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FOODLIT-tool: Development and validation of the adaptable food literacy tool towards global sustainability within food systems

Raquel Rosas [a,*], Filipa Pimenta [a], Isabel Leal [a], Ralf Schwarzer [b,c]

[a] WJCR - William James Center for Research, ISPA - Instituto Universitário, Lisboa, Portugal
[b] Department of Psychology, Freie Universität Berlin, Berlin, Germany
[c] Department of Clinical, Health, and Rehabilitation Psychology, SWPS University of Social Sciences and Humanities, Wroclaw, Poland

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ABSTRACT

Facing multiple anthropogenic challenges and considering the current global pandemic, food sustainability is stated as threatened by major intergovernmental agencies. Given the heterogeneity of food systems, the need to enhance food-related behaviours by promoting the acquisition of knowledge and competencies, and the demand to involve stakeholder's diversity, this study aims to develop and validate an instrument that measures food literacy (FL), its determinants and its influential factors in an adult sample. Based on the Food Literacy Wheel (FLW) framework and integrated within the FOODLIT-PRO - Food Literacy Project, this study has three phases and a total of 2406 participants: (1) item development and content validity, (2) instrument development entailing item reduction strategies, factor extraction methodologies (exploratory and confirmatory analyses) and sensitivity testing, with two samples of a total of 1447 adults, and (3) instrument validation encompassing tests of dimensionality (confirmatory factor analysis), reliability (composite reliability) and validity (convergent and discriminant validity), and measure invariance testing, with 959 adults. Concerning statistical and psychometric properties, (1) a pool of 40 items (26 for FL; single items: five for determinants and nine for influential factors) was developed with inductive and deductive methodologies and reflected the FLW, (2) a 5-factor structure was explored, demonstrated acceptable model fit, and good sensitivity indices, and (3) a 5-dimensional reliable structure with 24 items was validated, configural invariance was achieved, and convergent and discriminant validity were significant in most dimensions. The FOODLIT-Tool contributes with an innovative measure of FL in adults that allows for a tailored assessment when approaching food-related issues within global food systems, providing a multidisciplinary tool that can be cross-widely applied to promote food-related behaviour change.

1. Introduction

Food systems face major alterations generated from multiple anthropogenic sources, such as the growing global population, an unsettled development of world economy, and insecure climate changes; most recently, the global COVID-19 pandemic has already affected consumers' food consumption behaviours, with more severe impacts threatening food security (FAO, 2019; Laborde et al., 2020; O'Hara & Toussaint, 2021; The World Bank, 2021). Concerning eating behaviours, recent data are beginning to show an increase of unhealthier diets and eating patterns during home confinements across different countries (Ammar et al., 2020). On the topic of food security, COVID-19 has already impacted both people's food access and the stability of food supply chains, with the Food and Agriculture Organization (FAO) of the United Nations (UN) expecting a continuous increase in food insecurity due to the pandemic (UN, 2020).

On a universal call to action, the UN committed to deal with, among many others, significant food- and sustainability-related issues within the Sustainable Development Goals as part of the 2030 Agenda (UN, 2015). Particularly concerning food systems, the urgency to act has demanded for bold strategies and solutions in order to deliver healthier, more equitable, and more sustainable food systems; as a response, the UN will convene a Food Systems Summit mobilising diverse stakeholders from multiple fields, including science, policy, human and environmental health, food industry, among others (UN, 2021).

Intending to integrate these broader and heterogeneous food systems' contexts within the conceptualisation of food literacy, the FOODLIT-PRO - Food Literacy Project (Rosas et al., 2019) has developed

* Corresponding author.
E-mail address: rrosas@ispa.pt (R. Rosas).

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a conceptual and empirical framework designated as Food Literacy Wheel (FLW; Rosas et al., 2021). As so, the FLW (Fig. 1) describes: the essential set of food-related knowledge, competencies and behaviours (that is, food literacy's definition); its enablers and inhibitors (food literacy's determinants); and fields of interplay aiming to tackle wider challenges concerning global sustainability within food systems (food literacy's influential factors). In accordance with the UN's outlook on food systems, the FLW involves (i) nutritional, (ii) psychological, (iii) health, (iv) learning contexts, (v) policy, (vi) industry, (vii) sustainability, (viii) social, and (ix) cultural contexts as influential factors. This unique evidence-based strategy urges to broaden the prospect of developing further food systems-related actions integrating multi-stakeholders and multilevel approaches. Following the FOODLIT-PRO's contribution and considering the lack of evidence encompassing this diversity of stakeholders on the field of food literacy, the need to evaluate these heterogeneous attributes along with the assessment of consumers' food literacy arises (Amouzandeh et al., 2019; Vidgen, 2016).

A recent scoping review was conducted aiming to identify developed instruments that specifically measure food literacy in adults, while compiling their psychometric properties; a total of 12 different tools was reported and these where confronted with the food literacy conceptualisation by Vidgen and Gallegos (Amouzandeh et al., 2019; Fingland et al., 2021; Vidgen & Gallegos, 2014). Including instruments to assess not only food literacy or its indicators but also to evaluated food literacy interventions, this review assembled studies from eight different countries and summarised the psychometric properties of each one. However, as analysed and stated previously (Rosas et al., 2019), the lack of mention regarding environmental, social, political, and cultural features in this and other frameworks (e.g., Cullen et al., 2015; Desjardins et al., 2013) have led to the development of FOODLIT-PRO's FLW (Rosas et al., 2021). Furthermore, the crucial need of sustainable food systems - linking all economical, social, and environmental aspects - emphasises the demand to consider these influential factors within the assessment and posterior intervention not only on consumers' food literacy but also on food-related supply chains and associated contexts. More recently, and highlighting the topic of sustainability and food systems, a Korean team developed a questionnaire integrating multiple elements (such as production, processing, and distribution) as part of a food system domain, driven from a literature review (Park et al., 2020). Nonetheless, given (i) the limited literature scope regarding the absence of significant attributes despite evidence to impact food literacy (e.g., industry, policy or psychological features), and (ii) the limited studied sample and related psychometric analyses, further research is needed in order to integrate food systems' sustainability within food literacy's assessment (Park et al., 2020).

Hence, this study aimed to develop, test, and validate a quantitative assessment tool to measure (i) food literacy, (ii) its determinants, and

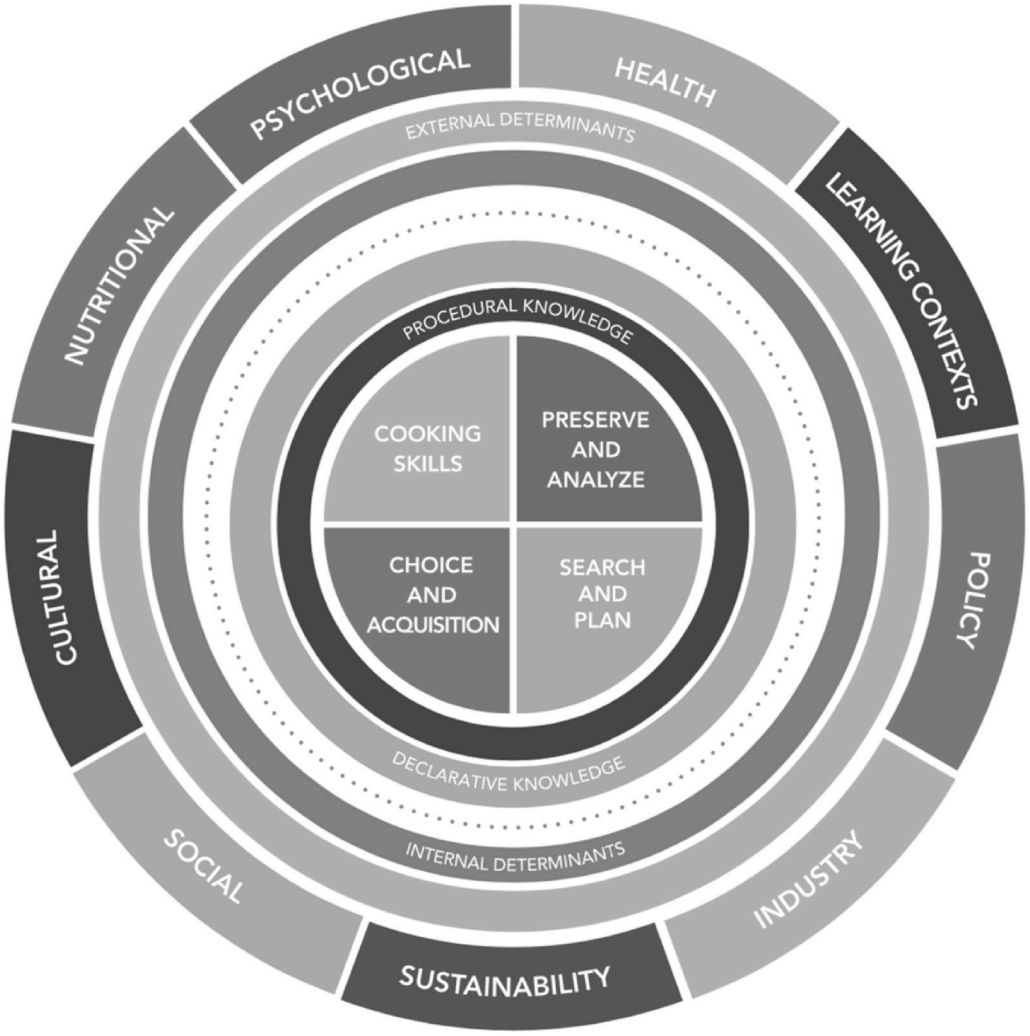

Fig. 1. Food Literacy Wheel (FLW) presenting (from the inner core to the outside rings) the four-dimensional definition of food literacy (cooking skills, preserve and analyse, search and plan, and choice and acquisition), associated knowledge (procedural and declarative), its determinants (internal and external), and its influential factors (health, learning contexts, policy, industry, sustainability, social, cultural, nutritional, and psychological).

(iii) influential factors, according to the conceptual and empirical framework FLW (Rosas et al., 2021), in the adult Portuguese population.

2. Methods

Subsequent to a qualitative exploration of food literacy's definition, determinants and influential factors (Rosas et al., 2019) and the development of a conceptual and empirical framework with a mixed methodology (Rosas et al., 2021), the present study was designed with three different Phases (incorporating a total of six Steps; according to Boateng et al., 2018) aimed to develop and validate an instrument that assesses the diverse food-related knowledge, competencies and behaviours included in the FOODLIT-PRO's FLW (Rosas et al., 2021).

2.1. Phase 1: item development and content validity

With the purpose of specifying the construct's (i) dimensions, (ii) its determinants, including its enablers and constrainers, and (iii) influential factors, the FLW indicated that food literacy incorporates four dimensions: Cooking Skills, Preserve and Analyse, Choice and Acquisition, and Search and Plan (Rosas et al., 2021). Driven by a mixed methodology, these dimensions provided the conceptual and empirical definition needed for the domain's identification (Boateng et al., 2018).

A pool of items was posteriorly generated by using both deductive and inductive methods. The first refers to the literature review previously performed (Rosas et al., 2019), which guided the development of the deductive-derived items. The second regards the qualitative data driven from semi-structured interviews with 30 food experts, which had been the stepping stone for designing the FLW (Rosas et al., 2021) and for the generation of the inductive-driven items.

According to Boateng et al. (2018), content validity entails the need for content pertinence, representativeness, and technical quality. The process of item generation and assembling considered both theory- and data-driven content, given its basis on a previously acknowledged conceptual and empirical framework of *food literacy* (Rosas et al., 2021). As the development of the constructs' dimensions within the FLW entailed (i) the literature review of the most recent state of the art (Rosas et al., 2019) and (ii) the contribution of 30 experts working on food-related contexts (including food production, processing, distribution, marketing, consumption and disposing, along with additional fields - such as education, human and environmental health, policy-making, and sustainability; Rosas et al., 2021), the matching of theoretical- and data-derived content on this process not only comprised specialised expertise but also ensured for content relevance and representativeness.

2.2. Phase 2: instrument development

2.2.1. Step 1 - pre-testing questions

In order to (i) minimise the misunderstanding of the items and consequent measurement error (Boateng et al., 2018), (ii) test for readability, (iii) account for usability of the online platform, and (iv) identify and rectify minor language amendments, pilot surveys were conducted with other psychology researchers from the William James Center for Research at ISPA - Instituto Universitário.

2.2.2. Step 2 - survey administration and sample size

All data were collected using software programs (namely, Typeform and SurveyHero) that allowed participants to fulfil the required survey on either laptops, tablets, or smartphones. The use of technology was preferred in all moments of data collection given its ability to (i) reduce the errors related with data logging, (ii) increase response rates, (iii) allow for data collection from larger samples with minimal costs, and (iv) constant monitoring of data collection (Fanning & McAuley, 2014; Greenlaw & Brown-Welty, 2009). Furthermore, given the onset of the COVID-19 pandemic during data collection, online participants' recruitment and data collection were chosen for all samples. The ideal ratio of 10:1 (the minimum of 10 participants for each item) was followed (Nunnally, 1978).

To ensure data availability for both the development and validation of the FOODLIT-Tool, three samples were collected at two points in time. The first two samples (for the instrument development) were concomitantly collected from May to July 2019, and the third sample (for the instrument validation) was collected in August 2020. These community samples were recruited through social media (Instagram and Facebook), by reaching out to diverse health-related platforms and accounts; inclusion criteria were: being at least 18 years old, and having minimum literacy and internet access in order to understand and reply to a digital and online questionnaire. Additionally to the items belonging to the FOODLIT-Tool, a sociodemographic questionnaire was applied to all samples, aiming to collect self-reported data concerning sociodemographic characteristics (e.g., sex, age, educational level) and health-related behaviours (e.g., tasks for which one is responsible for in the food routine, encompassing choice and decision, selection and acquisition, preparation, and cooking; Vidgen & Gallegos, 2014).

This study was approved by the Ethics Committee of ISPA – Instituto Universitário (ref. D/002/03/2018), performed in accordance with the Declaration of Helsinki, followed the ethical principles and deontological norms of the Order of Portuguese Psychologists, and adhered to General Data Protection Regulation.

2.2.3. Step 3 - item reduction, factor extraction, and sensitivity

In order to understand the internal structure on the assembled set of items, an exploratory factor analysis (EFA; Sample 1) was performed. To determine the potential number of underlying factors, the following criteria were applied: eigenvalues >1, scree plot analysis, factor loadings above 0.30, a minimum of 50% of explained variance, plausibility of the factors in terms of their substantive meaning, and link to their conceptual and empirical basis considering the FLW (Rosas et al., 2021). The Bartlett's test of sphericity (with a significance level of 0.05) and Kaiser-Meyer-Olkin (KMO; with a cut-off for suitability set at > 0.60) were used to assess the adequacy of the data for EFA (Kaiser, 1974).

To allow for the systematic comparison of the a priori factor structure obtained with the EFA, a confirmatory factor analysis (CFA; Sample 2) was conducted to estimate the relationship between latent variables and assess further model fit indices. The model fit indices considered were chi-square statistics (χ^2/df), standardised root mean square residual (SRMR), root mean square error of approximation (RMSEA), comparative fit index (CFI), goodness of fit index (GFI); reference values indicative of adequate model fit were considered according to Hu and Bentler (1999), Byrne (2016), and Boateng et al. (2018).

In both factor analysis, item reduction was performed (i) whenever criteria were not met, and (ii) as long as the removal of an item did not deprive the instrument of theoretical significance, according to the FLW (Rosas et al., 2021).

Sensitivity was analysed according to both minimum and maximum scores of the Likert-type scale, skewness and kurtosis; the latter should have absolute values below 3 and 7, respectively (Marôco, 2014).

2.3. Phase 3: instrument validation

2.3.1. Step 4 - tests of dimensionality and measurement invariance

To confirm and validate the factor structure and dimensionality of the developed measure, a CFA was performed with a new sample (Sample 3); model fit was verified using the same indices as indicated in Step 3.

Considered of essential significance for the test of dimensionality, configural invariance was tested as part of measurement invariance. Regarding the assessment of the hypothesised factor structure, configural invariance is achieved if the model of interest fits across different samples (Boateng et al., 2018; Yu & Shek, 2014). Configural invariance was tested with Sample 2 and Sample 3, and the above mentioned criteria for model fit were applied (Step 3).

2.3.2. Step 5 - tests of reliability

Internal consistency was assessed by composite reliability, and a threshold of 0.70 was applied (DeVellis, 2003; Nunnally, 1978).

2.3.3. Step 6 - tests of validity

Concerning the extent to which the FOODLIT-Tool is capable of measuring the concept of *food literacy* and its entailed domains (Rosas et al., 2021), construct validity was assessed. Occurring when the behaviour of a factor is strongly explained by its items, convergent validity was explored through the average variance extracted (AVE); an AVE equal or above 0.50 was considered appropriate (Fornell & Larcker, 1981). Regarding the ability to discern dissimilar constructs, discriminant validity was analysed by comparing the inter-factors' squared correlation (r^2) with each factor's AVE; when r^2 demonstrated to be smaller than each factor's AVE, discriminant validity was shown (Anderson & Gerbing, 1988; Fornell & Larcker, 1981).

3. Results

3.1. Phase 1: instrument development and content validity

According to the FLW (Rosas et al., 2021), food literacy's conceptualisation includes its four-dimensional definition (Cooking Skills, Preserve and Analyse, Choice and Acquisition, and Search and Plan), determinants (e.g., convenience and practicality, time and financial management), and influential factors (e.g., psychological, sustainability, policy, and industry). A pool of 40 items was developed considering the diverse attributes of food literacy's definition, determinants and influential factors (Table 1; original items in Portuguese are featured in Supplemental files). Intending to assess individuals' food-related knowledge, competencies, and behaviours (that is, *food literacy*; Block et al., 2011; Cullen et al., 2015; Desjardins et al., 2013; Perry et al., 2017; Slater et al., 2018; Thomas et al., 2019; Vidgen & Gallegos, 2014), the FOODLIT-Tool integrates the items referring to the FLW's core, which entails the definition of food literacy. Items concerning both food literacy's determinants and influential factors were designed as single items meant to be used when needed.

As so, a total of (i) 26 items were developed reflecting the four-dimensional definition of food literacy, (ii) five items were created portraying its determinants, and (iii) nine items were intended to represent its influential factors. All items were developed with a four-point Likert-type response scale referring to either frequency (0 - *never*; 1 - *sometimes*; 2 - *frequently*; 3 - *always*) or agreement (0 - *completely disagree*; 1 - *disagree*; 2 - *agree*; 3 - *completely agree*).

3.2. Phase 2: instrument development

3.2.1. Step 1 - pre-testing questions

The study participants (n = 5) regarding the pilot surveys reported that the measure was well understood, clear in meaning and length, and not being time consuming.

3.2.2. Step 2 - survey administration and sample size

The collected samples (Sample 1, 2, and 3) represented a total of 2406 adults, aged between 18 and 69 years ($M_{Sample\ 1} = 28.2$; $SD_{Sample\ 1} = 7.9$; $M_{Sample\ 2} = 27.9$; $SD_{Sample\ 2} = 7.8$; $M_{Sample\ 3} = 30.1$; $SD_{Sample\ 3} = 7.8$). Participants' characteristics are shown in Table 2.

Collected simultaneously for the instrument development (Phase 2) and in the same online platform, Sample 1 (n = 698) and Sample 2 (n = 749) achieved a completion rate of 58.7% and an average completion time of 13 min. Collected posteriorly for the instrument validation (Phase 3), Sample 3 (n = 959) had a response rate of 73.1% and an average completion time of 9 min. The decrease in the average completion time can be understood given that the items concerning food literacy's determinants and influential factors were applied in the samples for the instrument development (Phase 2; Samples 1 and 2), but

Table 1
Pool of items develop in Phase 1 (instrument development and content validity), according to each of the Food Literacy Wheel components (definition, determinants, and influential factors; Rosas et al., 2021).

Food Literacy Definition		Corresponding Items
Cooking Skills	**1**	I easily prepare everything that is necessary to make a meal.
	2	I combine different ingredients to create a suitable meal.
	3	I adapt recipes to be more to my taste.
	4	I use kitchen equipment and utensils (e.g., oven, blender) efficiently.
	5	I cook adequate meals with what I usually have at home.
	6	The quality of the food depends on its origin (e.g., domestic or industrial agricultural production, local or imported products).
	7	It is important for me to avoid consuming foods that contain additives.
	8	I cook in different ways (e.g., stewing, baking).
	9	I enjoy cooking.
Preserve and Analyse	**10**	I have knowledge of different types of preservation (e.g., freezing, salting*) suitable for different foods.
	11	I apply food hygiene and safety practices (e.g., storing food at appropriate temperatures, cleaning utensils).
	12	I recognise the impacts of pesticides and/or herbicides on food.
	13	I know what *organic products* are (e.g., food grown without pesticides).
	14	I know the impact that *organic products* have on food-related sustainability (e.g., less soil contamination).
	15	I buy local/national trade products to support local/national business.
	16	I control the calories and/or other nutritional characteristics of the food I eat daily.
Choice and Acquisition	**17**	I can identify the origin of a food (that is, where a food comes from).
	18	I can identify how a food is produced and processed (that is, how it is manufactured, how it is packaged).
	19	I read and interpret food labels to select the most appropriate foods.
	20	I make informed food choices.
	21	I dedicate time and invest in food selection (e.g., when I go shopping).
Search and Plan	**22**	I eat food according to its seasonality.
	23	I am aware of the time of year of each food.
	24	I can easily substitute one food for another nutritionally equivalent one.
	25	I plan various aspects of my diet.
	26	I plan my meals in advance.
Food Literacy Determinants		**Corresponding Items**
Internal and External	**27**	My financial resources influence my eating habits.
	28	It is hard to find time to invest in my diet.
	29	It is important that my diet is practical and convenient.
	30	Having an adequate diet is a priority for me.
	31	The available information on food is excessive and/or contradictory.
Food Literacy Influential Factors		**Corresponding Items**
Nutritional	**32**	In my diet, I take into account my nutritional needs.
Social	**33**	It is important for me to have the support of those around me (family, friends) regarding my diet.
Health	**34**	My health is influenced by what I eat.
Sustainability	**35**	My food decisions have an impact on the climate's sustainability.
Learning Contexts	**36**	When I have questions about food, I know where to find reliable information.
Cultural	**37**	Moments with my family or with my friends are always accompanied by food.
Industry	**38**	

(*continued on next page*)

Table 1 (*continued*)

Food Literacy Definition	Corresponding Items	
		As a consumer, my food decisions influence the food industry (e.g., availability of food outside its season, importation of food).
Food Policy	**39**	Food policies (e.g., tax on sugary drinks) influence my eating decisions.
Psychological	**40**	My emotions influence my eating habits.

*Salting is a common preservation method for Portuguese food, specifically used for codfish, as well as for some types of meat and cheeses.

Table 2
Participants' socio-demographic characteristics (Sample 1, 2, and 3).

Socio-demographic characteristics	Sample 1		Sample 2		Sample 3	
	n	%	n	%	n	%
Sex						
Female	632	90.5	668	89.2	906	94.5
Male	66	9.5	81	10.8	53	5.5
Affective-sexual relationship						
Yes	524	75.1	557	74.4	691	72.1
No	174	24.9	192	25.6	268	27.9
Children						
Yes	118	16.9	115	15.4	179	19
No	580	83.1	634	84.6	777	81
Educational level						
Middle school	10	1.4	8	1.1	12	1.2
High school	161	23.1	178	23.8	167	17.4
Bachelor	328	46.9	355	47.4	374	39
Master	188	26.9	203	27.1	394	41.1
Doctorate	11	11.6	5	0.7	12	1.3
Professional status						
Active	548	83.7	626	83.6	834	87
Unemployed	113	16.2	119	15.9	123	12.8
Retired	1	0.1	4	0.5	2	.2
Annual household income						
10.000 EUR or less	191	27.4	202	27	167	17.4
10.001 EUR - 20.000 EUR	253	36.2	268	35.8	333	34.7
20.001 EUR - 37.500 EUR	173	24.8	182	24.3	273	28.5
37.501 EUR - 70.000 EUR	61	8.7	75	10	115	12
Above 70.000 EUR	20	2.9	22	2.9	43	4.5
Body Mass Index						
Below normal	35	5	46	6.1	50	5.2
Normal weight	481	68.9	519	69.3	683	71.2
Overweight	142	20.3	137	18.3	160	16.7
Obesity	37	5.3	44	5.9	52	5.4
Food-related Responsability						
Choice and decision	629	90.1	668	89.2	900	93.8
Selection and acquisition	564	80.8	598	79.8	788	82.2
Preparation	556	79.7	594	79.3	821	85.6
Cooking	559	80.1	605	80.8	826	86.1
None	34	4.9	40	5.3	21	2.2

Note: Frequency (n) and percentage (%).

not for the stage of the instrument validation (Phase 3; Sample 3).

3.2.3. Step 3 - item reduction, factor extraction, and sensitivity

Items concerning food literacy's definition.

In all samples, responses to the 26 items regarding food-related knowledge, competencies, and behaviours ranged from 0 to 3 in the Likert-type scale and presented good values of skewness ($-1.901 < Sk < 0.347$) and kurtosis ($-0.975 < Ku < 4.897$).

With sampling adequacy (Sample 1) confirmed by Bartlett's test ($\chi^2 = 5704.2$; $p < .001$) and KMO (0.90), a five-factor structure with varimax rotation, eigenvalue >1 and a total of explained variance of 52.2%, was obtained in an EFA (Table 3). The first factor - Culinary Competencies - entailed items concerning food-related preparation and cooking skills (e.g., adapting recipes, matching ingredients), as well as the importance of one's enjoyment in culinary activities. Considering (i) the association of the items with the FLW (Rosas et al., 2021), (ii) the plausibility of the factors with the respective item loadings and (iii) the non-significant statistical differences, a theoretically-supported decision was made concerning this factor; it was determined that the item concerning preservation skills (item 10: "*I have knowledge of different types of preservation (*e.g.*, freezing, salting) suitable for different foods*") would be added to the Culinary Competencies factor (with a factor weight of 0.345) instead of remaining in its original structure (factor Origin, with a factor weight of 0.380). This decision also improved the reliability of the Origin factor (from 0.637 to 0.707; Table 3). The second factor - Selection and Planning - aggregated items concerning food acquisition practices (e.g., reading food labels, investing in food selection) and planning skills. The third factor - Production and Quality - regarded agricultural practices within food production (e.g., use of pesticides and herbicides) and its impact on food quality. The fourth factor - Environmentally Safe - combined items related to environmental-friendly actions (e.g., eating according to seasonality) and the use of food-related hygiene and safety practices. Finally, the fifth factor - Origin - entailed items related to how food is originated and processed in its source.

To draw further model fit comparisons with the previously obtained structure, a CFA was performed in a different sample (Sample 2). In this analysis, an a priori second-order model structure was elected given the seemingly distinctive but related dimensions ($0.496 < r^2 < 0.843$) which account for the common underlying construct of food literacy, validated in the FLW (Chen et al., 2005; Rosas et al., 2021). The first model, which included all 26 items across the five-factor structure demonstrated in the EFA, presented an acceptable fit ($\chi^2/df = 2.941$; SRMR = 0.057; RMSEA = 0.051; CFI = 0.905; GFI = 0.915). The first-order standardised factor loadings for Culinary Competencies (0.855), Selection and Planning (0.858), Environmentally Safe (0.604) and Origin (0.635) demonstrated acceptable levels; despite Production and Quality (0.476) having a loading weaker than 0.50, all factor loadings were statistically significant. Ranges of factor loading values for the five first-order factors were as following: 0.459–0.788 (Culinary Competencies), 0.556–0.749 (Selection and Planning), 0.658–0.788 (Origin), 0.329–0.758 (Production and Quality), and 0.240–0.739 (Environmentally Safe). The items with weaker factor loadings concerned food-related (i) hygiene and safety practices ($\lambda = 0.240$; $r^2 = 0.058$; item 11 - "*I apply food hygiene and safety practices (*e.g.*, storing food at appropriate temperatures, cleaning utensils)*"), (ii) quality ($\lambda = 0.329$; $r^2 = 0.108$; item 6 - "*The quality of the food depends on its origin (*e.g.*, domestic or industrial production, local or imported products)*"), and (iii) additives ($\lambda = 0.426$; $r^2 = 0.181$; item 7 - "*It is important for me to avoid consuming foods that contain additives*"). Given the current context of the global pandemic and the emphasis of international guidelines to ensure food-related hygiene and safety practices as precaution measures against COVID-19 (EC, 2020a), the authors decided to retain item 11 within these analyses, despite its poorer indicators. Items 6 and 7 were removed given their lower factor loading and squared multiple correlation values; this decision was made considering that the removal of these items did not deprive the developed measure of capability to assess any of the food literacy's domains and their respective features presented in the FLW (Rosas et al., 2021). Additionally, error correlations among two items (items 16 and 19; items 25 and 26) were established following high modification indices.

As so, the second and final model included a total of 24 items. Model fit ($\chi^2/df = 2.702$; SRMR = 0.053; RMSEA = 0.048; CFI = 0.927; GFI = 0.930) demonstrated slight improvements when compared with the first model. Fig. 2 shows the final model for the FOODLIT-Tool's development, including its standardised factorial loadings.

Single items concerning food literacy's determinants and influential factors.

In the samples where these items were developed (Samples 1 and 2), all items except one ranged from 0 to 3 in the response scales; the exception was item number 30, corresponding to a determinant ("*Having an adequate diet is a priority for me.*"), whose responses ranged from 1 to 3.

All items regarding both food literacy's determinants and influential factors demonstrated appropriate values of skewness ($-0.631 <$ Sk

Table 3
Results from the exploratory factor analysis (EFA) with Sample 1 (n = 698) - including the factor loadings (bold values indicating the most significant factor weights; bold and underlined values indicated the final EFA, after changing the preservation item from the Origin to the Culinary Competencies factor), eigenvalues, inertia, percentage of variance and Cronbach's alphas (including the modification on the Cooking Skills factor, regarding the addition of the item concerning preservation skills.

Items Food literacy definition		Factor Loading				
		Culinary Competencies	Selection and Planning	Production and Quality	Environmentally Safe	Origin
Cooking Skills						
1	I easily prepare everything that is necessary to make a meal.	**0.569**	0.369	0.027	0.157	0.152
2	I combine different ingredients to create a suitable meal.	**0.676**	0.297	0.140	0.169	0.197
3	I adapt recipes to be more to my taste.	**0.597**	0.182	0.086	0.007	0.159
4	I use kitchen equipment and utensils (e.g., oven, blender) efficiently.	**0.685**	0.105	0.086	0.135	0.006
5	I cook adequate meals with what I usually have at home.	**0.626**	0.306	0.045	0.167	−0.067
6	The quality of the food depends on its origin (e.g., domestic or industrial agricultural production, local or imported products).	0.125	−0.006	**0.493**	0.109	−0.274
7	It is important for me to avoid consuming foods that contain additives.	0.045	0.193	**0.591**	0.158	−0.045
8	I cook in different ways (e.g., stewing, baking).	**0.750**	0.063	0.077	0.134	0.126
9	I enjoy cooking.	**0.683**	0.103	0.123	−0.009	0.087
Preserve and Analyse						
10	I have knowledge of different types of preservation (e.g., freezing, salting) suitable for different foods.	**0.345**	0.039	0.030	0.297	**0.380**
11	I apply food hygiene and safety practices (e.g., storing food at appropriate temperatures, cleaning utensils).	0.248	0.099	−0.043	**0.441**	−0.038
12	I recognise the impacts of pesticides and/or herbicides on food.	0.070	0.127	**0.665**	0.164	0.083
13	I know what *organic products* are (e.g., food grown without pesticides).	0.136	0.024	**0.694**	−0.125	0.236
14	I know the impact that o*rganic products* have on food-related sustainability (e.g., less soil contamination).	0.070	−0.071	**0.769**	0.095	0.078
15	I buy local/national trade products to support local/national business.	0.025	0.136	0.210	**0.596**	0.125
16	I control the calories and/or other nutritional characteristics of the food I eat daily.	−0.004	**0.766**	−0.061	0.013	0.071
Choice and Acquisition						
17	I can identify the origin of a food (that is, where a food comes from).	0.169	0.163	0.057	0.065	**0.771**
18	I can identify how a food is produced and processed (that is, how it is manufactured, how it is packaged).	0.111	0.193	0.012	0.217	**0.755**
19	I read and interpret food labels to select the most appropriate foods.	0.126	**0.705**	0.193	0.078	0.219
20	I make informed food choices.	0.283	**0.601**	0.225	0.214	0.286
21	I dedicate time and invest in food selection (e.g., when I go shopping).	0.288	**0.614**	0.187	0.200	0.045
Search and Plan						
22	I eat food according to its seasonality.	0.096	0.088	0.082	**0.759**	0.096
23	I am aware of the time of year of each food.	0.114	0.060	0.158	**0.705**	0.167
24	I can easily substitute one food for another nutritionally equivalent one.	0.236	**0.460**	0.137	0.112	0.359
25	I plan various aspects of my diet.	0.325	**0.685**	−0.037	0.056	0.031
26	I plan my meals in advance.	0.202	**0.651**	−0.013	0.072	0.005
Eigenvalues		7.032	2.162	1.663	1.505	1.213
Percentage of Variance		27.048	8.316	6.394	5.787	4.666
Original Cronbach's alpha		0.835	0.828	0.690	0.608	0.637
Final Cronbach's alpha		**0.831**				**0.707**

$_{\text{Determinants}} < 0.175$; $-1.108 < \text{Sk}_{\text{Influential Factors}} < 0.298$) and kurtosis ($-0.716 < \text{Ku}_{\text{Determinants}} < 0.153$; $-0.823 < \text{Ku}_{\text{Influential Factors}} < 0.683$) in Sample 1 and Sample 2.

3.3. Phase 3: instrument validation

3.3.1. Step 4 - tests of dimensionality and measurement invariance

For the FOODLIT-Tool validation, a CFA was performed with Sample 3 in order to validate the previously obtained factor structure (Step 3). Maintaining the 24 items and the items' errors correlations, model fit for dimensionality testing was acceptable ($\chi^2/df = 3.958$; SRMR = 0.055; RMSEA = 0.055; CFI = 0.907; GFI = 0.917). When compared to the values obtained for the instrument's development final model (Fig. 1), the CFA regarding the instrument's validation (Fig. 3) presented higher first-order standardised factor loadings for four out of the five dimensions: Culinary Competencies (0.894), Environmentally Safe (0.764), Production and Quality (0.651), and Origin (0.874). Only the dimension Selection and Planning (0.874) had a slight decrease (from 0.890 in the instrument's development model). Factor loadings for the five first-order factors ranged between 0.437 and 0.704 (Culinary Competencies), 0.450–0.833 (Selection and Planning), 0.301–0.729 (Environmentally Safe), 0.613–0.746 (Production and Quality), and 0.553–0.728 (Origin). Despite showing a slight improvement, item 11 remains being the item with weaker factor loadings ("*I apply food hygiene and safety practices (*e.g.*, storing food at appropriate temperatures, cleaning utensils)*"; $\lambda = 0.301$; $r^2 = 0.091$).

As the first level in measurement invariance, configural invariance refers to testing if the construct maintains its pattern and factor loadings across different groups (Milfont & Fischer, 2010; Putnick & Bornstein, 2016). Given the adequacy of model fit for the developed factor structure in both Sample 2 and Sample 3, invariance of model form was achieved ($\chi^2/df = 3.330$; SRMSR = 0.053; RMSEA = 0.037; CFI = 0.916).

3.3.2. Step 5 - tests of reliability

Internal consistency of all dimensions was explored (Table 4); as shown, the five factors demonstrated acceptable to good reliability ($0.695 < CR < 0.892$).

3.3.3. Step 6 - tests of validity

Convergent validity was assessed through the AVE, where three out of the five dimensions had values above 0.50 ($AVE_{\text{Selection and Planning}} = 0.551$; $AVE_{\text{Production and Quality}} = 0.583$; $AVE_{\text{Origin}} = 0.538$); the factors Culinary Competencies and Environmentally Safe had AVE values slightly below the threshold (0.457 and 0.452, respectively).

Explored through the comparison of the AVE values with the inter-

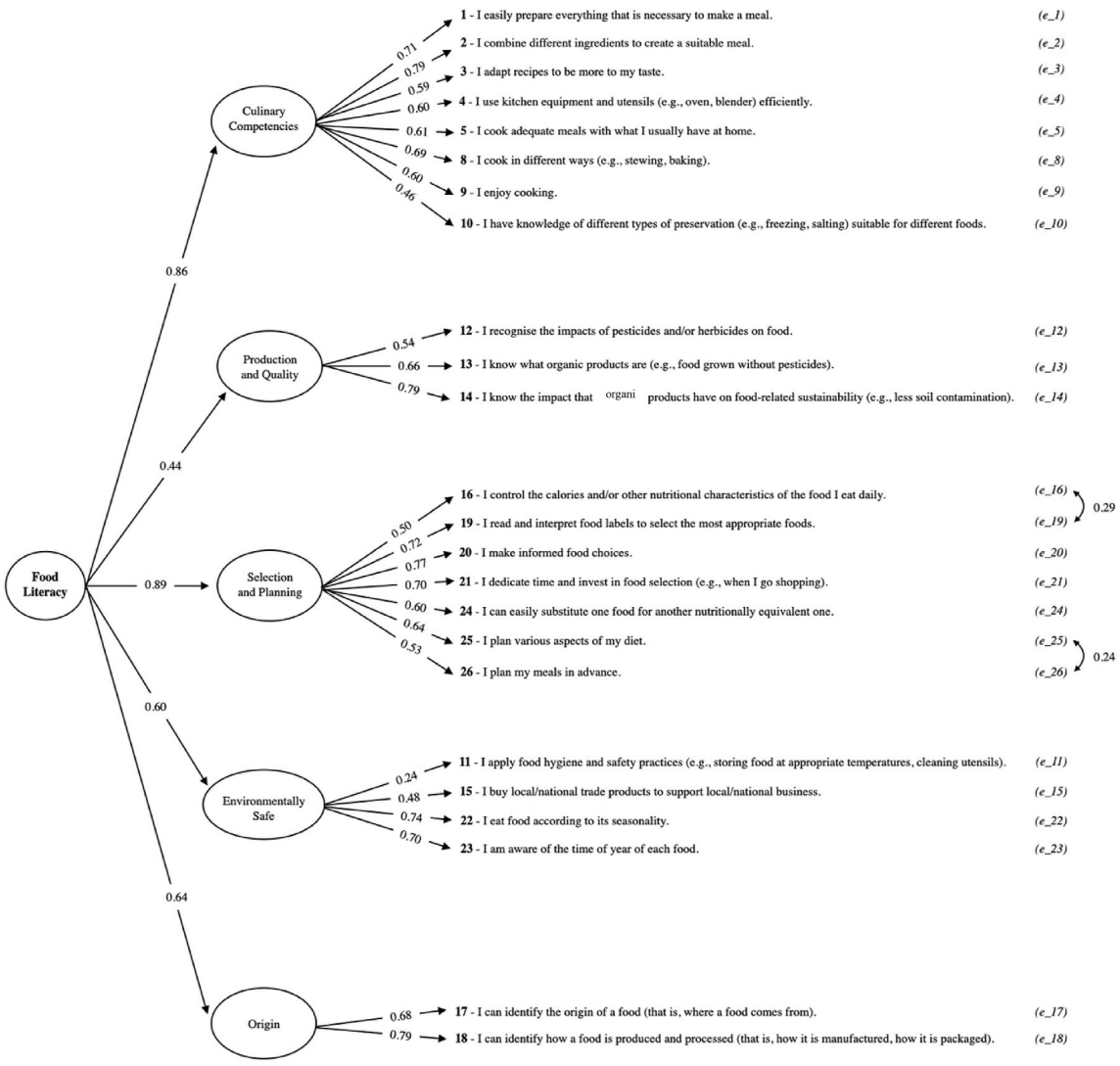

Fig. 2. Final model regarding the CFA for the instrument's development (Step 3; Sample 2; n = 749).

dimensions' squared correlation, six out of the 10 paired-factors presented discriminant validity (Table 5).

4. Discussion

Within the FOODLIT-PRO - Food Literacy Project and building upon the previously developed conceptual and empirical framework of food literacy (FLW; Rosas et al., 2021), this study created a tool with the purpose to assess not only adults' food literacy but also to evaluate its determinants and influential factors. The 40-item instrument incorporated a 5-dimensional definition of food literacy, internal and external determinants (e.g., financial management, convenience and practicality), and multi-stakeholder-related influential factors (such as policy, sustainability, and industry), and was developed and validated in a Portuguese sample, mirroring the FLW model formerly designed with food experts using both qualitative and quantitative methods. Thus, the FOODLIT-Tool portrayed (i) the four dimensions of the FLW core as a total of 26 items in order to assess food-related knowledge, competencies and behaviours that institute food literacy's definition, (ii) the middle rings of the FLW as a 5-item independent arrangement representing its determinants, and (iii) the outer ring as a 9-item distinct configuration depicting the influential factors.

Despite reflecting the framework's content for item development (Phase 1), the factor extraction (Phase 2, step 3) obtained a 5-factor structure. When comparing this structure with the FLW's four dimensional core, the FOODLIT-Tool (a) focused the association of acquisition skills and planning competencies (factor Selection and Planning), (b) emphasised the link among production aspects and its impact on food quality (factor Production and Quality), (c) highlighted the connection between food safety and sustainable food consumption (factor Environmentally Safe), and (d) particularised an origin-specific dimension (factor Origin). These dissimilarities accentuate the need to specify distinct sets of skills and practices previously understood as part of more general dimensions within the conceptual and empirical framework (from FLW's core - Choice and Acquisition, Preserve and Analyse, and Search and Plan; Rosas et al., 2021); as a quantitative assessment tool, the particularisation of discrete food-related competencies and behaviours was crucial to ensure the instrument's validity. Maintaining the majority of content equivalence, the factor Culinary Competencies was the most similar to its pair (the dimension Cooking Skills) from the FLW; the addition of the item regarding preservation skills reflected the application of these behaviours within the culinary context as a current practice to allow for food conservation.

Posteriorly to the exploratory analysis, the confirmatory analysis conducted with a second sample for the tool's development presented a similar structure considering the items and their respective factors. In this procedure, the decision to integrate a second-order model structure emerged from the accountability of the diverse dimensions for the

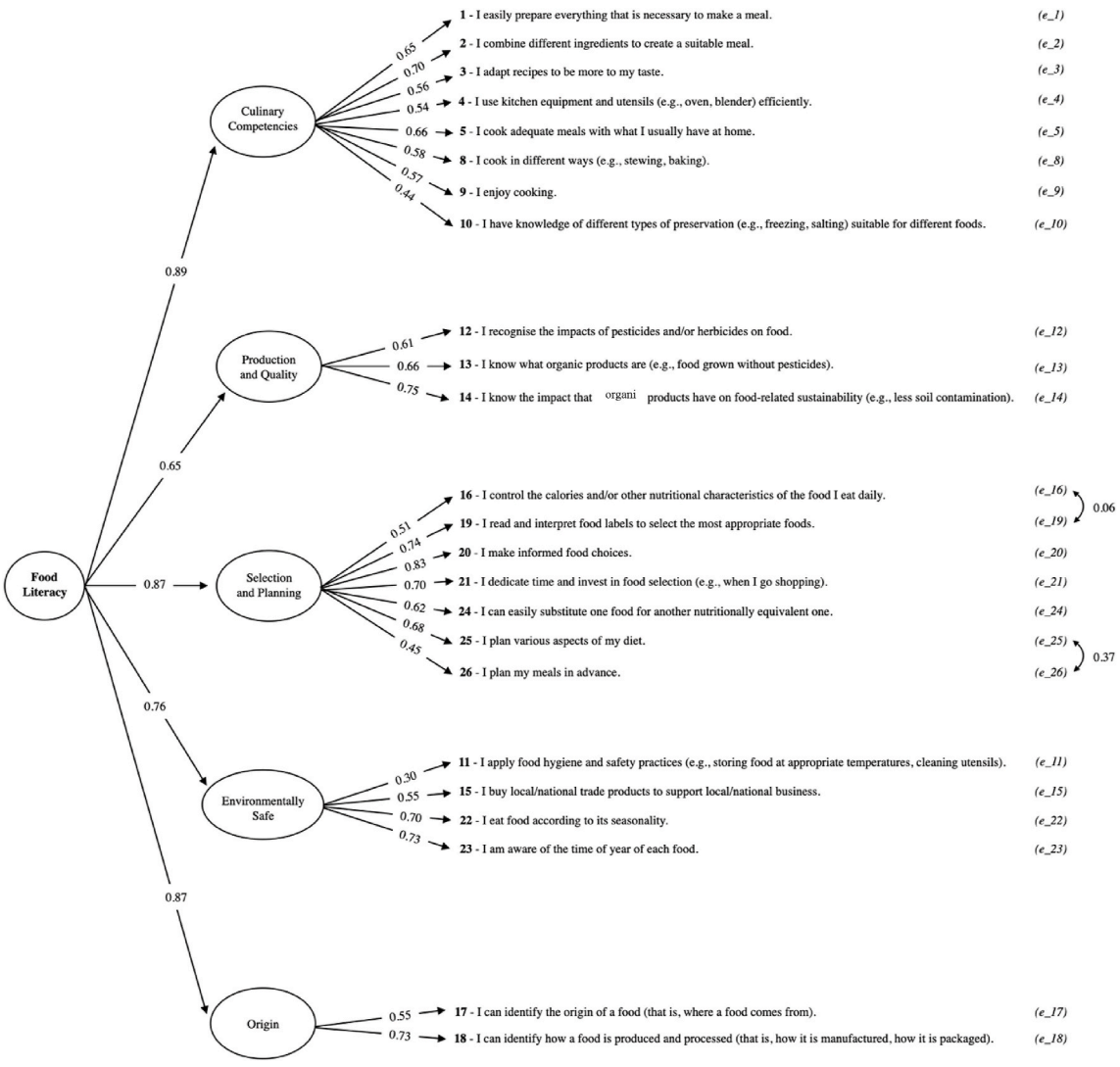

Fig. 3. Final model regarding the CFA for the instrument's validation (Step 4; Sample 3; n = 959).

Table 4
Reliability analysis (composite reliability) for all the dimensions of the FOODLIT-TOOL with Sample 3 (n = 959; instrument's validation; Step 6).

FOODLIT-Tool dimensions	Number of items	Composite Reliability
Culinary Competencies	8	0.869
Production and Quality	3	0.807
Selection and Planning	7	0.892
Environmentally Safe	4	0.752
Origin	2	0.695

construct's definition, formerly demonstrated on the conceptual and empirical framework from which the item development proceeded (Chen et al., 2005; Rosas et al., 2021).

On the process of item reduction (Phase 2, step 3), items with reference to hygiene and safety practices (item 11), food quality (item 6) and food additives (item 7) were identified as having weaker psychometric properties when the CFA was performed. The decision to remove two of those items (items 6 and 7) while retaining item 11 relied on the significance of hygiene and safety aspects in the current public health situation due to the COVID-19 pandemic. Though presenting the weaker factor loadings, item 11 represents the only item reflecting the importance to ensure food-related hygiene and safety behaviours as safeguarding practices on the *from farm to fork* context (EC, 2020b). However, despite the need of featuring hygiene and safety as essential subjects within the FOODLIT-Tool as a measure of food literacy, the poor psychometric properties of this item demonstrate the necessity to revise its form and content for future studies. As so, the authors strongly suggest that further developments of the instrument entail two separated items to encompass hygiene and safety competencies — two constructs that, though having common elements overlapping, present some crucial differences (CCOHS, 2021; FAO & WHO, 1969) — along with featuring more specific examples on how to implement these practices. For instance, a possibility for a transformed food hygiene item could be "*I apply food hygiene practices (*e.g.*, keep the kitchen and the food storage areas clean; wash my hands before and after handling food; use a clean spoon each time I taste food)*", and a modified food safety item could state "*I apply food safety practices (*e.g.*, make sure that food is safe to eat by looking to its expiration date and freshness characteristics; transporting and storing foods at appropriate temperatures; using adequate re-heating temperatures)*".

The final model for the instrument's development was then tested on a third sample for the instrument's validation (Phase 3). Concerning the dimensionality testing (Phase 3, step 4), the developed factor structure was validated with acceptable model fit; furthermore, establishing configural invariance highlighted the fact that the FOODLIT-Tool consistently measured food literacy and its dimensions across different groups. Given that the comparison and interpretation among groups is only valid if the basis of factorial invariance is achieved, this tool is

Table 5
Discriminant validity of the FOODLIT-TOOL's dimensions (Sample 3; n = 959; Step 6).

FOODLIT-Tool dimensions	Dimensions' AVE	Inter-dimensions' squared correlation	Discriminant validity
Culinary Competencies	0.457	0.415	Yes
Environmentally Safe	0.452		
Culinary Competencies	0.457	0.287	Yes
Production and Quality	0.583		
Culinary Competencies	0.457	0.710	No
Selection and Planning	0.551		
Culinary Competencies	0.457	0.511	No
Origin	0.538		
Selection and Planning	0.551	0.246	Yes
Production and Quality	0.583		
Selection and Planning	0.551	0.368	Yes
Environmentally Safe	0.452		
Selection and Planning	0.551	0.555	No
Origin	0.538		
Production and Quality	0.583	0.438	Yes
Environmentally Safe	0.452		
Production and Quality	0.583	0.438	Yes
Origin	0.538		
Environmentally Safe	0.452	0.612	No
Origin	0.538		

demonstrated to be successful on future assessments in different populations (Yu & Shek, 2014). Both testing of reliability (step 5) and validity (step 6) indicated favourable outcomes; particularly regarding the tests of validity, the absence of discriminant validity in almost half of the pairings mirrors the high correlations among dimensions as well as the need and justification for the second-order factor (Chen et al., 2005). Still regarding the tests of validity (step 6), the absence of the criterion validity analysis (particularly, predictive and concurrent validity) presents as a limitation of this study. Moreover, the strong predominance of female participants transversally to all samples is also a feature to be improved in future studies. However, as a psychometric study aiming for the development and validation of an assessment tool based on a recent and innovative framework which was built with a mixed methodology, the display of step-by-step statistical procedures as well as the availability of three different samples are main features of this work.

4.1. Future studies and implications for practice and research

Aiming to broaden the spectrum of food systems through the measurement of food literacy's enablers and inhibitors (that is, determinants) and by assessing the impact caused by fields of interplay (that is, influential factors), the development of the FOODLIT-Tool aimed to contribute with a more comprehensive approach towards food-related global sustainability. Intending to be used when needed, items concerning food literacy's determinants and influential factors were depicted in the steps concerning the tool's development (Phase 1, and steps 1, 2 and 3 from Phase 2) given that the instrument's validation (Phase 3) concerned food literacy skills exclusively.

Allowing for an expanded measurement of food literacy's contextual and individualised features, these single items highlight the required tailoring when approaching food-related issues within global food systems. This innovative feature of the FOODLIT-Tool grants the possibility to adapt its content according to its aim, personalising which items to include depending on the target population or on a food-related intervention with a particular context. For instance, (i) applying item 30, which concerns the priority of a healthy diet, to patients on weight management programs, or (ii) using item 38, regarding the consumer's influence on food industry, to understand to what extent a retail's final consumer perceives the responsibility of their food choices on more sustainable food consumption. As so, this singular feature of the FOODLIT-Tool provides for opportunities to widen the action on food-related interventions from diverse fields, from nutrition to psychology, policy, industry, and sustainability.

Future studies should investigate the potential cut-off points to differentiate levels of food literacy on each dimensions and on a global score. Assessing the instrument's psychometric qualities in different populations and specific target groups from multiple contexts (e.g., health professionals, food industry workers, policy-makers, teachers, students) is also advised.

5. Conclusions

The urgency to tackle issues that threaten sustainability within food systems demands for stakeholders diversity along with multilevel approaches (UN, 2021). Recognising the impact of these areas of interplay and promoting its action is crucial to enhance consumers' food-related knowledge, competencies and behaviours effectively. As so, it is essential to considerate the plurality of fields — from food policy to human and environmental health, along with industry and learning environments — in order to assess and further intervene to promote food-related behaviour change, nourishment, and quality of life.

In the ambit of the FOODLIT-PRO - Food Literacy Project, this study contributes with an innovative instrument that provides for tailoring within the assessment and allows for its use on diverse contexts. Based on the conceptual and empirical framework Food Literacy Wheel previously built with mixed methodologies, the FOODLIT-Tool is both valid and reliable and it is intended to assess not only food literacy but also to identify which determinants and influential factors have repercussions on one's food literacy. Lastly, the development of the FOODLIT-Tool aims to provide for a resourceful, adaptable and efficient assessment tool to be used in adult populations working towards more healthier, equitable and sustainable food systems by promoting behaviour change.

Ethical statement

This study was approved by the Ethics Committee of ISPA – Instituto Universitário (ref. D/002/03/2018), performed in accordance with the Declaration of Helsinki, followed the ethical principles and deontological norms of the Order of Portuguese Psychologists, and adhered to General Data Protection Regulation.

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Declaration of competing interest

No potential conflict of interest was reported by the author(s).

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F.P.; investigation and data collection, R.R.; formal analysis with software, R.R., F.P., and R.S.; writing original draft preparation, R.R.; writing reviewing and editing, F.P., I.L. and R.S.; supervision, F.P., I.L. and R.S.; funding acquisition, R.R., F.P., I.L. and R.S. All authors have read and agreed to the published version of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2021.105658.

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