Task 2.3: Market Analysis

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List of Abbreviations

CF	Citrus Fruit
CPW	Citrus Peel Waste
CPWW	Citrus Processing Water Waste
WTP	Willingness to Pay
CE	Circular Economy
MNL	Multinomial Logit
DCE	Discrete Choice Experiment
EGP	Egyptian Pound
DZD	Algerian Dinars
TND	Tunisian Dinars
EU	European Union
GHG	Green House Gases

Aim

Food waste (FW) is produced at several stages of the Food Supply Chain (FSC), the consuming stage is responsible for the largest proportion (56%) while the food processing stage produces 38% of the total waste. In contrast to food waste (FW) formed at the point of consumption, which exhibits a heterogenous composition, FW generated during processing maintains a homogenous stable composition, which promote its potential for the extraction of high-value goods, or to be valorized as functional products. The uniformity seen in this context offers a promising prospect for harnessing FW as a valuable raw material for the synthesis of high-value commodities. Citrus is one of the major fruit crops globally, grown in more than 140 countries around the world, approximately 44% of the whole citrus yield is used for industrial processing, which results in a waste percentage of 50% to 60% of the total processed citrus (Suri, S. et al. 2022). It has been estimated that the global production of citrus waste quantities to around 15-30 thousand tons. This waste has the potential to be utilized as a valuable resource for various food applications.

This report is to analyze the market for main by-products related to citrus supply chains. It will take into consideration the current socioeconomic situation of actors along the value chain, state of technology, and organizational innovation within a circular economy. More precisely, this document aims to explore the following issues:

- Types of waste generated along the citrus processing chain,
- its valorisation options for implementing a circular economy, and
- barriers against citrus waste valorisation.

To achieve this, a systematic literature review is conducted to explore how circular economy could be implemented in citrus processing chains.

Moreover, we are investigating customers' willingness to pay for innovative functional drinks prepared from “probiotics” which is an orange by-product. Probiotics have significant health benefits for human wellbeing according to the conducted review of the literature. Probiotic orange drink is prepared by adding functional probiotics ingredient that is prepared by utilization of citrus processing waste to orange juice, promoting circular economy concept.

Functional ingredients like probiotics added to beverages are less familiar to consumers, especially in South Mediterranean region, moreover the consumer willingness to pay and price sensitivity for orange juice is a key determinant for the economic viability of implementing circular citrus supply chain to produce functional products and by-products. Besides, we need to explore consumer willingness to pay for suitable production of orange juice indicated by food sustainability labels in the same research. To achieve this, consumer choice models has been built, based on data gathered from a stated preference on-line survey; to investigate consumer willingness to pay for probiotic orange drink against other types of orange juice existing in the market, as well as consumer willingness to pay for sustainability labels, taking into consideration socio-economic heterogeneity of consumers in 3 South Mediterranean countries Egypt, Algeria and Tunisia.

1 Introduction

The market analysis is conducted both qualitative and quantitative. The qualitative study is conducted by reviewing the literature and questioning the stakeholders to know more about physical nature of citrus processing waste, and its possible valorisations, at the same time identifying possible barriers to citrus by-products commercialization, industrial use, and consumption, which help strategic planners and policy makers in macro and micro environmental scanning of the market. The quantitative study is conducted to explore consumers' acceptance, knowledge, belief, and willingness-to-pay (WTP) towards sustainable production of orange juice and a new innovative type of orange drink (probiotic added) that is produced by utilizing orange processing waste as a functional by-product, taking into consideration sustainability attributes. Quantitative study is conducted by collecting numerical data using a stated preference survey "conjoint analysis", considering, customers' sustainability preferences and properties of three types of orange juice (in which one of the three types is derived from orange by-product). Using this data, we developed Multinomial logit model to obtain information on consumer preference, price sensitivity, and environmental awareness of the consumers. This model provides retailers and juice producers with a guideline for a price-strategy and how to react to consumer requirements that can be readily applied.

1.1 Report Structure

This report is elaborating on the results of two research, the first is a systematic review of literature to explore more about wastes generated along citrus processing chains, their valorisation paths, and barriers against them. The second is consumer choice model to investigate consumer WTP for sustainable production of orange juice.

This report consists of five sections. The first section presents the introduction. The second explains the methodology used. In the third section, the results obtained from both qualitative and quantitative studies are presented. The fourth section discusses the results from the analysis, and the fifth section concludes the work. Figure 1 illustrates the sections of the report.

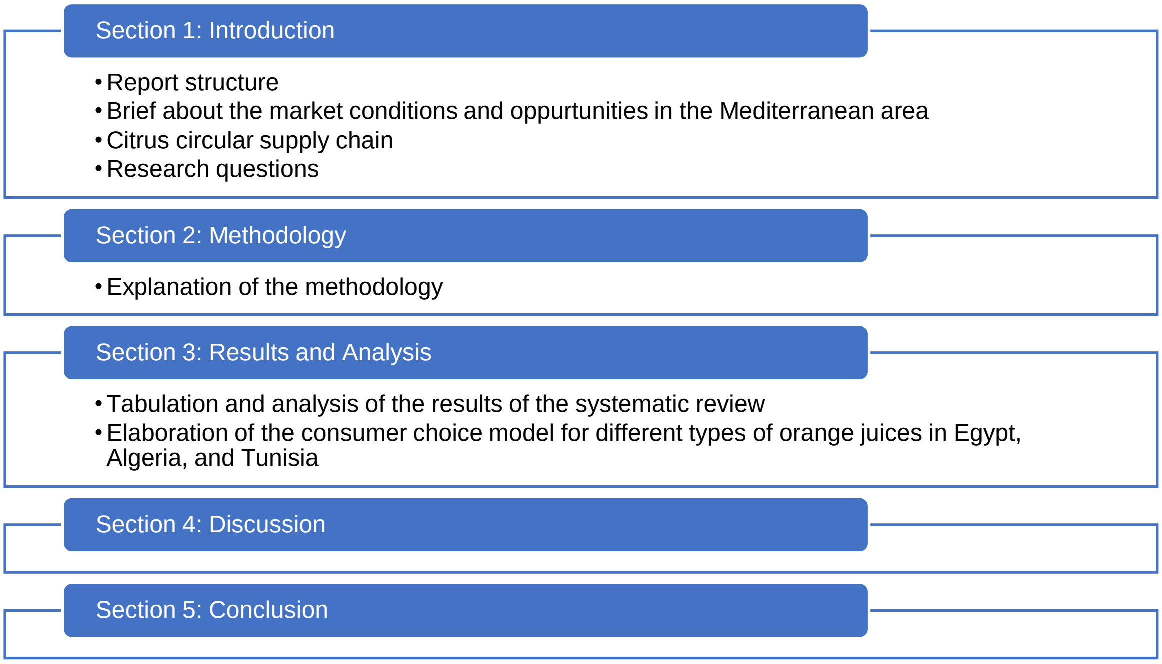

Figure 1 Illustration for report sections

1.2 Mediterranean basin Citrus Market Conditions and Opportunities

According to the Food and Agriculture Organization of the United Nations (FAO, 2020), Citrus is one of the most popular and widely grown fruit crops in the world, and oranges are around 10 % of the world's fruit production. Citrus and its products are a rich source of vitamins, minerals, and dietary fibers which are essential for overall nutritional well-being.

Citrus production in the Mediterranean basin area has considerable economic and cultural importance (Zema et al., 2018). Citrus production is distributed into four segments by species (oranges, lemons, tangerines, and grapefruit). Orange is the most produced species in the Mediterranean basin and worldwide(Gentile et al., 2020).

According to (FAOSTAT, 2020) data, the top orange producers in the region are Spain, Egypt, and Italy. Algeria is the fifth, but close to the fourth and Tunisia is the ninth. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the production of the top ten orange producers in the Mediterranean basin.

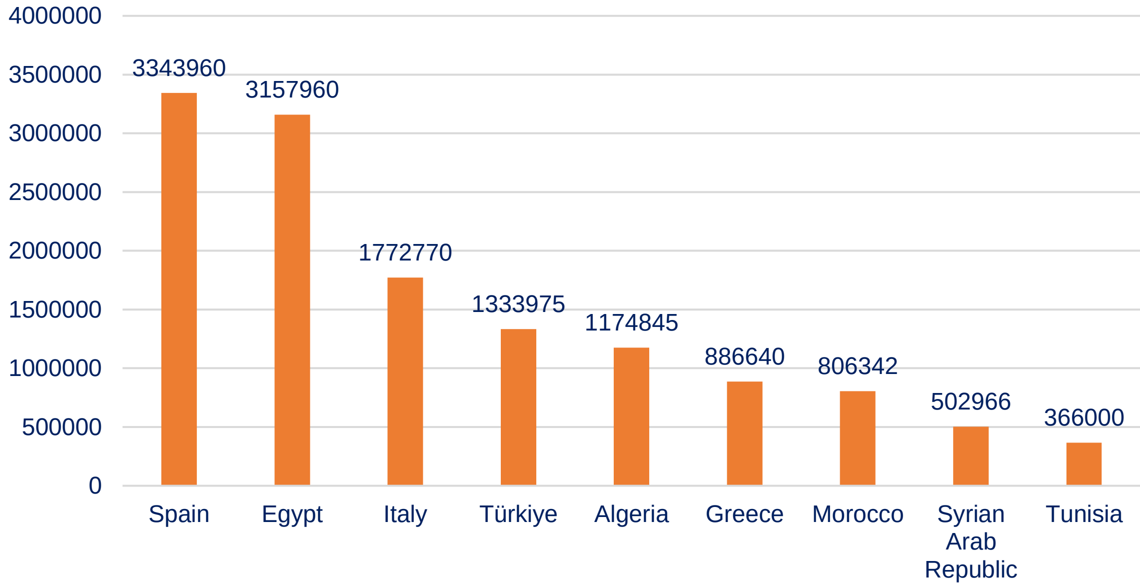

Figure 2 Production of the top ten orange producers in the Mediterranean basin

Egypt is the second producer of oranges in the Mediterranean, and the number one exporter worldwide for 3 years in succession(Ahmed Wally, 2022). However, in 2020 according to the Egyptian Central Agency for Public Mobilization and Statistics, Egypt's production of citrus superfluous the domestic consumption by 1751 thousand tons, this is after subtracting the amount exported, this surplus is considered as waste if not consumed. Adding value to the overall production would create a potential opportunity for Egypt by increasing the portions of citrus products and by-products in its portfolio of exports like orange juice, pulp, and essential oils. Moreover, there is a potential opportunity for citrus producers in the Southern Mediterranean basin located in North Africa, to add value to their exports by going industrial, especially that countries with high index values for citrus exports like Egypt, Algeria, Morocco, and Tunisia (DURU et al., 2022); this opportunity came from their geographical proximity to the demanding markets in European Union, as it offers shorter lead time and competitive price than Brazil, the main player in this industry. In the case of Egypt, only 4% of its orange production is processed, this is according to the United States Department of Foreign Agricultural Service USDA citrus report that is released in 2021, so increasing the portion processed of oranges will resolve the overabundance of Valencia oranges (Abobatta, 2019), which are used in juice production.

1.3 Circular Citrus Chains

Juice processing sustainability, and waste minimization, are key concerns for the modern food industry (Kandemir et al., 2022). Citrus Fruit CF is the most widely cultivated fruit in the world and its production is increasing along with consumers' demand, this leads to significant amounts of generated waste through the CF processing supply chain, which encounters high costs for waste disposal, causing economic losses and negative environmental impact.

Transforming the citrus chain from linear to circular chain, by vaporizing the generated waste, through the recovery of energy (i.e., using it as biofuel or fermentative product) and/or as a resource for valuable products (i.e., human food, cosmetics, or pharmaceuticals), would save land by reducing the greenhouse gas GHG emissions, generate new businesses and consequently creating jobs, all these potential outcomes support the three pillars of sustainability, economic, social, and environmental aspects.

The circular food supply chain originated from the processing of food by-products, by using emerging technologies to generate new foods, with target functionalities, this is to increase value concerning the output of the original linear process. The circular supply chain is not only focusing on the primary production of the main product but also by-products and waste and may involve several integrated loops for recovering materials (Lavelli, 2021). The circular supply chain is a typical model derived originally from the following four models: 'reverse logistics' which focuses on minimizing the flow of materials to landfill, 'green supply chain' which focuses on environmental impact, 'sustainable supply chain management' which focuses on social sustainability and 'closed-loop supply chain' that focuses on optimization of forward and reverse supply chain operations simultaneously (Lavelli, 2021).

The circular CF supply chain does not only impact the sustainability of the citrus industry potentially but also, may offer a solution for some problems facing low- and middle-income countries in the Mediterranean basin, like the problem of vulnerable increase of animal feed prices in North Africa due to the Russo-Ukrainian war, so valorising CF waste as animal feed could be a cost-effective solution(Eliopoulos et al., 2022), moreover using CF waste as animal feed has proven positive impact on the quality of the meat produced.

Despite the significance of a circular CF supply chain for sustainability some barriers and challenges needed to be explored for each valorisation path, to decide possible paths for the transition of citrus chains from linear to circular economy CE business models in the Mediterranean market.

Measuring customer willingness to pay for green product is a prerequisite to organization for implementing any sustainability measure through the supply chain like circular economy (Rodríguez-Espíndola et al., 2022).

1.4 Research Questions

To achieve the aim of the research we formulated the following five research questions (RQ):

RQ1: What are wastes generated in CF processing chains and their physical types?

RQ2: What are the valorization options listed in the literature and their classification according to the value-added?

RQ3: What are the barriers listed in the literature against each valorization option and its frequencies?

RQ4: What is the price sensitivity for sustainable green production of orange juice taking into consideration the socio-economic effect?

RQ5: What is consumer willingness-to-pay WTP and their behaviour towards the proposed innovative probiotic orange functional drink taking into consideration the socio-economic effect?

To answer questions 1 to 3 we conduct a systematic review of the literature.

To answer questions 4 to 5, A multinomial logit model MNL has been built, based on the collected data by discrete choice conjoint survey we built a multinomial logit model MNL.

2 Methodology

The methodology of the market analysis is structured in two different but connected research:

1. A Systematic literature review on the CF processing waste valorization options, a categorization according to the value-added, and the barriers that face each alternative.
2. Stated preference survey about willingness to pay for different types of orange juice to construct a set of consumers' choice models (Multinomial logit)

2.1 Systematic literature review methodology

In this research, we conduct a comprehensive analysis of literature focusing on the CF processing waste valorization options, its categories according to the value-added, and the barriers that face each option. In conducting this review, we follow the PRISMA framework, PRISMA stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. It is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses(Page et al., 2021). We follow the following six steps, the fourth and fifth steps illustrated in Figure 3, are done only for the review articles and the conference papers:

1. Identify the source, which is SCOPUS, as it is more appropriate for exploring complex research areas that are constantly changing(Feng et al., 2017)
2. Identified search keywords: citrus, orange, by-products, waste, juice, processing, extraction, valorization, valorisation, exploitation, and circular economy. The Keywords are identified and grouped in 3 sets as justified in Table 1:

Table 1 Search keywords justification

Set	Keywords	Justification
Set 1	Citrus, orange	The citrus fruit that is most processed is the orange. Therefore, it is important to obtain documents that encompass the topic of citrus fruits or specifically focus on the orange variety.
Set 2	Byproducts, waste, juice, processing, extraction	The focus of this group refers to the waste generated during the processing of citrus for juice extraction, as well as the valorization of the waste as by-products.
Set 3	Valorization, valorisation, exploitation, circular economy	The focus of our study revolves around the challenges and impediments faced in the implementation of circular citrus supply chains. We have conducted a comprehensive analysis of all potential synonyms for the terms "barriers and challenges" based on our existing understanding.

3. Identify the inclusion criteria as illustrated in the following table:

Table 2 Inclusion criteria justification

Criteria	Criteria Identified	Justification
Type of Documents	Review Articles, Articles, and Conference Papers	*Review Articles:* to obtain a comprehensive overview and evaluative analysis of the existing corpus of scholarly investigations. Articles: to possess insights that have yielded a unique and substantial contribution. Conference Papers: to have "state-of-the-art" research findings.
Language	English	English language academic publications often utilize stringent peer-review procedures to uphold the quality and integrity of the scholarly research that is published.

4. We used the following query using the previously mentioned keywords in the SCOPUS database:

TITLE-ABS-KEY ((citrus OR orange) AND (byproducts OR waste OR juice OR processing OR extraction) AND (valorization OR valorisation OR exploitation OR "circular economy")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))

This query is used to retrieve all English articles, review, and conference paper, except books and book sections, existing in 2 source types which are (journal and conference proceeding), no time constraint is used. That contain any of the keywords at the same time in three different sets represented in the diagram, set 1, set 2 "and set 3.

The used query retrieved 429 documents distributed among 3 types of documents 352 -articles, 57 reviews, and 20 conference papers.

5. In this step we specified the eligibility criteria or the criteria of inclusion for the review articles and the conference papers, it was that the document should include at least one valorization method for CF processing waste, even if no barrier is mentioned.
6. This step was for filtering documents that are conforming the eligibility criteria, for the identified 57 review articles and the 20 conference papers, they were firstly screened by title for relevant results in 53 review papers and 14 conference papers, then screened again by skimming the whole document. The number of included studies in the analysis 38 review article and 5 conference papers, the chart in Figure 3 shows the filtration steps for review and conference papers.
7. Full text reading for the 38-review article and the 5 conference papers, to find answers to the research questions.
8. Conducting a bibliometric analysis using the 352 articles using VOSviewer for the co-occurred keywords, to explore co-occurred keywords related to by-products, methods of valorization, and barriers, and the chronological distribution of keywords.

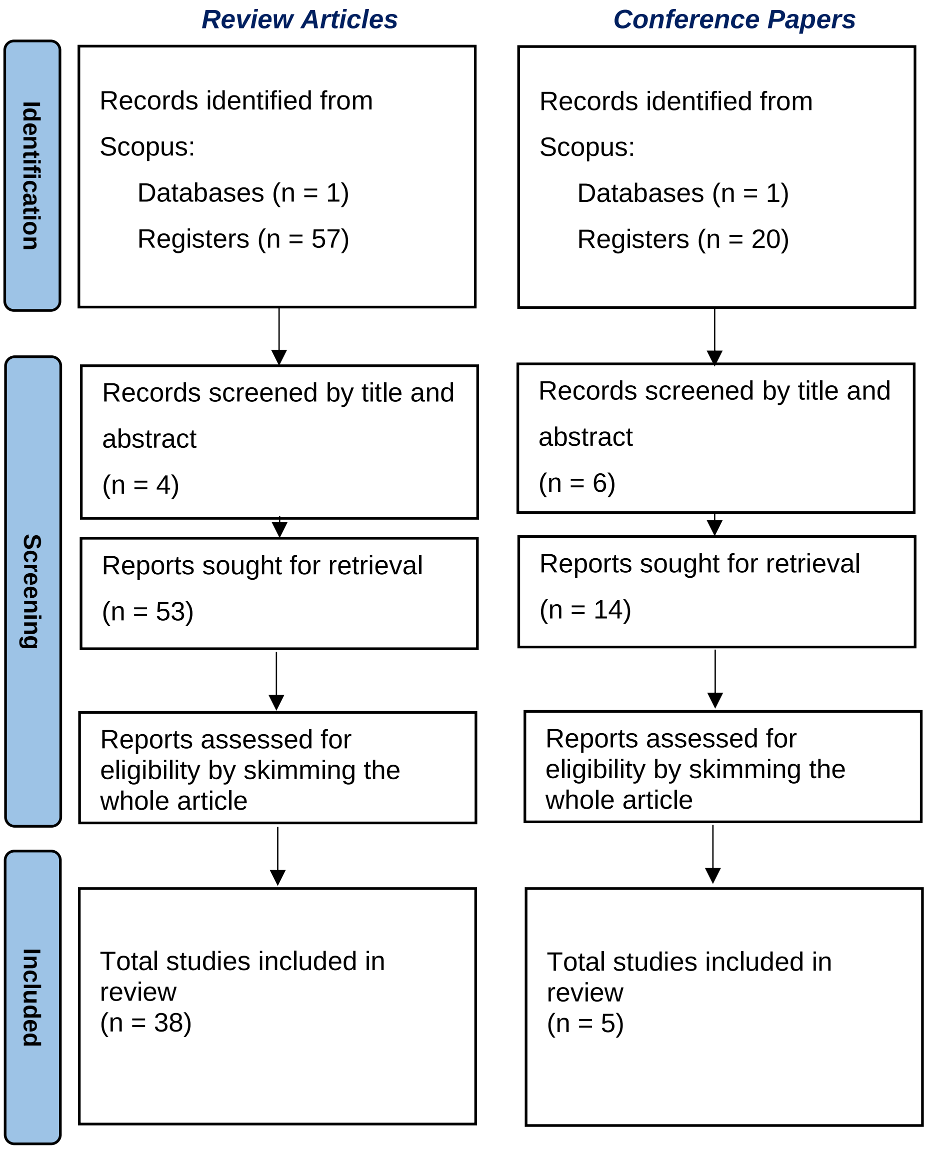

Figure 3 Steps of filtering records retrieved by the query

2.2 Surveys and consumers' choice modelling methodology

The following chart in shows the 10 steps of our research methodology.

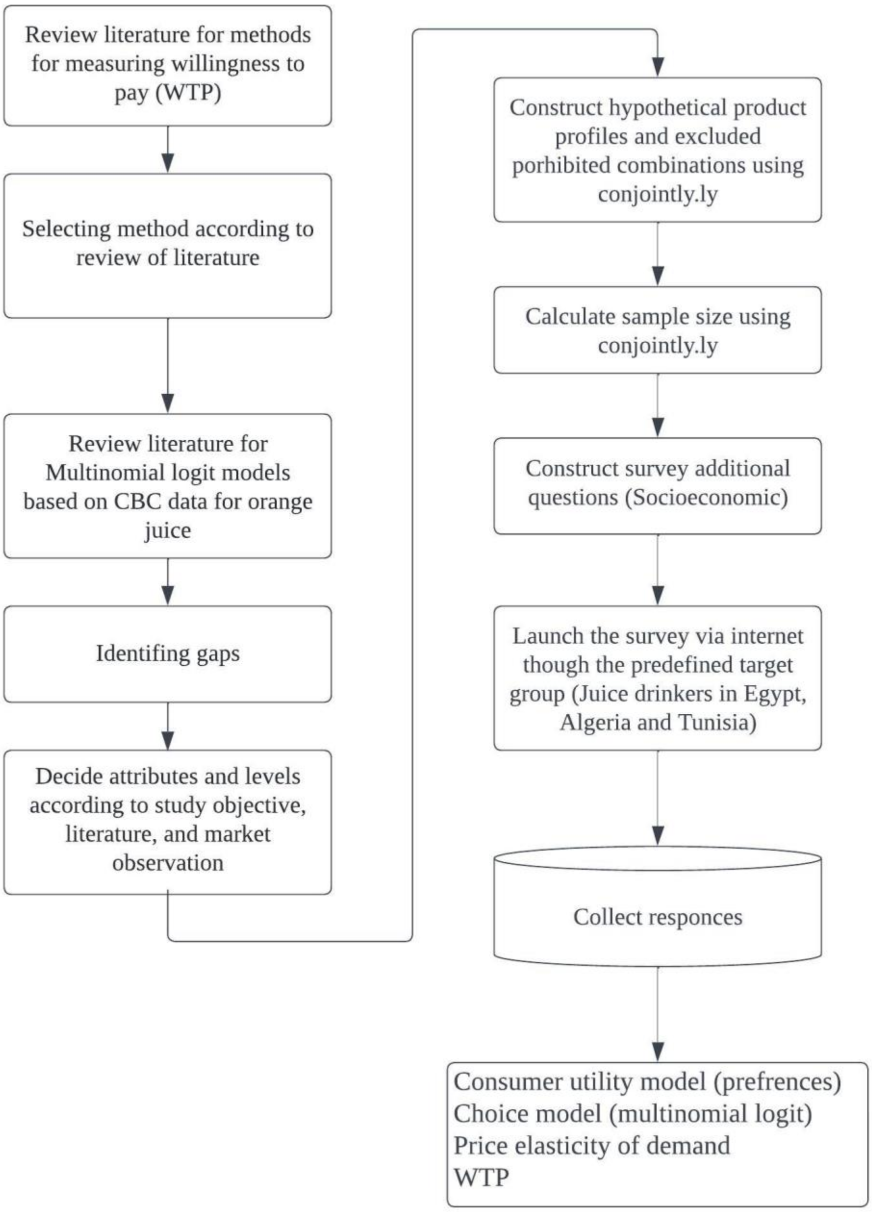

Figure 4 Research methodology for choice modelling

2.2.1 Measuring Willingness to Pay (WTP)

The price the number put on a tag on a product decide if the consumer will decide to buy it or not, it comes from statistically modelled data (Walter R. Paczkowski, 2019). There are many ways to set the price of a product, most of these methods but not all provide price sensitivity which is the heart of pricing as well as consumer choice analysis. Price sensitivity measure the effect of changing price and other product features on sales, revenues generated and other business metrics. The profit maximizing price is what costumers are willing to pay WTP. Willingness to pay is a theoretical number. It is defined as the maximum price a buyer accepts to pay for a given quantity of goods or services(Kalish et al., 1991). Knowledge about product's willingness-to-pay from its potential customers plays an important role in pricing decisions of and product development (Breidert et al., 2006). Methods used to measure WTP can be classified according to data collection method into two categories *revealed preference* and *stated preference* as presented in Figure 3.

The data obtained from price responses (i.e. data of consumer transactions) is called *revealed preference data*, these data are stored in large databases (e.g. Hadoop clusters). Internal customer databases are main sources for modelling pricing data for a product that is already existing in the market. Using revealed preference data has some drawbacks like: lake of variability which is very important for regression models, obsoleteness of data as the used data is old, and the data don't show how consumer make purchase decisions during comparing it with another substitute (Walter R. Paczkowski, 2019).

Stated preference is a survey-based technique for collecting data. The data collected are on the key purchase drivers mainly price to estimate price-response functions, data are collected under controlled conditions determined by the experimental design. The main approaches used to collect, and analysis data are conjoint analysis and discrete choice analysis (Walter R. Paczkowski, 2019) it is also known as "choice based conjoint analysis" (Raghavarao, 2010). The statistical models "supervised learning" built by stated data are the same as those for revealed data but, stated preference data don't have drawbacks mentioned for revealed preference data.

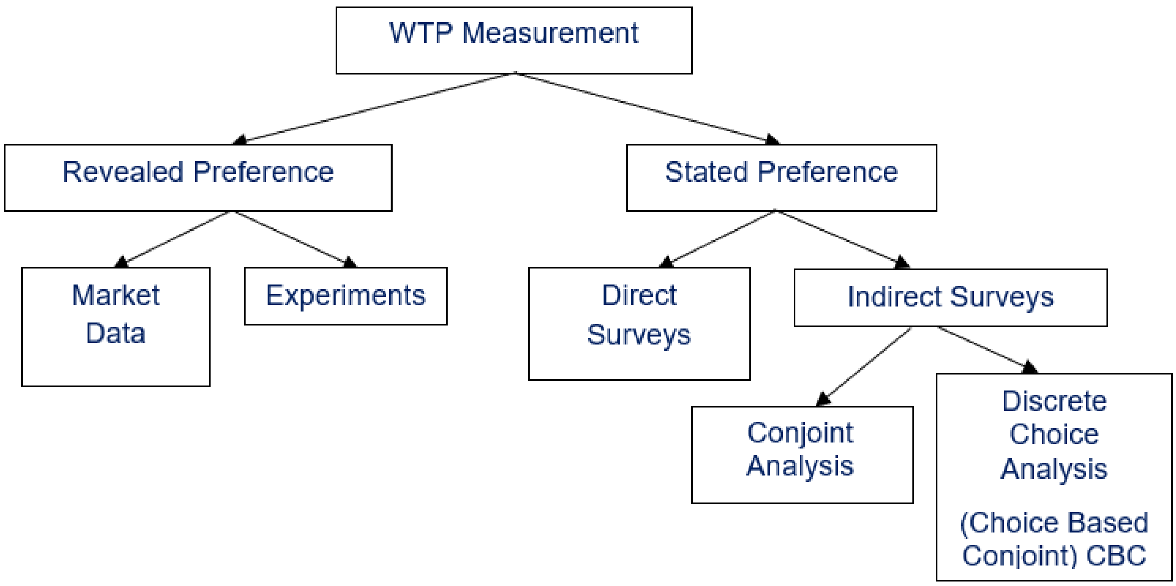

Figure 5 Classification of methods used in measuring WTP. (Breidert et al., 2006)

2.2.2 The choice based conjoint survey CBC survey.

Conjoint statistical analysis is a stated preference survey that is based on a statistical technique commonly employed in market research to get insights into the relative importance that customers assign to various components or aspects of products or services. Conjoint analysis operates on the fundamental premise that any product may be deconstructed into a collection of attributes that eventually influence the perceived value of the item or service for users. The primary aim of conjoint analysis is to determine the relative importance of different attributes in influencing the decision-making process of respondents. Conjoint analysis operates by administering a sequence of product profiles to participants, wherein the profiles show variations in features and levels under examination. The profiles ought to be formulated in a manner that emulates authentic purchasing scenarios, wherein respondents are prompted to exchange one option for another. Conjoint analysis data is typically collected by a market research survey, however it can alternatively be utilized in a meticulously constructed configurator or derived from a suitably prepared test market trial. Conjoint analysis is a valuable tool that may be employed by companies to enhance their research and development pipeline, ascertain the inclusion of new features in their products or services, and make well-informed choices regarding pricing, product development. Conjoint analysis is widely recognized as a very efficacious framework for elucidating consumer preferences throughout the purchasing journey. Subsequently, this data is subjected to statistical analysis to transform it into a quantitative metric.

In this research data are collected using a choice based conjoint survey, it is known academically as discrete choice experiment DCE. Data collected online using Conjointly.ly from the 3 South-Mediterranean countries Egypt, Algeria, and Tunisia. Survey is disseminated in the 3 most spoken languages in these countries Arabic, English, and French.

In the discrete choice experiment DCE used to collect data, each respondent is exposed to 10 different choice sets, each choice set consists of 2 hypothetical products and a no choice option, example of choice set illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.**, where health claim related to each type of juice is indicated (Mohebalian et al., 2012), and sustainability is indicated by three certificates (Organic, Environmental, and Fairtrade) (Li & Kallas, 2021). The choice sets are generated using block design-design of the experiment.

Figure 6 Choice set

The block design and the sample size are calculated using conjointly.ly platform based on attributes and levels shown in Table 1, the experiment has 160 blocks each block of 10 choice sets blocks. The sample size used to build the choice models is N≥200 for each country survey, it is calculated using conjointly.ly software.

The attributes that form the combinations of the hypothetical products is shown in the following table. Attributes are decided based on the aim of the research and using insights from the qualitative research conducted, for instance the probiotics prepared from utilization of citrus processing waste is one of the valorization paths found in the qualitative research, and lack of consumer insights was one of the market barriers, besides using pesticides was one of barriers, so are consumers willing to pay primum for organic product. Also, to produce primum green product it's important to understand consumer preferences for sustainability attributes that are indicated by environmental, and fairtrade labels. Levels of each attribute is decided based on market observations and gaps found in the literature for similar recent research made for orange juice, Table 1 shows findings and gaps existing in the literature:

Table 3 Literature for choice modelling studies for orange juice

Article	Data collection method	Model	Outcome measured	Findings	Gap
(Chitturi et al., 2019)	Choice Experiments	Binary Logistic Regression	Product's perceived quality from orange juice packaging and pricing	Colour and shape of orange juice packaging have a significant influence on consumer preference, can create synergy and augment quality perception, and showed that colour and shape of product packaging can affect pricing.	the study doesn't show the socio-economic effect on consumer choice.
(Kumar & Babu, 2021)	Choice Based Conjoint	Multinomial Logistic Regression MNL	- Consumers' preferences When Purchasing Orange Juice - Product Attributes: • Flavour •Preservatives •Sweetener •Brand •Taste •Pulp Concentration •Container •Production method of juice •Price •Market share for a new Product with desired levels	• Consumers gave more importance to the 'method of production' of orange, followed by 'brand', 'pulp concentration', 'sweeteners', and 'preservatives' when purchasing orange juice. • Product differentiation is a strategy firms in the food processing sector should consider under conditions of intense competition.	the lack of analysis of the effects of demographic factors on demand and orange juice attributes.

It was clear in the available literature that no studies test the effect of sustainability labels (organic, environmental and fair-trade labelling) on consumer preferences for orange juice. Also, no market studies found for orange functional drinks, besides both studies encounter data heterogeneity problems.

The following tables shows the attributes and levels that are used to build the hypothetical products viewed in the survey choice set:

Table 4 Levels and attributes

ATTRIBUTE	***LEVEL (Egypt)***	***LEVEL (Tunisia)***	***LEVEL (Algeria)***	***Description***
Type of juice	Pasteurized Juice	Pasteurized Juice	Pasteurized Juice	Healthy, Good Taste, Higher Price 100% Juice
	Orange Nectar	Orange Nectar	Orange Nectar	Lower Price, Good Taste, Not Healthy not 100% Juice
	Probiotic drink	Probiotic drink	Probiotic drink	Vegan probiotics prepared from citrus processing waste, Healthier, Good Taste, Higher Price
Prices per liter	34 EGP per liter	5.7 TND per liter	250 DZD per liter	Market price not valid for organic certified juice

	39 EGP per liter	6.7 TND per liter	290 DZD per liter	Market price
	44 EGP per liter	7.7 TND per liter	330 DZD per liter	Market price
	49 EGP per liter	8.7 TND per liter	370 DZD per liter	Market price not valid for not organic certified juice
Organic certification	Organic certified	Organic certified	Organic certified	No pesticides, no fertilizers, and no synthetic additives, not applied for Nectar
	Not organic certified	Not organic certified	Not organic certified	
Fairtrade certified	Fair trade certified	Fair trade certified	Fair trade certified	Ensure worker's safety, fair payment, and product data is recorded from farm to store
	Not fair trade certified	Not fair trade certified	Not fair trade certified	
Environmental certification	Environmentally certified	Environmentally certified	Environmentally certified	Product don't harm the environment
	Not environmentally certified	Not environmentally certified	Not environmentally certified	
Packaging	Plastic Bottle	Plastic Bottle	Plastic Bottle	1 Liter plastic bottle transparent with black cap 
	Tetra pack	Tetra pack	Tetra pack	1 Liter white carton bottle 

2.2.3 The main principle of choice modelling using multinomial logit models MNL and the conceptual framework

The main idea behind choice modelling with MNL is to estimate the likelihood of selecting among many discrete categorical or nominal variables, considering numerous observed explanatory factors(Bierlaire, 1997). The following are the fundamental aspects to comprehend regarding multinomial logit modelling:

- The main aim of MNL is to analyse and understand the decision-making process of individuals or segments by examining the discrete decisions they make within a certain environment. The available choices may consist of either options A and B, or option C, or neither or any other possible combinations.
- The modelling framework implies that the utility or advantage that an individual obtains from selecting one option over another is determined by the frequency with which they select that option in successive phases of decision-making. Utility can be conceptualized as a personal assessment or tendency towards a specific choice.
- The objective of MNL is to deduce the rankings of the choices on a relevant latent scale, commonly known as "utility" in the field of economics. The latent scale in question serves as a representation of the underlying preference or value that individuals attribute to each available option.
- The MNL is utilized to estimate the probability of selecting each alternative by considering the utility values attributed to the alternatives. The probabilities are computed by the utilization of multinomial logistic regression shown in Equation 1, a statistical technique that calculates the association between the explanatory variables X and the probabilities of different choices.
- The explanatory factors included X in MNL cover a range of observable variables that have the potential to influence the process of decision-making. These factors include demographic characteristics, product features, pricing, and other pertinent variables.

$$ln(\frac{Choice=1}{Choice=0}) = \sum \beta_{ij} . X_{ij}$$ *Equation 1*

The utilization of multinomial logit modelling offers a comprehensive framework for understanding as well as forecasting the decision-making process of individuals when faced with various choices, besides calculating consumer willingness to pay.

According to (Schlereth et al., 2012)The estimation of WTP in MNL is the price at which a consumer is indifferent between buying and not buying a product. This equality implies that the utility of buying a product at a price equal to the consumer's WTP which implies that the probability of a purchase at WTP price equal to exactly 50%, and that the WTP estimate for a product can be expressed as Equation 2:

$$\frac{\sum \beta_{ij} x_{ij}}{\beta_{price}} * -1$$ *Equation 2*

The utilization of this concept is common in many fields, such as product development, assortment planning, revenue management, economics, marketing, transportation, and the social sciences.

In the context of our research, we use MNL to explore consumer acceptance for orange probiotic drink compared to nectar orange drink, and pasteurized Not From the Concentrate NFC orange juice, along with exploring the influence of other attributes like price, packaging and different sustainability labelling on consumer choice and purchase decision, taking into consideration socioeconomic factors.

The conceptual framework of the quantitative research, as we are studying the effect of the following listed variables X on consumer choice for three different types of orange juice where health claims for each type are indicated:

- Three sustainability attributes indicated by three certifications organic, environmental, and fairtrade (Li & Kallas, 2021), where an explanation for each certificate is provided.
- Packaging are two types plastic bottles and cartoon tetra pack (Kumar & Babu, 2021).
- Price to calculate willingness to pay.
- socioeconomics is used as a moderating variable (educational level and average household income) (Pechey & Marteau, 2018), to explore how variation in socio-economic status affect the strength of the relation between dependent and independent variables, as illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

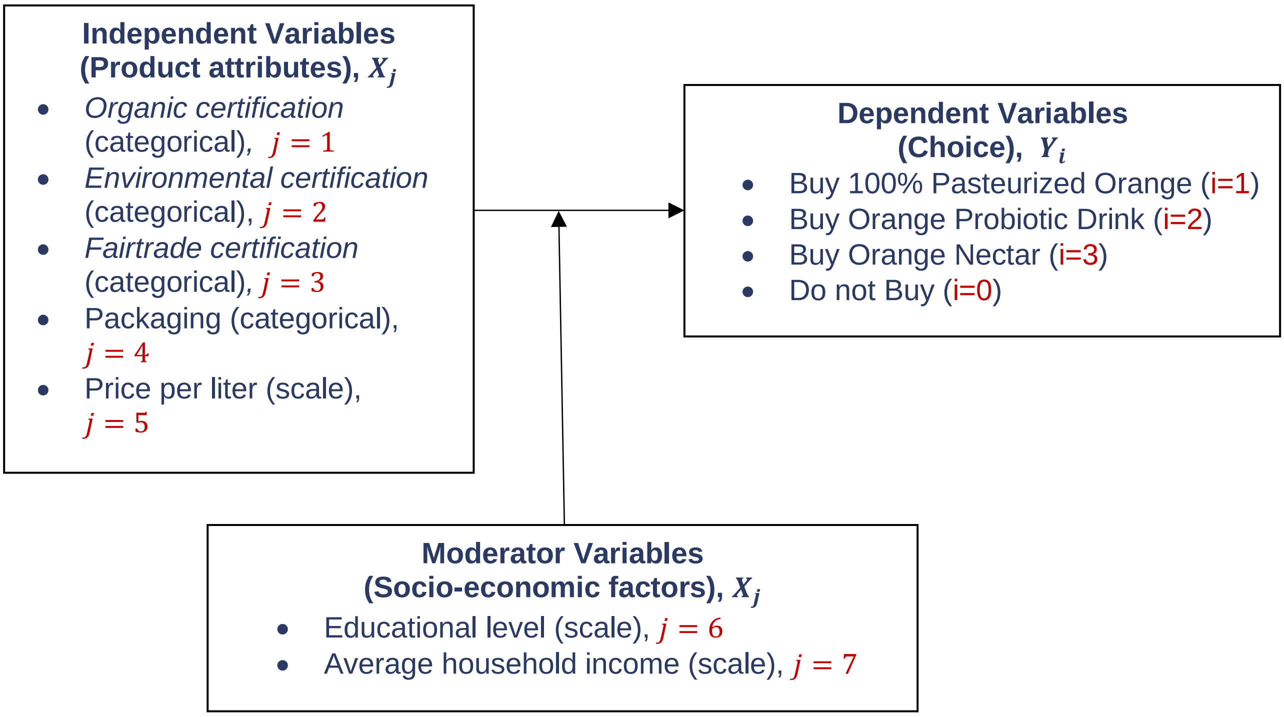

Figure 7 Conceptual framework for consumer choice models

3 Results and Analysis

3.1 Literature Review

3.1.1 Analysis of Reviewed Conference Papers and Review Articles

3.1.1.1 Types of wastes generated in the CF processing chain

(Singh & Singh, 2022) classified food agricultural waste into solid and water waste and described the type of losses in each activity along the chain in **Fehler! Ungültiger Eigenverweis auf Textmarke.**.

Table 5 Types of losses encountered along activities of the food chain (Singh & Singh, 2022)

Activity	**Type of loss**
Agricultural production	Losses during Pre-harvest
Handling and storage	Losses during Post-harvest
Processing	Losses during industrial processing for juice production
Distribution	Losses due to waste in the market system
Consumption	Losses during consumption at household

In the 38 review papers, three types of waste are suggested to be valorized in different paths. The wastes are citrus peel waste CPW, citrus processing water waste CPWW, pre-harvest, and post-harvest waste. The CPW and the CPWW take place during juice extraction processing, while the pre-harvest waste occurs during agricultural production.

Table 6 represents the frequency distribution of reviewed articles grouped by types of wastes generated in the citrus chain.

Table 7 shows the frequency distribution of conference papers grouped by types of wastes generated the in the citrus chain. Figure 8 shows the frequency distribution of the review articles and the conference papers among the three types of waste observed.

Type of waste to be valorized	Frequency	Authors
CPW	34	(Putnik et al., 2017), (Satari & Karimi, 2018), (Zema et al., 2018), (Ruiz & Flotats, 2014), (Negro et al., 2016), (Matharu et al., 2016), (Comunian et al., 2021), (Zuin & Ramin, 2018), (Ledesma-Escobar & Luque de Castro, 2014), (Zuin, 2016), (Sabater et al., 2020), (Jeong et al., 2021), (Gavahian et al., 2019), (Russo et al., 2021), (Tayengwa & Mapiye, 2018), (Baker & Charlton, 2020), (Farag et al., 2020), (Iqbal et al., 2021), (Teigiserova et al., 2021), (Mahawar et al., 2020), (Singh & Singh, 2022), (Eliopoulos et al., 2022), (Suri et al., 2021a), (Kandemir et al., 2022), (Kim et al., 2022), (Matei et al., 2021), (Antonio et al., 2021), (Sabater et al., 2022), (Sharma et al., 2022), (Shorbagi et al., 2022), (Suri et al., 2022a), (Pascoalino et al., 2021), (Nieto et al., 2021), (Gullón et al., 2020)
CPW/CPWW	1	(Panwar et al., 2021)
CPWW	2	(Zema et al., 2019), (Lucia et al., 2022)
Pre-harvest waste	1	(Khamsaw et al., 2022)
Total number of review articles	***38***	

Table 6 Frequency distribution of reviewed articles grouped by types of wastes generated in a citrus chain

Table 7 Frequency distribution of conference papers grouped by types of wastes generated in a citrus chain

Type of waste to be valorized	Frequency	Authors
CPW	5	(Prestipino et al., 2020), (Burguete et al., 2016), (Ningrum et al., 2018), (Strubinger et al., 2017), (Garcia-Castello et al., 2012)
Total number of conference papers	***5***	

89% of the review articles and 100% of the conference papers reviewed are concerned with the valorization of CPW, while 8% of the review papers are reviewing options for the valorization of CPWW, and 3% of the review papers are reviewing the valorization of pre-harvest waste. This means that 97% of the review articles are concerned with the valorization of wastes generated during the industrial processing of citrus for juice extraction.

As per (J. Peter Clark, 2009) Orange is the most industrially processed citrus species for juice extraction, the citrus-processing chain consists of fruit temporary storage, washing, grading, and sorting, juice extraction and finishing, heat treatment, product packaging and storage, Figure 9 shows citrus schematic process flow diagram for orange juice processing operations.

Figure 8 Frequency distribution of conference papers grouped by types of wastes generated in a citrus chain

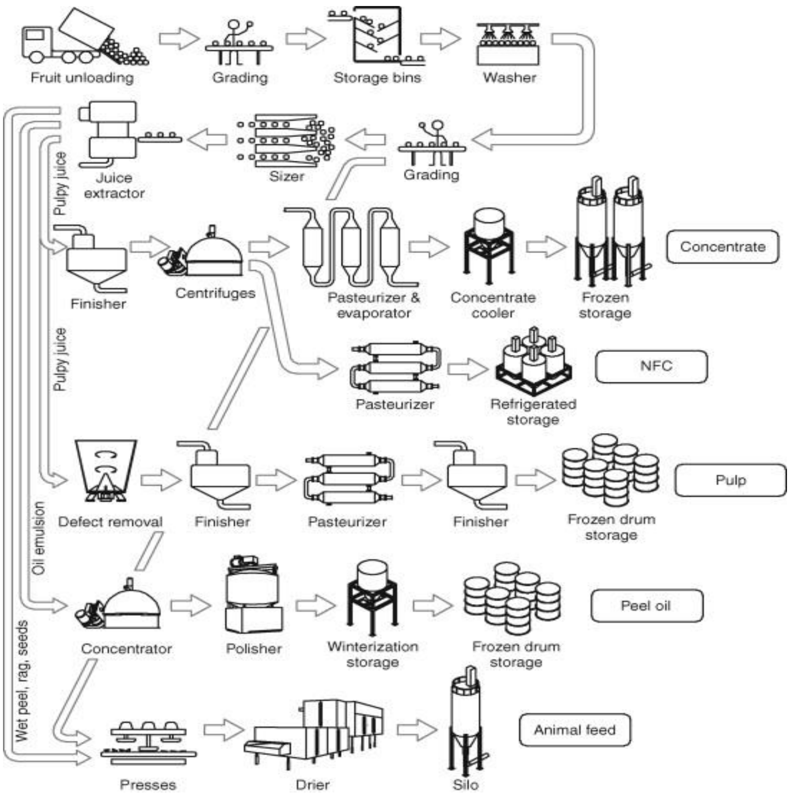

Figure 9 citrus schematic process flow diagram for orange juice processing operations.

According to (Zema et al., 2018) the extracted orange juice accounts for approximately 55% of the mass of the processed fruit, while the remaining is pulp, peel oil, and CPW divided in the ratios 3%, 0.3%, and 41.3% respectively, CPW composed of two fractions, peel, and pulp (seeds and membrane residues) in the ratio around 60–65% peel, 30–35% internal tissues, and up to 10% seeds by weigh. The CPWW generated as a liquid residue during the following citrus processing operations:

- fruit washing,
- centrifugation of the water/oil to recover essential oil (the highest amount of CPWW produced in this stage),
- evaporation of the citrus juice to produce concentrated juice, and at the end of the production cycle and during cleaning operations of industrial equipment.
- Moreover, if CPW is dried it generates water waste a, some citrus processing plants integrate the CPW dehydration process.

The amounts of CPWW generated during processing depends on water consumption per unit processed and this varies according to the water management system used in the plant, as citrus plants using water-recirculation systems were assumed to use $1m^3$ per ton processed, while another plant not using that system consumes may consume $17m^3$ per ton processed (Zema et al., 2019), Figure 10 represents portions of products and wastes generated during citrus fruit processing.

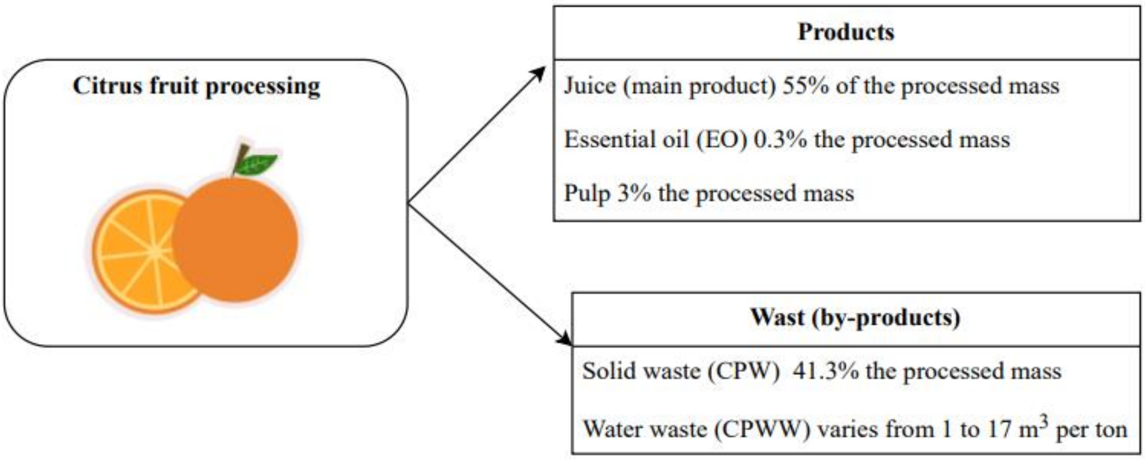

Figure 10 Portions of products and wastes generated during citrus fruit processing.

Fruit waste valorization is challenging as the circular economy concepts in food chains aim to reduce the environmental impact and enhance economic development (Comunian et al., 2021), whereas (del Borghi et al., 2020) considered, besides food waste management, environmental degradation, and climate change.

The fruit processing industries utilize around 20% of the total energy that is consumed in developed nations adding a significant burden on the environment, if this waste is not properly valorized and moves to a landfill a significant quantity of greenhouse gases GHG is produced (Sharma et al., 2022), total greenhouse gases GHGs generated by a product throughout its life cycle is expressed as its carbon footprint in Ton of equivalent CO_2, Figure 11 shows the carbon footprint of different citrus species emitted through its life cycle expressed in CO_2 equiv. per ton based on (Matei et al., 2021). According to the Regulation of the European Parliament, a ton of CO_2 equivalent is the amount of greenhouse gases GHGs expressed as the product of the greenhouse gas mass in tones and their global warming coefficient, the unit of measure of the carbon footprint determines the emission of carbon dioxide, nitrous oxide, and methane, as well as hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other greenhouse gases(Karwacka et al., 2020).

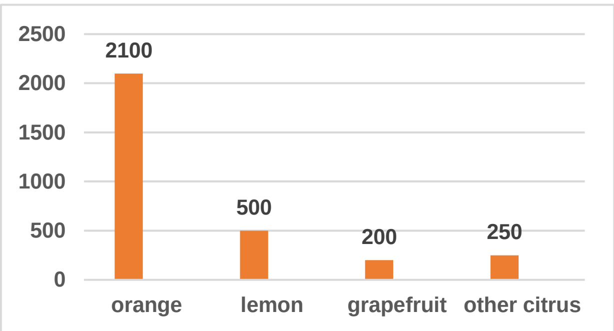

Figure 11 Carbon footprint of different citrus species as CO2 Equiv./Ton

3.1.1.2 *CPW waste valorization options to words circular economy*

(Chinnici, 2019), built a circular chain model for the cycle of valorization of citrus fruit CPW showing all the valorization options, his model is based on a study carried out in Sicily which is the main Italian region for citrus fruit production and processing, the following diagram in valorization is based on the circular model proposed by (Chinnici, 2019), it illustrates most of the valorization options exist in the literature.

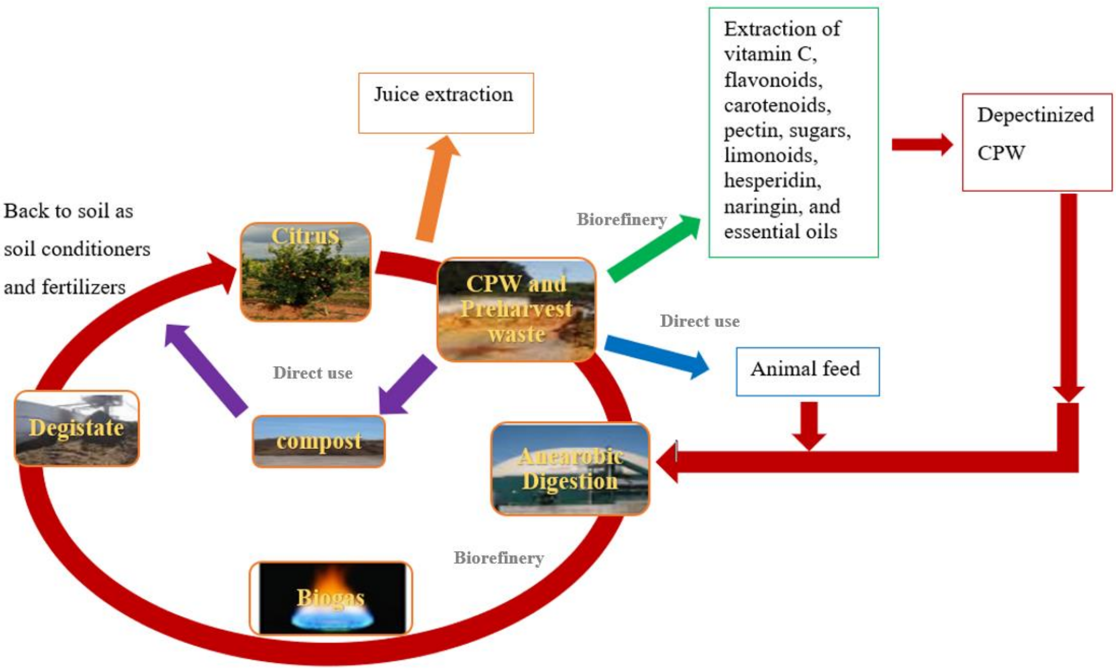

Figure 12 Circular chain model for CPW valorization

Table 8 shows the distribution of review papers, and conference papers grouped by valorization path for CPW. Papers from 1 to 34 are review articles, while from 35 to 39 are conference papers.

Figure 13 illustrates the frequency distribution of the valorization paths for CPW in literature.

Table 8 Distribution of review papers and conference papers grouped by valorization path

Papers	**CPW valorization paths**							
	Biorefinery				**Direct used**			
	Energy production			Value-added product extraction		Agronomic utilization		
	Direct combustion	Hydrolysis and alcoholic fermentation/ Bioethanol	Anaerobic digestion/ Biogas/ biomethane	EO/limonene source of pectin, dietary fibers, soluble solids, proteins, enzymes, acids, sugars, flavonoids, vitamins, and probiotics that could be used as foods, food additives, cosmetics, and pharmaceutics	Animal feed (Dried or wet)	Compost	Organic soil conditioner	**Bio-adsorbents**
1. (Zema et al., 2018)	√	√	√	√	√	√	√	
2. (Putnik et al., 2017)			√	√				
3. (Satari & Karimi, 2018)		√	√	√		√	√	√
4. (Negro et al., 2016)		√	√	√				
5. (Ruiz & Flotats, 2014)			√	√				
6. (Matharu et al., 2016)				√	√			

Papers	CPW valorization paths							
	Biorefinery				Direct used			Bio-adsorbents
	Energy production			Value-added product extraction		Agronomic utilization		
	Direct combustion	Hydrolysis and alcoholic fermentation/ Bioethanol	Anaerobic digestion/ Biogas/ biomethane	EO/limonene source of pectin, dietary fibers, soluble solids, proteins, enzymes, acids, sugars, flavonoids, vitamins, and probiotics that could be used as foods, food additives, cosmetics, and pharmaceutics	Animal feed (Dried or wet)	Compost	Organic soil conditioner	
7. (Zuin & Ramin, 2018)		√	√	√				
8. (Gullón et al., 2020)				√				
9. (Ledesma-Escobar & Luque de Castro, 2014)				√				
10. (Comunian et al., 2021)				√				
11. (Zuin, 2016)				√				
12. (Gavahian et al., 2019)				√				
13. (Farag et al., 2020)				√				
14. (Jeong et al., 2021)		√	√					
15. (Sabater et al., 2020)		√						
16. (Iqbal et al., 2021)				√				
17. (Russo et al., 2021)				√				
18. (Mahawar et al., 2020)				√	√			
19. (Tayengwa & Mapiye, 2018)					√			
20. (Baker & Charlton, 2020)				√				
21. (Nieto et al., 2021)				√	√			
22. (Suri et al., 2022a)		√	√	√	√	√	√	√
23. (Suri et al., 2021)		√	√	√				
24. (Pascoalino et al., 2021)				√				
25. (Kandemir et al., 2022)				√				
26. (Shorbagi et al., 2022)				√				
27. (Sharma et al., 2022)				√				√
28. (Matei et al., 2021)								√
29. (Antonio et al., 2021)				√				
30. (Kim et al., 2022)		√		√				
31. (Singh & Singh, 2022)		√	√	√				
32. (Eliopoulos et al., 2022)				√	√			

Papers	CPW valorization paths							
	Biorefinery				**Direct used**			
	Energy production			Value-added product extraction		Agronomic utilization		
	Direct combustion	Hydrolysis and alcoholic fermentation/ Bioethanol	Anaerobic digestion/ Biogas/ biomethane	EO/limonene source of pectin, dietary fibers, soluble solids, proteins, enzymes, acids, sugars, flavonoids, vitamins, and probiotics that could be used as foods, food additives, cosmetics, and pharmaceutics	Animal feed (Dried or wet)	Compost	Organic soil conditioner	**Bio-adsorbents**
33. (Sabater et al., 2022)	√	√	√	√	√	√	√	
34. (Panwar et al., 2021)				√				
35. (Burguete et al., 2016)			√					
36. (Ningrum et al., 2018)				√				
37. (Strubinger et al., 2017)		√	√					
38. (Garcia-Castello et al., 2012)				√				
39. (Prestipino et al., 2020)			√					

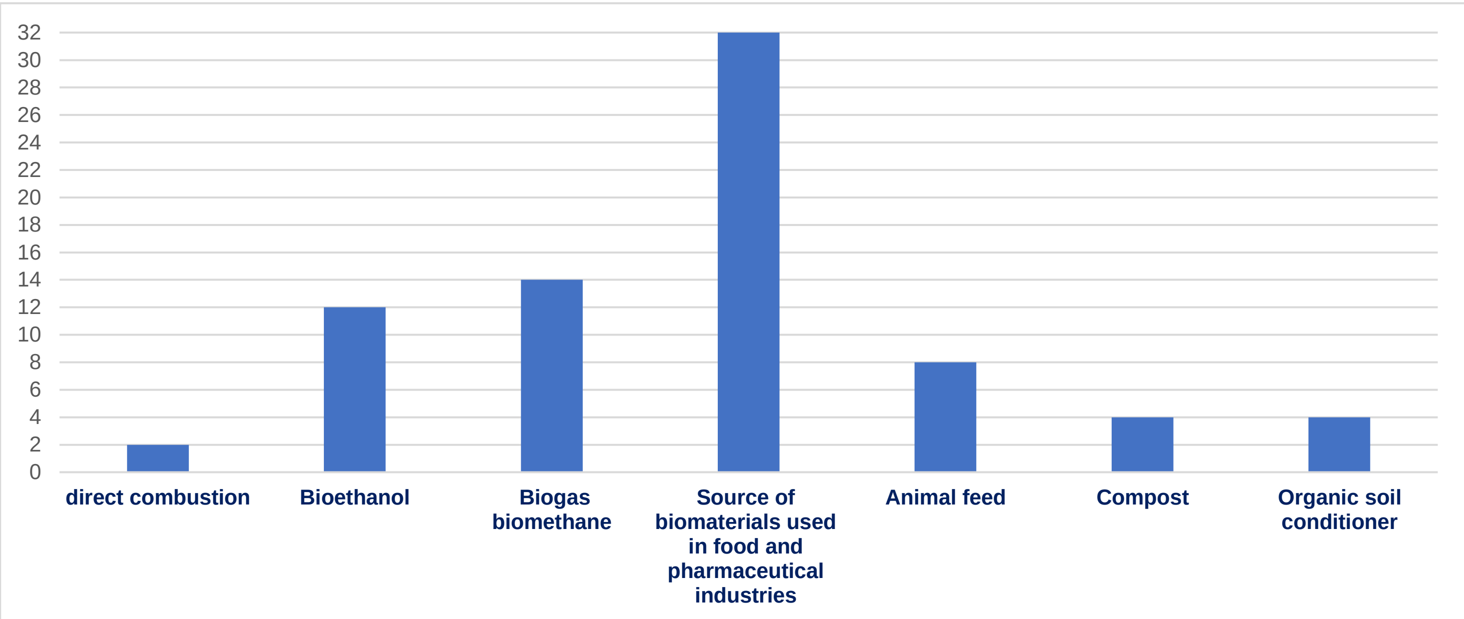

Figure 13 Frequency distribution of the vaporization paths for CPW in literature

3.1.1.3 CPWW waste valorization options towards circular economy

CPWW contains a portion of rotten fruit, pulp, seeds, and peels; causing the presence of high organic matter, essential oils, low pH, and highly suspended solids, where improper disposal is a threat to water bodies, soil, and environment. Currently, this wastewater is either discharged into water bodies' sewer systems or is treated in depuration plants such as biological ponds or bio-filters. Although CPWW is rich in polyphenols, pectin, essential oils, and carbohydrates which can be recovered using valorization techniques, but it is limited due to the complex nature of wastewater and the high cost of processing(Zema et al., 2019). Both (Zema et al., 2019), and (Lucia et al., 2022), suggested 4 paths for the valorization of CPWW, the four paths are represented in Figure 14.

There are only three papers that tackle valorization options for CPWW, which are (Zema et al., 2019) , (Panwar et al., 2021), and (Lucia et al., 2022).

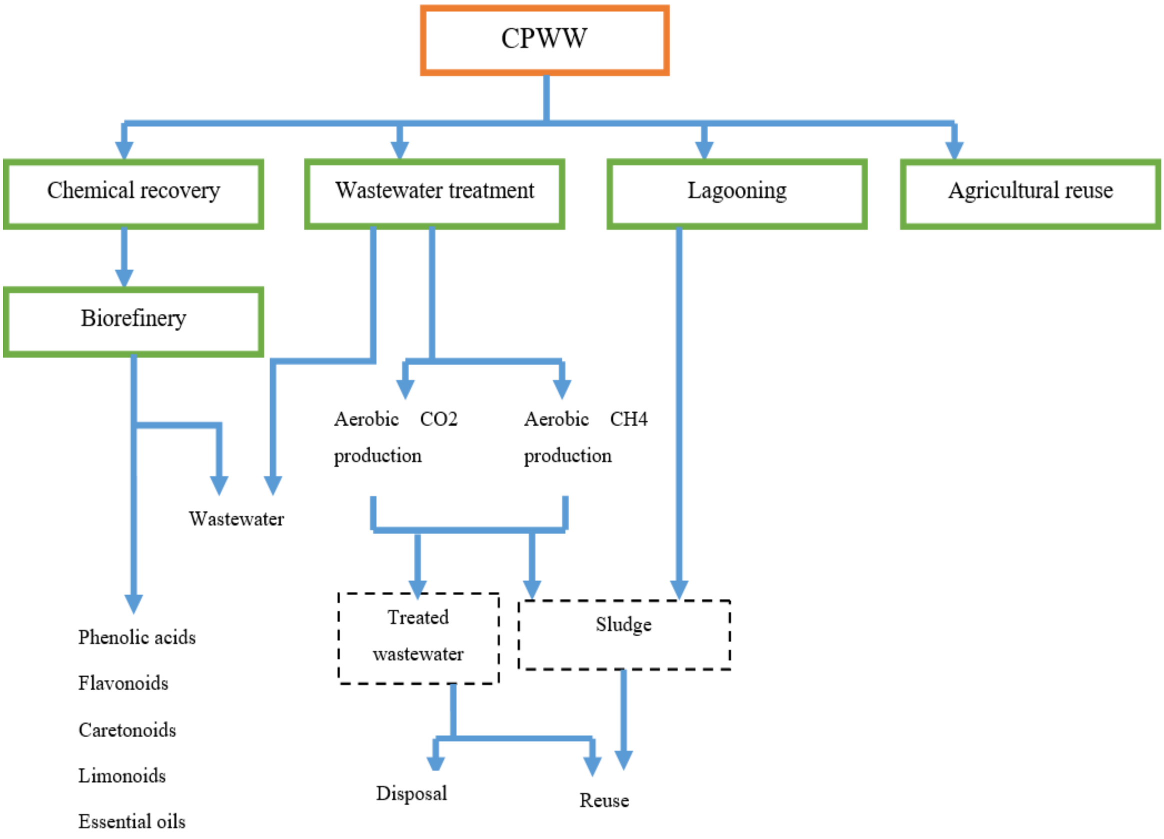

Figure 14 Valorization paths for CPWW

(Zema et al., 2019), mentioned the following barriers against utilization of CPWW:

1. Quantity and quality of liquid waste.
2. The location of the transformation industry is close to irrigated areas to marginal land due to phytotoxic effects on crops and decay of soil properties.
3. High processing cost.

3.1.1.4 Barriers against CPW valorization options as per the conducted review

There are five categories for the CPW valorization paths according to the value-added activities, namely, they are (agronomic utilization, animal feed, biofuel, and fermentative products, human and food additivese, and cosmetics and pharmaceuticals), as represented by the value pyramid in Figure 15, the value increases from bottom to top.

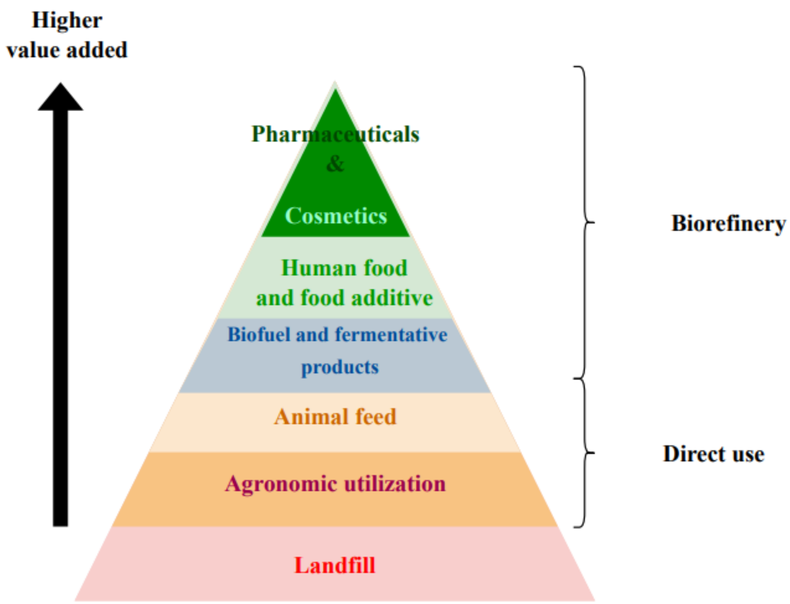

Figure 15 Categorization of CPW valorization paths by value-added activities

Each valorization path has its own barriers that may be distinct or same to other paths. Mainly valorization paths that are intenting by vaolrioztion waste as resource that can be cosumed by human (i.e. valorization paths that are at the top of the value pyramid) are releadted to food safety.

Although, there is no barrier in the review found against agronomic utilization.

The following Table 9 represents only barriers as per the conducted review, for review articles and conference papers only.

Table 9 Barriers against valorization paths as per conducted review

Valorization Category / Barrier	Animal feed	Biofuel and fermentative products	Human food and food additive	Pharmaceuticals and cosmetics
Transportation cost of the supply due to its nature (wet and perishable), distance between supplier and processor		(Burguthe ete et al., 2016)	(Panwar et al., 2021), (Sharma et al., 2022)	(Panwar et al., 2021), (Sharma et al., 2022)
Food safety and toxicity due to extraction method			(Ledesma-Escobar & Luque de Castro, 2014), (Mahawar et al., 2020), (Nieto et al., 2021), (Kandemir et al., 2022), (Sabater et al., 2022)	(Mahawar et al., 2020), (Kandemir et al., 2022), (Shorbagi et al., 2022), (Antonio et al., 2021)
Food safety and toxicity due to the use of pesticides			(Suri et al., 2021), (Pascoalino et al., 2021)	(Pascoalino et al., 2021)
Consumer acceptance			(Nieto et al., 2021)	
Degradation of nutrients, spoilage before valorization due to high moisture content	(Tayengwa & Mapiye, 2018)			
Environmental impact of the extraction method of the bioactive material			(Kandemir et al., 2022), (Baker & Charlton, 2020), (Sabater et al., 2022)	(Kandemir et al., 2022), (Ledesma-Escobar & Luque de Castro, 2014)
Thermal degradation of the extracted bioactive material			(Ledesma-Escobar & Luque de Castro, 2014), (Tayengwa & Mapiye, 2018)	(Antonio et al., 2021)
High drying costs			(Panwar et al., 2021)	(Panwar et al., 2021)
High capital costs			(Sharma et al., 2022), (Kandemir et al., 2022)	

3.1.2 Bibliometric Analysis for Keywords Co-occurrence for Article Documents

We are trying to explore the co-occurred keywords related to valorization paths which are tackled in the articles using VOSviewer. This analysis is based on the author and index keywords of the 352 articles retrieved. The tree illustrated in the following **Fehler! Verweisquelle konnte nicht gefunden werden.** for keywords key that occurred 10 times or more.

114 keywords meet the threshold out of 4534 keywords, the irrelevant keywords are excluded like human, animal, experiment, etc. The size of each node depends on the number of occurrences, so big nodes mean high occurrences. No keywords found related to barriers, all the key words are related to citrus processing waste valorization options.

Keywords are clustered in colours according to the year of publication, as the following:

- The most recent keywords are in *yellow and light green clusters* like circular economy, valorisation, valorization, polyphenols, citrus processing, sustainability, and pectin; this implies that the most recent research focuses on circular economy for waste valorization as a source of extraction of polyphenols, and pectin that is used in food industries and pharmaceuticals.
- While the *dark blue and green clusters* keywords represent analysis for older keywords that co-occurred from 2018 and before 2020, most of the keywords are related to biofuel and biogas valorization paths.

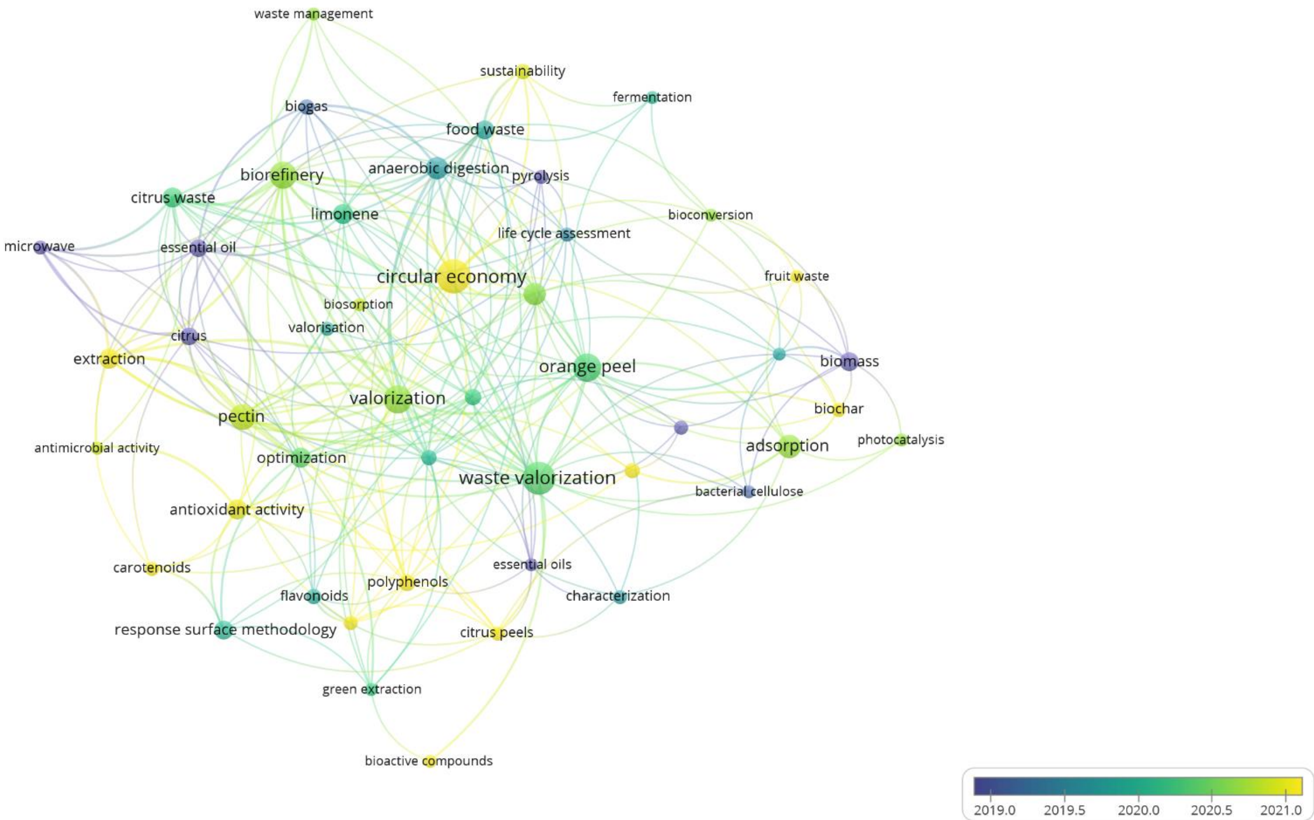

Figure 16 VOSviewer network for keywords co-occurrence for 352 articles chronologically clustered

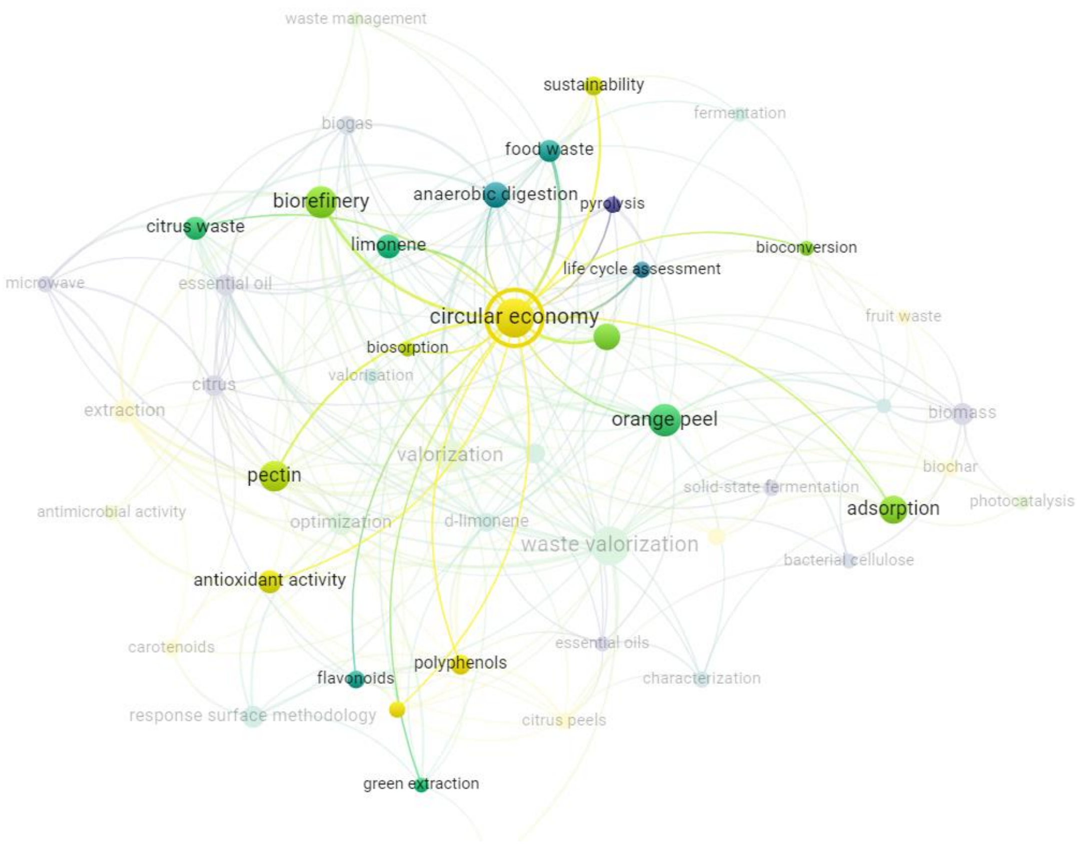

Figure 17 VOSviewer network focusing on circular economy node

- Figure 3 shows the word circular economy which makes the highest occurrences by presenting 35 occurrences, it co-occurred with most of the key words related to the biorefinery approach. A biorefinery refers to a holistic and sustainable method of converting biomass into an assortment of high-value goods, including food, feed, chemicals, fuels, and fertilizers. The biorefinery concept involves the application of hybrid techniques from diverse domains like agriculture, engineering, microbiology, and chemistry to the integrated process of biomass separation into its constituent components, such as carbohydrates, oils, and proteins.
- These compounds undergo additional transformations which produce a variety of value-added products, such as biofuels, industrial chemicals, and sources of energy.
- Within the framework of a green biorefinery concept, the solid residues of fruit pomace have the potential to serve as a viable feedstock. These residues can be treated by the process of fermentation, thereby enabling the production of a range of valuable goods. The integrated exploitation of citrus waste has the potential to generate many high-value products, including limonene, ethanol, pectin, and biogas. This is due to the significant content of sugars, oils, polyphenols, enzymes, vitamins, and minerals in citrus waste.

- Four-step-cascading biorefinery process was developed to extract select polyphenols, including fatty acid, while producing biogas.

3.2 Consumer Choice Models for Orange Juice

3.2.1 Results and analysis for Egyptian data

a) Demographics and socioeconomics of the target group

- ***Target population:*** Egyptians juice drinkers whose ages is ranging from 15 to more than 50
- ***Sample size:*** 201 respondent
- ***Gender distribution:***

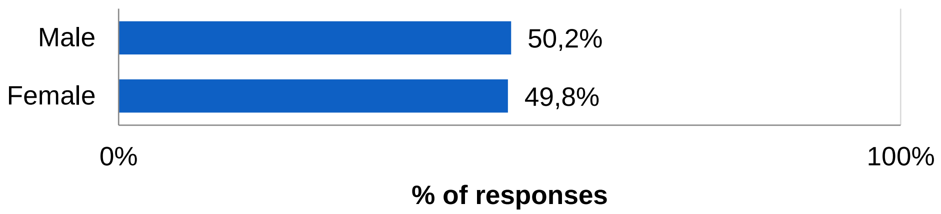

Figure 18 Gender distribution for Egypt survey

Egypt's population in 2022, 49.4 percent of Egypt's population are females, while 50.6 percent of the population are males. So, the sample gender distribution is almost same to the actual.

- ***Age distribution:***

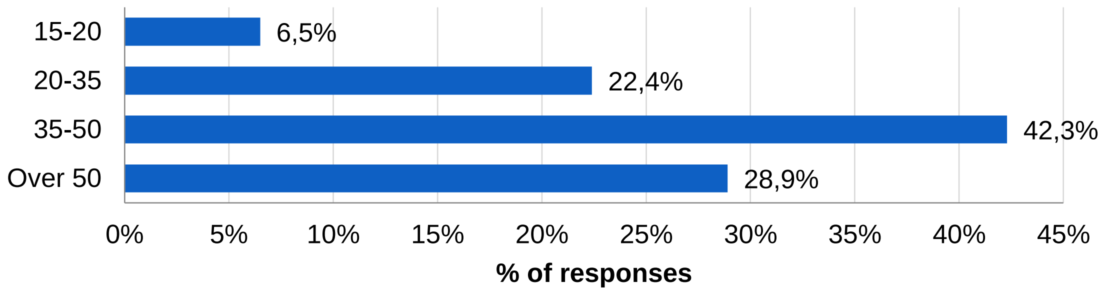

Figure 19 Age distribution for Egypt survey

- ***Educational level distribution[1]:***

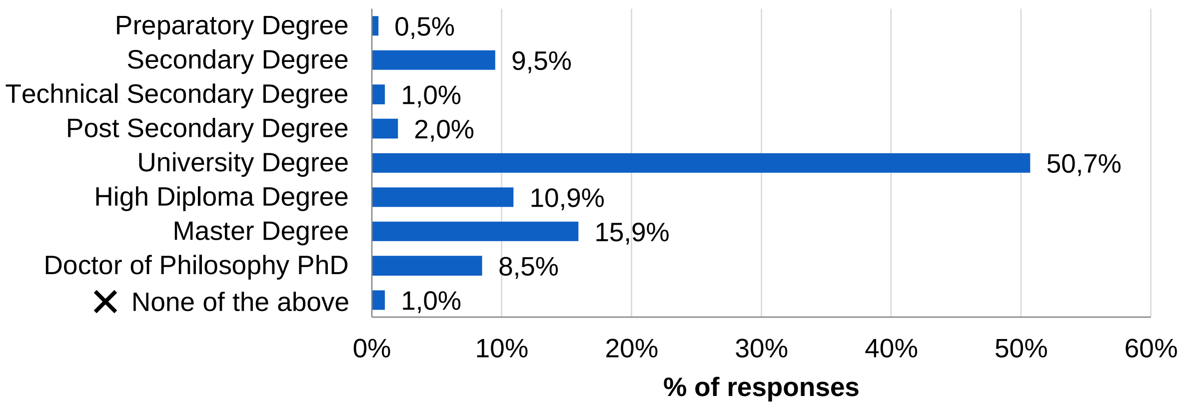

Figure 20 Educational level distribution Egypt survey

- ***Average household income distribution[2]:***

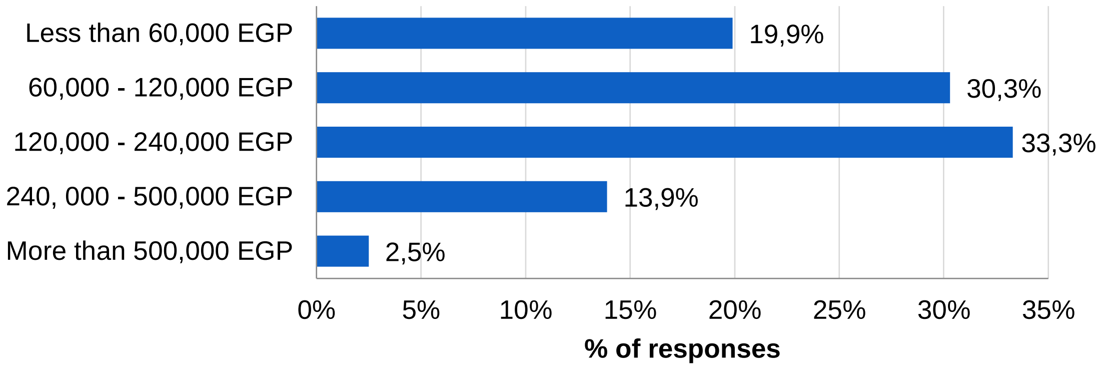

Figure 21 Average annual household income distribution Egypt survey

[1] The educational level used is according to the Egyptian census data
[2] The minimum average household income used is according to the Egyptian census data

b) Descriptive analysis

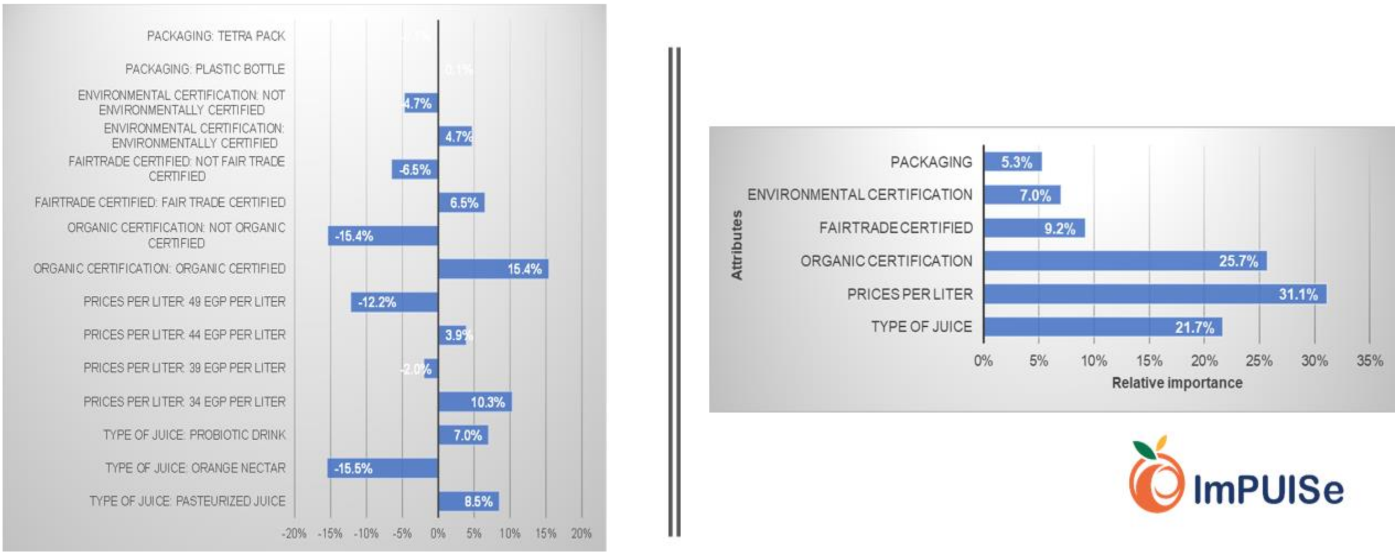

Figure 22 Average utility diagram and attribute importance for Egypt

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The average utility diagram in Figure 3 shows that organic certification has the highest utility followed by price level 34 EGP per Liter, then NFC pasturized orange juice, and then our innovative probiotic orange juice, at the same figure on the right attribute imporatnce is illustrated showing that the most important attribut was price folllowed by organic certification.

c) MNL Model for Egyptian consumers choice for orange juice

- **Model fitting information**

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Null	7734.166			
Final	3589.261	4144.905	21	.000

The likelihood ratio chi-square of 4144.905 with a p-value < 0.0001 means that the model fits significantly better than an empty model (i.e., a model with no predictors)

- **Model fitting information**

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Organic certification j= 1	4413.640	824.379	3	.000
Environmental certification j= 2	3607.727	18.466	3	.000
Fairtrade certification j=3	3615.745	26.483	3	.000
Price per litre j=5	4056.678	467.417	3	.000
Packaging j=4	3592.417	3.155	3	.368
Educational level j=6	3619.720	30.459	3	.000
Average household income j=7	3599.425	10.164	3	.017

The chi-square statistic is the difference in -2 log-likelihoods between the final and reduced models. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

These results contain likelihood ratio tests of the overall contribution of each independent variable to the model. All the predictors are statistically significant with a p-value < 0.05, except for (Packaging) with p-value=0.368 which implies that packaging is insignificant.

- **MNL Model**

The MNL model is analysed using IBM SPSS statistics 21

Choice[a]	Variables X_{ij}	β_{ij}	Std. Error	df	Sig.	Exp(B)
Pasteurized 100% Juice $i = 1$	*Organic certification* $j = 1$	2.238	.148	1	.000	9.376
	Environmental certification $j = 2$	.547	.106	1	.000	1.728
	Fairtrade certification $j = 3$	.657	.106	1	.000	1.929
	Packaging $j = 4$	.116	.105	1	.269	1.123
	Price per litre $j = 5$	-.623	.036	1	.000	.536
	Educational level $j = 6$	.116	.023	1	.000	1.123
	Average household income $j = 7$	.058	.040	1	.148	1.059
Probiotic $i = 2$	*Organic certification* $j = 1$	2.123	.139	1	.000	8.353
	Environmental certification $j = 2$	.495	.100	1	.000	1.640
	Fairtrade certification $j = 3$	.662	.101	1	.000	1.939
	Packaging $j = 4$	.203	.099	1	.042	1.224
	Price per litre $j = 5$	-.580	.034	1	.000	.560
	Educational level $j = 6$	.106	.022	1	.000	1.112
	Average household income $j = 7$	.037	.038	1	.327	1.038
Nectar $i = 3$	*Environmental certification* $j = 2$	.558	.124	1	.000	1.747
	Fairtrade certification $j = 3$	.793	.126	1	.000	2.209
	Packaging $j = 4$	.202	.123	1	.099	1.224
	Price per litre $j = 5$	-.347	.038	1	.000	.706
	Educational level $j = 6$	-.054	.026	1	.038	.947
	Average household income $j = 7$	.022	.047	1	.637	1.022

[a]The refrence category is 0

The model shows that the educational level for the Egyptian juice consumers affect significantly there choice for the type of juice, as the level of education increase consumers are more probable to go for healthier choices so, the consumer is more likely to choose NFC orange juice and probiotic orange drink. Also, the organic certifications signficantly influnce consumer choices for probiotic orange drink and NFC orange juice, while fairetrade certification influnce consumer selection of Nectar orange drink.

d) Willingness to pay and price sensitivity curves.

100% Pasteurized orange juice

Variables	B	WTP (EGP)
Price per liter (product attribute)	-0.083	
Organic certification (product attribute)	2.22	26.78
Environmental certification (product attribute)	0.264	3.18
Fairtrade certification (product attribute)	0.221	2.66
Packaging (product attribute)	-0.108	-1.30
Educational level (socio-economic variable)	0.088	1.060
Average household income (socio-economic variable)	0.072	0.867

Orange probiotic drink

Variables	B	WTP (EGP)
Price per liter (product attribute)	-0.088	
Organic certification (product attribute)	2.441	27.74
Environmental certification (product attribute)	0.07	0.795
Fairtrade certification (product attribute)	0.398	4.52
Packaging (product attribute)	-0.121	-1.375
Educational level (socio-economic variable)	0.06	0.682
Average household income (socio-economic variable)	0.131	1.49

Nectar orange juice

Variables	B	WTP (EGP)
Price per liter (product attribute)	-0.041	
Environmental certification (product attribute)	0.518	12.63
Fairtrade certification (product attribute)	0.471	11.48
Packaging (product attribute)	0.118	2.88
Educational level (socio-economic variable)	-0.192	-4.682
Average household income (socio-economic variable)	-0.096	-2.341

Figure 23 Egyptian consumer WTP based on the MNL model

Figure 3 shows willingness to pay for each product level, it is infered that consumers in Egypt are willing to pay 120% more for organic probiotic orange drinks, and they are willing to pay 112% more for oraganic certified NFC, than the traditional commertial nectar orange dring that is environmentally certified.

Figure 3 showes the impact of the educational level on consumers willingness to pay for 1 Liter of organic NFC orange juice and probiotic orange drink that are sold in cartoon tetra pack packaging.

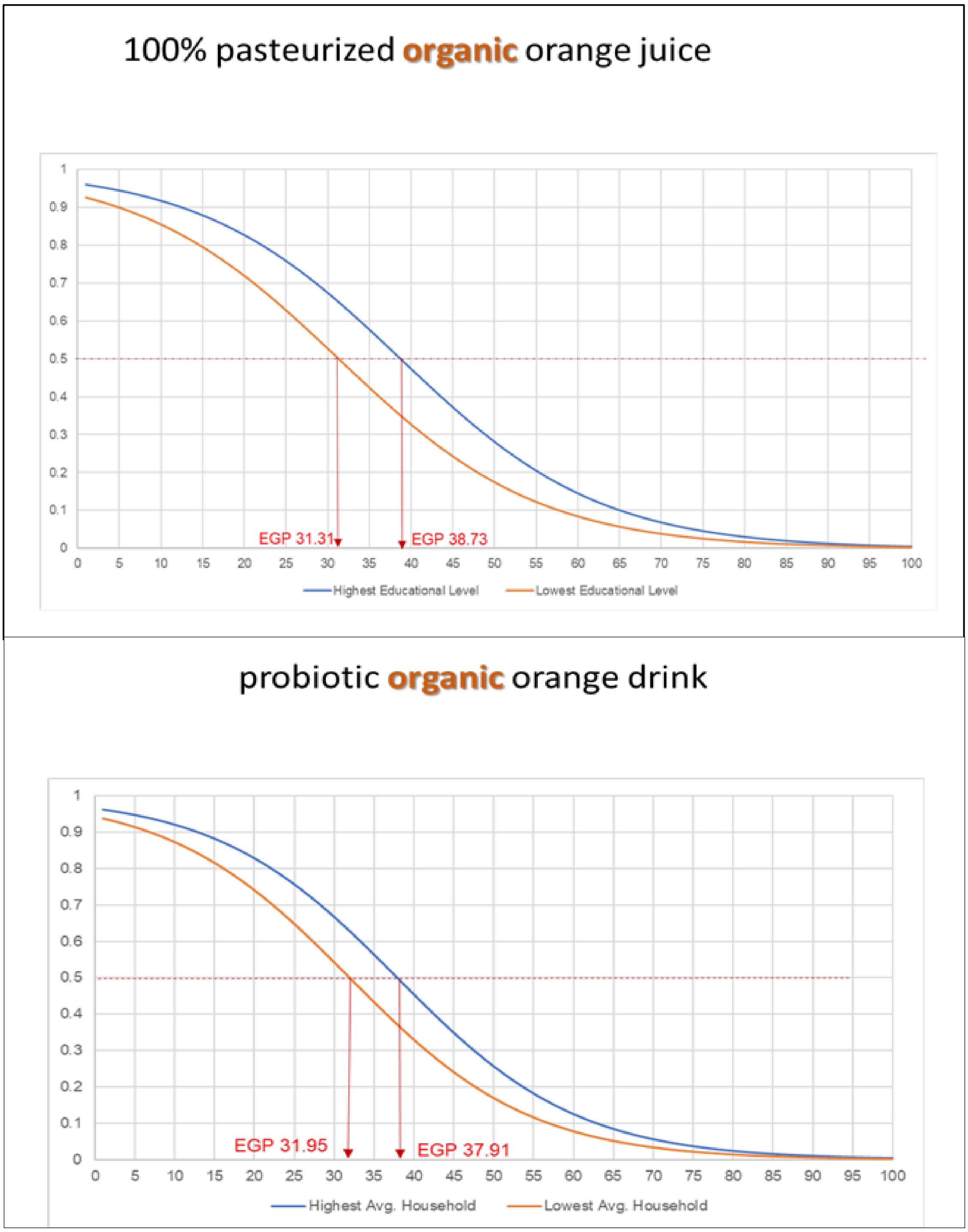

Figure 24 Price sensitivity curves for organic NFC and Probiotic (Egypt)

3.2.2 Results and analysis for Tunisian data

a) Demographics and socioeconomics of the target group

- ***Target population:*** Tunisian juice drinkers whose ages is ranging from 15 to more than 50
- ***Sample size:*** 200 respondent
- ***Gender distribution:***

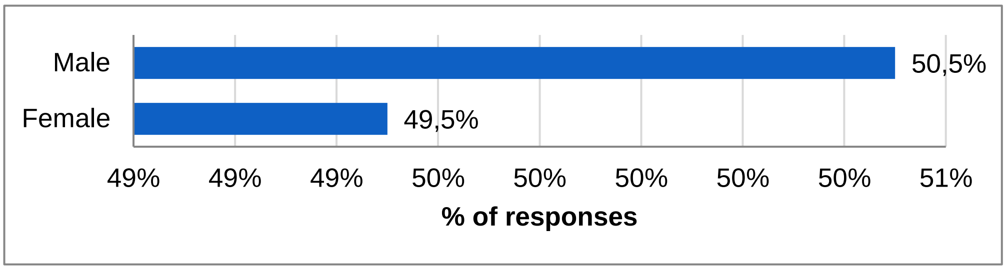

Figure 25 Gender distribution for Tunisia survey

Tunisia's population in 2022, 49.995 percent of Tunisian's population are male, while 50.05 percent of the population are fmale. So, the sample gender distribution is almost same to the actual.

- ***Age distribution:***

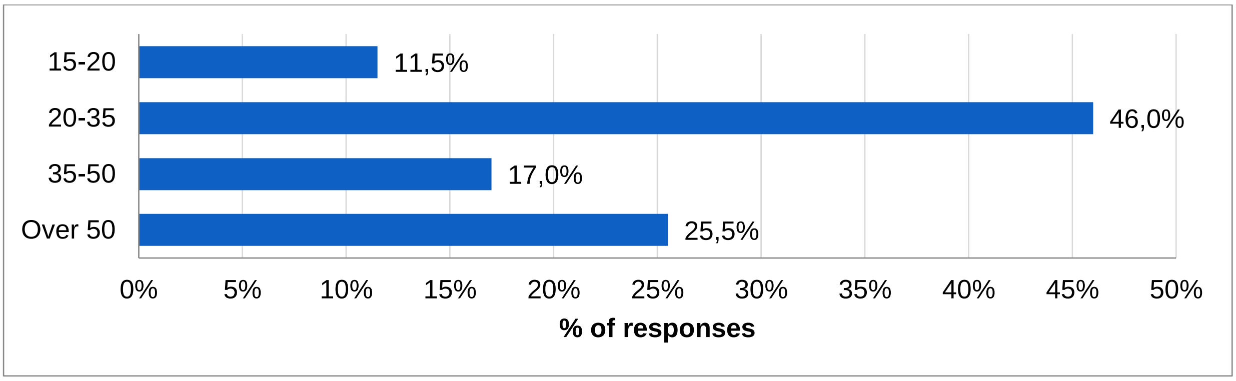

Figure 26 Age distribution for Tunisia survey

- ***Educational level distribution[3]:***

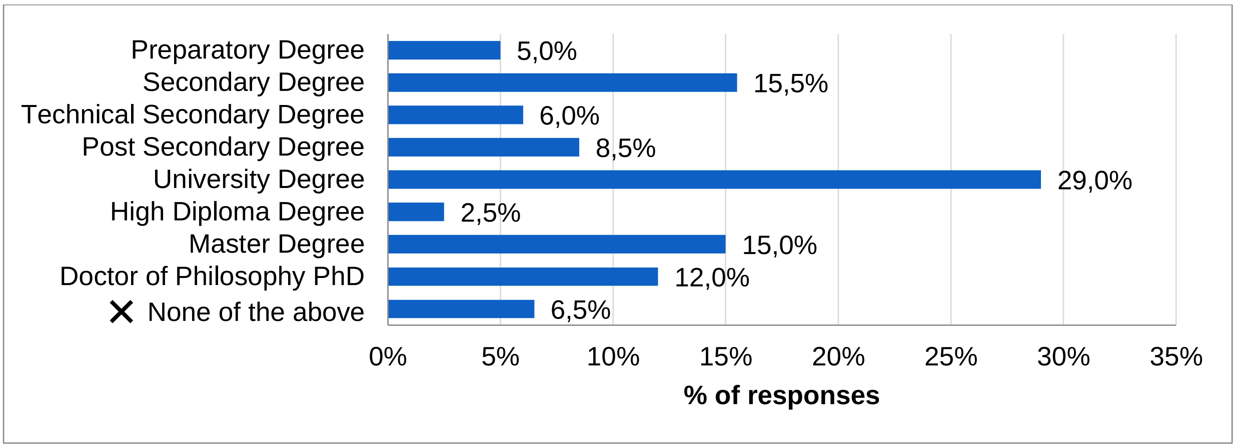

Figure 27 Educational level distribution Tunisia survey

- ***Average household income distribution[4]:***

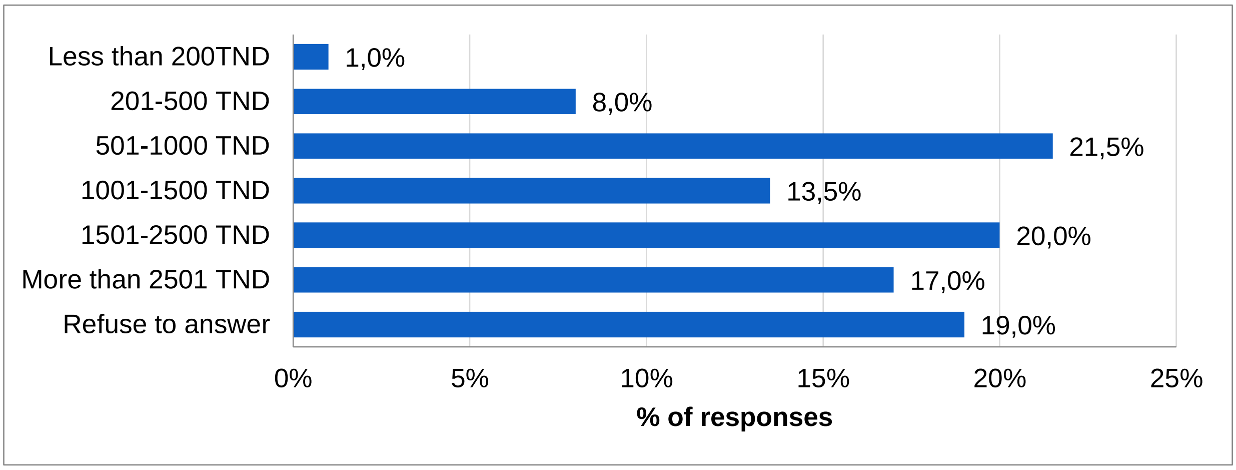

Figure 28 Average monthly household income distribution Tunisia survey

[3] The educational level used is according to the Tunisian census data
[4] The minimum average household income used is according to the Tunisian census data

b) Descriptive analysis

.

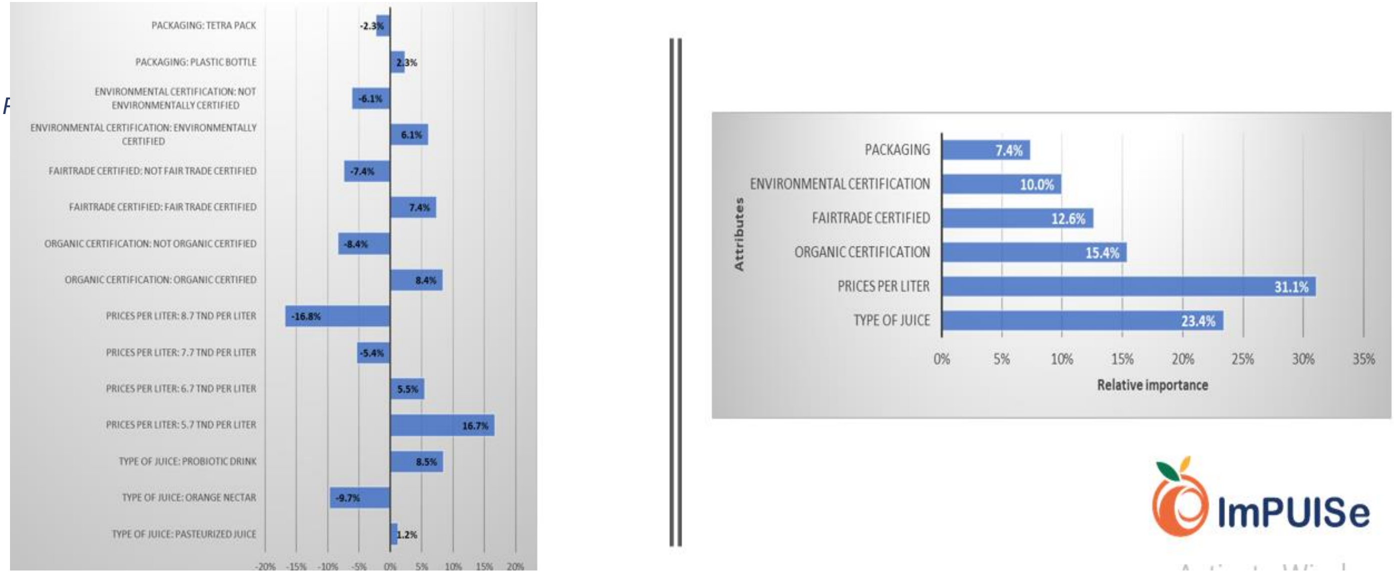

Figure 29 Average utility diagram and attribute importance for Tunisia

The average utility diagram in Figure 3 shows that the price level 5.7 TND per Liter has the highest utility followed our innovative probiotic orange juice, at the same figure on the right the attribute importance is illustrated, showing that the most important attribut was price folllowed by type of juice and at the third place the organic certification.

c) MNL Model for Tunisian consumers choice for orange juice

- **Model fitting information**

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Null	8188.765			
Final	4041.327	4147.438	21	.000

The likelihood ratio chi-square of 4147.438 with a p-value < 0.0001 means that the model fits significantly better than an empty model (i.e., a model with no predictors)

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Organic certification j= 1	4678.183	636.856	3	.000
Environmental certification j= 2	4741.930	700.603	3	.000
Fairtrade certification j=3	4098.923	57.597	3	.000
Packaging *j*=4	4141.104	99.777	3	.084
Price per litre j=5	4047.978	6.651	3	.000
Educational level j=6	4090.978	49.651	3	.000
Average household income j=7	4043.982	2.656	3	.448

The chi-square statistic is the difference in -2 log-likelihoods between the final and reduced models. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

These results contain likelihood ratio tests of the overall contribution of each independent variable to the model. All the predictors are statistically significant with a p-value < 0.05, except for (Packaging) with p-value=0.084 which implies that packaging is insignificant, and, the average household income with p-value=0.084.

- **MNL Model**

The MNL model is analyzed using IBM SPSS statistics 21

Choice[a]	Variables X_{ij}	β_{ij}	Std. Error	df	Sig.	Exp(B)
Pasteurized 100% Juice $i = 1$	*Organic certification* $j = 1$	2.238	.036	1	.000	9.376
	Environmental certification $j = 2$	.547	.148	1	.000	1.728
	Fairtrade certification $j = 3$	.657	.106	1	.000	1.929
	Packaging $j = 4$	.116	.106	1	.269	1.123
	Price per litre $j = 5$	-.623	.105	1	.000	.536
	Educational level $j = 6$	.116	.023	1	.000	1.123
	Average household income $j = 7$	.058	.040	1	.148	1.059
Probiotic $i = 2$	*Organic certification* $j = 1$	2.123	.139	1	.000	8.353
	Environmental certification $j = 2$	.495	.100	1	.000	1.640
	Fairtrade certification $j = 3$	.662	.101	1	.000	1.939
	Packaging $j = 4$	.203	.099	1	.042	1.224
	Price per litre $j = 5$	-.580	.034	1	.000	.560
	Educational level $j = 6$	.106	.022	1	.000	1.112
	Average household income $j = 7$	.037	.038	1	.327	1.038
Nectar $i = 3$	*Environmental certification* $j = 2$	.558	.000	1	.000	.706
	Fairtrade certification $j = 3$	.793	.000	1	.000	1.747
	Packaging $j = 4$	.202	.099	1	.099	2.209
	Price per litre $j = 5$	-.347	.000	1	.000	1.224
	Educational level $j = 6$	-.054	.038	1	.038	.947
	Average household income $j = 7$	.022	.637	1	.637	.915

[a]The refrence category is 0

The model shows that the educational level for the Tunisian juice consumers affect significantly there choice for the type of juice, as the level of education increase consumers are more probable to go for healthier choices so, the consumer is more likely to choose NFC orange juice and probiotic orange drink. Also, the organic certifications signficantly influnce consumer choices for probiotic orange drink and NFC orange juice, while fairetrade certification influnce consumer selection of Nectar orange drink. Tunisian conumers are behaving simailr to Egyptians in making drink choices.

d) Willingness to pay and price sensitivity curves.

100% Pasteurized orange juice

Variables	B	WTP (TND)
Price per liter (product attribute)	-0.623	
Organic certification (product attribute)	2.238	3.59
Environmental certification (product attribute)	0.547	0.88
Fairtrade certification (product attribute)	0.657	1.05
Packaging (product attribute)	0.116	0.19
Educational level (socio-economic variable)	2.238	3.59
Average household income (socio-economic variable)	0.547	0.88

Orange probiotic drink

Variables	B	WTP (TND)
Price per liter (product attribute)	-0.58	
Organic certification (product attribute)	2.123	3.66
Environmental certification (product attribute)	0.495	0.85
Fairtrade certification (product attribute)	0.662	1.14
Packaging (product attribute)	0.203	0.35
Educational level (socio-economic variable)	0.106	0.18
Average household income (socio-economic variable)	0.037	0.06

Nectar orange juice

Variables	B	WTP (TND)
Price per liter (product attribute)	-0.347	
Environmental certification (product attribute)	0.558	1.61
Fairtrade certification (product attribute)	0.793	2.29
Packaging (product attribute)	0.202	0.582
Educational level (socio-economic variable)	-0.054	-0.156
Average household income (socio-economic variable)	0.022	0.0634

Figure 31 Tunisian consumer WTP based on the MNL model

Figure 3 shows willingness to pay for each product level, it is infered that consumers in Tunisia are willing to pay 127% more for organic probiotic orange drinks, and they are willing to pay 123% more for oraganic certified NFC, than the traditional commertial nectar orange dring that is environmentally certified.

Figure 3 showes the impact of the educational level on consumers willingness to pay for 1 Liter of organic NFC orange juice and probiotic orange drink that are sold in cartoon tetra pack packaging.

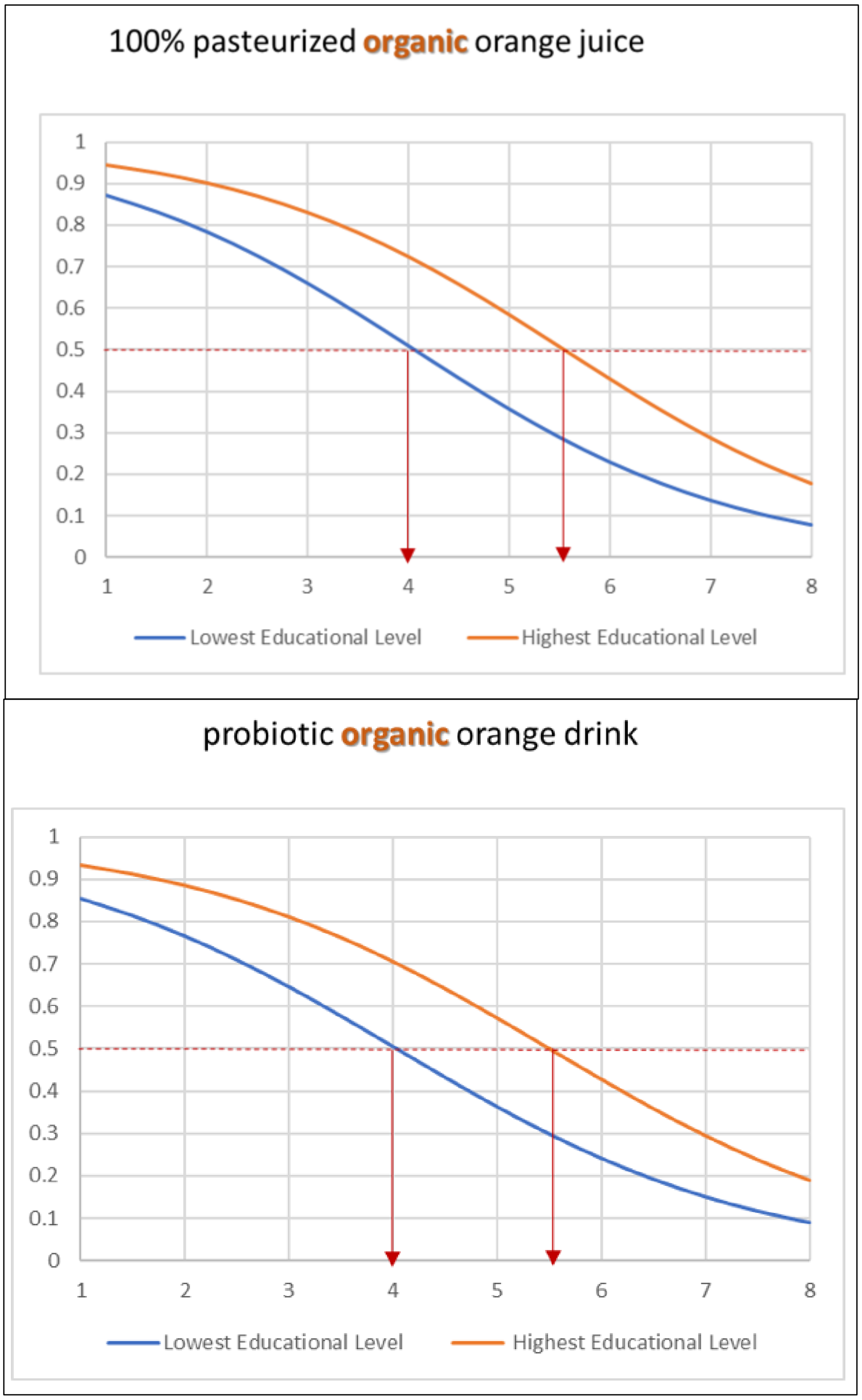

Figure 32 Price sensitivity curves for organic NFC and Probiotic (Tunisia)

3.2.3 Results and analysis for Algerian data

a) Demographics and socioeconomics of the target group

- ***Target population:*** Algerian juice drinkers whose ages is ranging from 15 to more than 50
- ***Sample size:*** 209 respondents
- ***Gender distribution:***

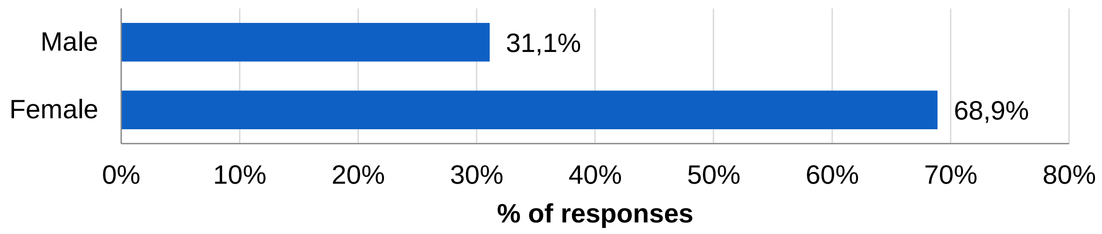

Figure 33 Gender distribution for Algeria survey

Algerians 's population in 2022, 49.995 percent of Tunisian's population are male, while 50.05 percent of the population are fmale. So, the sample gender distribution is almost same to the actual.

- ***Age distribution:***

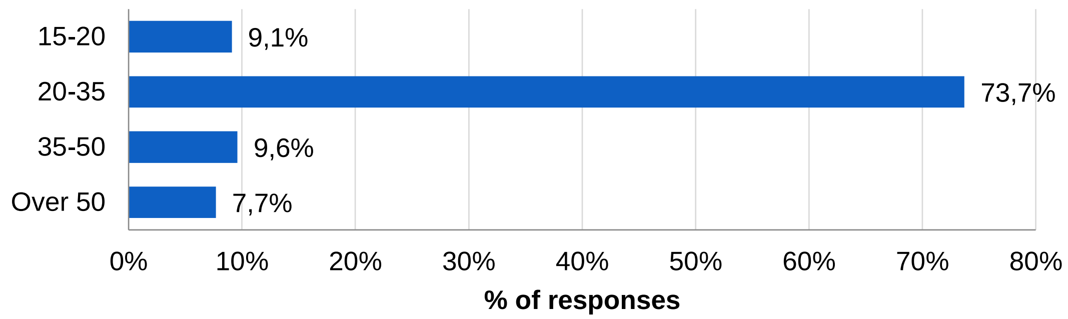

Figure 34 Age distribution for Algeria survey

- ***Educational level distribution:***

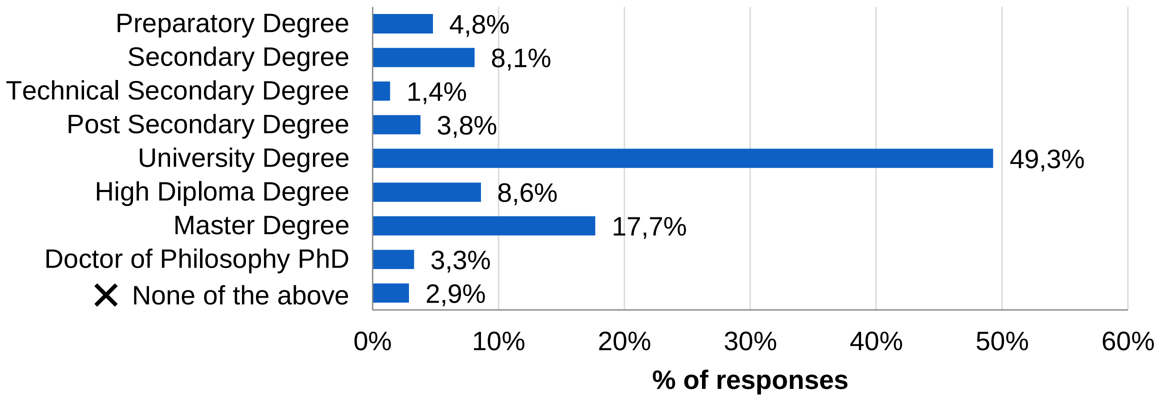

Figure 35 Educational level distribution for Algeria survey

- ***Average household income distribution:***

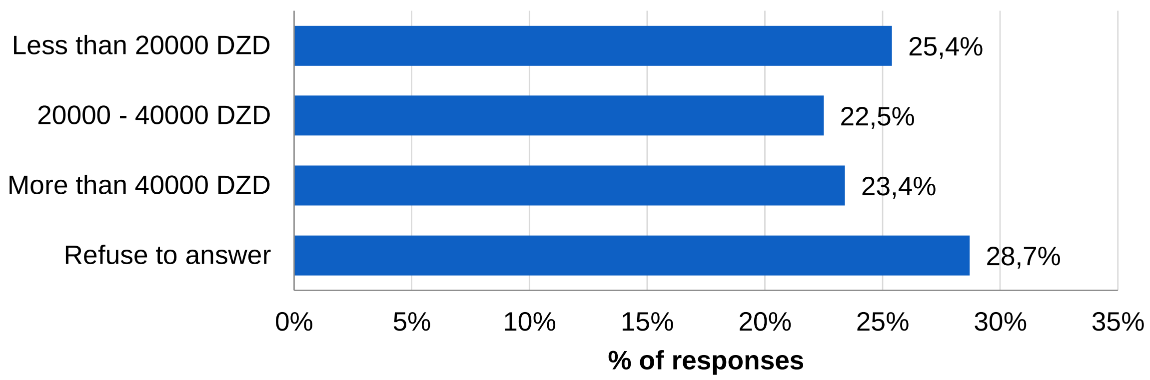

Figure 36 Average household income distribution for Algeria survey

b) Descriptive analysis

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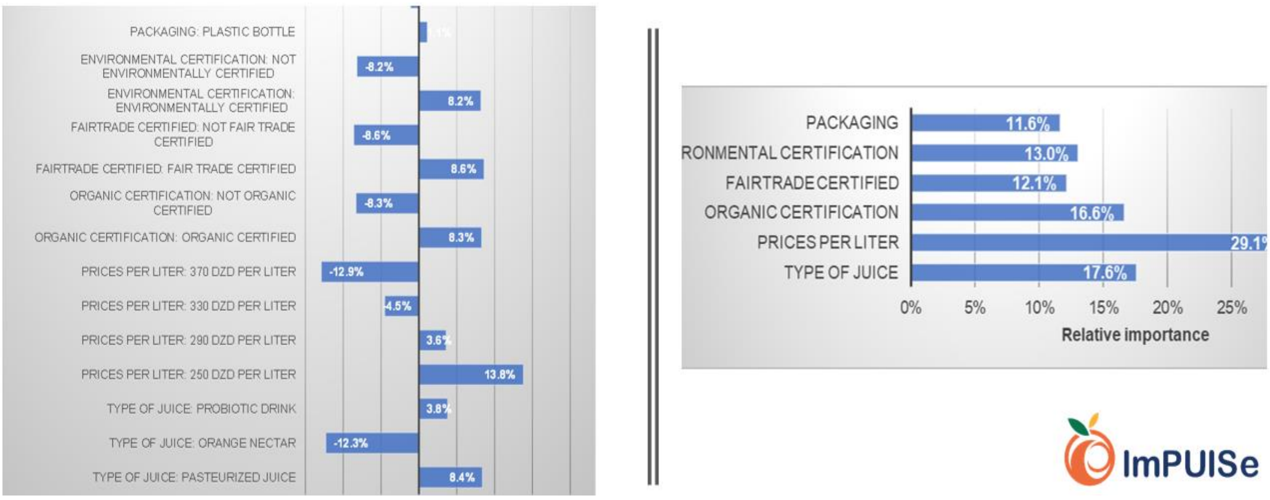

Figure 37 average utility diagram and attribute importance for Algeria

The average utility diagram in Figure 18 shows that the price level 250 DZD per Liter has the highest utility followed by the our innovative drink the probiotic orange juice, at the same figure on the right the most important attribut was price folllowed by type of juice and at the third place the organic certification.

c) MNL Model for Algerian consumers choice for orange juice

- **Model fitting information**

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Null	7232.578			
Final	3928.395	3304.183	21	.000

The likelihood ratio chi-square of 3304.183 with a p-value < 0.0001 means that the model fits significantly better than an empty model (i.e., a model with no predictors)

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Organic certification j= 1	4700.962	772.567	3	.000
Environmental certification j= 2	3985.536	57.141	3	.000
Fairtrade certification j=3	3990.221	61.826	3	.000
Packaging *j*=4	3929.263	0.868	3	.833
Price per litre j=5	4226.644	298.250	3	.000
Educational level j=6	3931.251	2.856	3	.414
Average household income j=7	3935.291	6.897	3	.075

The chi-square statistic is the difference in -2 log-likelihoods between the final and reduced models. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

These results contain likelihood ratio tests of the overall contribution of each independent variable to the model. All the sustainability predictors and price per litre are statistically significant with a p-value < 0.05, packaging, educational level, and average household income are insignificant with a p-value > 0.05, for the average household income it is slightly insignificant with a p-value = 0.075.
This is as 28.7% of the respondents refused to state their average household income, so their average household income is assumed to be at the highest level, this assumption is made according to the distribution of the educational level as it is skewed to the right the following table shows the results of kurtosis test done for educational levels excluding the “none of the above” which are negligible number of responses. While “none of the above” responses are used for the educational level variable by setting their values at the highest educational level.

	Kurtosis	
	Statistic	Std. Error
Educational level	1.459	.076

- **MNL Model**

The MNL model is analyzed using IBM SPSS statistics 21

Choice[a]	Variables X_{ij}	β_{ij}	Std. Error	df	Sig.	Exp(B)
Pasteurized 100% Juice $i = 1$	*Organic certification* $j = 1$	1.624	.121	1	.000	5.071
	Environmental certification $j = 2$	0.516	.092	1	.000	1.675
	Fairtrade certification $j = 3$	0.535	.092	1	.000	1.708
	Packaging $j = 4$	-0.007	.091	1	.943	.993
	Price per litre $j = 5$	-0.009	.001	1	.000	.991
	Educational level $j = 6$	-0.020	.024	1	.395	.980
	Average household income $j = 7$	0.057	.039	1	.145	1.059
Probiotic $i = 2$	*Organic certification* $j = 1$	1.867	.129	1	.000	6.469
	Environmental certification $j = 2$	0.485	.095	1	.000	1.624
	Fairtrade certification $j = 3$	0.449	.095	1	.000	1.567
	Packaging $j = 4$	0.072	.094	1	.447	1.074
	Price per litre $j = 5$	-0.010	.001	1	.000	.990
	Educational level $j = 6$	-0.006	.025	1	.812	.994
	Average household income $j = 7$	0.020	.041	1	.620	1.020
Nectar $i = 3$	*Environmental certification* $j = 2$	0.512	.108	1	.000	1.668
	Fairtrade certification $j = 3$	0.454	.108	1	.000	1.575
	Packaging $j = 4$	-0.043	.107	1	.685	.957
	Price per litre $j = 5$	-0.004	.001	1	.000	.996
	Educational level $j = 6$	-0.043	.028	1	.117	.958
	Average household income $j = 7$	-0.089	.046	1	.052	.915

[a]The refrence category is 0

The model shows that for the Algerian juice consumers the socio-economic factors have no influence on there choice for orange juice, unlike the Egyptian and Tunisian consumers. The average household income has a slight influence on purchase decision for Nectar drink, as the household income increase Algerian consumer are less likely to buy Nectar dring. The organic certification highly impact their choice for NFC orange juice and probiotic orange drink. Also, price is a significant determinant for the consumer choice for all three types of juice.

d) Willingness to pay and price sensitivity curves.

100% Pasteurized orange juice

Variables	B	WTP (DZD)
Price per liter (product attribute)	-0.009	
Organic certification (product attribute)	1.624	180.4
Environmental certification (product attribute)	0.516	57.3
Fairtrade certification (product attribute)	0.535	59.4
Packaging (product attribute)	-0.007	-0.778
Educational level (socio-economic variable)	-0.02	-2.22
Average household income (socio-economic variable)	0.057	6.33

Orange probiotic drink

Variables	B	WTP (DZD)
Price per liter (product attribute)	-0.01	
Organic certification (product attribute)	1.867	186.7
Environmental certification (product attribute)	0.485	48.5
Fairtrade certification (product attribute)	0.449	44.9
Packaging (product attribute)	0.072	7.2
Educational level (socio-economic variable)	-0.006	-0.6
Average household income (socio-economic variable)	0.02	2

Nectar orange juice

Variables	B	WTP (DZD)
Price per liter (product attribute)	-0.004	
Environmental certification (product attribute)	0.512	128
Fairtrade certification (product attribute)	0.454	113.5
Packaging (product attribute)	-0.043	-10.75
Educational level (socio-economic variable)	-0.043	-10.75
Average household income (socio-economic variable)	-0.089	-22.25

Figure 38 Algerian consumer WTP based on the MNL model

Figure 3 shows willingness to pay for each product level, it is infered that consumers in Algeria are willing to pay 45.9% more for organic probiotic orange drinks, and they are willing to pay 40.6% more for oraganic certified NFC, than the traditional commertial nectar orange dring that is environmentally certified.
Figure 3 showes the insignificant impact of the household income on consumers willingness to pay for 1 Liter of organic NFC orange juice and probiotic orange drink that are sold in cartoon tetra pack packaging.

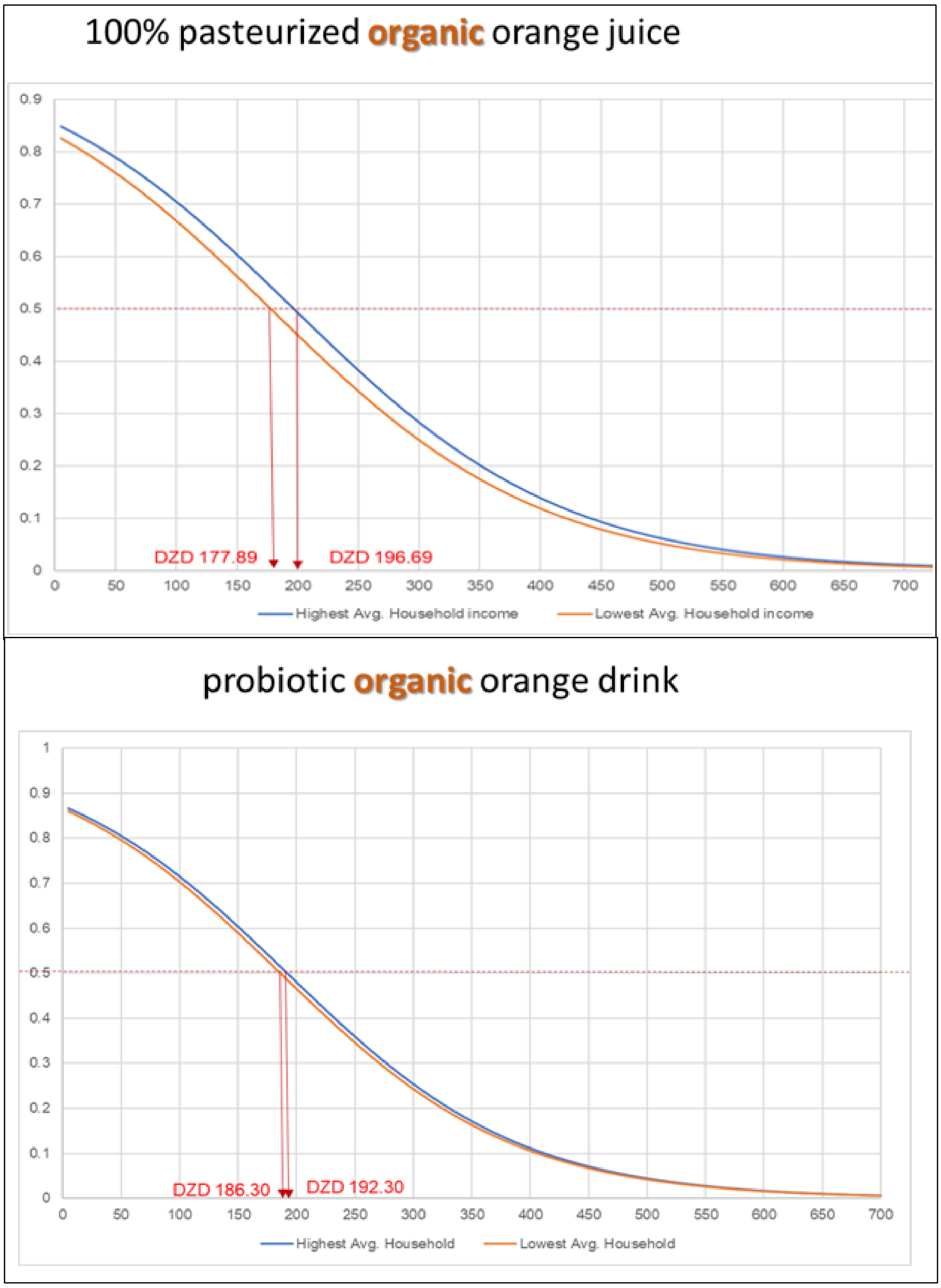

Figure 39 Price sensitivity curves for organic NFC and Probiotic (Algeria)

4 Discussion

For the qualitative research, although the conducted review was systimatic but, it encounters some limitations as all the articles are not fully read due to its large number unlike review and conference papers that was fully read and analysised, however we used the articles to conduct another type of analysis (bibliometric analysis for keywords co-occurrence), the analysis results was that all keywords are related to citrus processing waste valorization no keywords releated to barriers was found.

In other search using googlescholare other papers founds that are stating barriers, some highlighted the same concluded from the systematic review research, and someother mentioned futher barriers. The barriers and there related litreture is listed in Table 1 .

Table 10 Barriers listed in sources outside the reviewed papers.

Barrier	Source
1. Chemical fertilizers, pesticides, and fungicides	(Yadav et al., 2022), (Durán-Lara et al., 2020), (Beccali et al., 2010), (Drábová et al., 2022)
2. Plant bacterial diseases	(Fava Neves et al., 2020), (Mendonca LBP, 2017)
3. Exotic and emerging dangerous citrus viruses	(Catara et al., 2021)
4. Irrigation water availability	(Beccali et al., 2010)
5. Irrigation water quality	(Fava Neves et al., 2020)
6. Toxic heavy metals	(Mamma & Christakopoulos, 2014),(Fava Neves et al., 2020)
7. Fuel used in cultivation, transportation, and processing	(Beccali et al., 2010), Egyptian dried peels exporter
8. Dynamics of consumption that impact consumer choices for food and fruit beverage market (consumer behavior towards the choice of orange juice)	(Fava Neves et al., 2020)
9. The preference of citrus processors regarding the contract characteristics between juice processors and CPW processors such as length of contract	(Raimondo et al., 2018)
10. The distance between the citrus processors and the citrus by-products factory	(Raimondo et al., 2018)
11. Technical and economic feasibility of by-products processing	(Raimondo et al., 2018)
12. Marketing of by-products	(Said & Mamdouh, 2018)
13. Fragmented landholding	(Said & Mamdouh, 2018), Horticultural Export Improvement Association
14. No lands are planted for processing (lack of vertical integration)	The Egyptian Horticultural Export Improvement Association
15. Organic cultivation	(Yadav et al., 2022)
16. Climate change	(Santos et al., 2017)

One of the further barriers fund was to orange juice industries listed the eighth in Table 6, as the fluctuation of demand and its variability within different demographic regions (i.e., a shift in the consumption pattern) was considered a barrier for citrus by-products also, as these by-products are generated during preperation on the main product which is orange juice (Fava Neves et al., 2020), the variability was suggested to be due to the increase in consumer health awareness, and the entrance of innovative and healthier drinks into the marketplace (Fava et al., 2013). (Sorenson & Bogue, 2005) mentioned that fruit juice-based probiotic drinks would become an increasingly important category in future years, and studied the attributes of probiotic orange juice beverages, moreover, one of the valorization paths for CPW in the literature by (Suri et al., 2022) is the utilization of CPW as an ingredient of a functional probiotic drink of significant health benefits. So, from a new product design perspective, it is important to explore what are the functional product attributes, and consumer groups to target with novel functional foods and beverages (Sääksjärvi et al., 2009), so valorization of citrus processing waste for preperation of orange probiotic drink will resolve a problem and achieve a win-win scenario. Other further barriers is listed in the table. Also, (Drábová et al., 2022) highlighted a barrier that was concluded in the systimatic review which is the use of pesticieds, as he proved that residues of chemicals used to protect citrus fruit against various pests, are transferred to beverages and juices, while no residues were detected in citruses from organic farming, which may cause health problems.

Moreover, there are obarriers figured out by governmental bodies and juice processors in Egypt during a workshop conducted in June 2022 at Alexandria University as a part of IMPULSE project activities, the barriers are as follows:

- Lack of farmers awarness about best farming practices, for conforming the eligibility requirements EU market entrance, specially for food products.
- No land is planted for processing, the fruit processed are those left over.
- Distance between juice processor and CPW processor.
- Cost of fuel for drying CPW fuel.
- Lack of marketing practices.

For the quantitive research, however the survey showed that Egyptian, Tunisian, and Algerian consumers, of higher socio-economic status are willing to pay more for probiotic orange drink, there are some limitations to the findings releaded to sensory attribute of the innovative drink, as it was not investigated in this study. Besides, the organic certification showed high influence on consumer purchace descision in the three countries.

5 Conclusion

The citrus processing industry through the circular economy concept carries a lot of opportunities as well as challenges that need further exploration and has a potential impact on the sustainability of the industry.

It's clear that challenges associated to each valorization path are significantly different, according to the degree of value added. As the degree of value added increase some barriers arouse related to:

- High implementation cost which is considered an economic threat.
- Technological readiness.
- Food safety for those applications related to human use.
- Use of pesticides.
- For utilization path related to extraction of bioactive materials there is an environmental barrier related to the use of solvent during extraction although, some literature provides a solution which is so called green extraction processes, but still there is a barrier related to, technological gap, as the study findings are based on lab experiments, and there is a lack of knowledge about requirements for implementation in the industrial scale.
- Logistic barrier related to location of the waste transformation facility, as the distance between waste feedstock supplier and the waste processors implies high transportation cost, besides the supply undergoes degradation in its quality.

Although, utilization of citrus processing waste as a source of functional probiotics is one of the promoted valorization paths in the literature, there is a lack of knowledge about technical requirements production, and consumer willingness to pay for it. However, in our research we examined the market for orange probiotic drink in 3 South Mediterranean countries (Egypt, Algeria, and Tunisia), we found that consumers are willing to pay more significantly, for probiotic orange drink in the 3 countries, than the traditional alternatives existing in the market. It is also found that in Egypt and Tunisia socioeconomic factors significantly influence consumer choice, while in Algeria it has no significant influence.

Our findings may help orange juice processors in these countries, to utilize processing waste to produce functional differentiated product that can compete in the market and promote circular economy using the best option according to waste management hierarchy. By providing willingness to pay information processor can set optimum pricing strategy and can assess the economic viability of producing the innovative probiotic orange drink.

Moreover, through the same study we explored consumer willingness to pay premium for sustainability labels, which is crucial for assessing the economic viability for implementing any change to the supply chain for supporting its sustainability.

At last but not least, despite the significant impact of citrus processing waste valorization on sustainability aspects of citrus supply chains, there is lack of information in regarding the following:

- Pilot-scale systems, industrial transfer, and economic feasibility.
- the applicability of the proposed valorization options that may vary at macro and micro levels according to the technological readiness level and PESTLE analysis.

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