seemed aligned, the analysis reveals significant inconsistencies in how these classifications portray the spectrum of processing from raw to highly processed commodities (see Table 1); for example, IFIC does not include raw or unprocessed foods.

Table 1. Comparison of food processing classification systems

Classification Systems	Degree of Processing Groups			
	1	2	3	4
IARC—Europe (2009)	Non Processed Food		Moderately PF	Highly PF
NOVA—Brazil (2010, 2016)	Unprocessed food or Minimally PF	Processed culinary ingredients	Processed food	Ultra-processed food
IFPRI—Guatemala (2011)	Unprocessed Food	Primary PF		Highly PF
IFIC—USA (2012)	Minimally PF		FP for preser-vation	Prepared foods/meals
			Mixtures of combined ingredients	Ready-to-eat processed
UNC—USA (2016)	Unprocessed food	Basic PF	Moderately PF	Highly PF

Source: De Araújo et al. (2022)

These inconsistencies limit the comparability and interpretation of results arising from the use of these classifications in dietary studies or interventions. De Araújo et al. (2022) concluded that a "*consensual classification system, based on clear criteria would be of great public health relevance*".

Nova, a prominent classification, has played a valuable role in directing attention toward highly processed foods and their impact on diet and health. However, the robustness and functionality of Nova are subjects of debate. Critics argue that equating processing to healthiness oversimplifies the complex relationship between processing and nutritional quality (Petrus et al., 2021). Despite not being WHO-endorsed, Nova is widely used, and has also popularised the term 'ultra/processed foods (UPFs)', defined as having high energy density, high sodium, saturated fat, and free sugars, and lacking dietary fibre and essential nutrients found in whole foods (Monteiro et al., 2018; Kliemann et al., 2022). Common examples include carbonated soft drinks, many types of breakfast cereals, confectionery, instant soups, ice cream. Other deliberations to provide a food classification system based on food processing have been put forward (e.g., Moubarac et al., 2014), yet these provide an insufficient basis for the purpose of the exercise here: to link and observe international trade in processed food.

2.3 Approach: Processed Food Trade

This technical paper constructs a trade matrix to reveal and quantify global bilateral trade patterns of food categories guided by the HS classification, which are themselves categorized by processing. While the HS classification system does not serve the purpose of assessing dietary intakes or nutrient content of foods, it offers essential information to observe and monitor global food movements. The proposed categories in this technical paper are constrained by the degree of disaggregation allowed by the HS headings and sub-headings. Nevertheless, they provide insights into specific food groups, global trade patterns, and market dynamics.

The HS, therefore, without providing detailed information to mark these considerations on healthiness or nutrient content of foods, offers valuable information about the global movement of foods and food products reaching world markets with some level of disaggregation to support the observation of processed food trade. The primary goal of the HS system is to establish a universal language for customs and trade authorities, facilitating the classification and regulation of food products across borders. Utilizing this foundational information, we have proposed categories that align with the degree of disaggregation permitted by the HS inclusion terms to reveal varying degrees, or categories of processing of food items marked in the HS.

The approach adopted in this technical paper abstains from categorizing foods and processes as 'healthy' or 'unhealthy.' Instead, it assigns a number to major food categories (see section 3.2) and a letter to broad processing groups (see Table 2), aligning with the original HS groupings and descriptions. This facilitates queries by food or processing category, or a combination of both, offering valuable insights into global food movements and market dynamics. The aim is not to imply increasing 'levels of processing' but to illustrate and understand the trade flow of food by varying level of processing, that is, by kinds of processing and ingredients. This experimental classification involves a mix of processing steps, avoiding a consistent trend of higher processing levels as categories ascend. Nevertheless, they are designed to offer sufficient level of details for analysis of food items being traded, once linked to the HS (see next chapter). The classification of processed food categories is presented in Table 2 and following descriptions.

Table 2. Classification of processed food

Code	Text
A	Raw: unprocessed*, fresh, chilled, frozen
B	Minimally processed: cooked, steamed, or dried; crude oils
C	Processed: added salt/pickled/brined; added sugar**; smoked
D	Processed: fermentation*** / smoking (neither salted nor brined)
E	Composite foods; Preparations/refined oils
F	Ingredients: spices et al; products provisionally preserved but unsuitable for immediate consumption in that form; ingredients for brewing
G	Precursors - seeds, trees etc. for sowing, fertilized eggs, livestock, bees

Notes: * Non-alcoholic beverages: will include non-SSBs (unsweetened water).
** Non-alcoholic beverages: will include SSBs; where salted and smoked, salted is ID as processing.
*** Alcoholic beverages.

Source: Authors' deliberations

Each of these categories of processing is described in turn.

A. Raw (fresh, chilled and frozen)

The HS classification amalgamates these processing operations, thereby restricting further disaggregation. In accordance with the explanatory notes for HS 2017, all products categorized under this heading remain unchanged and unflavoured. This encompasses unsweetened waters in any volume.

B. Cooked (steamed or broiled), dried or desiccated foods; and crude oils.

The HS classification amalgamates the processing operations of "cooked, dried or desiccated foods". Products in this category undergo minimal processing steps, which exclude the addition of sugars, salts, smoking, or brining. Crude oils are also included here to facilitate their differentiation from refined oils. Refined oils undergo extensive processing.

C. Foods which have been sweetened, salted/brined, whether smoked or not.

Foods falling into this category encompass those that have been sweetened, salted/brined, regardless of whether they are smoked or not. This group also comprises non-alcoholic beverages, specifically those identified by WHO as Sugar Sweetened Beverages (SSBs). Additionally, any foods categorized as salted under the HS headings, regardless of smoking status, are incorporated into this classification. The focus of this category on sweetened or salted/brined as opposed to smoked is the reflection of a current push to reduce salt and sugar consumption due to their association with chronic disease, especially in poorer populations (see previous sections). It may be noted that for analysis, a two-step approach, i.e., processed and food categories as outlined in Chapter 3, offers further separation of food items under study to meet the needs of a more disaggregated approach.

D. Fermented, smoked (but neither salted nor brined)

The primary objective is to distinguish smoked foods as much as possible from those that undergo both salting and smoking. Additionally, this category encompasses fermented foods, including beverages and cheeses. However, it is crucial to note that the inclusion of fermented items does not imply an equivalence in terms of processing level or nutritional profile 'level'.

E. Composite foods, preparations; and refined oils

This category includes broadly any food commodities covered by HS chapters 19 – 25, excluding those classified under earlier categories but which derived from or corresponding to the food types under those earlier processing categories. For instance, infant food preparations made of poultry. It includes foods which have multiple ingredients, and which are highly processed, or ready to eat.

F. Ingredients

Spices; products which are provisionally preserved and exported/imported for further processing at country of destination, but which are not suitable for immediate consumption; hops and other ingredients which are of comestible grade but intended for use in brewing rather than direct consumption.

G. Precursors

This group includes seeds, trees, and seed crops for sowing, propagation or to establish crops; fertilised poultry eggs, live animals and live bees traded to establish flocks, herds or colonies. These are intended for future food production at destination, but not for immediate consumption.

Building on this classification of processing, the present technical paper employs a two-part matrix approach to combine the processing categories with food categories to provide sufficient level of details for analytical purposes. The initial proposal to construct the matrix which would reveal and quantify patterns in global bilateral food trade, based on the healthfulness of food, was not retained, as classifying food as "healthy" or "unhealthy" appeared to be not scientifically-sound (see Section 1.1).

A two-part matrix informed by the HS classification was categorized as follows: a letter was assigned to a broad processing group, as defined in Table 2; and a number was assigned to each major food group (e.g., vegetables, fruits, poultry) as defined in Table 3. It is determined by the level of aggregation in the HS classification. The resulting database (see Chapter 4) can be queried by either a food group (e.g., A: raw, unprocessed) or a processing group (e.g., 3: cereals, grains), or a more specific alphanumeric, e.g. A3: Raw cereals and grains. These allow us to observe specific food groups of interest, providing insights into global trade patterns and market dynamics, albeit with certain limitations. Next chapter focuses on the process of constructing this two-part classification and trade matrix for trade in processed food.

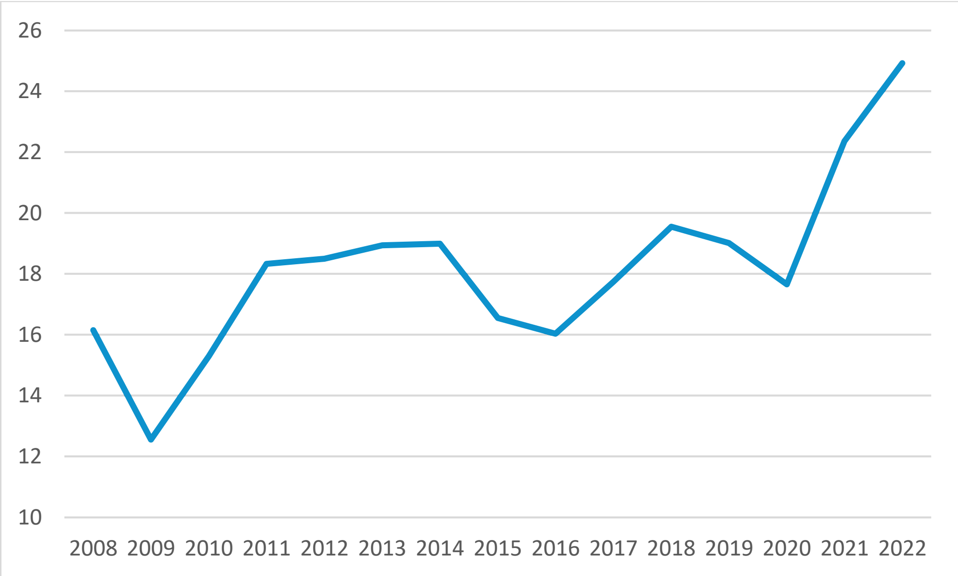
3

METHODOLOGY

3.1 Trade statistics and processing

International trade plays a central role in a globalized and ever-more connected world. Despite occasional setbacks it is on an increasing path in time: in 2022, the value of world merchandise exports increased by 11.4 per cent, reaching global value of US$24.9 trillion, US$2.5 trillion higher than in the previous year (see Figure 1) (UNCTAD, 2023b).

Figure 1. World merchandise exports (Trillions of United States dollars)



Source: UNCTAD (2023b)

Recording and monitoring international trade flows, including food trade, can only be possible with a unified and comparable underlying system, linking trading partners and commodities traded. The HS provides such an infrastructure. Originally adopted by the Customs Co-operation Council in June 1983, the International Convention on the Harmonized System (HS Convention) came into effect on January 1, 1988. Currently used by over 200 countries, it covers about 98 per cent of global trade of goods. The classification does not cover trade in services. The HS has been developed to capture foreign trade data in an internationally consistent way, mainly for customs authorities, statistical and analytical purposes, and trade negotiations (UNSD, 2011). The UN Statistical Commission, during its twenty-seventh session in 1993, recommended the adoption of HS by countries for the compilation and dissemination of trade statistics, emphasizing its role in ensuring international consistency (UNSD, 2011).

The HS is regularly reviewed and revised, with the latest revision, the HS 2022, coming into force on 1 January 2022. Countries are encouraged to use the most current version, and to apply the most detailed level in the collection, compilation and dissemination of international merchandise trade statistics. (UNCTAD, 2021).

Revisions made to the HS classification system may lead to inconsistencies in analyses of trade data spanning more than one classification period. This necessitates correspondence between versions, or concordance, forward and backward mapping of corresponding codes. Explanatory notes for each HS classification allow to correctly handle the coding of goods with more than one code in either classification.

Depending on year or time period studied, or the reporting or partner economies, the relevant HS version may thus vary. To provide a comprehensive time series analysis of trade flows, correspondences were established for data across all HS revisions for 1992, 1996, 2002, 2007, 2012, 2017, and the most recent 2022. This approach allows for tracking changes and ensuring consistent coverage, particularly with the more detailed classifications introduced in the latest HS revision. Inherently, this comprises challenges of relating commodities, or in our case, the related classification of food categories by processing, from one HS version to another, where additional information, including breakdown of one food category (based on six-digit HS code) can be provided in recent versions that was not available before. This brings along challenges and considerations well known to any work corresponding various versions of the classification and the approach taken in this technical paper builds on correspondence tables available for all HS versions and certain decisions how to address food commodities that would be linked to more than one processing code in the used classification of processing as in Table 2. This is briefly outlined in the following paragraphs.

Given data availability in recent years and with respect to the latest version of the HS (consult United Nations (2023b) or Figure 5), the initial deliberations within this project have been conducted on HS 2017 version. Of the 21 Sections and 97 Chapters in HS 2017 serving as broad categories of related products based on their characteristics, the first 25 chapters[1] encompass the detailed food commodity descriptions. Each chapter is further subdivided into specific 'Headings' identified at the four-digit level. These headings are then broken down into more detailed 'subheadings,' recognized by their six-digit code, and representing the most detailed international harmonized level of disaggregation. The initial six digits of the HS code provide a comprehensive and detailed description of the product. This level has been used as a basis for the methodological work of corresponding and classifying in this technical paper.

For example, the HS code for coffee beans has the following structure:

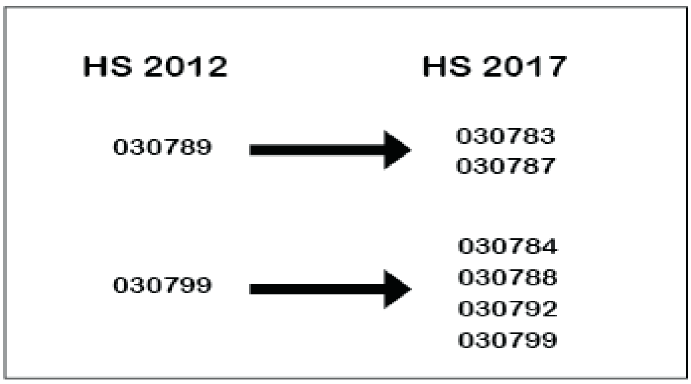
Chapter 09: Coffee, Tea, Mate, and Spices

Heading 0901: Coffee; whether or not roasted or decaffeinated

Subheading 0901.21: Not roasted

Linking various HS versions to each other is processed using the concordance tables available at United Nations (2023c). While most HS subheading codes maintained a consistent one-to-one (1:1) relationship across different versions, certain codes exhibited complex concordances, such as many-to-many (n:n), many-to-one (n:1), or one-to-many (1:n) relationships, where 'n' represents a single product. In instances of non-1:1 relationship, where new codes were introduced in subsequent versions, food group and processing codes were applied based on detailed explanatory notes. For example, the code 030789 in HS 2012 was split into two distinct codes in HS 2017: 030783 and 030787, each representing a more refined category within the original code (see Figure 2). Similarly, the code 030799 underwent further disaggregation, resulting in four distinct codes in the HS 2017 classification. This meticulous approach ensured accuracy and consistency in the representation of trade data across different HS versions.

Figure 2. Example of correspondence across HS versions, 1:n



Source: Authors' deliberations

[1] Except chapters 23 – Residues and waste from the food industries; prepared animal fodder, and 24 - Tobacco and manufactured tobacco substitutes

Where a product heading encompassed a wide range of processing methods at the 4-digit level (e.g., salted or brined, whether or not smoked), the explanatory notes subheadings were examined, to check if greater specificity (e.g., live, fresh, vs. other) and possibly greater disaggregation, was permitted.

Where a heading at the 4-digit level is all inclusive, the highest level of processing was applied. For example: for all the products under the heading of "smoked, whether or not salted or brined" were assumed to be smoked and salted or brined, unless a subheading specifies otherwise.

The second step of a two-part trade matrix of processed food categories creates the food categories, to be then linked to the processing levels. This step is important to provide a consolidated view for subsequent analysis and can also address additional refinement of processing food categories, e.g., delineating smoked meat from fermented dairy products. Providing analysis and informing policy, i.e., catering to the usefulness and relevance of such provided statistics is of central importance to this technical paper.

3.2 Food categories defined

While the analysis and methodology processing were conducted at a six-digit HS level, the trade matrix is represented at a more aggregated level for practical reasons as mentioned above, to cater to the needs of the analysis. Although aggregation leads to some loss of information of the underlying data, it is noted that HS even at the lowest level does not allow for a fully disaggregated analysis of food processing due to the construction of six-digit codes. Additionally, the level of aggregation and grouping makes it challenging to separate the sub-groups of processing, such as smoking vs brining, or fresh vs frozen comprehensively across food groups in the HS classification. Despite this limitation, the step of certain aggregation was adopted to strike a balance between detail (which may not always in fact be available) and practical considerations.

Based on the 2017 HS, from Sections 1 to 5, chapters 1 to 25, food commodities defined at the six-digit level were investigated and items not intended for human consumption were removed[2]. Within the limits of the HS classification, the six-digit HS commodities were divided into 19 food groups as outlined in Table 3.

Table 3. Food categories

Code	Text
1	Vegetables, meals and flours thereof
2	Fruits
3	Cereals and grains, flours thereof
4	Meat, insects (for human consumption)
5	Poultry
6	Fish
7	Shellfish, crustacea, other aquatic *spp*.
8	Dairy and dairy products
9	Eggs
10	Nuts
11	Oil seeds and oleaginous fruits, flours thereof

[2] This approach may merit further deliberations in the future work, e.g., for the OneHealth perspective of looking at where human food manufacturing residues enter the animal food chain as feed and other potential links.

Code	Text
12	Animal fats and oils
13	Vegetable fats and oils (assumes nuts, seeds and plant origin)
14	Non-alcoholic beverages
15	Alcoholic beverages
16	Sugars, jams and confectionery
17	Cocoa and cocoa preparations
18	Edible preparations and formulations, beyond scope of HS chapters of 1 - 17
19	Other, Not Elsewhere Classifiable in the above categories *also allowing for future evolution of market or HS in response to technology

Source: Authors' deliberations

The following text provides additional information on the food categories.

1. Vegetable, meals and flours thereof

   Defined under the HS2017 classification Section II – Vegetable Products, Chapter 7 Edible vegetables and certain roots and tubers, Headings 07.01 - 07.14.

2. Fruits

   Defined under the HS2017 classification Section II – Vegetable Products, Chapter 8 Edible fruit and nuts; peel of citrus fruit or melons, Headings 08.03 - 08.14. Olives are included with oil seeds and oleaginous fruits, because of their oil content and role in dietary considerations.

3. Cereals and grains, flours thereof

   All grains, cereals and milling products of these, as defined under HS 2017 classification Section II – Vegetable Products, Chapter 10 Cereals, Headings 10.01 -10-08.

4. Meat, insect

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 1 Live animals, Headings 01.01 - 01-06, and Chapter 2 Meat and edible meat offal, Headings 02.01 - 02.10.

5. Poultry

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 1 Live animals, heading 01.05, and Chapter 2 Meat and edible meat, Heading 02.07.

6. Fish

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 3 Fish and crustaceans, molluscs and other aquatic invertebrates, Headings 03.01-03.05.

7. Shellfish, crustacea, other aquatic species.

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 3 Fish and crustaceans, molluscs and other aquatic invertebrates, Headings 03.06-03.08.

8. Dairy

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 4 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included, Headings 04.01 - 04.06.

9. Eggs

   Defined under the HS2017 classification Section I – Live Animals; Animal Products, Chapter 4 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included, Headings 04.07 - 04.08.

10. Nuts

    Defined under the HS2017 classification Section II – Vegetable Products, Chapter 8 Edible fruit and nuts; peel of citrus fruit or melons, Headings 08.01 - 08.03, 08.11-08.13.

11. Oil seeds and oleaginous fruits, flours thereof (includes olives)

    Defined under the HS2017 classification Section II – Vegetable Products, Chapter 12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw. Headings 12.01-12.14, and 08.01-08.02 Olives included here rather than with fruits,

12. Animal fats and oils

    Defined under Section III -- Animal or Vegetable Fats and Oils and Their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes Chapter 15, Headings 15.01 - 15.06

13. Vegetable fats and oils (assumes nuts, seeds and plant origin)

    Defined under Section III -- Animal or Vegetable Fats and Oils and Their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes, Chapter 15, Headings 15.07 - 15.14

14. Non-alcoholic Beverages

    Defined under Section IV -- Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes, Chapter 22 Beverages, spirits and vinegar, Headings 22.03 - 22.08

15. Alcoholic beverages

    Defined under Section IV -- Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes, Chapter 22 Beverages, spirits and vinegar, Headings 22.01 - 22.02.

16. Sugars, jams and confectionery

    Defined under Section IV -- Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes, Chapter 17 Sugars and sugar confectionery, Headings 17.01 - 17.04 Honey is included here also.

17. Cocoa and cocoa preparations

    Defined under Section IV -- Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes, Chapter 18 Cocoa and cocoa preparations, Headings 18.01 - 18.06.

18. Edible preparations and formulations, beyond the scope of chapters 1 – 18

    Defined under Section IV -- Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes, Chapters 19 –20, and preparations or mixed items of multiple ingredients under all Headings, for example, mixed animal and vegetable fats that cannot be disaggregated under our category 12 or 13 at the HS six-digit level.

19. Other, NEC

    This category is presently vacant but has been established to encompass products that may be manufactured in the future, and which cannot be adequately represented in preceding categories.

3.3 Food items by processing and food categories

Combining the processing classification (Table 2) and food categories (Table 3), the ultimate infrastructure for the trade matrix is set, defining food processing and food categories. While unified at this stage across all HS versions, meaning that regardless of which HS version original trade data are reported, different HS versions due to evolving codes, including additional breakdowns as mentioned above, comprise different number of respective six-digit codes pertaining to food items. A general trend is that with more recent HS versions, food items are more detailed as indicated by higher number of six-digit codes included (Table 4). This is important not only to acknowledge that HS versions are becoming increasingly more disaggregated to meet (more specific) user needs, but also to consider in analysis of the thus constructed trade matrix. The latter would imply that later, more recent versions of HS would be better suited for analysis for food categories by processing.

Table 4. Six-digit HS codes included in the processing and food categories, by HS version

HS version	Number of six-digit codes included
HS 1992	562
HS 1996	585
HS 2002	611
HS 2007	606
HS 2012	799
HS 2017	838
HS 2022	837

Source: Authors' deliberations

While the trade matrix is constructed on a 7 x 19 metric, underlying inputs by HS versions may also be important for any detailed and subsequent analysis by various users. To that end, the full correspondence tables of each food item by HS version at six-digit are available to interested users at https://unctadstat.unctad.org/EN/ProcessedFood.html (UNCTAD, 2023a). Annex 1 provides a correspondence table for HS version 2022.

3.4 Trade matrix of processing by food categories

This technical paper focuses on international trade in processed food categories. As such, it comprises trade flows considering commodities being traded. More specifically, it comprises exports and imports, where the figures on international merchandise trade measure the value of goods which add or subtract from the stock of material resources of an economy by entering (imports) or leaving (exports) its territory (United Nations, 2011). The value of exports is mostly recorded as the free-on-board (FOB) value, whereas the value of imports includes cost, insurance and freight (CIF). Services trade is excluded from analysis.

Re-exports, defined as exports of foreign goods which were previously recorded as imports, and re-imports, defined as re-imports of goods imported in the same state as previously exported, are not considered by the present study. Although some countries report these flows separately in their international trade statistics, yet not all of them do so consistently.

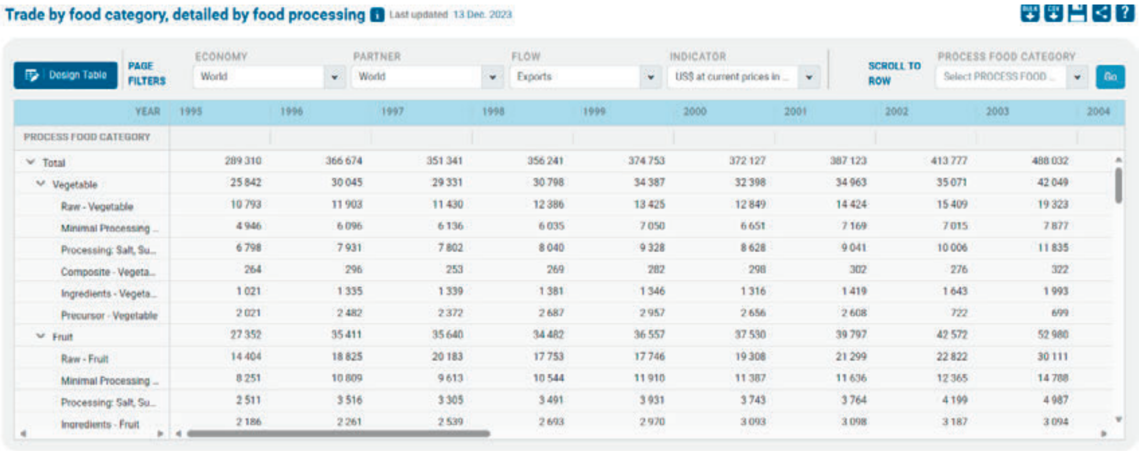
A trade balance of exports and imports, calculated as exports minus imports, is also provided as an additional flow in the trade matrix.

Trade flows are observed by reporting and partner economy, but also provided for several pre-defined groups of economies as available at UNCTADStat (UNCTAD, 2023c). They are measured in value, expressed in US dollars.

Underlying data for the trade matrix are contracted from UN Comtrade database, available at United Nations (2023d). Resulting trade matrix is available at UNCTADStat (UNCTAD, 2023c) and provides trade by food category, detailed by food processing (Figure 3) or, alternatively, trade by food processing, detailed by food category (Figure 4). In each case, the (currently) available indicators represent the following:

- Value, US$ at current prices in millions;
- Share, Percentage of total food;
- Growth rate, year-on-year, percentage; and
- Revealed Comparative Advantage (RCA) indicator for processed food categories.

Figure 3. Screenshot of trade by food category, detailed by food processing

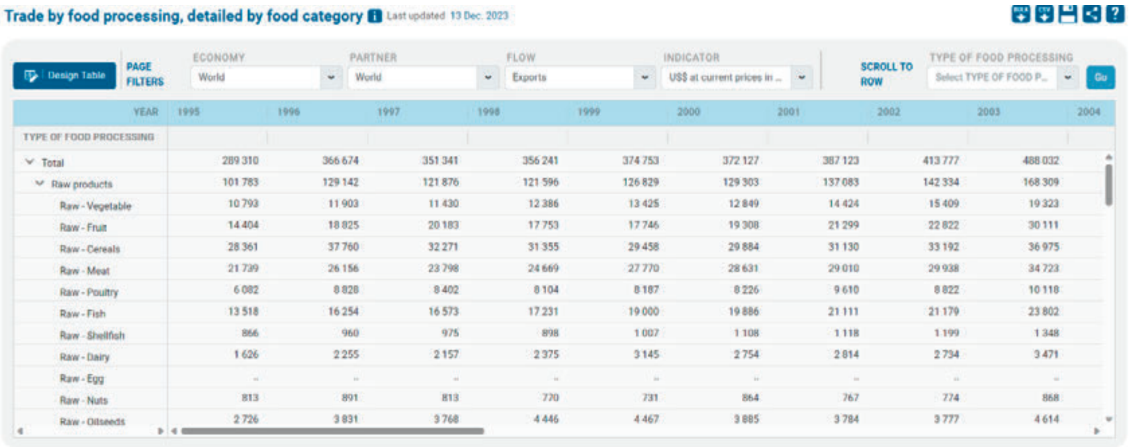

Trade by food category, detailed by food processing — Last updated 13 Dec. 2023

Design Table | PAGE FILTERS | ECONOMY: World | PARTNER: World | FLOW: Exports | INDICATOR: US$ at current prices in ... | SCROLL TO ROW | PROCESS FOOD CATEGORY: Select PROCESS FOOD ... | Go

YEAR / PROCESS FOOD CATEGORY	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total	289 310	366 674	351 341	356 241	374 753	372 127	387 123	413 777	488 032	
Vegetable	25 842	30 045	29 331	30 798	34 387	32 398	34 963	35 071	42 049	
Raw - Vegetable	10 793	11 903	11 430	12 386	13 425	12 849	14 424	15 409	19 323	
Minimal Processing ...	4 946	6 096	6 136	6 035	7 050	6 651	7 169	7 015	7 877	
Processing: Salt, Su...	6 798	7 931	7 802	8 040	9 328	8 628	9 041	10 006	11 835	
Composite - Vegeta...	264	296	253	269	282	298	302	276	322	
Ingredients - Vegeta...	1 021	1 335	1 339	1 381	1 346	1 316	1 419	1 643	1 993	
Precursor - Vegetable	2 021	2 482	2 372	2 687	2 957	2 656	2 608	722	699	
Fruit	27 352	35 411	35 640	34 482	36 557	37 530	39 797	42 572	52 980	
Raw - Fruit	14 404	18 825	20 183	17 753	17 746	19 308	21 299	22 822	30 111	
Minimal Processing ...	8 251	10 809	9 613	10 544	11 910	11 387	11 636	12 365	14 788	
Processing: Salt, Su...	2 511	3 516	3 305	3 491	3 931	3 743	3 764	4 199	4 987	
Ingredients - Fruit	2 186	2 261	2 539	2 693	2 970	3 093	3 098	3 187	3 094	

Source: UNCTADStat (UNCTAD, 2023c)

Figure 4. Screenshot of trade by food processing, detailed by food category


Trade by food processing, detailed by food category — Last updated 13 Dec. 2023

Design Table | PAGE FILTERS | ECONOMY: World | PARTNER: World | FLOW: Exports | INDICATOR: US$ at current prices in ... | SCROLL TO ROW | TYPE OF FOOD PROCESSING: Select TYPE OF FOOD P... | Go

YEAR / TYPE OF FOOD PROCESSING	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total	289 310	366 674	351 341	356 241	374 753	372 127	387 123	413 777	488 032	
Raw products	101 783	129 142	121 876	121 596	126 829	129 303	137 083	142 334	168 309	
Raw - Vegetable	10 793	11 903	11 430	12 386	13 425	12 849	14 424	15 409	19 323	
Raw - Fruit	14 404	18 825	20 183	17 753	17 746	19 308	21 299	22 822	30 111	
Raw - Cereals	28 361	37 760	32 271	31 355	29 458	29 884	31 130	33 192	36 975	
Raw - Meat	21 739	26 156	23 798	24 669	27 770	28 631	29 010	29 938	34 723	
Raw - Poultry	6 082	8 828	8 402	8 104	8 187	8 226	9 610	8 822	10 118	
Raw - Fish	13 518	16 254	16 573	17 231	19 000	19 886	21 111	21 179	23 802	
Raw - Shellfish	866	960	975	898	1 007	1 108	1 118	1 199	1 348	
Raw - Dairy	1 626	2 255	2 157	2 375	3 145	2 754	2 814	2 734	3 471	
Raw - Egg	..	..	..	..	..	..	..	..	..	
Raw - Nuts	813	891	813	770	731	864	767	774	868	
Raw - Oilseeds	2 726	3 831	3 768	4 446	4 467	3 885	3 784	3 777	4 614	

Source: UNCTADStat (UNCTAD, 2023c)

Using the trade matrix of processing by food categories, users are advised to exert usual caution when using and interpreting the data. First, it needs to be noted that the use of data in this trade matrix should be used with good knowledge of the coverage and the limitations of UN Comtrade, the main data source. The most important limitations are outlined at their website (United Nations, 2023e).

Second, the trade matrix reveals separately imports and exports flows, without any attempt to provide a balanced trade matrix. This also entails no modifications, edits, or imputations are made to the missing values, or reported to try and account for different valuation, i.e., FOB vs CIF. Numbers reported are as in the original data source.

Third, for analysis and interpretation purposes, it is worth mentioning that trade flows do not reveal domestic consumption. That does not only mean that the absolute value of traded food is less than the absolute value of consumed food. There is also likely to be relative differences between levels of processing in the proportion of food that is internationally traded. Processed and packaged food is less perishable and therefore more suitable for trade. Indeed, low values of traded unprocessed food could be seen as something positive as it could indicate a lot of sustainable and healthy food consumed as farm to table. Any interpretation of what trade of specific processed level of food groups therefore needs to be complemented with subject-expert knowledge and additional data series, e.g., on national production and consumption.

Furthermore, trade flows are measured in value, not volume. This may impact direct comparison of values of different processing groups, as such values may incorporate for example packaging values (indeed, processed food products also include more packaging than raw commodities). Processed, packaged and branded food costs more per calorie than raw commodities. A ton of tomatoes imported has a lower import value than the export value of the same tomatoes processed and exported, e.g., as ketchup. These considerations need to be accounted for in any interpretation of results of the analysis and in informing policies, to provide a reliable and robust evidence base (usually needs to be complemented with additional subject expertise).

Additionally, further considerations on more specific items, including economies and groups of economies considered, or coverage of different food items in specific processing and/or food categories, need to be accounted for when processing analysis. Users are requested to consult this technical paper and/or technical documentation at UNCTADStat (UNCTAD, 2023a, 2023c, 2023d).

The next chapter provides preliminary and generic analysis of the trade matrix of processed food categories and should be considered with above-mentioned limitations in mind.

4

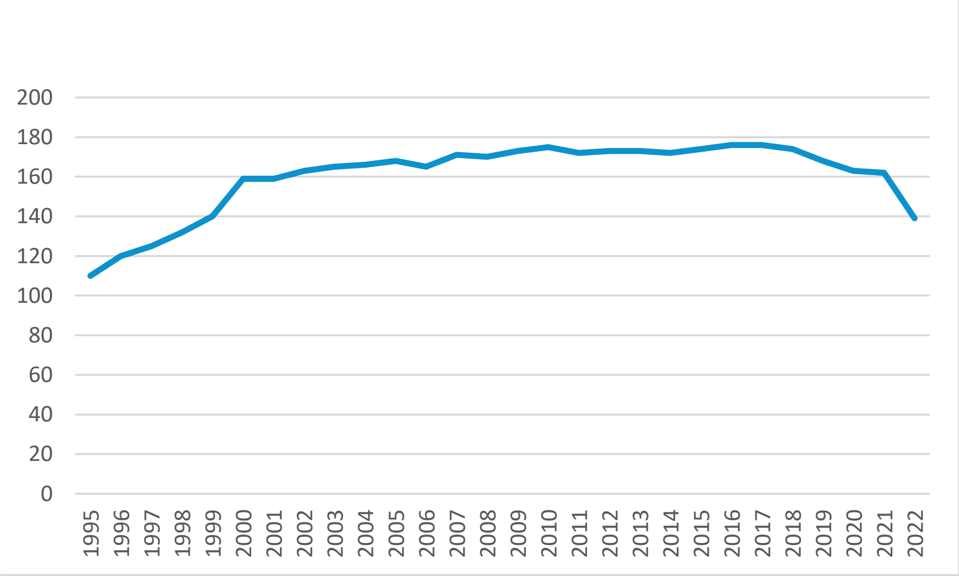
ANALYSIS

4.1 Observing general patterns in trade in processed food

This chapter provides an initial and preliminary analytical approach to the trade matrix of food items by level of processing and by food categories. Such an approach stems from the fact that a specific user need has not been identified yet, as this is the first such attempt to analyse international trade of food by its processing level. Considerations are taken into account of the limitations outlined above, primarily of the potential (mis)interpretations based on observed trade patterns, which may not clearly or directly relate to the questions that processed food would in general want to address: health and well-being. Similarly, again, the purpose of the designed classification of processing and its reflection in trade matrix by food categories, is to avoid any value assignments to the level of processing without further, detailed, and complementary research by subject-matter experts. To that end, further sections provide exploratory analysis of some aspects of the newly constructed trade matrix and test its applicability to some of the tabular, graphical, and indicator analytical tools.

Trade matrix covers the time period from 1995 until 2022. With statistical capacities of countries having improved over time, this resulted also in better data availability of international trade statistics reported by economies, which is reflected in the number of economies having reported data by each year (see Figure 5). Early years, before 2000, reveal a poor(er) coverage of economies reporting data, which would limit the reliability and suitability of data set to be applied for a global and/or regional analysis, depending on which data points would be sought after. Having fewer economies providing data on their international trade would result in global values being less complete, hence lower in that period, requiring specific caution in analysing such trends. On the other hand, a clear drop in coverage by economies is observed in recent years, most notable in 2022. This is an expected outcome as national authorities require time to process recent data, including their validation and proper dissemination for international use. Global and/or regional analysis for recent years is thus heavily cautioned against. It needs to be stated that the dataset used in the trade matrix represented in this technical paper refers to the data available at UN Comtrade at the end of October 2023. In time, data availability in recent years, or specifically, in 2022, will have improved. There is a notable issue with lack of data reported for some big reporters, population-wise, for example Algeria, Bangladesh, and Venezuela in period after 2018, which may have an impact on observed values in recent years. Based on this, some of the analysis in this chapter will focus on a 2000-2020 period alone for illustrative purposes.

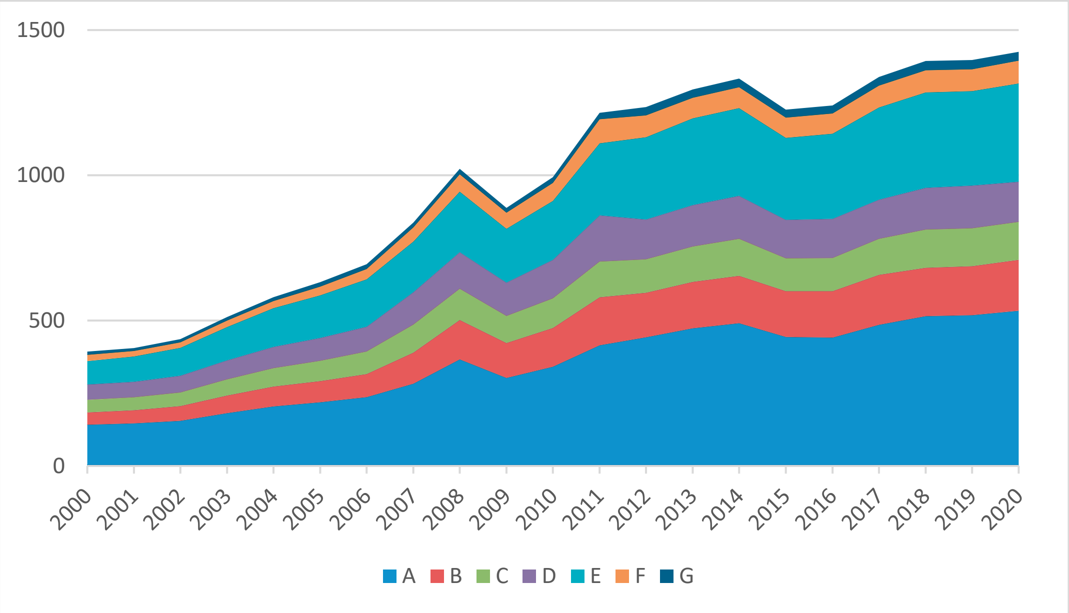
Figure 5. Data availability of trade in processed food by years (number of economies reporting)



Source: Authors' calculations based on UNCTAD (2023a)

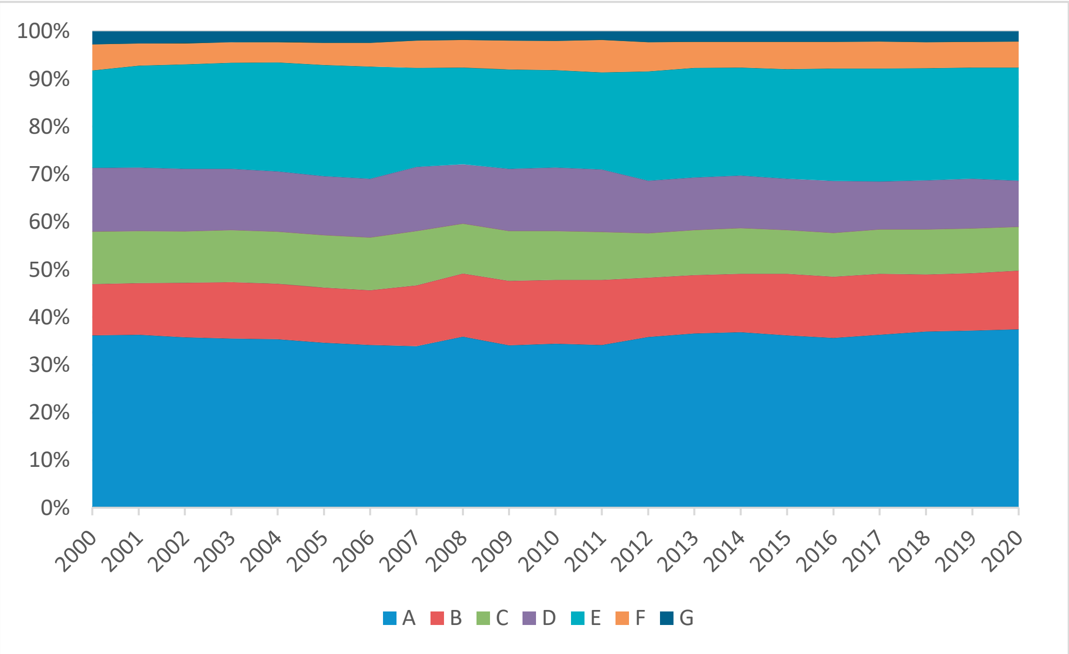
Globally, imports of food items have increased in the studied period from 2000 until 2020 (and continued increase until 2022, too). The increase was significant (see Figure 6, where the seven categories A-G correspond to the categories as defined in Table 2), with notable dominance of raw food (category A), followed by the category of composite foods (category E). Overall total movement follows roughly the same pattern as the total word exports movements presented in Figure 1: noting lower levels in times of economic crisis around 2009 and, to a lesser degree in the times of COVID-19 pandemic. Figure 7 offers an alternative view, inspecting their relative movement in time, showcasing there has been very little changes in that regards, noting a minor decrease in relative share of categories C and D, and a slight increase in categories A and E.

Figure 6. World imports of food categories by processing (Billons of United States dollars)



Source: Authors' calculations based on UNCTAD (2023a)

Figure 7. Distribution of world imports of food categories by processing (Percentage)

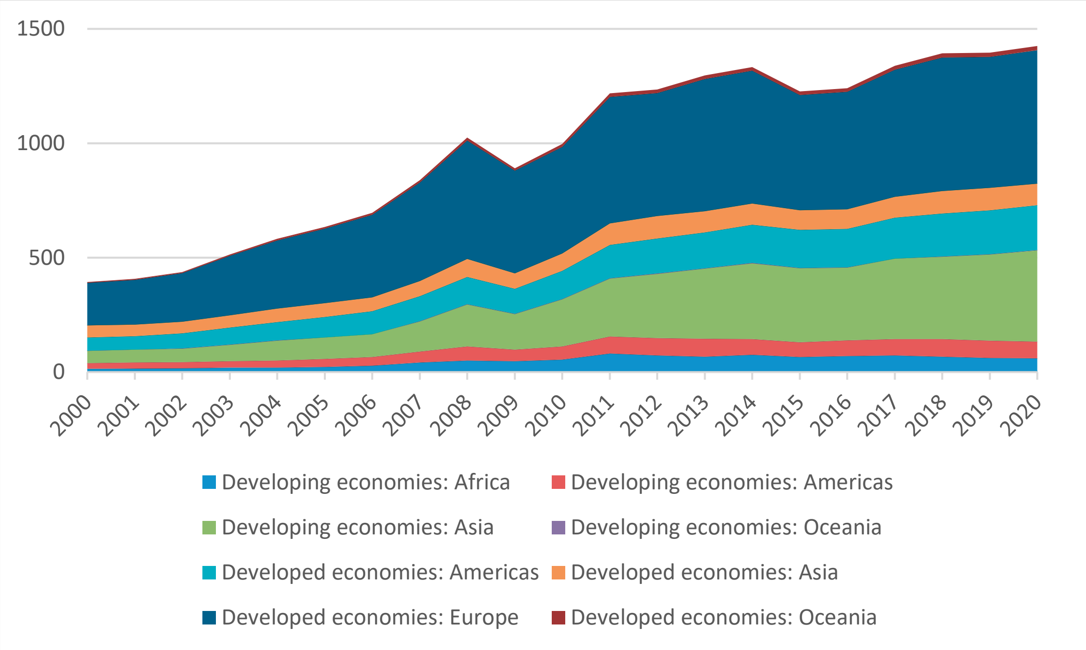


Source: Authors' calculations based on UNCTAD (2023a)

Global exports of food items by processing show a very similar dynamic and are therefore not analysed at this stage separately.

Observing the total imports of food items by region, a clear dominance of Europe is observed in Figure 8, followed by developing economies in Asia. Other regions, e.g., developing economies in the Americas or Africa, exhibit much smaller shares, in part driven by their lower populations, although these values and patterns appear to have stronger connections to their geographic locations as linking various regions and trade paths, or income levels, explaining in part the high shares observed in Europe and developing Asia, and smaller shares in Africa[3]. The same pattern is also observed in the case of imports of processed food only, when defined by categories C, D, and E combined (not shown specifically here).

Figure 8. Total food imports by region (Billons of United States dollars)

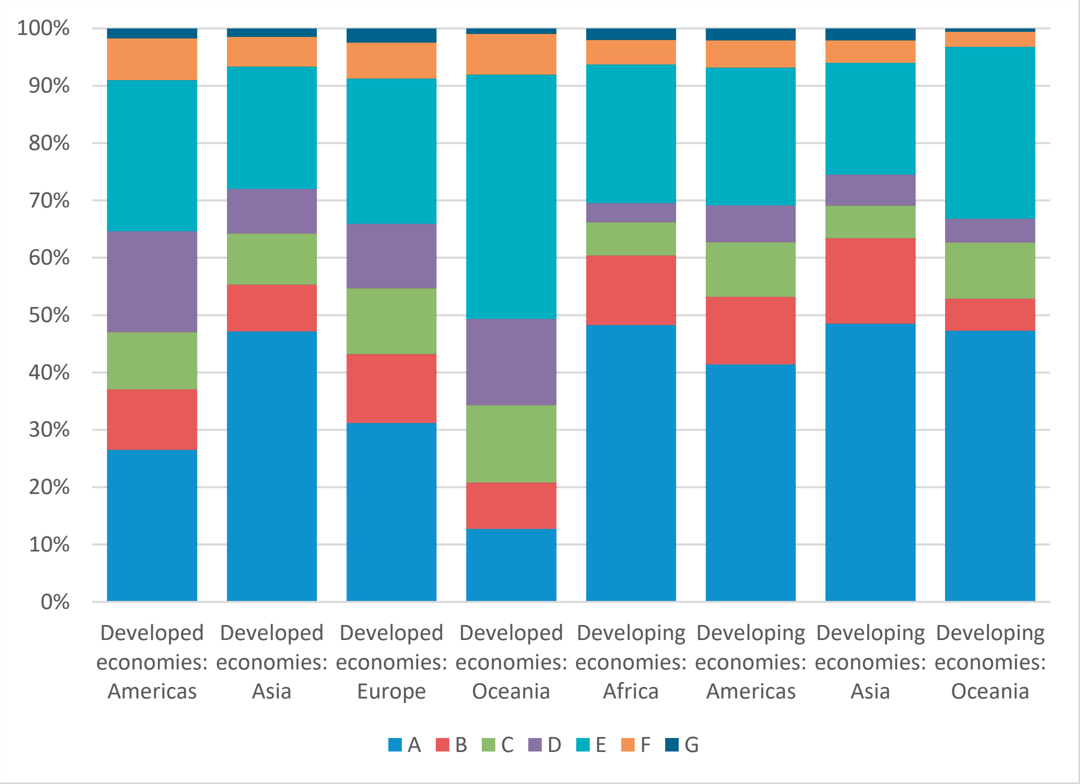


Source: Authors' calculations based on UNCTAD (2023a)

Within each region's imports, for 2020 (with a similar pattern for the latest available year, 2022, but not shown here due to data deficiency as explained previously) the regions with highest shares of their imports of processed food, as observed by categories C, D, and E, are by far developing economies in Oceania, followed by developed economies in Americas and Europe. Other developing economies, on the other hand, in general have smaller relative shares of imports of categories C, D, and E, but appear to have larger (largest) imports shares of processing categories A (raw) and B (minimally processed) – see Figure 9. On the exports side, however, the observed patterns appear to be different (Figure 10). For example, developing economies in Africa, Asia, and Oceania exhibit lower shares of exports of categories A, while larger shares of B compared to their imports, combining to a somewhat lower share of A and B categories overall in 2020. At the same time, developing economies in Asia exhibit much lower exports of raw food (A) than imports, while exports of processed food significantly surpass their import shares. Reasons behind, and implications of these observed patterns lie outside the scope of this technical paper, but merit further investigation to understand better linkages between trade metrics and health aspect, domestic consumption, or even structural and strategic features of respective economies.

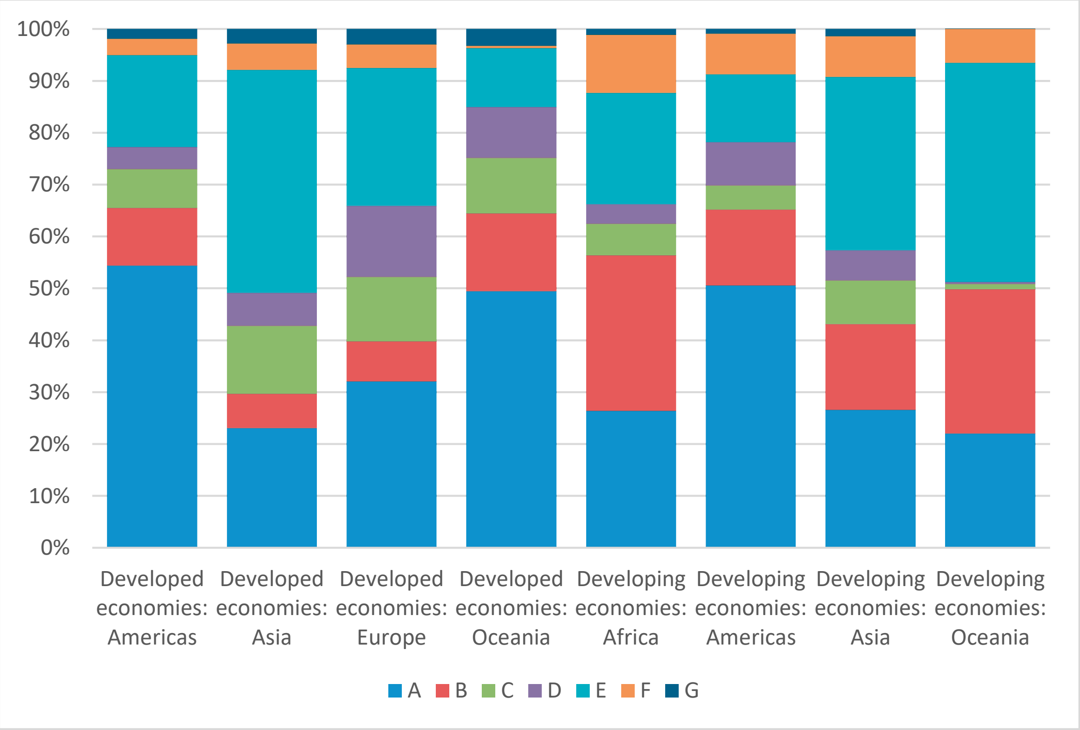
[3] With expanding support towards an African Continental Free Trade Area (AfCFTA) (UNCTAD, 2023e), also observed trade values may reflect this, including intra-region trade, which may in fact be a strong reason behind high values/shares in both Europe (internal single market of the European Union or European Free Trade Area (EFTA)), and Asia where China, Hong Kong SAR, China, Macao SAR, and China, Taiwan Province of, may serve as major trading hubs with significant intra-region trade.

Figure 9. Breakdown of imports by category for each region, 2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

Figure 10. Breakdown of exports by category for each region, 2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

When defining processed food as the combination of processing categories C, D, and E, the biggest import globally in 2020 were observed for the category E18 – Composite: edible preparations, reaching a value of US$157 billion, followed as above half this value by alcoholic beverages (category D15) and composite: vegetable fats (Table 5). On the other side of the spectrum (Table 6), edible preparations (category C18) and sugars and jams (D16) recorded a modest US$2 million and US$19 million in global imports. Entire range of processed food imports for 2020 is displayed in Annex 2.

Table 5. Top 5 imports of processed food categories, 2020 (Millions of United States dollars)

Processed food category	Processed food category label	Value
E18	Composite Edible preparations	157295
D15	Processing: Salt, Sugar Alcoholic beverages	82164
E13	Composite Vegetable fats	47754
E16	Composite Sugars, jams	40647
E17	Composite Cocoa and cocoa preparations	39171

Source: Authors' calculations based on UNCTAD (2023a)

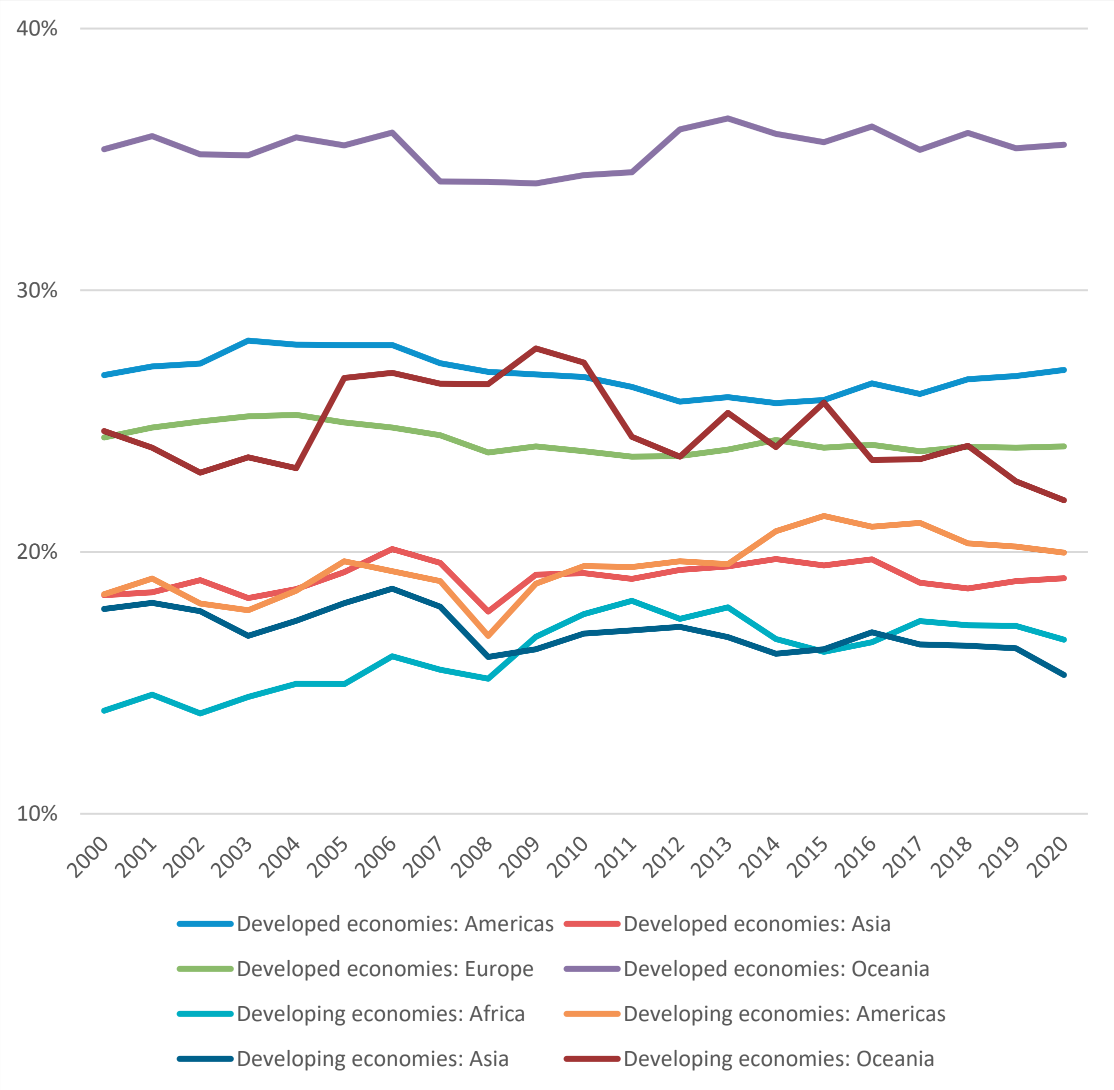
Table 6. Bottom 5 imports of processed food categories, 2020 (Millions of United States dollars)

Processed food category	Processed food category label	Value
C18	Processing: Salt, Sugar Edible preparations	2
D16	Processing: Salt, Sugar Sugars, jams	19
E08	Composite Dairy	141
C17	Processing: Salt, Sugar Cocoa and cocoa preparations	435
E01	Composite Vegetable	495

Source: Authors' calculations based on UNCTAD (2023a)

Looking at processed food (categories C, D, and E) as a proportion to total imports, Figure 11 shows that Developed Oceania and Developed Americas have the largest shares. No strong or clear pattern across regions over time is seen, except that some developing regions, e.g., Developing Africa or Developing Americas have seen growth in their proportions over the time period studied.

Figure 11. Imports of processed food as a proportion of food imports, by region, 2000-2020 (Percentage)

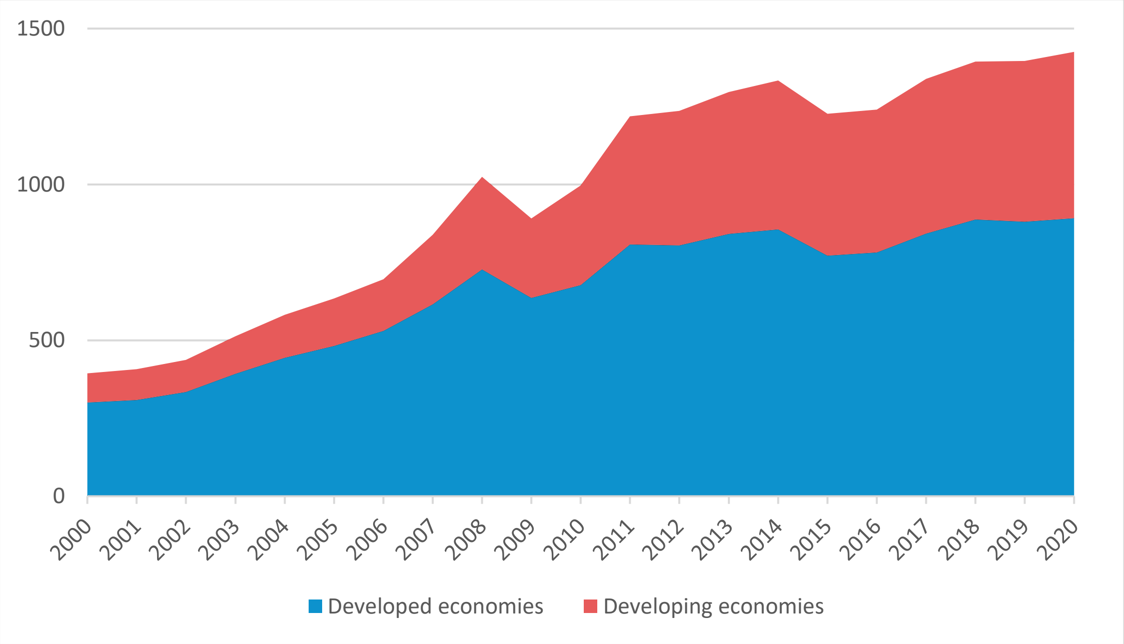


Source: Authors' calculations based on UNCTAD (2023a)

Analysis thus far merits the question of a general comparsion of developed and developing regions for any consistent differences in their food trade.

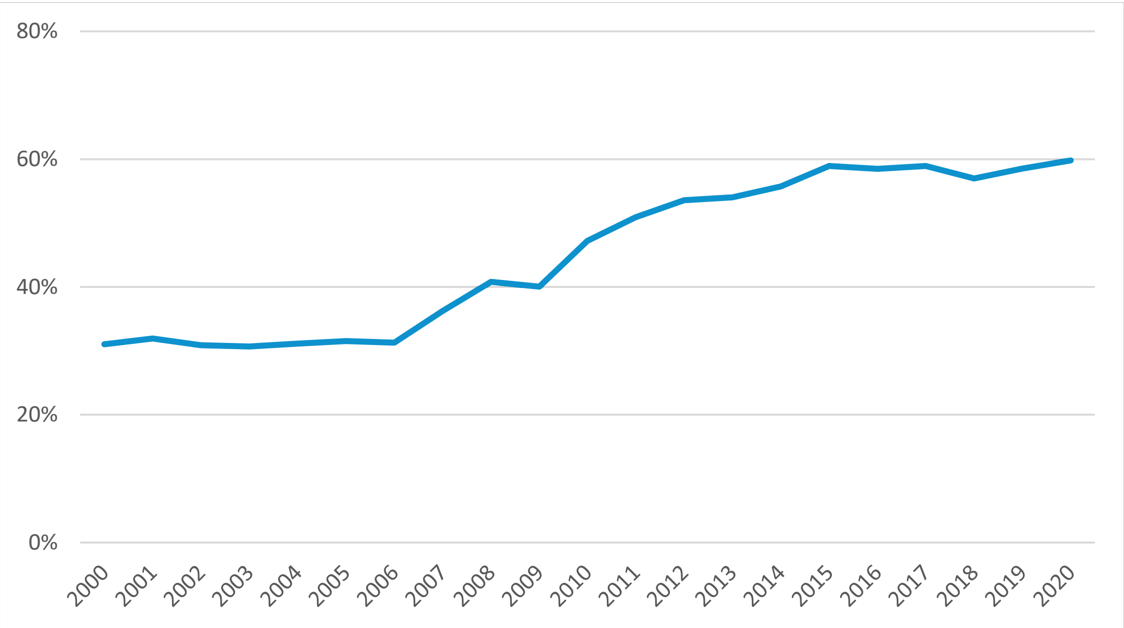
Figure 12 reveals that developed economies import more food than developing, reaching US$892 billions and US$533 billions in 2020, respectively. Their relative share, expressed as value of developing in value of developed economies remained very stable at around 30 per cent up until 2006, when it entered a steady rise in the next decade to plateau at around 60 per cent since 2016 until 2020 (Figure 13).

Figure 12. Food imports of developed and developing economies. 2000-2020 (Billons of United States dollars)



Source: Authors' calculations based on UNCTAD (2023a)

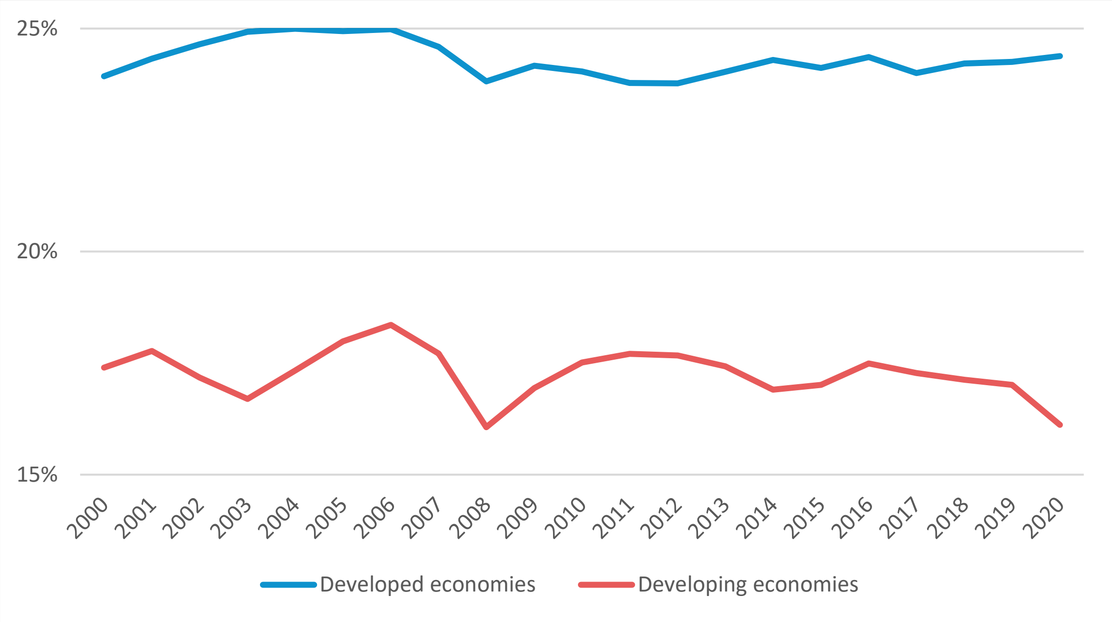
Figure 13. Share of food imports of developing economies with respect to developed economies, 2000-2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

Developed economies also consistenly import more processed food as a share of their food imports, ranging at about 25 per cent, compared to about 17 per cent for developing economies. While their overall trends do not seem to diverge much, both being more or less stable in the studied period, developing economies do exhibit a somewhat higher volatility of their shares, as depicted in Figure 14.

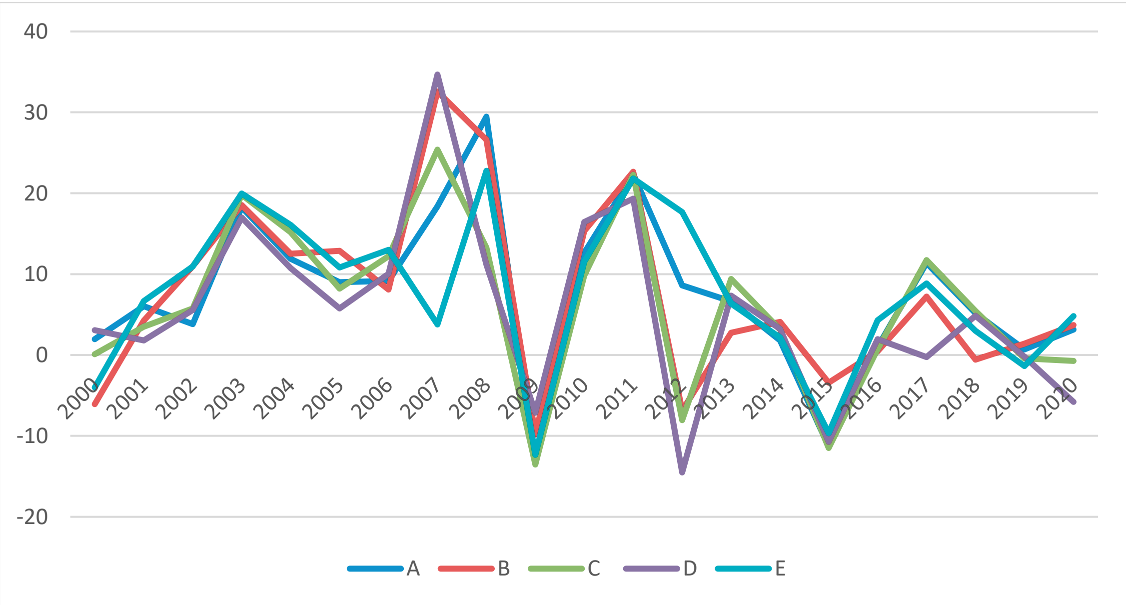
Figure 14. Shares of processed food imports in total food imports for developed and developing economies, 2000-2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

By observing growth rates of global exports' processing food categories (and focusing for simplicity on categories A, B, C, D, and E alone – see Figure 15) a general alignment among all the categories is observed in the studied period, noting negative growth rates in 2009 and for some also repeated cycles in subsequent years. Interesting to note is that categories B (minimally processed) and D (processed by fermentation and smoking) exhibit largest variance of annual growth rates, whereas categories A (raw) and E (composites) appear to be most stable in time (which may relate to their highest shares in global trade, as depicted in Figure 6 or Figure 7).

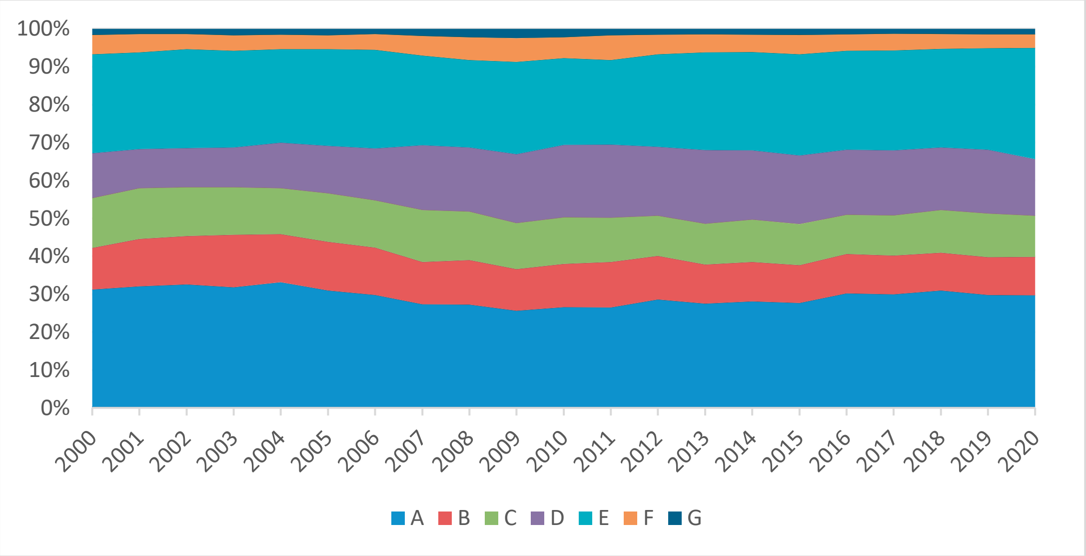
Figure 15. Growth rates of global exports of food by processing, selected categories, 2000-2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

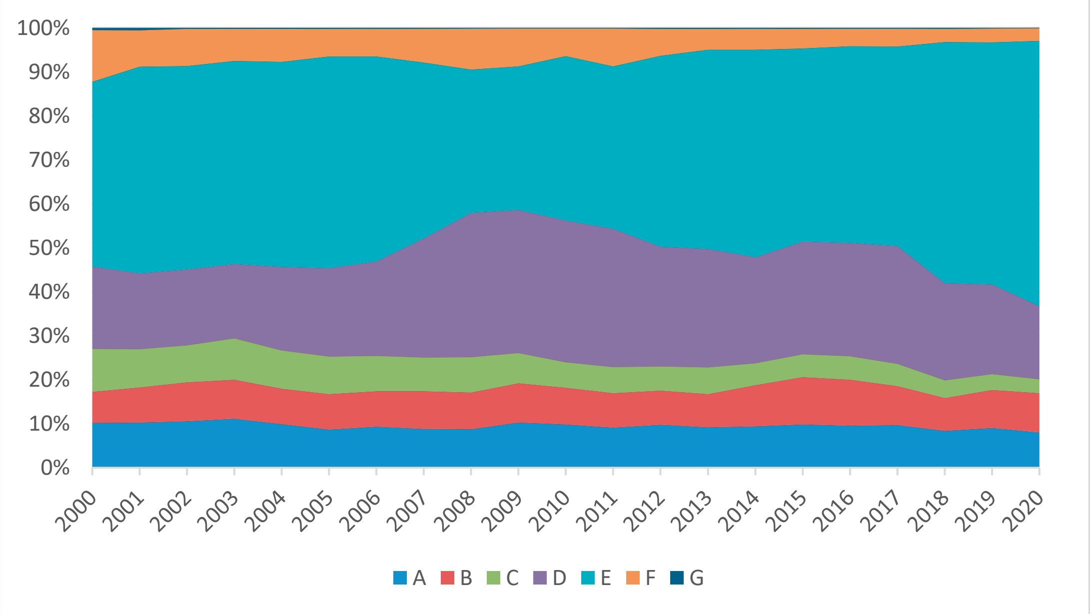
By going into more detailed, or focused analysis, this can be done at the level of specific group of economies, or specific economy itself. For example, focusing on Small Island Developing States (SIDS) as an example to observe trade patterns in their foods imports and exports, one can observe a relative stable, albeit slowly growing share of processed food (C, D, and E) imports in their total imports: having grown from around 50 to 55 per cent in 2000-2020 period: Figure 16. For simple comparison, the corresponding value in Europe stands at about 48 per cent in 2020. On the other hand, SIDS exports (Figure 17) reveal a different story, specifically, that category E is observing a significant relative increase in recent years, having reached 60 per cent in 2020.

Figure 16. SIDS imports by processing category, 2000-2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

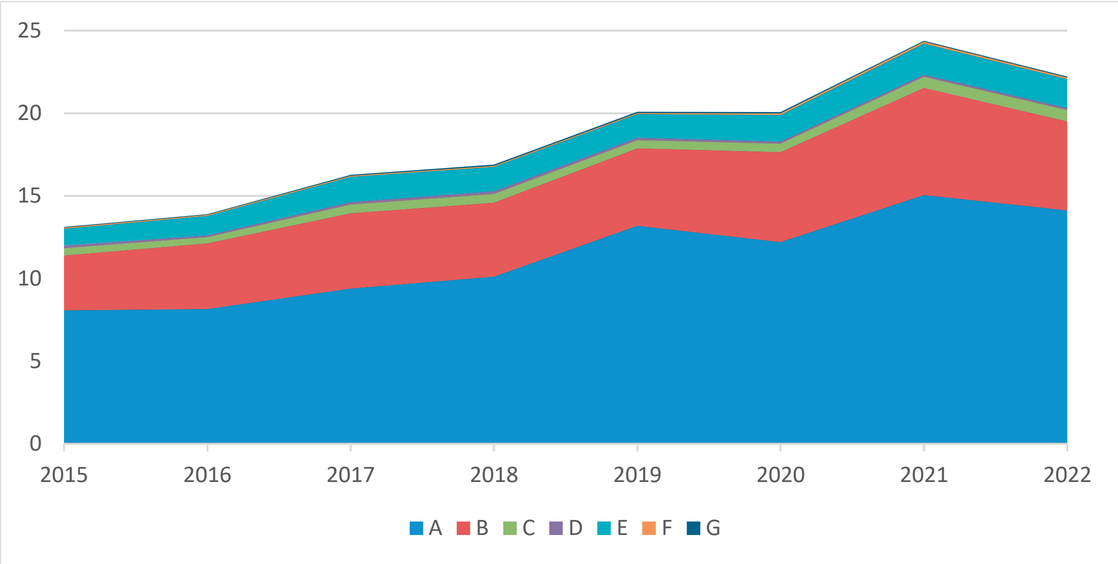
Figure 17. SIDS exports by processing category, 2000-2020 (Percentage)



Source: Authors' calculations based on UNCTAD (2023a)

Going further to a lower level, the level of economy, specific economy could be analysed with respect to their trade in processed food. For example, looking at Ukraine, recent-years data showcase the well-established and studied pattern in limitations in exports of their grains (see e.g., UNCTAD (2023f)): their overall exports of food reversed the growing trend up until 2021 surpassing US$24 billion, dropping to US$22 billion in 2022 (Figure 18). The majority of these exports were in the category A (raw), with its share rising to almost 64 per cent in 2022, up from just below 62 per cent in previous year.

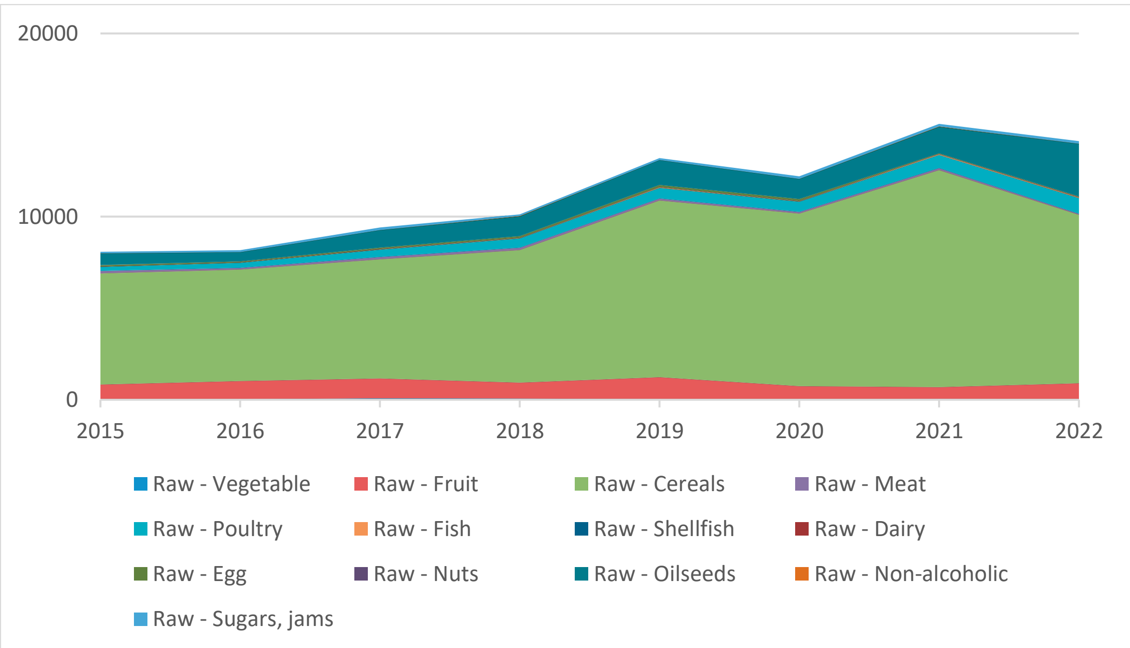
Figure 18. Ukrainian exports of food by processing category, 2015-2022 (Billons of United States dollars)



Source: Authors' calculations based on UNCTAD (2023a)

Within the raw food categories, cereals dominate the exports, with a notable fall in 2022 due to the conflict (Figure 19).

Figure 19. Ukrainian exports of raw food, by food category, 2015-2022 (Millions of United States dollars)

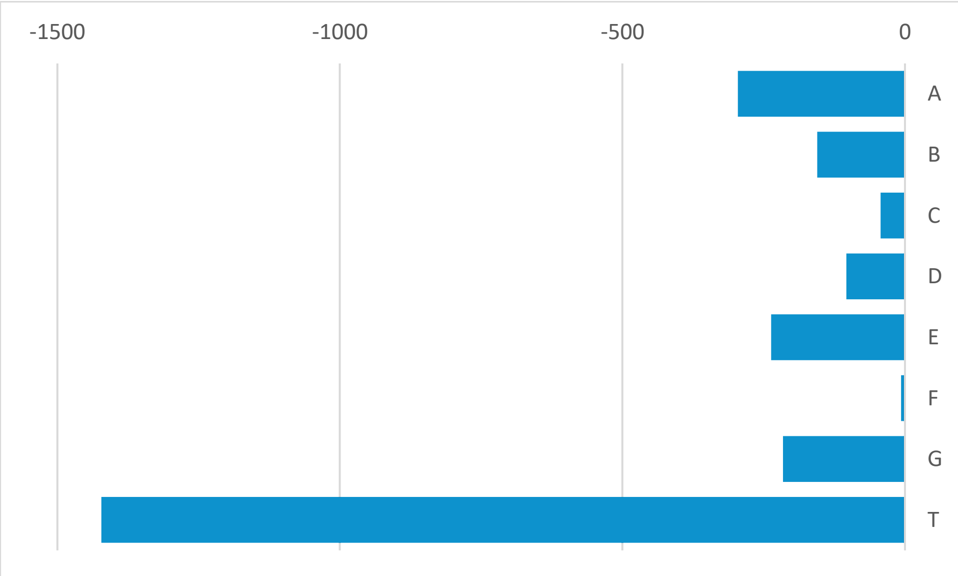


Source: Authors' calculations based on UNCTAD (2023a)

Furthermore, the trade matrix offers the analysis of the trade balance (export – imports). In the case of Ukraine, trade balance for Raw – Cereals category continued to exhibit the fast-growing pattern also in 2022 (following a significant increase in 2021), possibly indicating the consequences of trade limitations due to the war, while certain agreements (The Black Sea Initiative (UNCTAD, 2023f)) allowed for exports of certain products to continue, or expand, relative to their imports. Specifically, imports of Raw – Cereals category was historically at very low levels, in 2015-2022 not surpassing the value of US$200 million, with a steady drop from 2019, when it reached US$191 million, to US$153 million in 2022. Corresponding exports reached more than US$11 844 million in 2021, dropping to just above US$9 000 million in 2022 (Figure 19).

Such detailed and specific analysis may be used to study the impact of other shocks to the national, regional, or international economies status with respect to the food trade and access, food safety and related, signalling potential reconciliation measures or policies. A recent case, not yet revealed in officially reported trade statistics, would be the observance of implications of conflict in the State of Palestine, with, for example, an already notable negative trade balance in all food processing categories in recent years (for 2021, see Figure 20), leading to dire policy circumstances of the economy. National and international community may explore the data provided at UNCTAD (2023a) to inform relevant policies in such cases.

Figure 20. Trade balance for food trade by processing category in the State of Palestine, 2021 (Millions of United States dollars)



Source: Authors' calculations based on UNCTAD (2023a)

Additional options and tools, including interactive visualizations are available (and remain updated and enhanced) at UNCTAD (2023a).

4.2 Key indicators for global processed food trade

In this section, four essential indices that shed light on different aspects of international trade in food, particularly in processed food. First, the normalised trade in food balance (NTFB) will help understand how economies focus on trading processed foods, weather they are in surplus or deficit.

Second, the Relative Reliance on Trade in Processed Food (RTPF) will reveal how much an economy depends or relies on importing or exporting processed foods. This indicator caters to the needs of a more relative aspects of economy's exports vis-à-vis their imports.

Third, the Processed Food Similarity Index (PSI) will evaluate the similarity of a country's processed food exports to the global average.

Lastly, the Revealed Comparative Advantage (RCA) measures the comparative advantage of the economy for a given product, inferring an economy to be a competitive producer and exporter of that product, meaning it is considered to have an export strength in that product.

Each index offers some insights into the diverse dynamics of processed food trade on a global scale, yet requires complementary measures and approaches, or a series of the analytical aspects listed in this technical paper, including subject-matter expertise for proper interpretation and application of results.

4.2.1 Normalised trade in food balance (NTFB)

The NTFB is used to measure a relative degree of specialization in the production and subsequent trade of specific goods in general, and particularly the processed food. This indicator is used for any of the categories of processed food. This certain degree of specialization is measured by comparing the net flow of processed food (exports minus imports) to the total flow of processed food (exports plus imports) with partner world. A positive value indicates that an economy exports more of a specific food product within all food product groups than it imports, signifying a certain degree of specialization in the production of that specific food category[4]. The index is calculated across different product groups, sub-categories, and over time. The usefulness of the indicator is in monitoring trade flows of food items by level of processing, which is further paired with other indicators. The NTFB is a valuable tool for monitoring trade flows of food items based on the level of processing. When paired with other indicators, it provides insights into a country's global trade performance, offering a quick assessment of trade surpluses or deficits for the specific food product being traded (refer to section 3.4.1 for more details).

The indicator uses classification of food processing categories, based on food categories and/or 6-digit HS (see sections 2.3 and 3.2).

The NTFB is calculated according to the following formula:

$$NTFB_{ji} -= \frac{X_j^i - M_j^i}{X_j^i + M_j^i}$$

Where:

$NTFB_{ji}$ … the index of trade relative specialization of economy *j* for specific food product

i … specific food product/food product category (processed food for example)

j … economy (or group of economies) except World

X_j^i … economy's *j* exports of specific food product/food product category *i* to World

M_j^i … economy's *j* imports of specific food product/food product category *i* from World

The NTFB is computed for all food products, with a particular emphasis on processed foods, as they are the main focus of interest in this paper. The processed food is defined as a group of three categories according to level of processing as defined under in section 2.3, or used in various instances in section 4.1, namely: C (Foods which have been sweetened, salted/brined, whether or not smoked.), D (Fermented, smoked (but neither salted nor brined)), and E (Composite foods, preparations and refined oils). The indicator is calculated for all economies[5]. Economy's imports (exports) of food items (by categories) are obtained from the international trade flows and assigned to different food processing categories. Trade in processed food, as defined above, is compared to respective total trade in food categories, then comparing imports to exports of processed food.

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[4] While the net export ratio can provide some information about an economy's specialization in trade goods, it may not be the best measure to use in isolation. For example, the net export ratio may not accurately reflect an economy's specialization in a particular trade good, as it takes into account all goods traded by an economy rather than just one specific trade good. This means that an economy may have a high net export ratio for a particular trade good but still be less specialized in that good compared to another economy with a lower net export ratio but higher specialization. This is why additional indicators to complement the picture are suggested.

[5] The NTBF for the world is near zero for all products, considering that ideally total export value should be same as total imports value at World level.

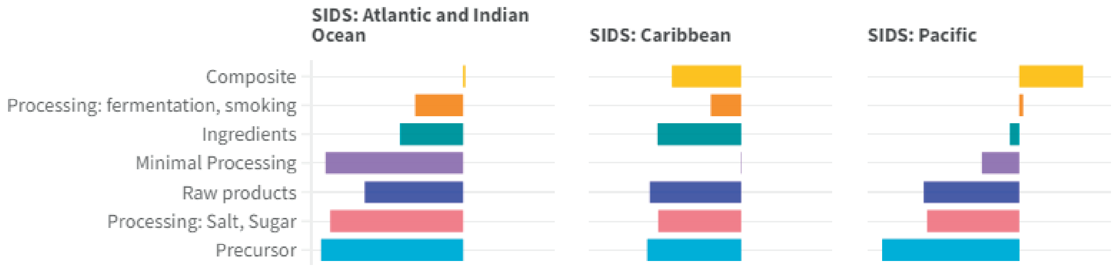
The range of NTFB values is between -1 and 1. The positive value indicates that an economy has net exports or surplus, hence it relatively specializes in a certain degree on the production of that specific product. The negative values mean a deficit, indicating that the economy imports more than it exports. Figure 21 shows significant variations in how specific food categories' trade balances are distributed among regions.

Figure 21. Normalised net trade in food balance, by continent and food category, 2019 (Index)

Source: Authors' calculations based on UNCTAD (2023a)

The Oceania illustrates a certain degree of production and exports specialization in Precursor, Raw Products, and Minimal Processing, ranging from 0.69 to 0.82. The Americas exhibit high positive values for Raw Products (0.40) and Minimal Processing (0.27), and Africa – for Minimal Processing (0.37) and Ingredients (0.29), signalling a certain degree of specialization in production and exports of these food categories. Europe registers positive values for all categories, except for Ingredients and Minimal Processing. By contrast, Africa displays negative values in all categories, except Ingredients and Minimal Processing, indicating that this region imports more of these products than it exports. Negative values (-1 to 0), also observed for Asia in specific categories, indicate specialization in imports, having -0.38 for Precursor, -0.43 for Raw Products, and -0.21 for Processing: fermentation, smoking. Oceania showing high negative values for Ingredients (-0.6). Finally, Europe records almost zero value for Processing: Salt, Sugar, Composite, and Raw Products, showing a balance between its exports and imports in these categories.

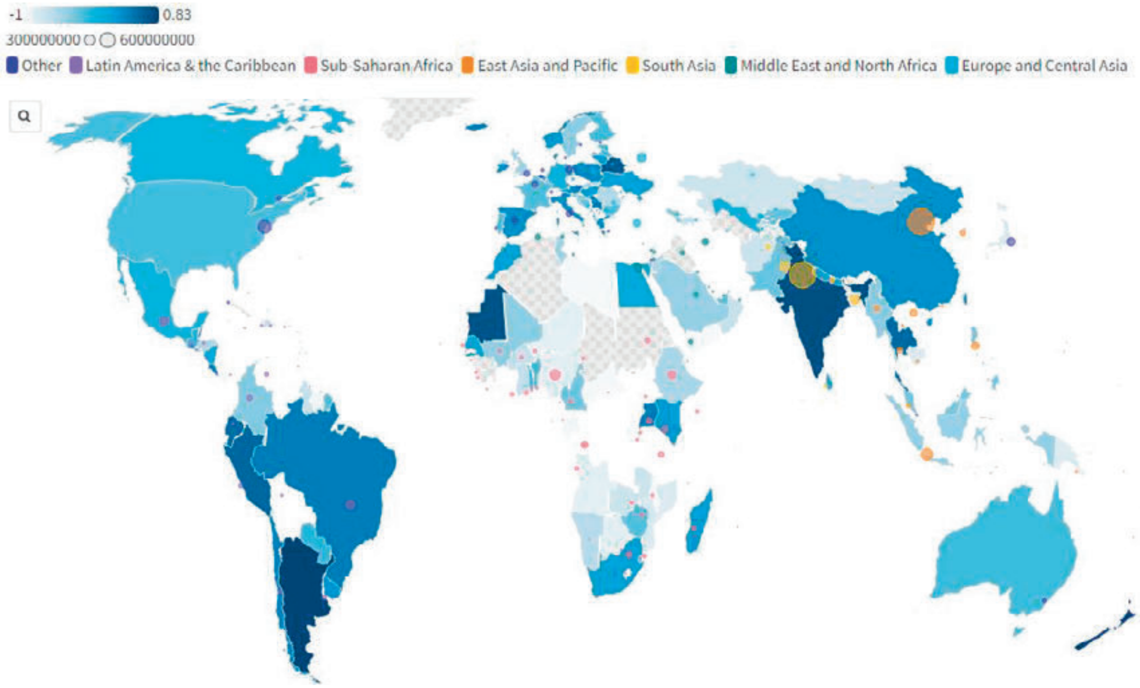
Figure 22. SIDS Normalised net trade in food balance, by food category, 2019 (Index)



Source: Authors' calculations based on UNCTAD (2023a)

Several SIDS are dealing with the challenge of expensive food and growing bills for importing food and raw products. The SIDS heavily depend on importing food products. Additionally, important sectors like tourism are making less money from exports, leading to reduced income and increased concerns about having enough food (FAO et al., 2023). This economic vulnerability is also reflected in the NTFB of the SIDS. Figure 22 represent the NFTD of the SIDS. Notably, the data illustrates a clear dependence on imports for all processed food categories as well as the raw products across SIDS. The SIDS in the Pacific register a net surplus for the composite product. The SIDS in the Atlantic and Indican Ocean show high negative values in trade of Minimal Processing (-0.90), Processing, salt and sugar (-0,88), and Precursor (-0.93). Caribbean SIDS, show deficits in Composite (-0.45) and Ingredients (-0.55), highlighting external dependencies. Conversely, Pacific SIDS present a surplus in Composite products (0.42), indicating self-sufficiency in more processed food products. These contrasting trade patterns underscore the economic challenges and variations in self-sufficiency within the global processed food market for SIDS.

Map 1. Net trade in processed food balance for Processing: salt, sugar; 2019 (Index)



Note: Borders of economies do not reflect the official position of UNCTAD. The map used is for illustrative purposes and based on specific software used, and does not imply the expression of any opinion on the part of UNCTAD, concerning the legal status of any economy or concerning the delimitation of frontiers or boundaries.

Source: Authors' calculations based on UNCTAD (2023a)

Net trade in processed food balance varies across economies in the "Processing: Salt, Sugar" category, as shown by Map 1 and measured by the NTFB index. Economies such as Central African Republic, Yemen, and Sao Tome and Principe have strong negative values nearing -1, suggesting a pronounced imports pattern of processed food products related to salt and sugar. In contrast, New Zealand, Argentina, Türkiye, Mauritania, and India showcase positive values indicating significant trade surplus (exporting more of these specific products than importing). New Zealand ranks first with a value of 0.82, implying a substantial specialization in the production and exports of these groups of products. The consumption of processed foods high in salt and sugar, is a leading global health risk, as highlighted by World Health Organization (2020). It underscores the importance of limiting the intake of free sugars to less than 10 per cent of total energy and reducing salt to less than 5g per day to prevent hypertension and related diseases. The study emphasizes the need for countries to address trade imbalances in processed salty and sugar-laden products to promote healthier diets and tackle the associated health risks. However, it is essential to note that a trade surplus/deficit of the specific food product does not necessarily correlate with higher/lower domestic consumption or production. To obtain a comprehensive understanding, it is crucial to integrate the interpretation of trade indicators such as the NTFB, with other relevant metrics for a fuller picture and accurate interpretation.

4.2.2 Relative reliance of trade on processed food (RTPF)

This indicator of trade in processed food measures the degree to which national trade flows in food rely on or are composed of processed food. It monitors trade flows of food items by level of processing, further to be paired with domestic consumption, to arrive at a comprehensive understanding of processed food trade and consumption.

By doing so, RTPF provides an insight into how much of the trade is reliant on processed food, both at exports and imports side. By comparing the two flows, and relative reliance of trade on processed food in each, the overall situation in an economy can be assessed by indicating whether an economy relies more on imports of processed food than exports, hinting at higher level of domestic market saturation with processed food (all else being equal), hence potentially indicating more domestic consumption of processed food[6]. The indicator also offers analysis at levels of numerator and denominator separately, i.e., observing the imports side separately (in time and place) and exports side separately.

Also RTPF uses classification of food processing categories, based on food categories and/or 6-digit HS (see sections 2.3 and 3.2). RTPF is intended to be calculated at an economy level without additional breakdowns. It is useful for comparison in time and across economies.

The RTPF is calculated according to the following formula[7]:

$$RTPF_{j,t} = \frac{\sum_i w_{IM,i} * \frac{IM_{p,i}}{IM_i}}{\sum_i w_{EX,i} * \frac{EX_{p,i}}{EX_i}}$$

Where:

$RTPF_{j,t}$	… the index of relative reliance on trade on processed food of economy *j* in time *t*
i	… food item / group
p	… processed food
j	… economy (country or country group) except World
IM_i / EX_i	… import/export of the specific product group *i*
$w_{IM,i}$	… the import share of the specific product group *i* in economy's total imports

[6] Such inference is subject to thorough verification by subject-matter experts at national and international levels and additional relevant information to combine for a proper ground to make informed interpretation.

[7] While the formula could be rewritten in a more effective way, i.e., using items from the weights *w* and cancelling elements of IM_i out, the logic of the indicator builds on the construct of ${IM_{p,i}}/{IM_i}$.

Processed food is defined as a group of three categories according to level of processing as defined in classification of processed food (see section 2.3), namely: C (Foods which have been sweetened, salted/brined, whether or not smoked.), D (Fermented, smoked (but neither salted nor brined)), and E (Composite foods, preparations and refined oils).

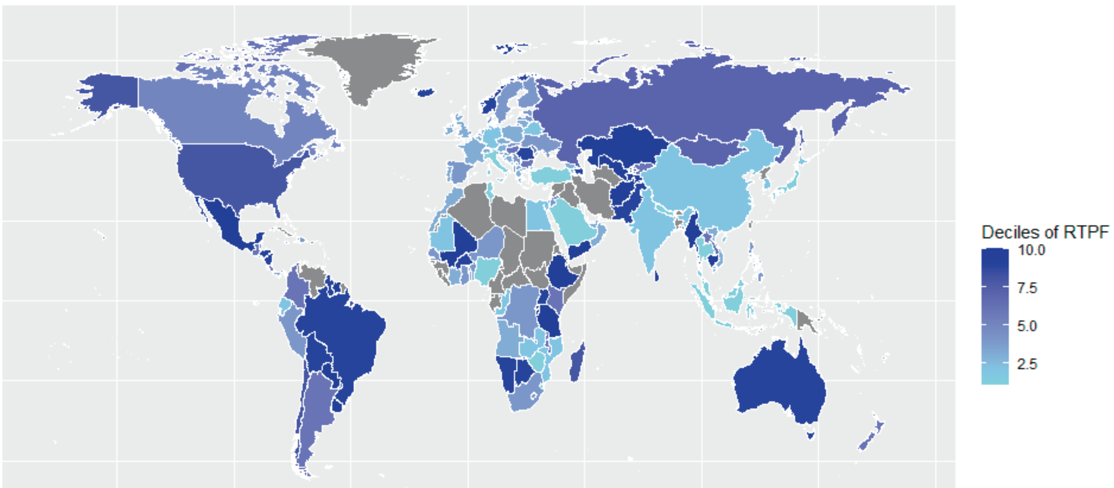
An economy's imports (exports) of food items (by categories) are obtained from the international trade flows and assigned to different food processing categories. Cases where values are not reported, they are treated as value of zero. Where imports or exports are zero, the relative share (as per formula, for numerator or denominator, respectively) is treated as zero for calculation purposes.

The indicator produces values from 0 onwards, with 0 indicating the country is not importing any processed food (hence, from trade perspective, supporting healthy diet), countries with the indicator value of 1 would mean the imports and exports of processed foods are balanced in relative (not absolute) terms, and values above 1 indicate a higher reliance on processed food in imports/trade. Separately observing values of numerator and denominator provide additional insights into trade of processed food at national level (comparison in time) or across economies.

Conducting an analysis using the indicator RTPF, one can observe differences both in time and in place, i.e., across countries. For the latter, considering the 2019 as a year of observation, the following results are obtained.

While most of the economies have the values of the indicator below 5 (90 per cent of the economies lie below 4.92, overall average is 11.32, while the median stands at 1.05), there is an extreme value of 1333 for Comoros. This hugely skews the distribution, rendering analysis difficult. For continued analysis, excluding the outlier and for the 156 remaining economies included in the dataset, the values lie between 0.13 for Qatar and 55.27 for Yemen (mean of 2.85; median 1.05). Moreover, visualizing these distributed by deciles of RTPF (Map 2), the pattern reveals that Americas, Oceania, Northern and Central Asia, as well as some parts of Africa and Europe exhibit high values of the indicator. Interpreting the results is beyond the scope of this technical paper, and although one of the interpretation avenues would be that such a result would imply (relatively) high imports of processed food vis-à-vis their exports, indicating that their (domestic) markets would be becoming more saturated, relatively speaking, with processed food, this would not be taking into account the domestic production and consumption, as it may be a reflection of high domestic production of non-processed food and also their exports. Additionally, subject-matter experts would need to complement the results with additional expertise and data sources/analysis, hence results are to be considered merely for illustrative purposes. While spatial comparison would need to be accompanied by various other metrics, the comparison of the same economy performance with respect to RTFP in time would indicate how its relative international trade reflects processed food and would therefore merit further investigation and direct application.

Map 2. RTPF values are lowest in Europe, some parts of Africa and South-East Asia, 2019



Note: Borders of economies do not reflect the official position of UNCTAD. The map used is for illustrative purposes and based on specific software used, and does not imply the expression of any opinion on the part of UNCTAD, concerning the legal status of any economy or concerning the delimitation of frontiers or boundaries.

Source: Authors' calculations based on UNCTAD (2023a)

Alternative view is to consider the top and bottom values of the indicators. It appears that denominator, i.e., relative exports of processed food, is predominantly driving the value of the indicator RTPF. Observing in Table 7, this pattern can clearly be observed with values in several cases below 0.05. This results, even if the numerator (relative value of imports of processed food within national total imports) does not always reach high values, e.g., above 0.7, in a high value of RTPF, as shown in the table below. This is most vividly the case for the top RTPF value of a staggering 1 333 for Comoros, whose numerator is at 0.32, while denominator at a negligible 0.0002. While for some economies, notably Paraguay, Rwanda, Tanzania, and Myanmar, the numerator of the indicator reaches values of around 0.7, their corresponding values of denominator appear to be comparably (to other economies) high as well.8 For these economies, one could argue that their reliance on trade in processed food is high(er). Implications for national consumption patterns of processed food, however, remain beyond the scope of this indicator and work.

Table 7. In top 10 economies by value of RTPF, the high values are mostly due to low exports of processed food

Year	**Reporter**	**Numerator**	**Denominator**	**RTPF**
2019	Comoros	0.3155	0.0002	1333.11
2019	Yemen	0.3333	0.0060	55.27
2019	Lesotho	0.1212	0.0025	48.08
2019	Ethiopia	0.4361	0.0150	28.99
2019	Paraguay	0.7773	0.0343	22.66
2019	Rwanda	0.6097	0.0358	17.02
2019	United Rep. of Tanzania	0.7464	0.0485	15.39
2019	Montserrat	0.5243	0.0405	12.96
2019	Myanmar	0.7510	0.0757	9.91
2019	Tajikistan	0.1356	0.0145	9.35

Source: Authors' calculations based on UNCTAD (2023a)

From the perspective of linking trade in processed food to (potential) national consumption of processed food, the RTPF indicator supports the premise that higher values of RTPF indicate that more processed food is being imported than exported, hence feeding processed food to national consumption. Again, such a view can be contested and requires robust and detailed further analysis of trade, but also consumption patterns and subject-matter experts to support relevant linkages and reliable interpretation. Nevertheless, along this rationale, value of RTPF above 1 would therefore indicate an increased national reliance on processed food. More than half of the analysed economies have RTPF values above 1.

On the other hand, looking at the lowest-RTPF economies (Table 8), a distinctive pattern can be observed, namely that the value of denominator is again the main driving force behind the values of the indicator. In the case of Qatar, this would imply that almost all their food exports are of processed

[8] For more analysis of separately imports and exports, also in relative terms (numerator and denominator of RTPF), see section 4.1.

food, whereas the reverse holds for their imports (value of the numerator), resulting in a very low value of RTPF. Complementary information from other indicators or economy-level analysis as done in section 4.1, along with other subject-matter research will provide sufficient information to make final and robust interpretation of these results and especially in light of their linkages to healthy diet and nutritional value of food consumption.

Table 8. In bottom 10 economies by value of RTPF, the high values are mostly due to high exports of processed food

Year	Reporter	Numerator	Denominator	RTPF
2019	Qatar	0.1308	0.9951	0.13
2019	Nigeria	0.1503	0.8276	0.18
2019	Nepal	0.1624	0.7631	0.21
2019	Saudi Arabia	0.2455	0.6030	0.41
2019	Tunisia	0.2091	0.4882	0.43
2019	Seychelles	0.3653	0.7943	0.46
2019	Indonesia	0.3145	0.6635	0.47
2019	Aruba	0.3112	0.6488	0.48
2019	Zimbabwe	0.2371	0.4865	0.49
2019	Malaysia	0.3834	0.7667	0.50

Source: Authors’ calculations based on UNCTAD (2023a)

Full result of RTPF calculation for 2019 is presented in Annex 3.

Based on these results, it does appear that the value of the denominator is setting also driving the distinction of the group of economies with similar pattern in the values of the indicator. Examples of further analysis, concretely using cluster analysis with k-means is presented in Annex 4 for illustrative purposes only.

4.2.3 The processed food trade similarity index (PSI)

The processed food similarity index (PSI) is used to measure a certain degree of similarity (also certain degree of specialization) in the production of processed food. This indicator is used for processed food or any other disaggregated processed food categories. It is used to measure the similarity between an economy's export structure and the global average export structure, taking into account both the structure and composition of an economy's exports.

With the objective of measuring a certain degree of similarity/specialization on trade of processed food in an economy, the indicator monitors trade flows of food items by level of processing, further, to be paired with other indicators. The resulting PSI score for the specific product group (processed food category) would provide an indication of the degree of specialization of a country in that particular product group (processed food category), as well as how similar or different its export structure is compared to the global average for that product group (processed food category).

Similarly to NTFB and RTPF, the PSI also uses classification of food processing categories, based on food categories and/or 6-digit HS (see sections 2.3 and 3.2).

The PSI is calculated according to the following formula:

$$PSI_{ji} = \left|S_{ji} - W_i\right| /2$$

Where:

PSI_{ji}	… the index of trade relative specialization/similarity of economy *j* for product group (processed) food *i* in a specific period
i	… product / goods (processed food for example)
j	… economy (country or country group) except World
S_{ji}	… the share of the specific product group *i* in a economy’s *j* total exports/imports
W_i	… the share of the specific product group *i* in world total exports/imports

The PSI is calculated by summing up the absolute differences between a country's export shares and the corresponding global export shares for each/specific product group (processed food or other products), and then dividing this sum by two.

Economy’s imports (exports) of food items (by categories) are obtained from the international trade flows and assigned to different food processing categories. Trade in processed food, as defined above, is compared to respective total trade in food categories, then comparing imports to exports of processed food.

The PSI ranges from 0 to 0.5 where a value of 0 indicates full similarity between a country's export basket and the global average, while a value of 0.5 indicates no similarity. The PSI score highlights the relative importance of international trade of a specific product for a country. In this section, both exports and imports similarities are analysed.

Exports similarities

Table 9 highlights distinctive trade similarity patterns among top regions in specific food product categories. In Middle Africa, there is moderate similarity in Minimal Processing: Cocoa and cocoa preparations (0.27). LDCs: Islands and Haiti show moderate specialization in Ingredients: Fruit (0.24). SIDS: Pacific demonstrate lower similarity in Composite Edible preparations (0.20). Western Africa follows with higher specialization in Minimal Processing Cocoa and cocoa preparations (0.19). SIDS: Atlantic and Indian Ocean and Eastern Africa showcase higher similarity in Composite Fish and Ingredients Non-alcoholic, respectively, with PSI values of 0.16 and 0.13. Developed economies in Oceania and Oceania demonstrate specialization in Raw Meat, with PSI values of 0.12 and 0.11, respectively. Additionally, developing economies in Oceania specialize in Minimal Processing Vegetable fats, as indicated by a PSI of 0.10. Central Asia presents higher similarity in Raw Cereals, with a PSI of 0.1025.

Table 9. Top values of PSI, 2019

Economy	Food Product Group	PSI
Middle Africa	Minimal Processing Cocoa and cocoa preparations	0,27
LDCs: Islands and Haiti	Ingredients Fruit	0,24
SIDS: Pacific	Composite Edible preparations	0,20
LDCs: Islands and Haiti	Ingredients Non-alcoholic	0,20
Western Africa	Minimal Processing Cocoa and cocoa preparations	0,19
SIDS: Atlantic and Indian Ocean	Composite Fish	0,16
SIDS	Composite Edible preparations	0,15
Eastern Africa	Ingredients Non-alcoholic	0,13
Developed economies: Oceania	Raw Meat	0,12
Oceania	Raw Meat	0,11

Source: Authors' calculations based on UNCTAD (2023a)

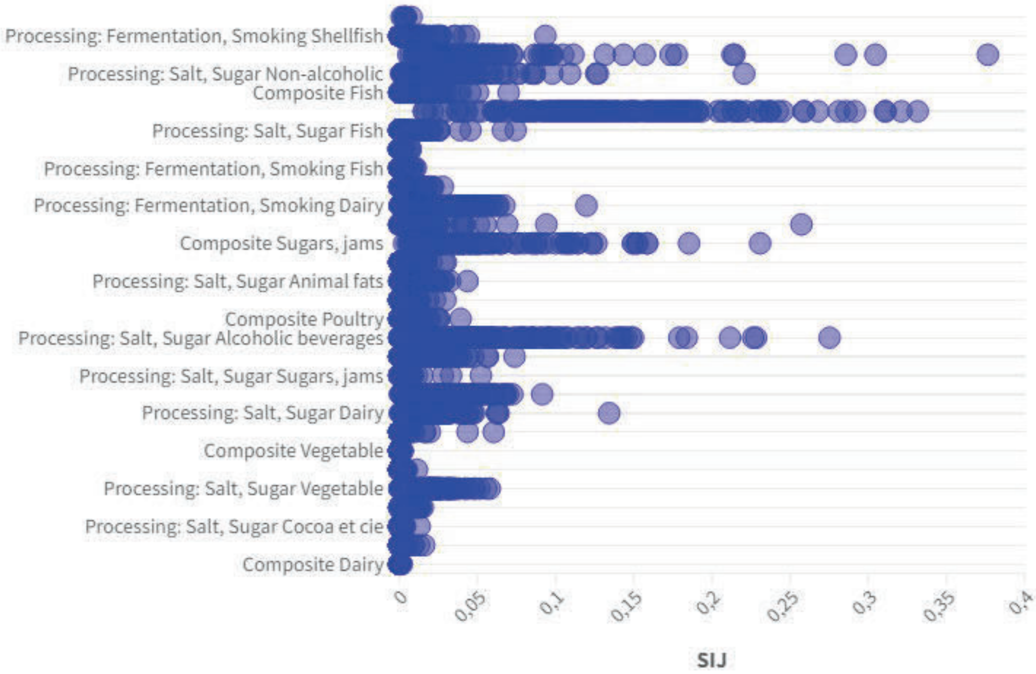
Table 10. Top and bottom values of PSI for categories C, D, and E, 2019

Economy	Food Product Group	PSI
Top values of PSI		
Qatar	Processing: Salt, Sugar Meat	0,48
Aruba	Processing: Salt, Sugar Alcoholic beverages	0,43
Bermuda	Processing: Salt, Sugar Alcoholic beverages	0,41
Bahamas	Processing: Fermentation, Smoking Shellfish	0,40
Eswatini	Composite Sugars, jams	0,39
Cabo Verde	Composite Fish	0,38
Seychelles	Composite Fish	0,38
Andorra	Processing: Salt, Sugar Alcoholic beverages	0,34
Nepal	Composite Vegetable fats	0,29
Antigua and Barbuda	Processing: Salt, Sugar Alcoholic beverages	0,29
Bottom values PSI		
France	Processing: Salt, Sugar Alcoholic beverages	0,10
United States of America	Composite Edible preparations	0,00
Germany	Composite Edible preparations	0,04
Indonesia	Composite Vegetable fats	0,19
Netherlands (Kingdom of the)	Composite Edible preparations	0,01
United Kingdom	Processing: Salt, Sugar Alcoholic beverages	0,13
Italy	Composite Edible preparations	0,05
Italy	Processing: Salt, Sugar Alcoholic beverages	0,07
Malaysia	Composite Vegetable fats	0,21
France	Composite Edible preparations	0,01

Source: Authors' calculations based on UNCTAD (2023a)

Table 10 also reveals distinctive patterns of trade relative similarity among various economies in specific processed food product categories (C, D, E). The PSI scores highlight notable trade patterns among countries in specific food product groups. Qatar, with a PSI of 0.48, demonstrates a substantial dissimilarity in its exports of processed foods, particularly in salt, sugar, and meat. Aruba (PSI: 0.43) and Bermuda (PSI: 0.41) also show significant divergence, emphasizing the importance of salt, sugar, and alcoholic beverages in their exports. On the contrary, the United States of America stands out with a PSI of 0.00, indicating full similarity in its trade of composite edible preparations with the global average. Germany (PSI: 0.04) and the Netherlands (PSI: 0.01) show slight dissimilarity in their export baskets of composite edible preparations.

Figure 23. Values of PSI by product categories within processing categories C, D, and E, 2019 imports



Note: While this figure is best viewed as an interactive chart, and will be available at UNCTAD (2023a), it is showcased here for illustrative purposes.

Source: Authors' calculations based on UNCTAD (2023a)

As illustrated in Figure 23, in cases where PSI scores are extremely low, as observed in Greece (almost 0) and the United States of America (almost 0), it indicates an almost negligible divergence, signifying a high degree of similarity with global import trends. This is notable in the context of composite dairy for Greece and processed foods (salt, sugar, shellfish) for the United States of America, respectively. In contrast, economies like Cambodia exhibit significantly higher PSI scores, highlighting substantial dissimilarity in their imports, particularly in processed foods such as salt, sugar, and non-alcoholic items, compared to the world average. Similarly, Belize, Gambia, Paraguay, Bolivia, Nicaragua, Lao People's Democratic Republic, Myanmar, Pakistan, and Tanzania also demonstrate notable dissimilarity in their imports, emphasizing distinctive import dynamics in specific food product groups (C, D, E) relative to global trends. These findings underscore the diverse import patterns and preferences of these economies in comparison to the world average. While a few economies show dissimilarities, it's noteworthy that a substantial majority of economies exhibit near-perfect similarity in their imports (shown with many marks for each economy (bubbles), representing economies, stacked to the value of PSI 0, i.e., close to the y-axis where values of x-axis is zero).

4.2.4 The Revealed Comparative Advantage (RCA)

Revealed comparative advantage (RCA) is an indicator observing an economy's comparative advantage in producing and exporting certain commodity. It is based on Ricardian trade theory, which posits that patterns of trade among economies are governed by their relative differences in productivity. Although such productivity differences are difficult to observe, an RCA metric can be calculated using trade data to "reveal" such differences. While the metric can be used to provide a general indication and first approximation of an economy's competitive export strengths, it should be noted that applied national measures which affect competitiveness such as tariffs, non-tariff measures, subsidies and others are not taken into account in the RCA metric. This section builds on the work presented at UNCTAD (2023g).

Economy A is said to have a revealed comparative advantage in a given product *i* when its ratio of exports of product *i* to its total exports of all goods (products) exceeds the same ratio for the world as a whole. RCA is calculated based on the following formula:

$$RCA_{Ai} = \frac{\frac{X_{Ai}}{\sum_{j \in P} X_{Aj}}}{\frac{X_{wi}}{\sum_{j \in P} X_{wj}}}$$

Where

P is the set of all products (with $i \in P$),

X_{Ai} is the economy *A*'s exports of product *i*,

X_{wi} is the worlds's exports of product *i*,

$\sum_{j \in P} X_{Aj}$ is the economy *A*'s total exports (of all products *j* in *P*), and

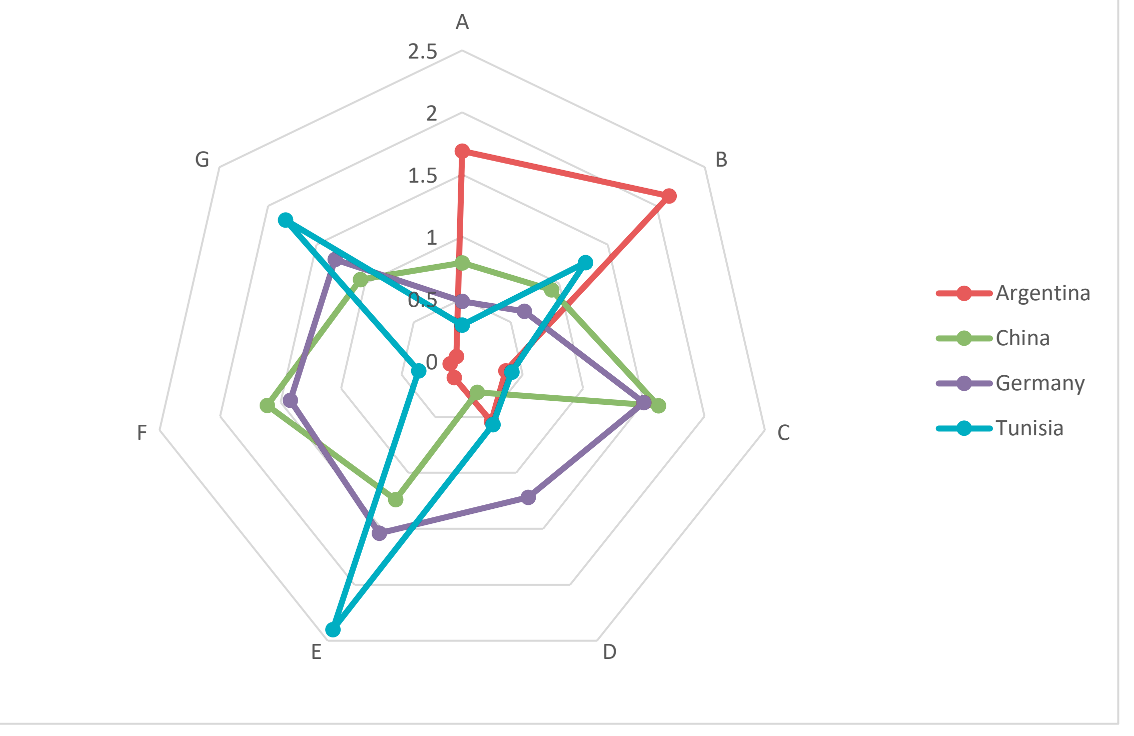
$\sum_{j \in P} X_{wj}$ is the world's total exports (of all products *j* in *P*).

When an economy has a revealed comparative advantage for a given product (with values of RCA >1), it is inferred to be a competitive producer and exporter of that product relative to an economy producing and exporting that good at or below the world average. An economy with a revealed comparative advantage in product *i* is considered to have an export strength in that product. The higher the value of an economy's RCA for product *i*, the higher its export strength in product *i*. (UNCTAD, 2023g)

Trade matrix provides calculated values of RCA indicator for each of the individual economy (yet not groups of economies) and for each of the processing food categories, hence observations in time and place can be conducted. UNCTAD (2023g) showcases the use of so-called RCA radar plots, designed to present a full picture of any economy's revealed comparative advantage in producing and exporting a range of products in a given year. That work builds on all products, stretching beyond food products, but the idea can be adopted also for the studying of food products by level of processing.

Exploring the RCA values for processed food categories for selected economies (Figure 24 for 2022) reveals that economies, expectedly, differ to the extent of which processed food category provides a comparative advantage to its exports. For example, Argentina is revealing a strong comparative advantage in categories B and A; Tunisia in category E; China in categories C and F; and Germany in categories C, E, F, and G.

Figure 24. RCA values for selected economies, 2022



Source: Authors' calculations based on UNCTAD (2023a)

Exploring further for 2022 the distribution of values of RCA for economies by processing food categories, one can observe that for some categories, namely A, C, and E, the highest values of RCA are relatively limited, reaching values less than 4; and these values are also more evenly distributed as measured by the variance across economies of about 0.5. On the other hand, categories B, D, and especially F and G, exhibit much higher variability (variance surpassing the value of 9 in category G – see Table 11) and significantly higher maximum values of RCA: starting at about 10 and reaching more than 30 for G. Table 12 reveals the top and bottom values of RCA, by processing food categories, listing economies in each of the A-G processing food categories. No clear or apparent immediate trend is observed in terms of which economies, e.g., developed or developing, or large or small, lead the certain category. Further, in-depth analysis, coupled with previous indicators and analytics, and food-related expertise, including health, nutrition, and well-being, are needed to provide reliable interpretation and policy information.

Table 11. Descriptive statistics of RCAs for economies in 2022 by processing food category

	A	B	C	D	E	F	G
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	2.4	8.7	3.8	10.4	3.9	17.2	31.7
Variance	0.4	2.3	0.6	4.4	0.5	7.4	9.2

Source: Authors' calculations based on UNCTAD (2023a)

Table 12. Top 5 and bottom 5 RCA values by processed food categories, 2022

A		B		C		D		E		F		G	
Economy	*RCA*	*Economy*	*RCA*	*Economy*	*RCA*	*Economy*	*RCA*	*Economy*	*RCA*	*Economy*	*RCA*	*Economy*	*RCA*
Top 5													
Mauritania	2.4	Sao Tome and Principe	8.7	Montenegro	3.8	Aruba	10	Cabo Verde	3.9	Timor-Leste	17	Botswana	32
Norway	2.3	Congo, Dem. Rep. of the	7.8	Austria	3.3	Bermuda	9.6	Mauritius	3.2	Burundi	14	Kyrgyzstan	9.8
Albania	2.2	Côte d'Ivoire	6.3	Trinidad and Tobago	2.9	Brunei Darussalam	9	Indonesia	2.9	Madagascar	13	Jordan	9.4
Paraguay	2.2	Nigeria	5.1	Serbia	2.8	Antigua and Barbuda	8.4	Nepal	2.9	Ethiopia	11	Niger	7.6
Lesotho	2.2	Bolivia (Plurinational State of)	4.9	Finland	2.7	Andorra	7.5	Malaysia	2.9	Sri Lanka	11	Israel	5
Bottom 5													
Nepal	0	China, Macao SAR	0	Ethiopia	0	Paraguay	0	Tajikistan	0	Mauritania	0	Guyana	0
Bahamas	0	Iceland	0	Congo, Dem. Rep. of the	0	Bolivia (Plurinational State of)	0	French Polynesia	0	Namibia	0	Jamaica	0
China, Macao SAR	0	Andorra	0	Malawi	0	Lesotho	0	Grenada	0	Norway	0	Mauritania	0
Sao Tome and Principe	0	Bahamas	0	Timor-Leste	0	Malawi	0	Burundi	0	Bahamas	0	Paraguay	0
Timor-Leste	0	Mauritania	0	Lesotho	0	Tajikistan	0	Timor-Leste	0	Maldives	0	Togo	0

Source: Authors' calculations based on UNCTAD (2023a)

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FURTHER WORK ON TRADE IN PROCESSED FOOD

This technical paper sets the conceptual elements of the work behind the analysis of trade in processed food, by describing the process of defining processed food and setting up a comprehensive approach to classifying processing food categories that can provide inputs into analysis and debate on healthy and nutritious food as well as well-being, yet avoids directly establishing a valuation of whether specific processing category is deemed good or bad, thus supporting the approach of inclusive and diverse diet. Next, it offers a design of the processing food categories and their linkage to trade statistics by providing direct correspondence tables of six-digit HS codes to processing food categories, whereby linking the vast ocean of international trade data to the analysis of food processing. Despite some limitations, this attempt opens up the possibility of new analytical tool to be applied to research and study on trade in processed food. When coupled with additional information and expertise, namely on domestic production, consumption, health and well-being, a more comprehensive picture of the status of world food markets and consumption can be established.

A unique element of this work stretches beyond the design of processed food categories linked to the HS. It builds the trade matrix of processed food, offering viewing and analysis by processing and food categories; by reporter and partner of both individual economies and their groups; by imports and exports, including trade balance; in a longer time series from 1995 to 2022; and by offering various representation or indicator selection, namely the value of trade, shares of trade of specific food processing categories, their growth rates, or the indicator of comparative advantage, the RCA. The trade matrix remains unbalanced at this point and inherits several limitations of the underlying data source, hence caution is needed when used, especially at a more aggregated level. However, users are guided through the trade matrix and potential analytical approaches to take in analysing this unique data set.

The analysis of trade in processed food to inform research and policy requires complementary inputs and guidance from subject-matter experts and other relevant data sources and research to provide a comprehensive and robust evidence base for further use. To that end, this technical paper presents the processes and describes the output, the trade matrix of processed food, while its analytical part is to be understood as preliminary and indicative of what types of analysis could be performed, although not limiting them to the ones listed in the paper. Several modern approaches, including data explorations, filtering, interactivity and dynamic maps, charts, and infographics will be developed and updated on the dedicated website at UNCTAD (2023a). This site builds on the work by UNCTAD and WHO experts and represents their results for further and wider use by the general public, experts in the field of food and nutrition, as well as researchers and policy makers in economics, trade, development and other fields.

Interest for the use of the trade matrix and its analysis extends to international and inter-agency collaboration and work, such as the interest in researching the trade flow and population access to relative proportions of foods by processing status and associations with dietary practice and economic development; addressing expressed interest by member State representative in examining trends in food trade; feeding the other trade- and health-related areas, such as the World Trade Organization work on illicit trade in food and food fraud; SIDS and economic development relationship to unhealthier diets and increased in proportion of highly processed foods in overall diet; and many more.

While further analytical work will build directly on the trade matrix, exploring further data patterns, providing additional and alternative approaches, metrics, visualizations, it offers unique, open and inclusive platform and opportunities for multistakeholder engagement in supporting related research, debates, and policy formulation.

Important contribution to further related work is also the potential informing of future revisions of the HS, by guiding further disaggregation of established six-digit codes to fit the user needs, e.g., to separate artificial and natural sugars, or foods based on these. Currently, the HS classification amalgamates these processing operations, thereby restricting further disaggregation and in-depth analysis.

Dedicated website at UNCTAD (2023a) will provide regular updates of new deliberations, developments in related concepts, analytics, data, and presentation of results.

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ANNEXES

Annex 1: HS 2022 by level of processing and food category

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
010221	G4	030791	A7	110820	B3
010229	G4	030792	A7	110900	B3
010231	G4	030799	C7	120110	A2
010239	G4	030811	A7	120190	A2
010290	G4	030812	A7	120230	A10
010310	G4	030819	C7	120241	A10
010391	G4	030821	A7	120242	A10
010392	G4	030822	A7	120300	B10
010410	G4	030829	C7	120400	A11
010420	G4	030830	C7	120510	A11
010511	G5	030890	C7	120590	A11
010512	G5	040110	A8	120600	A11
010513	G5	040120	A8	120710	A11
010514	G5	040140	A8	120721	A11
010515	G5	040150	A8	120729	A11
010594	G5	040210	C8	120730	A11
010599	G5	040221	B8	120740	A11
010641	G4	040229	C8	120750	A11
010649	G4	040291	B8	120760	A11
020110	A4	040299	C8	120770	A11
020120	A4	040320	D8	120791	A11
020130	A4	040390	D8	120799	A11
020210	A4	040410	C8	120810	B11
020220	A4	040490	C8	120890	B11
020230	A4	040510	C12	120910	G1
020311	A4	040520	C12	120921	G1
020312	A4	040590	C12	120922	G1
020319	A4	040610	C8	120923	G1
020321	A4	040620	D8	120924	G1
020322	A4	040630	D8	120925	G1
020329	A4	040640	D8	120929	G1
020410	A4	040690	D8	120930	G1
020421	A4	040711	G9	120991	G1
020422	A4	040719	G9	120999	G1
020423	A4	040721	A9	121010	F2
020430	A4	040729	A9	121020	F2
020441	A4	040790	B9	121221	B1

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
020442	A4	040811	C9	121291	B1
020443	A4	040819	C9	121292	B2
020450	A4	040891	C9	121293	B16
020500	A4	040899	C9	121294	B14
020610	A4	040900	A16	121299	B1
020621	A4	041010	D4	130120	F1
020622	A4	041090	D18	130190	F1
020629	A4	050400	C4	130212	F1
020630	A4	060220	G1	130213	F1
020641	A4	070110	G1	130219	F1
020649	A4	070190	A1	130220	F2
020680	A4	070200	A1	130231	F1
020690	A4	070310	A1	130232	F2
020711	A5	070320	A1	130239	F1
020712	A5	070390	A1	150110	E12
020714	A5	070410	A1	150120	E12
020724	A5	070420	A1	150190	E12
020725	A5	070490	A1	150210	E12
020726	A5	070511	A1	150290	E12
020727	A5	070519	A1	150300	E12
020741	A5	070521	A1	150410	E12
020742	A5	070529	A1	150420	E12
020743	A5	070610	A1	150430	E12
020744	A5	070690	A1	150600	E12
020745	A5	070700	A1	150710	B13
020751	A5	070810	A1	150790	E13
020752	A5	070820	A1	150810	B13
020753	A5	070890	A1	150890	E13
020754	A5	070920	A1	150920	E13
020755	A5	070930	A1	150930	E13
020760	A5	070940	A1	150940	E13
020810	A4	070951	A1	150990	E13
020830	A4	070952	A1	151010	E13
020840	A4	070953	A1	151090	E13
020850	A4	070954	A1	151110	B13
020860	A4	070955	A1	151190	E13
020890	A4	070956	A1	151211	B13
020910	C12	070959	A1	151219	E13
020990	C12	070960	A1	151221	B13
021011	C4	070970	A1	151229	E13
021012	C4	070991	A1	151311	B13
021019	C4	070992	A1	151319	E13
021020	C4	070993	A1	151321	B13
021091	C4	070999	A1	151329	E13

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
021092	C4	071010	B1	151411	B13
021093	C4	071021	B1	151419	E13
021099	C4	071022	B1	151491	B13
030191	G6	071029	B1	151499	E13
030192	G6	071030	B1	151511	B13
030193	G6	071040	B1	151519	E13
030194	G6	071080	B1	151521	B13
030195	G6	071090	B1	151529	E13
030199	G6	071120	E8	151530	E13
030211	A6	071140	E1	151550	E13
030213	A6	071151	E1	151560	E12
030214	A6	071159	E1	151590	E13
030219	A6	071190	E1	151610	E12
030221	A6	071220	B1	151620	E13
030222	A6	071231	B1	151630	E13
030223	A6	071232	B1	151710	E13
030224	A6	071233	B1	151790	E18
030229	A6	071234	B1	160100	E4
030231	A6	071239	B1	160210	E4
030232	A6	071290	B1	160220	E4
030233	A6	071310	B1	160231	E5
030234	A6	071320	B1	160232	E5
030235	A6	071331	B1	160239	E5
030236	A6	071332	B1	160241	E4
030239	A6	071333	B1	160242	E4
030241	A6	071334	B1	160249	E4
030242	A6	071335	B1	160250	E4
030243	A6	071339	B1	160290	E4
030244	A6	071340	B1	160300	E18
030245	A6	071350	B1	160411	E6
030246	A6	071360	B1	160412	E6
030247	A6	071390	B1	160413	E6
030249	A6	071410	B1	160414	E6
030251	A6	071420	B1	160415	E6
030252	A6	071430	B1	160416	E6
030253	A6	071440	B1	160417	E6
030254	A6	071450	B1	160418	E6
030255	A6	071490	B1	160419	E6
030256	A6	080111	B10	160420	E6
030259	A6	080112	A10	160431	E6
030271	A6	080119	B10	160432	E6
030272	A6	080121	B10	160510	E7
030273	A6	080122	B10	160521	E7
030281	A6	080131	B10	160529	E7

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
030282	A6	080132	B10	160530	E7
030283	A6	080211	B10	160540	E7
030284	A6	080212	B10	160551	E7
030285	A6	080221	B10	160552	E7
030289	A6	080222	B10	160553	E7
030291	A6	080231	B10	160554	E7
030292	A6	080232	B10	160555	E7
030299	A6	080241	B10	160556	E7
030311	A6	080242	B10	160557	E7
030312	A6	080251	B10	160558	E7
030313	A6	080252	B10	160559	E7
030314	A6	080261	B10	160561	E7
030319	A6	080262	B10	160562	E7
030345	A6	080270	B10	160563	E7
030346	A6	080280	B10	160569	E7
030349	A6	080291	B10	170112	E16
030351	A6	080292	B10	170113	E16
030353	A6	080299	B10	170114	E16
030354	A6	080310	B2	170191	E16
030355	A6	080390	B2	170199	E16
030356	A6	080410	B2	170211	E16
030357	A6	080420	B2	170219	E16
030359	A6	080430	B2	170220	E16
030363	A6	080440	B2	170230	E16
030364	A6	080450	B2	170240	E16
030365	A6	080510	B2	170250	E16
030366	A6	080521	B2	170260	E16
030367	A6	080522	B2	170290	E16
030368	A6	080529	B2	170310	E16
030369	A6	080540	B2	170390	E16
030381	A6	080550	B2	170410	E16
030382	A6	080590	B2	170490	E16
030383	A6	080610	A2	180100	B17
030384	A6	080620	B2	180310	E17
030389	A6	080711	A2	180320	E17
030391	A6	080719	A2	180400	E17
030392	A6	080720	A2	180500	E17
030399	A6	080810	A2	180610	C17
030431	A6	080830	A2	180620	E17
030432	A6	080840	A2	180631	E17
030433	A6	080910	A2	180632	E17
030439	A6	080921	A2	180690	E17
030441	A6	080929	A2	190110	E18
030442	A6	080930	A2	190120	E18

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
030443	A6	080940	A2	190190	E18
030444	A6	081010	A2	190211	E18
030445	A6	081020	A2	190219	E18
030446	A6	081030	A2	190220	E18
030447	A6	081040	A2	190230	E18
030448	A6	081050	A2	190240	E18
030449	A6	081060	A2	190300	E18
030451	A6	081070	A2	190410	E18
030452	A6	081090	A2	190420	E18
030453	A6	081110	C2	190430	E18
030454	A6	081120	C2	190490	E18
030455	A6	081190	C2	190510	E18
030456	A6	081210	F2	190520	E18
030457	A6	081290	F2	190531	E18
030459	A6	081310	B2	190532	E18
030461	A6	081320	B2	190540	E18
030462	A6	081330	B2	190590	E18
030463	A6	081340	B2	200110	C1
030469	A6	081350	B10	200190	C1
030471	A6	081400	F2	200210	C1
030472	A6	090111	F14	200290	C1
030473	A6	090112	F14	200310	C1
030474	A6	090121	F14	200390	C1
030475	A6	090122	F14	200410	C1
030479	A6	090190	F14	200490	C1
030481	A6	090210	F14	200510	C1
030482	A6	090220	F14	200520	C1
030483	A6	090230	F14	200540	C1
030484	A6	090240	F14	200551	C1
030485	A6	090300	F14	200559	C1
030486	A6	090411	F2	200560	C1
030487	A6	090412	F2	200570	C1
030488	A6	090421	F2	200580	C1
030489	A6	090422	F2	200591	C1
030491	A6	090510	F2	200599	C1
030492	A6	090520	F2	200600	C1
030493	A6	090611	F2	200710	C16
030494	A6	090619	F2	200791	C16
030495	A6	090620	F2	200799	C16
030496	A6	090710	F2	200811	C10
030497	A6	090720	F2	200819	C10
030499	A6	090811	F2	200820	C2
030910	B6	090812	F2	200830	C2
030520	C6	090821	F2	200840	C2

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
030531	C6	090822	F2	200850	C2
030532	C6	090831	F2	200860	C2
030539	C6	090832	F2	200870	C2
030541	D6	090921	F2	200880	C2
030542	D6	090922	F2	200891	C2
030543	D6	090931	F2	200893	C2
030544	D6	090932	F2	200897	C10
030549	D6	090961	F2	200899	C10
030551	C6	090962	F2	200911	C14
030552	C6	091011	F2	200912	C14
030553	C6	091012	F2	200919	C14
030554	C6	091020	F2	200921	C14
030559	C6	091030	F2	200929	C14
030561	C6	091091	F2	200931	C14
030562	C6	091099	F2	200939	C14
030563	C6	100111	A3	200941	C14
030564	C6	100119	A3	200949	C14
030569	C6	100191	A3	200950	C14
030571	C6	100199	A3	200961	C14
030572	C6	100210	A3	200969	C14
030579	C6	100290	A3	200971	C14
030611	D7	100310	A3	200979	C14
030612	D7	100390	A3	200981	C14
030614	D7	100410	A3	200989	C14
030615	D7	100490	A3	200990	C14
030616	D7	100510	A3	210111	F18
030617	D7	100590	A3	210112	F18
030619	D7	100610	A3	210120	F18
030631	A7	100620	A3	210130	F18
030632	A7	100630	A3	210210	F18
030633	A7	100640	A3	210220	F18
030634	A7	100710	A3	210230	F18
030635	A7	100790	A3	210310	E18
030636	A7	100810	A3	210320	E18
030639	A7	100821	A3	210330	E18
030691	D7	100829	A3	210390	E18
030692	D7	100830	A3	210410	E18
030693	D7	100840	A3	210420	E18
030694	D7	100850	A3	210500	E18
030695	D7	100860	A3	210610	E18
030699	D7	100890	A3	210690	E18
030711	A7	110100	B3	220110	A14
030712	A7	110220	B3	220190	A14
030719	C7	110290	B3	220210	C14

Commodity code	Processed and Food category	Commodity code	Processed and Food category	Commodity code	Processed and Food category
030721	A7	110311	B3	220291	D14
030722	A7	110313	B3	220299	C14
030729	C7	110319	B3	220300	D15
030731	A7	110320	B3	220410	D15
030732	A7	110412	B3	220421	D15
030739	C7	110419	B3	220422	D15
030742	A7	110422	B3	220429	D15
030743	A7	110423	B3	220430	D15
030749	C7	110429	B3	220510	D15
030751	A7	110430	B3	220590	D15
030752	A7	110510	B3	220600	D15
030759	C7	110520	B3	220710	F15
030760	C7	110610	B3	220720	F15
030771	A7	110620	B3	220820	D15
030772	A7	110630	B3	220830	D15
030779	C7	110710	B3	220840	D15
030781	A7	110720	B3	220850	D15
030782	A7	110811	B3	220860	D15
030783	A7	110812	B3	220870	D15
030784	A7	110813	B3	220890	D15
030787	A7	110814	B3	220900	E18
030788	C7	110819	B3	250100	E18

Annex 2: Imports of processed food categories in 2020

Processed food category	Processed food category label	Value
C18	Processing: Salt, Sugar Edible preparations	2
D16	Processing: Salt, Sugar Sugars, jams	19
E08	Composite Dairy	141
C17	Processing: Salt, Sugar Cocoa and cocoa preparations	435
E01	Composite Vegetable	495
D14	Processing: Fermentation, Smoking Non-alcoholic	823
D18	Processing: Fermentation, Smoking Edible preparations	941
C09	Processing: Salt, Sugar Egg	967
C07	Processing: Salt, Sugar Shellfish	1278
D06	Processing: Fermentation, Smoking Fish	2420
C16	Processing: Salt, Sugar Sugars, jams	3047
C06	Processing: Salt, Sugar Fish	3433
E12	Composite Animal fats	5294
C10	Processing: Salt, Sugar Nuts	6564
C04	Processing: Salt, Sugar Meat	7960
E05	Composite Poultry	8324
E07	Composite Shellfish	8805
C12	Processing: Salt, Sugar Animal fats	9344
E04	Composite Meat	12584
C02	Processing: Salt, Sugar Fruit	15292
E06	Composite Fish	17241
C08	Processing: Salt, Sugar Dairy	21015
D07	Processing: Fermentation, Smoking Shellfish	22411
C01	Processing: Salt, Sugar Vegetable	27215
D08	Processing: Fermentation, Smoking Dairy	30137
C14	Processing: Salt, Sugar Non-alcoholic	33686
E17	Composite Cocoa and cocoa preparations	39171
E16	Composite Sugars, jams	40647

Processed food category	Processed food category label	Value
E13	Composite Vegetable fats	47754
D15	Processing: Salt, Sugar Alcoholic beverages	82164
E18	Composite Edible preparations	157295

Annex 3: Values of Relative reliance of trade on processed food (RTPF) indicator for 2019

Reporter	Numerator	Denominator	RTPF
Afghanistan	0.39309	0.057009	6.9
Albania	0.530322	0.38268	1.39
Angola	0.438805	0.547821	0.8
Antigua and Barbuda	0.476882	0.911754	0.52
Argentina	0.233485	0.153038	1.53
Armenia	0.486061	0.736599	0.66
Aruba	0.311164	0.648788	0.48
Australia	0.713737	0.266254	2.68
Austria	0.546048	0.703685	0.78
Azerbaijan	0.419533	0.160555	2.61
Bahrain	0.45796	0.882083	0.52
Barbados	0.653681	0.900268	0.73
Belarus	0.396216	0.648987	0.61
Belgium	0.512724	0.631669	0.81
Belize	0.756576	0.696481	1.09
Benin	0.225989	0.204394	1.11
Bermuda	0.62504	0.946019	0.66
Bolivia (Plurinational State of)	0.581136	0.160125	3.63
Bosnia Herzegovina	0.542556	0.621636	0.87
Botswana	0.644781	0.248384	2.6
Brazil	0.314422	0.155597	2.02
Brunei Darussalam	0.490717	0.40312	1.22
Bulgaria	0.492626	0.320823	1.54
Burkina Faso	0.342686	0.134649	2.55
Burundi	0.441238	0.058924	7.49
Cabo Verde	0.481774	0.796757	0.6
Cambodia	0.760853	0.16025	4.75
Canada	0.526727	0.373578	1.41
Chile	0.452392	0.241901	1.87
China	0.277566	0.437214	0.63
China, Hong Kong SAR	0.33715	0.353741	0.95
China, Macao SAR	0.62533	0.931784	0.67
Colombia	0.310344	0.207953	1.49
Comoros	0.315533	2.37E-04	1333.11
Congo	0.363671	0.535518	0.68
Costa Rica	0.528509	0.325764	1.62
Croatia	0.516915	0.551556	0.94
Cyprus	0.577917	0.732161	0.79
Czechia	0.512874	0.541771	0.95
Côte d'Ivoire	0.187219	0.22744	0.82
Dem. Rep. of the Congo	0.333989	0.240285	1.39
Denmark	0.532569	0.507966	1.05

Reporter	Numerator	Denominator	RTPF
Dominican Rep.	0.476612	0.415601	1.15
Ecuador	0.382888	0.535637	0.71
Egypt	0.19255	0.285022	0.68
El Salvador	0.516773	0.803949	0.64
Estonia	0.601331	0.584477	1.03
Eswatini	0.509247	0.906603	0.56
Ethiopia	0.436117	0.015042	28.99
Fiji	0.409368	0.303803	1.35
Finland	0.603973	0.609413	0.99
France	0.512833	0.59816	0.86
French Polynesia	0.557676	0.197059	2.83
Gambia	0.267198	0.443124	0.6
Georgia	0.512563	0.543452	0.94
Germany	0.452255	0.626582	0.72
Ghana	0.387936	0.344101	1.13
Greece	0.422751	0.562492	0.75
Grenada	0.400767	0.124192	3.23
Guatemala	0.525481	0.341327	1.54
Guyana	0.650259	0.263693	2.47
Honduras	0.577928	0.22725	2.54
Hungary	0.565953	0.374101	1.51
Iceland	0.679827	0.204707	3.32
India	0.199219	0.341504	0.58
Indonesia	0.314493	0.663511	0.47
Ireland	0.630879	0.66681	0.95
Israel	0.392181	0.421091	0.93
Italy	0.380746	0.729737	0.52
Jamaica	0.59976	0.745621	0.8
Japan	0.38182	0.670442	0.57
Jordan	0.388874	0.327206	1.19
Kazakhstan	0.555128	0.109928	5.05
Kenya	0.279656	0.172975	1.62
Kuwait	0.401418	0.707714	0.57
Kyrgyzstan	0.527968	0.332371	1.59
Lao People's Dem. Rep.	0.496877	0.308379	1.61
Latvia	0.547454	0.504211	1.09
Lebanon	0.427281	0.651307	0.66
Lesotho	0.121189	0.00252	48.08
Lithuania	0.436553	0.484028	0.9
Luxembourg	0.609752	0.613165	0.99
Madagascar	0.352666	0.185695	1.9
Malawi	0.494568	0.283218	1.75
Malaysia	0.383362	0.766688	0.5
Maldives	0.455561	0.268189	1.7
Mali	0.444695	0.092006	4.83

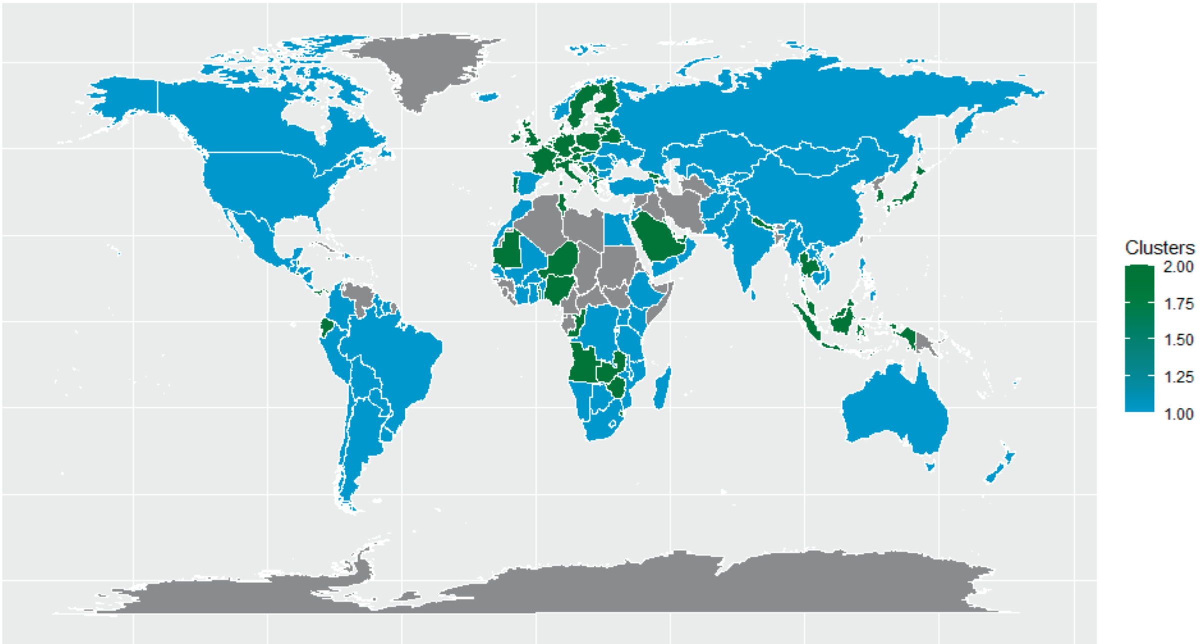
Reporter	Numerator	Denominator	RTPF
Malta	0.547226	0.320272	1.71
Mauritania	0.422911	0.704308	0.6
Mauritius	0.431042	0.740825	0.58
Mexico	0.318726	0.06764	4.71
Mongolia	0.707827	0.396463	1.79
Montenegro	0.511682	0.892253	0.57
Montserrat	0.524284	0.040454	12.96
Morocco	0.302325	0.334864	0.9
Mozambique	0.192544	0.277823	0.69
Myanmar	0.75099	0.075749	9.91
Namibia	0.6332	0.189931	3.33
Nepal	0.162395	0.763087	0.21
Netherlands	0.404228	0.51005	0.79
New Zealand	0.687691	0.408504	1.68
Nicaragua	0.632651	0.310996	2.03
Niger	0.431922	0.455166	0.95
Nigeria	0.15026	0.82765	0.18
North Macedonia	0.539291	0.635494	0.85
Norway	0.564997	0.135854	4.16
Oman	0.376388	0.424538	0.89
Other Asia, nes	0.401181	0.498351	0.81
Pakistan	0.393672	0.143178	2.75
Panama	0.739779	0.615855	1.2
Paraguay	0.777311	0.034303	22.66
Peru	0.302445	0.286277	1.06
Philippines	0.373273	0.364125	1.03
Poland	0.406715	0.55529	0.73
Portugal	0.410865	0.550818	0.75
Qatar	0.130834	0.995051	0.13
Rep. of Korea	0.363184	0.62052	0.59
Rep. of Moldova	0.252664	0.15078	1.68
Romania	0.460742	0.19823	2.32
Russian Federation	0.438564	0.248882	1.76
Rwanda	0.609659	0.035823	17.02
Saint Lucia	0.292455	0.305497	0.96
Saint Vincent and the Grenadines	0.476908	0.284125	1.68
Samoa	0.161205	0.067994	2.37
Sao Tome and Principe	0.560913	0.06585	8.52
Saudi Arabia	0.245546	0.603039	0.41
Senegal	0.381314	0.31033	1.23
Serbia	0.554506	0.47297	1.17
Seychelles	0.365268	0.794286	0.46
Singapore	0.5874	0.927845	0.63
Slovakia	0.548385	0.489799	1.12
Slovenia	0.524218	0.536325	0.98

Reporter	Numerator	Denominator	RTPF
South Africa	0.491703	0.400118	1.23
Spain	0.391453	0.374565	1.05
Sri Lanka	0.363974	0.154651	2.35
State of Palestine	0.156417	0.111268	1.41
Suriname	0.617188	0.11827	5.22
Sweden	0.462999	0.458785	1.01
Switzerland	0.553806	0.657316	0.84
Tajikistan	0.13562	0.014501	9.35
Thailand	0.309094	0.603254	0.51
Togo	0.564311	0.681735	0.83
Trinidad and Tobago	0.367439	0.139888	2.63
Tunisia	0.209093	0.488182	0.43
Turkey	0.21537	0.418514	0.51
USA	0.535098	0.299349	1.79
Uganda	0.341631	0.158421	2.16
Ukraine	0.19125	0.17359	1.1
United Arab Emirates	0.391689	0.45163	0.87
United Kingdom	0.581053	0.697363	0.83
United Rep. of Tanzania	0.746399	0.048499	15.39
Uruguay	0.501316	0.110073	4.55
Uzbekistan	0.4443	0.067368	6.6
Viet Nam	0.264003	0.288287	0.92
Yemen	0.333329	0.006031	55.27
Zambia	0.438152	0.725382	0.6
Zimbabwe	0.237063	0.486488	0.49

Annex 4: K-means clustering for indicator of Relative reliance of trade on processed food

Applying the k-means clustering to the values of numerator and denominator values of RTPF, this section highlights how certain groups of economies can be grouped/clustered to allow for potential further group-specific analysis and to guide further research for identification of reasons behind and implications of these results for the robust analysis and interpretation of results based on this indicator. Again, notion of complementing results with additional analysis and mostly subject-matter expertise is crucial in ensuring reliable interpretation. For these reasons, the showcasing of cluster analysis here is purely and merely for illustrative purposes. The analysis reveals results using k-means clustering for 2 and 3 clusters separately, providing extract of output from using R package, and providing a result using a map for each of the two results.

```
K-means clustering with 2 clusters of sizes 89, 68 economies
Cluster means:
  Numerator Denominator
1 0.4326603   0.2249426
2 0.4635554   0.6600944
Clustering vector:
  [1] 1 1 2 2 1 2 2 1 2 1 2 2 2 2 2 1 2 1 2 1 1 1 1 1 1 2 1 1 1 1 1 2 1 1 2 1 2 2 2 1 1 2 1 2 1 2 2
 [48] 2 1 1 2 2 1 1 2 2 1 2 1 1 1 1 1 1 1 2 2 1 2 2 2 1 1 1 2 1 1 2 2 1 2 2 1 1 2 1 1 1 2 2 1 1 2 1
 [95] 1 1 1 1 2 2 1 1 2 2 2 1 1 2 1 2 1 1 1 2 2 2 2 1 1 1 1 1 1 1 1 2 1 2 2 2 2 2 1 1 1 1 1 2 2 1 2
[142] 2 1 2 1 1 1 1 2 2 1 1 1 1 1 2 2
Within cluster sum of squares by cluster:
[1] 3.634115 2.424201
 (between_SS / total_SS =  54.8 %)
Available components:
[1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss" "betweenss"
[7] "size"         "iter"         "ifault"
```

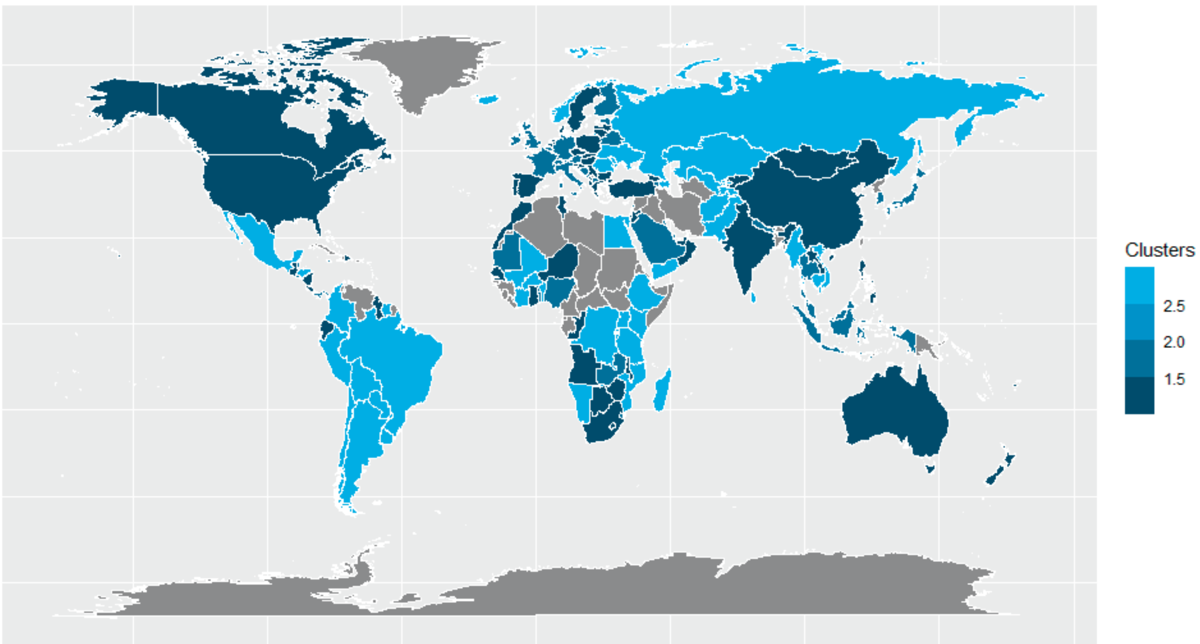


Similarly, for 3 clusters, the output/results are as follows, confirming that numerator values withing the clusters does not change much, hence indicating that the value of denominator appears to be driving the analysis using the RTPF:

K-means clustering with 3 clusters of sizes 58, 46, 53

Cluster means:

	Numerator	Denominator
1	*0.4549349*	*0.4108904*
2	*0.4754752*	*0.7308285*
3	*0.4107633*	*0.1406898*







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