TECHNICAL UNIVERSITY OF MOLDOVA

As a manuscript

C.Z.U.:613.2:614:616.3(478)(043)

ȚURCANU DINU

NUTRITIONAL SECURITY OF PEOPLE WITH GLUTEN RELATED DISORDERS IN THE REPUBLIC OF MOLDOVA

Scientific Speciality: 253.04 Food Security

Summary of the doctoral thesis in engineering sciences

CHISINAU, 2023

The thesis was developed within the Department of Food and Nutrition, Faculty of Food Technology, Technical University of Moldova, as well as within the following scientific projects:

- National State Project no. 20.80009.5107.10. *Personalized nutrition and smart technologies for my well-being*
- Postdoctoral project no. 21.00208.5107.06. *Contributions regarding the nutritional eradication of gluten-related disorders.*
- Project on issues of urgent interest: *Exploratory analysis of food security in the Republic of Moldova based on metrics of nutritional and sustainable quality (CNuD) of food products.*

Scientific supervisor:
SIMINIUC Rodica, PhD., associate professor

Composition of the Doctoral Thesis Examination Committee (DTEC):

	Name, surname	Function within the DTEC	Academic title	Institution
1.	Aliona GHENDOV-MOȘANU	President	Dr. Hab., associate professor	UTM
2.	Viorica BULGARU	Scientific secretary	PhD., associate professor	UTM
3.	Rodica SIMINIUC	Member	PhD., associate professor	UTM
4.	Tatiana RABA	Member	Dr. Hab., associate professor	USMF
5.	Rodica STURZA	Referent	Correspondent member of ASM, Dr. Hab., Professor	UTM
6.	Ninel REVENCO	Referent	Dr. hab., Professor	USMF
7.	Petre SĂVESCU	Referent	Dr. hab., Professor, Chemist and Engineer Technologist in Food Industry	Faculty of Agronomy, University of Craiova, Romania

Public defense will take place on the 29th of August 2023, at 14.00, in the Meeting of the Doctoral Thesis Examination Committee within the Technical University of Moldova, 9/9 Studentilor street, academic building nr. 5, Faculty of Food Technology, lecture hall 5-1, MD-2045, Chisinau, Republic of Moldova.

The doctoral thesis and the summary can be consulted at the library of the Technical University of Moldova and on the ANACEC website.

The summary was sent on 26.07.2023

Scientific supervisor:
SIMINIUC Rodica, PhD., associate professor *signature*_____

Author:
ȚURCANU Dinu *signature*_____

ADNOTARE

ȚURCANU Dinu: „Securitatea nutrițională a persoanelor cu tulburări corelate consumului de gluten în Republica Moldova”, teză de doctor în științe inginerești la specialitatea științifică 253.04 - Securitatea produselor alimentare. Chișinău, 2023.

Structura tezei include: introducere, 5 (cinci) capitole, concluzii generale și recomandări, 118 pagini de text de bază, bibliografie din 262 de titluri, 20 tabele și 31 de figuri. Rezultatele obținute sunt publicate în 27 lucrări științifice.

Cuvinte-cheie: securitate alimentară și nutrițională, terapie nutrițională fără gluten, indicatori de evaluare, standarde nutriționale, politici publice, modele compozite, calitate nutrițională, etichetare, declarația nutrițională, nivel de asistență, tulburări asociate consumului de gluten, maladia celiacă, Republica Moldova.

Motivația alegerii subiectului de cercetare: Securitatea nutrițională și provocările de sănătate, economice și de mediu în Republica Moldova se confruntă cu frustrări majore, fiind mai accentuate la persoanele cu tulburări asociate consumului de gluten (TACG), și solicită identificarea unor acțiuni îndrăznețe, imperative, susținute și coordonate.

Problema de cercetare constă în identificarea, dezvoltarea și fundamentarea științifică a unor intervenții și instrumente de evaluare și monitorizare eficientă a nivelului de asistență a persoanelor cu tulburări asociate consumului de gluten, aplicabile în Republica Moldova prin prisma securității nutriționale, pentru asigurarea Obiectivului de Dezvoltare Durabilă 2 (Zero foame) și generarea impactului în favoarea Obiectivului de Dezvoltare Durabilă 3 (Sănătate și bunăstare).

Scopul cercetării constă în evaluarea multidimensională a securității nutriționale a persoanelor cu tulburări asociate consumului de gluten în Republica Moldova prin prisma unor modele aplicabile la nivel național și la nivel individual.

Obiectivele lucrării: evaluarea incidenței TACG și a strategiilor de asistență a persoanelor afectate în Republica Moldova; Evaluarea calității și conformității produselor fără gluten; dezvoltarea unui software de evaluare nutrițională; Dezvoltarea unui model de evaluare a nivelului de asistență a persoanelor cu TACG prin prisma politicilor publice naționale; Dezvoltarea unui cadru conceptual de evaluare a securității nutriționale a persoanelor cu tulburări asociate consumului de gluten, în baza unor indicatori compoziți relevanți.

Gradul de noutate al temei constă în dezvoltarea unor metode și modele unice de evaluare a securității nutriționale a persoanelor cu TACG, și anume: un model de evaluare a calității nutriționale a pâinii și a produselor de panificație fără gluten, ca cea mai provocatoare categorie de produse în terapia nutrițională fără gluten; un model de evaluare a nivelului de asistență a persoanelor cu TACG prin prisma politicilor publice naționale; un software de evaluare nutrițională a persoanelor cu TACG, bazat pe abordarea sistemică a Procesului de Îngrijire a Nutriției; un cadru conceptual de evaluare a securității nutriționale a persoanelor cu TACG, focusat pe dimensiunea nutrițională, care să includă metodologii bazate atât pe acțiuni, cât și pe metrici cantitative.

ANNOTATION

Dinu ȚURCANU: „Nutritional security of people with disorders related to gluten consumption in the Republic of Moldova". The scientific specialty: 253.04. Food security. Scientific title requested: Doctor in engineering sciences. Chisinau, 2023.

Thesis structure includes: the Introduction, 5 (five) chapters, general conclusions and recommendations, 118 pages of basic text, a bibliography of 262 sources, 20 tables and 31 figures. The obtained results were published in 27 scientific papers.

Key words: food and nutritional security, gluten-free nutritional therapy, assessment indicators, nutritional standards, public policies, composite models, nutritional quality, labeling, nutritional declaration, level of assistance, disorders related to gluten consumption, celiac disease, Republic of Moldova.

The motivation for choosing the research topic: Nutritional security and health, economic and environmental issues in the Republic of Moldova face major challenges, affecting especially the people with Gluten-related disorders (GRDs) and require the identification of bold, imperative, sustained and coordinated actions.

The research problem consists in the identification, development and scientific substantiation of some actions and tools for effective assessment and monitoring of the assistance level for people with GRDs, applicable in the Republic of Moldova, through the prism of nutritional security, in order to ensure the Sustainable Development Objective 2 (Zero hunger) and to generate impact in favor of Sustainable Development Goal 3 (Good health and well-being).

The purpose of research consists in the multidimensional assessment of the nutritional security of people with disorders related to gluten consumption in the Republic of Moldova through the prism of some models applicable at the national and individual level.

The objectives of research: Evaluating the incidence of GRDs and assistance strategies for affected people in the Republic of Moldova; Evaluating the quality and conformity of gluten-free products; Developing a nutritional assessment software; Developing a model for evaluating the assistance level for people with GRDs through the prism of national public policies; Developing a conceptual framework for assessing the nutritional security of people with disorders related to gluten consumption based on relevant composite indicators.

The degree of scientific novelty of research consists in the development of unique methods and models for assessing the nutritional security of people with GRDs, namely: the model for assessing the nutritional quality of gluten-free bread and bakery products - as the most challenging product category used in the gluten free nutritional therapy; the model for evaluating the assistance level for people with GRDs through the prism of national public policies; a software for nutritional assessment of people with GRDs, based on the systemic approach of the Nutrition Care Process; a conceptual framework for assessing the nutritional security of people affected by GRDs, focused on the nutritional dimension and including both action-based methodologies and quantitative metrics.

CONTENTS

INTRODUCTION

The global food and nutrition crisis is considered the leading cause of poor health (Popkin et al., 2020) which continues to worsen, being exacerbated by the Covid pandemic and by the war in Ukraine, accompanied by worrying trends in all forms of malnutrition, from hunger to obesity and multiple associated chronic diseases. The number of people affected by hunger has increased by 150 million since the outbreak of the Covid-19 pandemic: from 618 million in 2019 to 768 million in 2021, while the number of those who cannot afford a healthy diet has increased by 112 million, reaching 3.1 billion only in 2020. Almost a third (2.3 billion or 29.3%) of the world's population was moderately or severely food insecure in 2021, compared to 25.4% before pandemic (Global Nutrition Report, 2023). Experiencing food insecurity is increasingly associated with adverse health effects and a higher probability of having chronic diseases. As a top priority, but also as a core component of the global development paradigm, food security is essential for strengthening human capacities (Levi et al., 2022).

For people with Gluten-related disorders (GRDs), the pressure of food and nutritional insecurity is two-fold, as it threatens the cornerstone - the gluten-free diet (GFD), the only effective therapy for people with GRDs, unanimously accepted by the medical community (Al-Toma et al., 2019; Ma et al., 2022). However, adherence to a GFD may be extremely difficult, as gluten is a common ingredient in most diets (Aspasia et al., 2022; Oliveira et al., 2022), and the risk of accidental exposure to gluten is extremely high (gluten or traces of gluten are found in about 80% of the products). Accidental gluten exposure triggers the autoimmune response that may have devastating and debilitating consequences by increasing mortality risks for other diseases, including cardiovascular and respiratory diseases. Beyond the risk of mortality, the celiac disease also is associated with an increased risk of a variety of chronic diseases, including additional autoimmune diseases and cancers, such as intestinal cancer and lymphoma (Conroy et al., 2023; Leffler et al., 2003).

Patients with celiac disease (CD) may face difficulties because gluten-free (GF) foods are more expensive and less available, which in turn may affect their health, life quality and emotional state. There is strong evidence that CD is associated with depression, anxiety, social stigma and difficulties in daily social relationships due to the nature of the disease and/or adherence to a GFD (Al-sunaid et al., 2021).

Food and nutrition security has become a global concern and assumes an increasingly complex dimension. The right to food is a fundamental human right, and the absence of food that meets the specific needs, such as those of people with GRDs, represents a specific case, when most

of the time, the right of this group of people to adequate food/nutrition is violated, and, as a result, they get the status of food and nutritional insecurity.

Globally, various strategies and actions are being undertaken to ensure the food and nutritional security of people with GRDs (Pinto-Sanchez et al., 2021). Special emphasis is given to nutrition education policies, standardized color-coded front-of-pack-labelling (FOPL) of products that indicate the nutritional properties of certain products, including healthy products, especially for individuals with gluten intolerance. CD doctors and associations support the protection and expansion of government programs to ensure that people with GRDs are protected in conditions of a food crisis (Bilaver et al., 2021).

National programs for the diagnosis and control of GRDs promote both awareness and knowledge of these diseases, as well as contribute to the implementation of labeling requirements to create a national logo for all packaged foods certified *gluten-free*. Support and protection policies, as well as social inclusions, represent other types of assistance, which promote adherence to GFD by reducing the financial burden for patients and by ensuring a greater degree of adherence to nutritional therapy (Hanci et al., 2019; Kurien et al., 2018).

The motivation for choosing the research topic. The issues of ensuring nutritional security and the human right to adequate food for people with GRDs in the Republic of Moldova are extremely sensitive, becoming even more prominent under the pressure of crisis situations (Covid-19 pandemic and the war in Ukraine). Being among the most common chronic digestive disorders, GRDs are often underdiagnosed and neglected, both by patients and doctors, and the number of people affected, in reality, is much higher. The official data with reference to CD or other GRDs in the Republic of Moldova is contradictory, decentralized, often being stored by different medical institutions and by different doctors.

The process of adopting and adhering to a GFD is a rather difficult one, vulnerable on all dimensions of food security, because GF products are not produced or certified in the Republic of Moldova. Limited participation of nutritionists in the development of balanced menus or their total lack in public catering units, low diversity of GF products and their high price, compared to conventional foods, the risk of cross-contamination of foods, the incipient offer of social assistance and nutritional care services etc. - all this reflects only some aspects of the challenges faced by people with GRDs in the Republic of Moldova (Siminiuc et al., 2022a).

Nutritional security along with health, economic and environmental issues in the Republic of Moldova face major challenges, affecting especially the people with GRDs and require the identification of bold, imperative, sustained and coordinated actions. (Global Nutrition Report, 2023; Martini et al., 2022; Pinto-Sanchez et al., 2021).

The research problem consists in the identification, development and scientific substantiation of some actions and tools for effective assessment and monitoring of the assistance level for people with GRDs, applicable in the Republic of Moldova, through the prism of nutritional security, in order to ensure the Sustainable Development Objective 2 (Zero hunger) and to generate impact in favor of Sustainable Development Goal 3 (Good health and well-being).

The purpose of research consists in the multidimensional assessment of the nutritional security of people with GRDs in the Republic of Moldova through the prism of some models applicable at the national and individual level.

To achieve the purpose of research, the following **research objectives** were established**:**

Objective 1. Evaluating the incidence of GRDs and assistance strategies for affected people in the Republic of Moldova;

Objective 2. Developing a nutritional assessment model for evaluating the nutritional quality of GF bread and bakery products;

Specific objectives within objective 2:

- Developing a nutritional assessment model for evaluating the nutritional quality of GF bread and bakery products, harmonized with national and international acts;
- Evaluating the compliance of GF products sold in the Republic of Moldova with the presence of toxic prolamin.

Objective 3. Developing a nutritional assessment software for people with GRDs;

Objective 4. Developing a conceptual framework for assessing the nutritional security of people with GRDs based on relevant composite indicators.

Specific objectives within objective 4:

- Developing a model for evaluating the assistance level for people with GRDs in the Republic of Moldova through the prism of national public policies;
- Designing the framework and compiling it with the indicators of the developed models, as well as with the indicators developed by the competent bodies.

The degree of scientific novelty of research. The research focused on the multidimensional analysis of nutritional security and the assistance level for people with GRDs - a research field insufficiently explored in the Republic of Moldova.

A wide spectrum of strategies was identified and actions applied, at the international level, to ensure the nutritional security of people with GRDs, which include: the availability of food and nutritional policies and standards, health policies, support programs for the eradication of food insecurity of people with GRDs in crisis situations, investments in research and development, as well as the availability of national organizations for celiacs.

In the research, unique methods and models were applied to assess the nutritional security of people with GRDs, developed by the author while carrying out the thesis, and namely:

- The model for assessing the nutritional quality of GF bread and bakery products - as the most challenging product category used in the GF nutritional therapy;
- A software for nutritional assessment of people with GRDs, based on the systemic approach of the Nutrition Care Process, which enables graphical visualization representing the steps of the nutrition care process, as well as the internal and external factors that influence the use of the process;
- The model for evaluating the assistance level for people with GRDs through the prism of national public policies;
- A conceptual framework for assessing the nutritional security of people affected by GRDs, focused on the nutritional dimension and including both action-based methodologies and quantitative metrics.

Generally, the thesis provides a broad picture of the assistance level for people with GRDs, as well as the tools and actions developed, which lead to an assessment, a diagnosis and, subsequently, an improvement of the state of nutritional security in the Republic of Moldova.

The methodology used in carrying out this research included methods of systematic review of documents (data triangulation, systematic review through the PRISMA flow chart), methods based on composite indicators, with applicability at the national level, as well as nutritional assessment methods using the newly developed software, which include indicators applicable at the individual level, but also statistical data processing methods.

Thesis structure includes: the Introduction, 5 (five) chapters, general conclusions and recommendations, 118 pages of basic text, a bibliography of 262 sources, 20 tables and 31 figures.

SYHTHESIS OF THE CHAPTERS

The introduction highlights the actuality and relevance of the topic addressed, noting that food and nutritional security has become an ascending priority of the global development paradigm, and the pressure of food and nutritional insecurity on people with GRDs is twofold, as it threatens the cornerstone – the GFD, the only effective therapy for this category of people, unanimously accepted by the medical community (Al-Toma et al., 2019; Siminiuc et al., 2020a). Also, the motivation for choosing the research topic is argued, the research problem, the purpose and objectives, as well as the novelty degree of the topic addressed are presented. The lack of tools and models for assessing the nutritional security of people with GRDs in the Republic of Moldova justifies the need to develop a conceptual system, which will take into account the vulnerabilities, challenges and specifics of this category of people (Siminiuc et al., 2020a).

Chapter 1, ***Quality of life without gluten through the prism of nutritional security***, outlines the GRDs, presenting their triggers, classification and how they affect life quality of people with GRDs. Also, an incursion is made into the terminology of food security with a focus on nutritional security, on the evaluation of the GRDs incidence and on the spectrum of actions applied to ensure the assistance of people with GRDs at the international level and, in particular, in the Republic of Moldova.

Chapter 2, ***Methodologies for evaluating the nutritional security of people with GRDs***, describes the methods of systematic review of documents (data triangulation, systematic review through the PRISMA flow chart), the immuno-chromatographic method of identifying toxic prolamin in GF products, the methods for evaluating the nutritional quality of carbohydrate products, as well as the models for evaluating the assistance level for people with GRDs based on composite indicators, with national applicability. Also, the methods and tools for developing a nutritional software are presented, which includes indicators applicable at the individual level, as well as statistical data processing methods, etc.

In Chapter 3, ***Assessing the quality and compliance of GF products***, argues the role of carbohydrates in understanding the development of non-communicable diseases (NCDs), in particular bread and bakery products, as basic carbohydrate products of human nutrition, providing 70% of human nutrition (Siminiuc et al., 2022a). The nutritional quality of GF bread and bakery products, sold in markets in Chisinau, was evaluated by 3 methods:

- according to the information provided on the nutrition declaration of the label;
- according to the composite score model (developed by the author);
- according to the health-related notices (through which the validation was carried out).

The selected product categories (n = 151), according to the *European Food Groups (EFG)* classification codes, were the following: bread and baguette (code 01, n = 87) and bakery products (code 05, n = 64), which included crispbread (crumbs, pretzels, crackers) and flatbread (pita, lavash, tortillas, piadini). The information on the nutrition declaration was taken from the label and transferred to an *Excel* table, according to the *Compilation tool version 1.2.1* (FAO/INFOODS).

Evaluation of nutritional quality according to nutritional values on the label. GF bread and bakery products are characterized by high energy density, with average values between 211.0 and 319.0 kcal/100g, for bread, and between 249 and 365 kcal/100g, for crispbread and for flatbread. The nutritional quality of GF bread is characterized by a low protein content (5.9% - 11.0%), variable fat content (0.4%...20.0%) and added sugars (0,7%...9.2%) and a relatively higher share of carbohydrate content (14%...51%) (Figures 1-3).

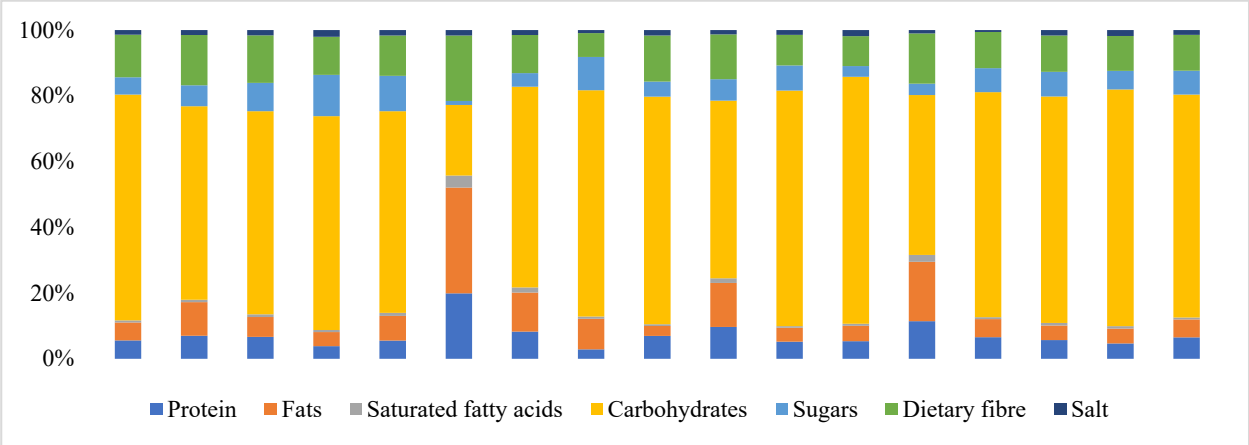

Figure 1. General nutritional characteristics of gluten-free bread

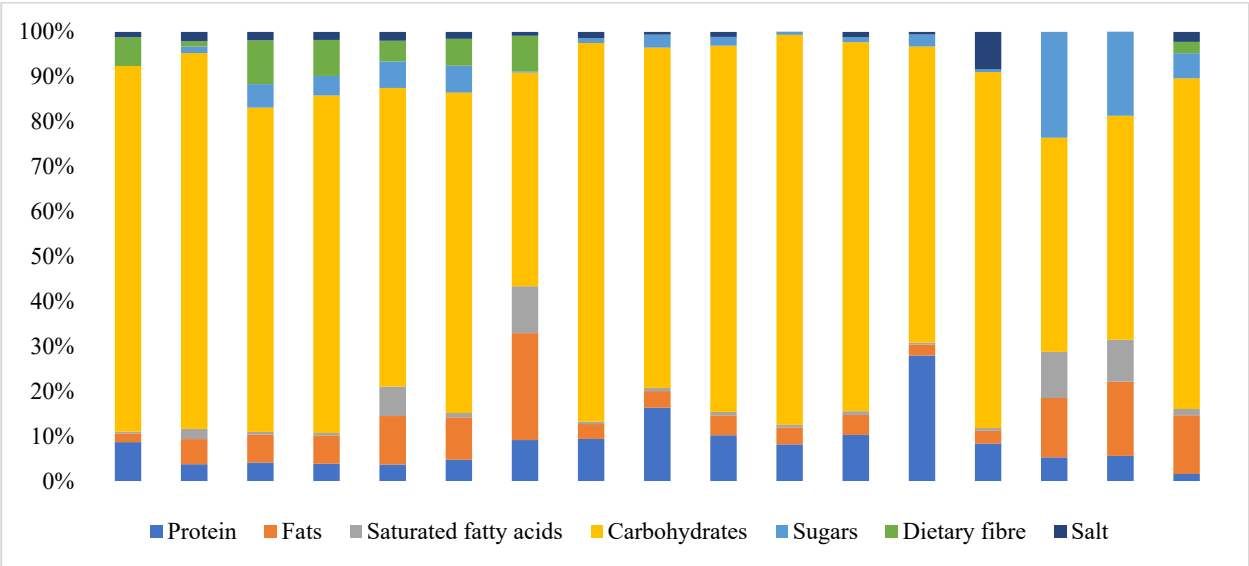

Figure 2. General nutritional characteristics of GF crispbread

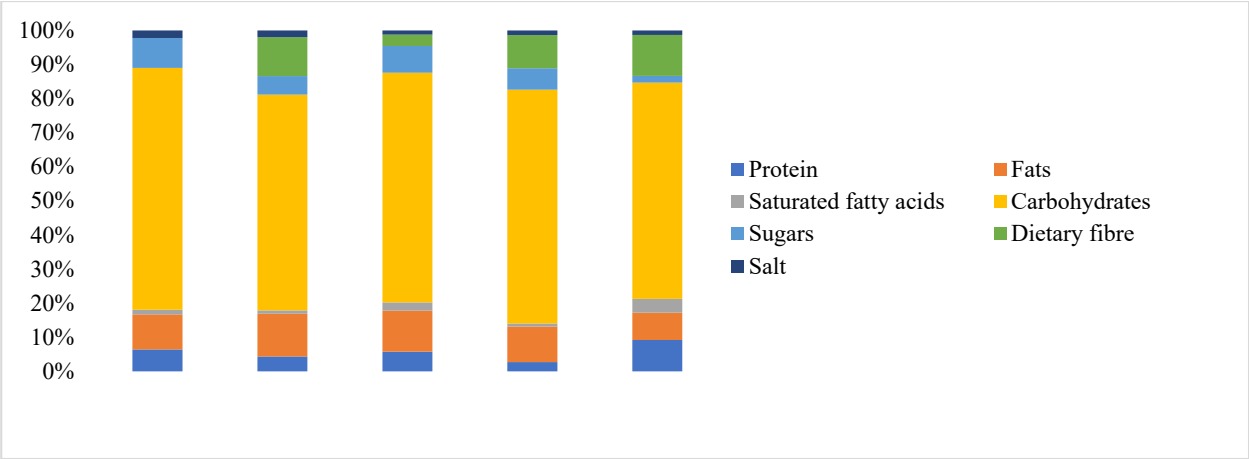

Figure 3. General nutritional characteristics of the GF flatbread

The presented nutritional characteristic gives rather a picture of the nutrient category than the satisfaction degree related to the optimal nutritional needs of different groups of nutrients, nor of the product quality as a whole. As a result, it is very difficult for consumers to distinguish truly good nutritious foods. Therefore, in-depth studies are required to evaluate the nutritional quality of foods based on valid and efficient evaluation systems or models that take into account multidimensional indicators (Wang et al., 2022).

Evaluation of nutritional quality according to the FiZSIM model. A score-based FiZSIM composite model (Dietary Fibre, Sugar, Salt, Wholemeal flour, Sourdough) was developed to assess the nutritional quality of GF bread and bakery products. The model takes into account five indicators, aligned with current nutrition trends, scientifically proven and with demonstrated health impact (Siminiuc et al., 2022b; Croitoru et al., 2019). The model is eligible to achieve a maximum of five or six points for the "high quality" qualification (Table 1).

Table 1. The evaluated components of the proposed model

Components/parameters	***Score***		
	Zero points	**1 point**	**2 points**
Sugar (free/added)	≥ 5%	< 5%	-
Dietary fibre, per 100 g product	< 6%	-	≥ 6%
Salt, per 100 g product	≥ 1%	< 1%	
Sourdough *(as a fermentation agent)*	No	Yes	-
Wholemeal flour and/or other flours *(from legumes, pseudocereals, seeds, nuts)*	No	Yes	-
Score interval	**Qualification**		
5 - 6 points	High quality		

3 - 4 points	Medium quality
≤ 3 points	Low quality

According to the evaluation results using the FiZSIM model, 76.5% of the bread assortment (GF), 64.7% of the crispbread (GF) and 60.0% of the flatbread (GF) were assigned the maximum score = 1 for sugars content (Tabel 2). The dietary fibre component plays a major role in this model, thanks to the evidence – reliable and proven – of its health benefits. In 82.4% of GF bread, 29.4% of crispbread and 80% of flatbread the fibre content exceeded 6%. As for the salt content, the share of GF bread, with salt content < 1%, constituted 41.2%, and of crispbread – 35.3%. All GF flatbread (100%) and 70.6% of GF crispbread are made according to formulations that include whole grains, seeds or other flours. Manufacturing trends in GF bread and bakery products are adapted to current consumer preferences, which include long fermentation periods and artisanal technologies, which was demonstrated by the fact that 64.7% of products have sourdough as a leavening agent (Siminiuc et al., 2020b; 2023) (Table 2).

Table 2. The share of the maximum unit qualifications, granted per product category

Type of products		***The components of the model (score)***				
	Specifications	**Sugar < 5% Score=1**	**Dietary Fibre ≥ 6% Score=2**	**Salt < 1% Score=1**	**Whole grains and/or other flours Score=1**	**Sourdough Score=1**
Bread	From local producers (n=58)	n = 57 (98.3%)	n = 6 (10.3%)	n = 25 (43.1%)	n = 25 (43.1%)	n = 5 (8.6%)
	imported (n=12)	n = 7 (58.3%)	n = 2 (16.7%)	n = 2 (16.7%)	n = 9 (75%)	n = 0
	GF (imported) (n=17)	n = 13 (76.5%)	n = 14 (82.4%)	n = 7 (41.2%)	n = 17 (100%)	n = 11 (64.7%)
Crispbread	From local producers (n=26)	n = 12 (46.2%)	n = 5 (19.2%)	n = 9 (34.6%)	n = 11 (42.3%)	n = 0
	Imported	n = 7	n = 2	n = 2	n = 3	n = 1

	(n=10)	(70%)	(20%)	(20%)	(30%)	(10%)
	GF (imported) (n=17)	n = 11 (64.7%)	n = 5 (29.4%)	n = 6 (35.3%)	n = 12 (70.6%)	n = 0
Flatbread	From local producers (n=6)	n = 4 (66.7%)	n = 0	n = 1 (16.7%)	n = 1 (16.7%)	n = 0
	GF (imported) (n=5)	n = 3 (60%)	n = 4 (80%)	n = 1 (20%)	n = 5 (100%)	n = 1 (20%)

Quality score of bread and bakery products based on the developed model. According to the developed model, the score results show that GF bread is more nutritionally balanced. Thus, 47.06% of the GF bread assortment fell into the *medium quality* qualification and 47.06% - into the *high quality* qualification (Figure 4).

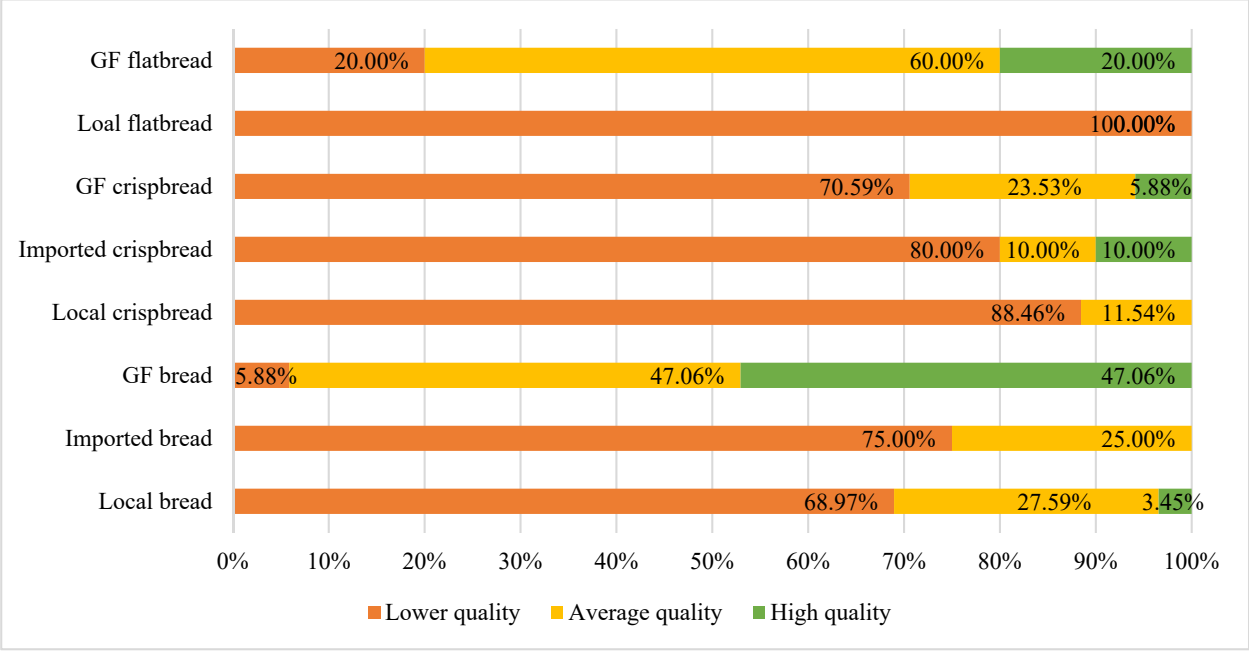

Figure 4. Composite score per product category based on the FiZSIM model

Legend: GF- gluten free

Nutritional quality of bread and bakery products, as assessed by the FiZSIM model, ranks higher than their gluten counterparts, which mostly have a low fibre content and use rapid fermentation methods. At the same time, the results obtained show that the insistence of research and efforts in the development of GF products, with the purpose of improving nutritional aspects, have determined an active vector recording positive results, while nutritional quality of bread and bakery products with gluten has remained, somewhat, unchanged in recent years and requires reformulations, especially in terms of fibre content.

Evaluation of the conformity of GF products sold in the Republic of Moldova. As a "pervasive" nutrient, gluten can contaminate GF items throughout the production chain – from the field to the milling, storage and manufacturing stages, including marketing (Verma et al., 2017). A series of GF products (n=48), sold in the markets in Chisinau, were tested to determine the presence of toxic prolamin. The tests were carried out using the standardized GlutenToxPro kit (AOAC-RI), an immunochromatographic test, based on the presence of *G12* antibodies, which specifically recognize the peptide 33 of the α-gliadin protein, responsible for inducing CD (AOAC, Performance Tested Researh Institute. License number 061502, f.a.; Siminiuc et al., 2022a).

The results showed that the assortment of GF food products in the Republic of Moldova is extremely reduced and insufficiently diversified, and local products (cereals, legumes and their derivatives, etc.), labeled as GF products, are safe. Local, non-packaged GF products (developed and made available to consumers by the supermarkets included in the research) pose an increased risk of cross-contamination and, respectively, a risk to people with GRDs (Siminiuc et al., 2022a) (Table 3).

Table 3. Gluten contamination degree in the examined products

Category of tested GF products	**Number of products**	**Gluten content**		
		> 20 ppm	> 10 ppm	< 10 ppm
Imported GF labelled products	n = 13	-	1 (8%)	12 (92%)
Imported products with crossed grain logo	n = 18	-	-	18 (100%)
Local packaged products	n = 15	-	5 (33%)	10 (67%)
Local non-packaged products	n = 2	2 (100%)	-	-

The lack of certification policies for this category of products lowers people's confidence level in the safety of local GF products.

Chapter 4, ***Development of a software for the nutritional management of people with GRDs*****,** presents the SNUTM - UTM nutritional evaluation software, which is intended for students-nutritionists and is made based on the information system *Embarcadero RAD Studio Alexandria Edition*, having as database *Microsoft SQL Server*. The block diagram of the SNUTM software is represented in Figure 5.

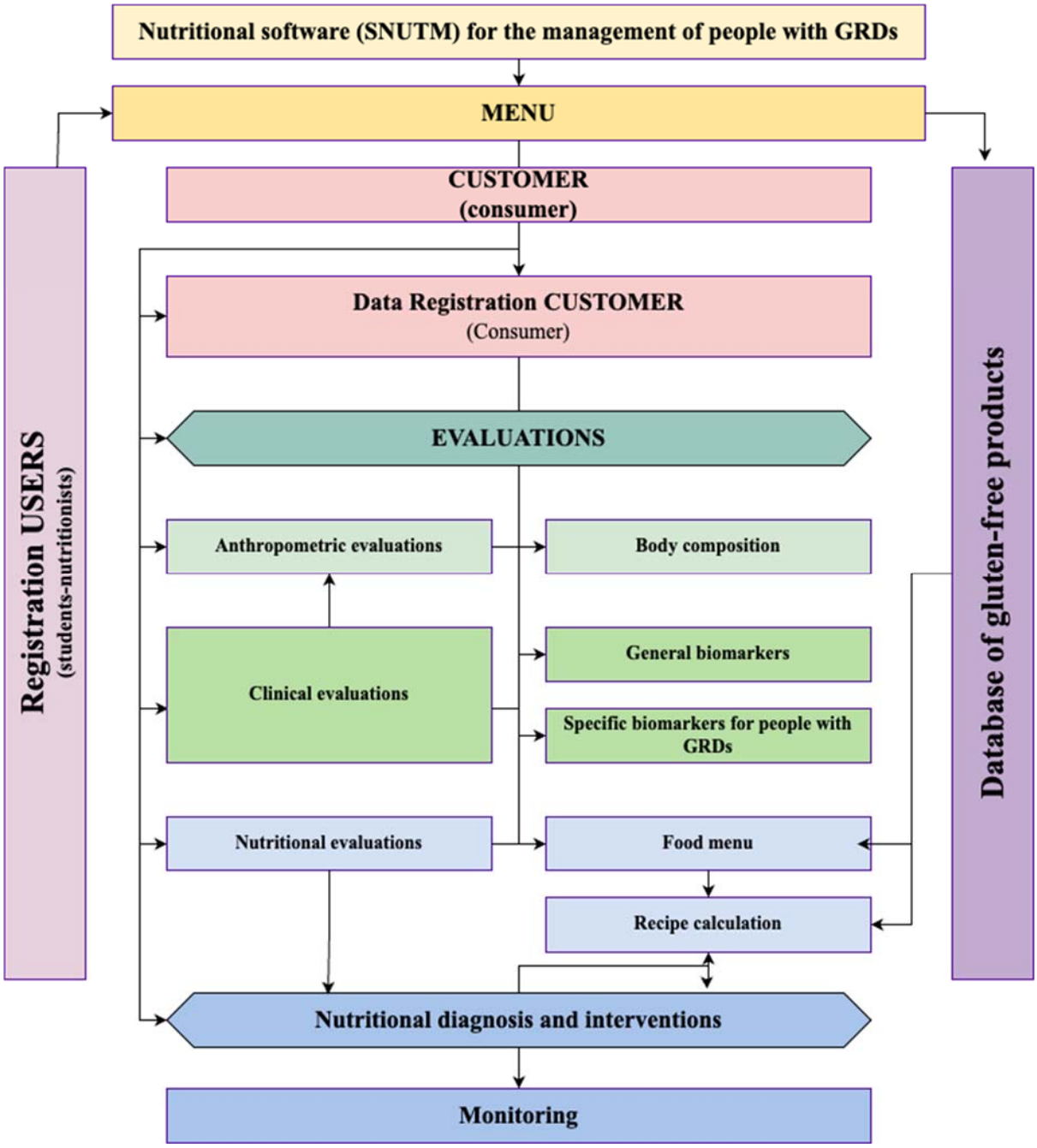

Figure 5. Map of the nutrition software SNUTM

The development of the Software followed the systemic approach of the Nutrition Care Process. The parameters included in the SNUTM system are general (Table 4) and specific (Table 5), taken from the scientific literature:

Table 4. Parameters used in software development

Software components	Source
Anthropometric measurements (height, weight, Body Mass Index, waist circumference, thigh circumference, etc.)	(Casadei et al., 2023; Eaton–Evans, 2005; Hume et al., 2017; Pietrobelli, 2005; Schofield, 1985; WHO Expert Committee on Physical Status: the Use and Interpretation of Anthropometry, 1995)
Biomarkers, medical tests, etc., to detect nutritional deficiencies	(Husby et al., 2012)
*Biomarkers for the diagnosis of CD	(Husby et al., 2012)
Parameters and equations for body composition Body Mass Index (BMI), Basal Metabolic Rate (BMR), Energy Needs (EN)	(Wideman et al., 2013)
FAO-INFOOD Food Composition Databases	(FAO/INFOODS, f.a.)
GF product database (bread and bakery products)	(Excel, UTM)
Equations for calculating energy value and nutrients	(Miller et al., 1984)
*Guidelines for the Diagnosis of Coeliac Disease elaborated by ESPGHAN - European Society for Paediatric Gastroenterology, Hepatology, and Nutrition	(Beth, 2015; Parkman, 2005, Husby, 2012)
Menu analysis questionnaire	(Beth, 2015; Cade et al., 2002; Swindale et al., 2004)
***GSRS - Gastrointestinal Symptom Rating Scale Questionnaire**	(Hopman et al., 2009; Souza et al., 2016; Svedlund et al., 1988)
* Questionnaire for the assessment of adherence to GFD	(Silvester et al., 2016; Zingone et al., 2013)
*Questionnaire for assessing the quality of life of people with GRDs	(Beth, 2015; Dwyer, 2004)
Dietary Reference Values (DRVs)	(Institute of Medicine (U.S.) et al., 1998; Alves Durães et al., 2021)

Dietary data collected following the schedule of a 24-hour food recall and food group frequency of consumption	(FAO/INFOODS, f.a.; Casadei et al., 2023; Alves Durães et al., 2021; Lasa et al., 2019)
* Links to useful guides on Celiac Disease	(Dolinsek et al., 2021)

Source: (MacLean et al., 2003). *Legend:* *specific GRDs parameters

Table 5. Biomarkers for the diagnosis of celiac disease (CD)

Symptoms
Malabsorption syndrome
Other symptoms associated with CD (type 1 diabetes mellitus (T1DM) or people who have first-degree relatives with CD)
Asymptomatic
Serum antibodies
EMA positivity and/or high positivity (>10 ULN) for anti TG2
Weakly positive for TG2 antibodies or positive for isolated anti-DGP
Serology not performed
Serology performed, but all specific celiac antibodies are negative
HLA
Full presence of all HLA (in *cis* or *trans*) or presence of HLA-DQ8
Lack of HLA or half of DQ2 (only HLA-DQB1* 0202)
Nor HLA DQ2 neither DQ8
Histology
Marsh 3b or 3c (subtotal villous atrophy, flat lesion)
Marsh 2 or 3a (moderately decreased villus height/crypt deph ratio) OR Marsh 0-1 plus intestinal TG2 antibodies
Marsh 0-1 or no biopsy performed
**With reference to IgA deficiency to EMA, TG2 and DGP antibodies of the IgG class*

Source: (Husby et al., 2012)

General markers, along with specific ones, may be registered, with the possibility of scanning and archiving the results obtained from the analysis sampling laboratories (Figures 6 - 9).

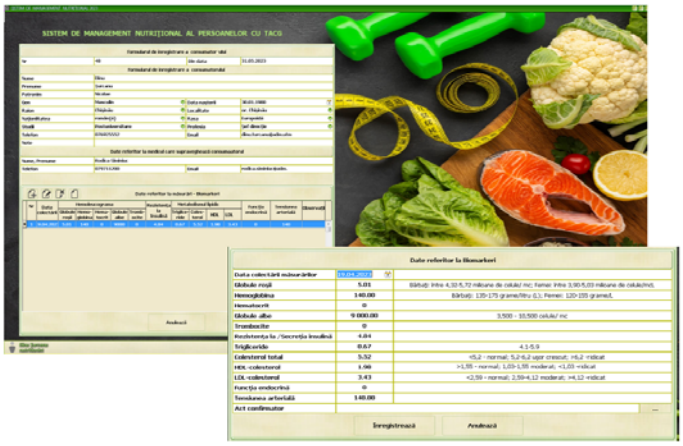

Figure 6. Registration of biomarkers

Figure 7. Confirmatory act attesting the origin of biomarkers

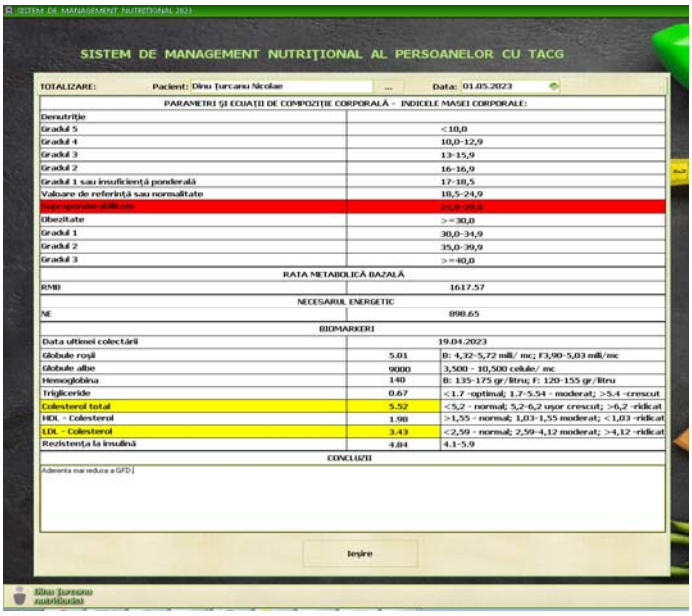

Figure 8. The answer generated by the software as a result of anamnesis and data collection

Figure 9. Compiling the questionnaire on the GFD adherence

The system includes the functionality to monitor and evaluate users' progress toward health goals, and on the other hand users and nutrition professionals can effectively track progress and make appropriate adjustments. The system, at the current stage, generates a (fractional) feedback to the user, so that, subsequently, to come up with a nutritional solution related to the nutritional management of the consumer with GRDs.

In Chapter 5, ***Conceptual Framework for Assessing the Nutritional Security of People with GRDs***, two major components for assessing the assistance level for people with GRDs are developed and described:

The model for evaluating the assistance level through the prism of local public policies is based on a composite score of 6 items (Does the country have regulations regarding packaged

industrial food products for people with CD? Does the country have regulations regarding meals and non-packaged food for people with CD? Is there a specialized healthcare service for celiac patients? Is there a governmental grocery allowance and/or financial incentive for CD patients? Is there a *gluten-free* certification program for manufactured products intended for people with CD? Does the country have a national CD association?), with dichotomous response options and score values between zero and six.

The score obtained by applying this model was 2.5 points, which corresponds to *a low level of assistance*. The average level of assistance for people with CD, per continents, is the highest on the European one – 3.63, followed by South America – 2.86 and North America – 1.05. Only six European countries reached the maximum score = 6 points (France, Italy, Netherlands, Slovenia, Sweden and Great Britain) (Falcomer et al., 2020; Siminiuc et al., 2022b) (Figure 10).

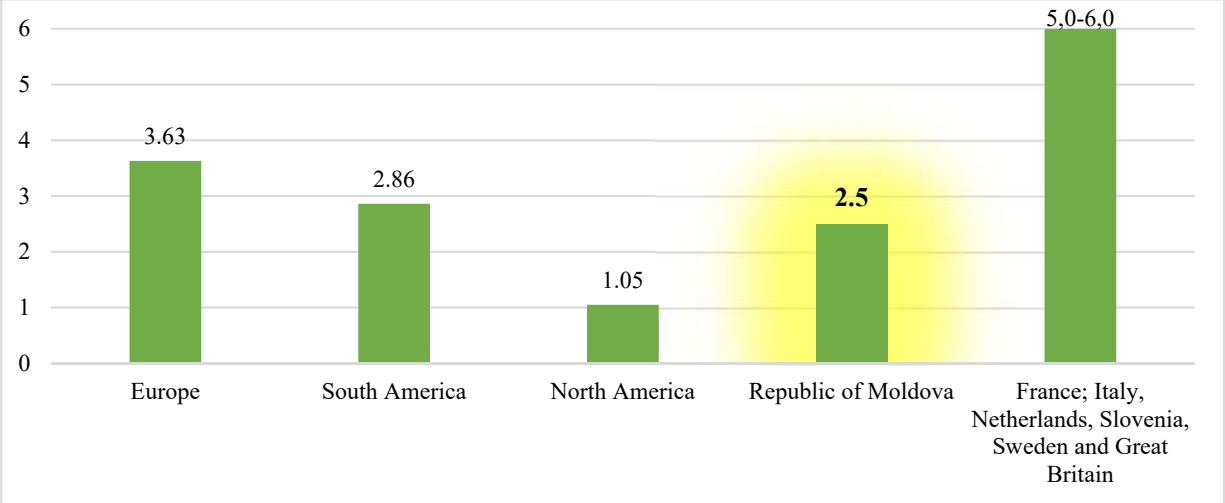

Figure 10. The comparative score of the assistance level for people with GRDs in the Republic of Moldova and in different countries and regions

The results of this study related to the assistance level for people with GRDs in the Republic of Moldova highlight major gaps in the design and content of policies and programs governing the food security of people with GRDs, in the implementation of policies, including their monitoring and evaluation. Existing policies and standards do not adequately respond to the challenges faced by people with special nutritional needs, especially those with GRDs, and the burden of malnutrition on this category is even greater.

In the *Conceptual Framework for Assessing the Nutritional Security of People with GRDs*, the author describes the stages, identifies the decision factors considered in the design of the framework, classifies and describes the indicators that are part of the framework and which are in correlation with the guidelines of WHO, FAO and Global Food Security Index (2023), with the recommendations of the *Codex Alimentarius* and of the Global Nutrition Report, etc. The proposed

conceptual framework includes only the nutritional dimension, which determines the relationship between food, body and individual (Siqueira et al., 2022), and includes both action-based methodologies and quantitative metrics (Figure 11).

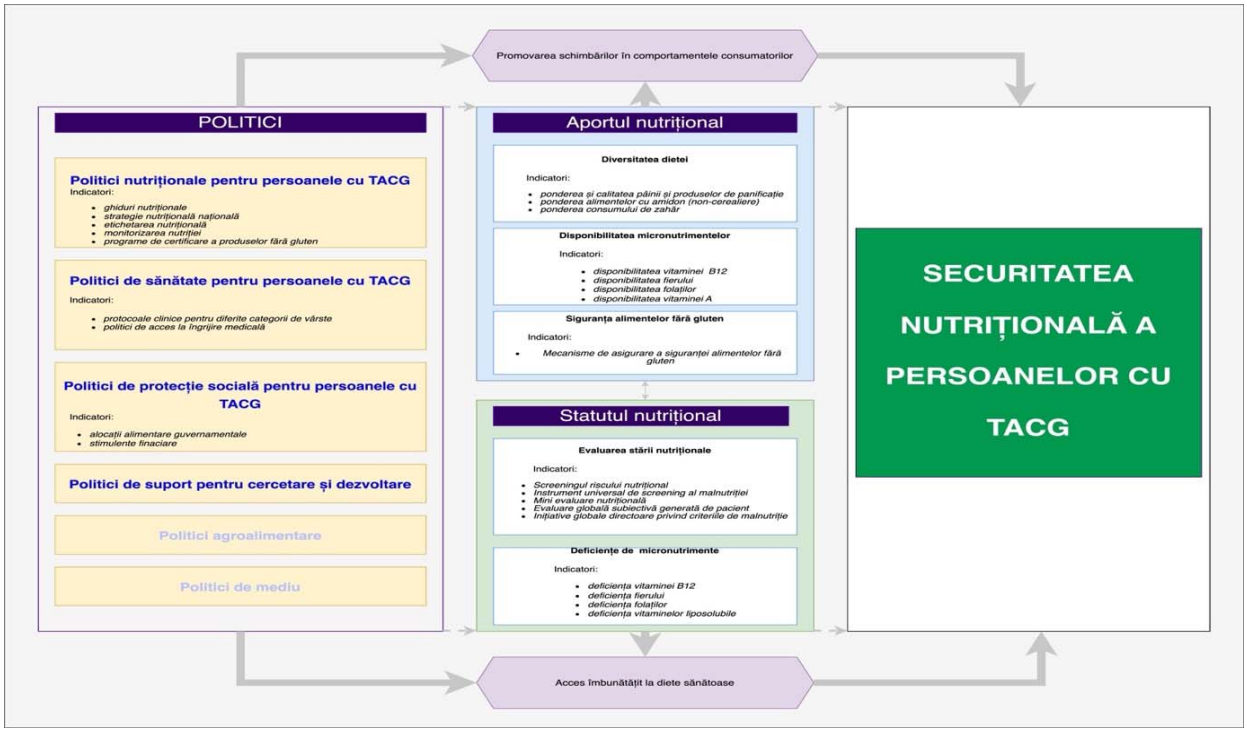

Figure 11. The conceptual framework for evaluating the nutritional security of people with GRDs in the Republic of Moldova

Developed by the author, based on (Siminiuc et al., 2022b; 2020a; 2022a; The Economist Group, 2022; Global Nutrition Report, 2023).

The developed model for evaluating the assistance level for people with GRDs through the prism of local public policies is part of the action-oriented approaches, while the FiZSIM model for evaluating the quality of GF bread and bakery products and the indicators included in the nutritional software is part of systems based on quantitative metrics. The comprehensiveness of the framework was ensured by the inclusion of indicators developed by international bodies in the Food and Nutrition Security field: nutrition monitoring and surveillance; nutritional intake assessment indicators; share of sugar consumption; share of non-starchy foods; availability of deficient micronutrients.

The thesis ends with general conclusions and recommendations.

GENERAL CONCLUSIONS OF THE RESEARCH:

- Information regarding the incidence of CD or other GRDs is decentralized, contradictory, often being stored by different medical institutions and by different doctors, and the real number of patients (children and adults) diagnosed with CD remains an imprecise one (In subchapters 1.1 și 1.3 [Siminiuc et al., 2020a]).
- Over the period 2010 - 2016, the pediatric share of CD, at the national level, recorded a continuous increase, being estimated from 3 to 19 cases annually. Currently, 67 patients (adults and children) diagnosed with CD and with a confirmed degree of disability are registered in the Single Register of patients with CD, but it is believed that their number is much higher (In chapter 1. Monograph. Siminiuc R. and Țurcanu D. Provocări și tendințe în dezvoltarea produselor fără gluten / Challenges and trends in gluten-free product development).
- In the Republic of Moldova, GF products are not produced or certified, there are no public or private catering services for people with GRDs, the participation of nutritionists and dieticians in the development of balanced menus is limited or there is no one of them in the public units of food services, there is a limited assortment of imported GF products, very expensive, and the offer of social assistance and nutritional care services is incipient, etc. (In subchapters 1.3 and 5.1 [Siminiuc et al., 2022b; 2020a; 2023]).
- In order to evaluate the nutritional quality of GF bread and bakery products, the FiZSIM model was developed, based on five indicators aligned with current nutrition trends, scientifically argued and with proven health impact. According to the score obtained by the FiZSIM model, about 47.06% of commercial GF bread is of medium quality and 47.06% - of high quality, the qualifications obtained being mainly due to the high fiber content, the prolonged fermentation time and careful selection of raw materials (In chapter 3: Approved for publication in: ICNBME-2023. 6th International Conference on Nanotechnologies and Biomedical Engineering, September 2023, Scopus; [Siminiuc et al., 2023]).
- The safety of *GF* products, sold in the Republic of Moldova, was evaluated, as a basic indicator serving the presence of toxic prolamin. It was established that all imported products, certified *GF* (n=13) or *Crossed grain* (n=18), recorded a content of toxic prolamin below the allowed limit of 20 ppm, being in 92% of cases < 10 ppm for imported products, certified *GF*. Local *GF* bakery products, non-packaged and non-certified, but marketed as *GF* products (n=2) pose a risk to consumers with GRDs, due to the presence

of peptide 33 of the α-gliadin protein, responsible for inducing the CD, above the permissible values of 20 ppm. (In subchapter 3.4 [Siminiuc et al., 2022a]).

- The evaluation of the assistance level for people with GRDs in the Republic of Moldova through the prism of local public policies established a low level of assistance (2.5 points), placing the country lower, according to the assistance level, compared to France, Italy, Netherlands, Slovenia, Sweden and Great Britain (6.0 points), compared to the average values attributed to the European continent (3.63 points), but also compared to South America (2.86 points). Thus, policy review and integration of nutrition goals to support people with CD is needed at all levels: legislative, educational and training, community support through social events, workshops, business/industry support (In subchapters 5.1 and 5.2 [Siminiuc et al., 2022b]).
- The system generates a (fractional) feedback to the user, so that, subsequently, it comes up with a solution related to the nutritional management of the consumer with GRDS.
- An information system (SNUTM) was developed for people with GRDs based on the *Embarcadero RAD Studio Alexandria Edition* information system, with *Microsoft SQL Server* as database, which provides a personalized and precise approach, taking into account the consumer's anamnesis, the results of clinical tests, anthropometric parameters and specific GRDs biomarkers. The software analyzes factors such as age, gender, physical activity level, health goals and dietary preferences, providing the ability to record data and archive results obtained from analysis sampling laboratories. The system generates a (fractional) feedback to the user, so that, subsequently, it comes up with a solution related to the nutritional management of the consumer with GRDs (Patent MD 1563Y of 30.09.2021; Positive result of the examination of patent applications no. 4417; 4419; 4421 from 2023.06.27).
- The author developed a Conceptual Framework for the assessment of nutritional security of people with GRDs, based on the indicators developed by international organizations, which govern nutritional security. The conceptual framework will serve to systematically analyze the complex drivers of nutrition security, identify gaps and recommend evidence-based actions, and monitor the progress and overall well-being of people with GRDs.

RECOMMENDATIONS:

Based on the research carried out and the results obtained, it is recommended:

- To focusing on strategic planning in the field of health and to recognize policies as umbrella terms in ensuring food and nutritional security, which justifies the need for the model to assess the assistance level for people with GRDs through the prism of local public policies.
- The model for evaluating the assistance level for people with GRDs in the Republic of Moldova, through the prism of policies, will allow to identify and systematize national policies and standards, to carry out their complex evaluation including their role in ensuring nutritional security and public health, and also the human right to adequate food for people with GRDs. At the same time, it could be used to prioritize nutritional problems and identify the most effective strategies and specific actions adapted to the needs of the target populations.
- The FiZSIM model, being a complex one, in compliance with national and international normative acts, may be designed in a frontal labeling model or in nutritional evaluation systems, providing the consumer with information about the nutritional quality of the product, thus contributing to improving the diet, to reducing the incidence of diet-related diseases and promoting appropriate food choices.
- The nutritional software (SNUTM) is recommended for students-nutritionists, but also for nutrition professionals, to provide personalized advice to people with GRDs. It can help assess nutrient intake, identify nutritional deficiencies, and generate dietary recommendations tailored to individual needs, enabling students-nutritionists to better learn nutrition concepts and principles, manage nutrition-related data more effectively and to test different scenarios and solutions regarding nutrition and health plans, at the same time contributing to the nutritional education of the population.
- A team approach is required, which would include the celiac and his/her family, the doctor, the nutritionist and celiac support group, in order to better understand the issues related to the well-being of people with GRDs, etc., which could help improve their life quality.
- The conceptual framework developed could be applied:
    - In nutrition education and counseling: the framework may be integrated into nutrition education and counseling programs to support people with GRDs.
    - In scientific research, to investigate the impact of the GFD on the nutrition and health of celiacs, involving the assessment of dietary composition, nutritional status, inflammatory markers, antibody levels and other relevant GRDs indicators.

- In communities and non-governmental organizations: through this framework, the nutritional status of community members can be assessed and monitored, specific nutritional needs can be identified and appropriate programs and interventions can be developed to support specialized nutrition.
- In the food industry and catering services: to assess and monitor the supply of safe and GF foods, which would include the assessment of quality control and food safety policies, correct and clear information about gluten content etc.

Nutrition and food research plays a key role in ensuring nutritional security and the right to adequate food for people with special nutritional requirements. They contribute to the understanding of nutritional requirements, meeting special nutritional needs, establishing relationship between nutrition and health, developing balanced and healthy foods, developing nutrition programs and evaluating nutritional education policies. All of this, as a whole, would lead to the inclusion of healthy diets in the priority list of the national agenda for ensuring Food and Nutrition Security, including, the achievement of the Sustainable Development Objective 2 (Zero hunger) and generating impact in favor of Sustainable Development Goal 3 (Good health and well-being), especially for people with GRDs.

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LIST OF SCIENTIFIC PAPERS PUBLISHED ON THE TOPIC OF DOCTORAL THESIS

Author Dinu ȚURCANU,
PhD student of the Doctoral School, Technical University of Moldova

1. Monographs (recommended for publishing by the UTM Senate)

1.1. SIMINIUC Rodica, **ȚURCANU Dinu.** *Challenges and trends in gluten-free product development.* First Ediție. Chisinau: Publishing house Kim Art, 2023. 160 pp. ISBN 978-9975-3595-3-5.

2. Papers in in scientific journals

2.1. in journals from the Web of Science and SCOPUS databases

2.1.1. SIMINIUC, R., **ȚURCANU, D.** Technological approaches applied in the design of gluten free bakery products. In: *Czech J. Food Sci*. 2023, 41(3):155-172. DOI: 10.17221/180/2022-CJFS (IF = 1.3).

2.1.2. SIMINIUC, R., **ȚURCANU, D.** Food security of people with celiac disease in the Republic of Moldova through prism of public policies. In: *Frontiers in Public Health*. 2022, vol.10. 3639. https://doi.org/10.3389/fpubh.2022.961827 (IF= 6,46).

2.1.3. SIMINIUC, R., **ȚURCANU, D.** Impact of artisanal technologies on the quality indices of the cozonac. In: *Food systems*. 2020, 3(3):25-31. https://doi.org/10.21323/2618-9771-2020-3-3-25-31. Scopus Indexed.

2.2. in international recognized journals

2.2.1. SIMINIUC, R., **ȚURCANU, D.** Study of Edible Spontaneous Herbs in the Republic of Moldova for Ensuring a Sustainable Food System. In*: Food and Nutrition Sciences*. 2021, **12**, 703-718. DOI: 10.4236/fns.2021.127053.
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2.3. in journals from the National Register of professional journals, indicating the category

2.3.1. SIMINIUC, R., **ȚURCANU, D.** Evaluation of gluten contamination in gluten-free products in the Republic of Moldova. In: *JES,* 2022, Vol. XXIX (3).
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3. Papers in the proceedings of conferences and other scientific events

3.1. in the proceedings of scientific events included in the Web of Science and SCOPUS databases

3.1.1. SIMINIUC, R., **ȚURCANU, D.** Nutritional quality of bread and bakery products. Case study: Republic of Moldova. In: *ICNBME-2023. 6th International Conference on Nanotechnologies and Biomedical Engineering*: Chisinau, September 2023. *Accepted for publication (Scopus).*

3.2. in the proceedings of scientific events abroad included in databases accepted by ANACEC

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3.3. in the proceedings of scientific events included in the Register of materials published on the basis of scientific events organized in the Republic of Moldova

3.3.1. **ȚURCANU, D.** Biologically active compounds of *Sambucus nigra* fruits. In: *Technical-Scientific Conference of UTM Bachelor's, Master's and Doctoral Degree students*, Chisinau, 2023. *(In Press)*

3.3.2. SIMINIUC, R., **ȚURCANU, D.** (*plenary session presentation*). Food Security of People with Celiac Disease in the Republic of Molodova through Prism of Public Policies. In: *International Conference Modern Technologies in the Food Industry*, UTM, Chisinau, October 20-22, 2022. https://mtfi.utm.md/files/Materialele_Conferintei_MTFI-2022.pdf

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4. Intellectual property. Patents

4.1. SIMINIUC, R., **ȚURCANU, D.** Compositions and procedure for obtaining cozonak with sourdough with spontaneous flora. Patent MD 1563Y 30.09.2021. http://cris.utm.md/bitstream/5014/1087/1/55.%20MD%201563%20Y%20Compozi%C5%A3ii%20%C5%9Fi%20procedeu%20de%20fabricare%20a%20cozonacului%20cu%20maia%20cu%20flor%C4%83%20spontan%C4%83.pdf

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5. Awards/participation in international/national invention salons:

5.1. SIMINIUC, R., **ȚURCANU, D.** Procedure and composition for obtaining gluten-free bread with the addition of pulp from spinach leaves (*Spinacia Oleracea*). In: *The XXVII-th International Exhibition of Inventics,* INVENTICA, Iasi, Romania, June 21-23, 2023. Diploma and Gold Medal.

5.2. SIMINIUC, R., **ȚURCANU, D.** Procedure and composition for obtaining gluten-free bread with the addition of elderberry berry pulp *(Sambucus Nigra*). In: *The XXVII-th International Exhibition of Inventics,* INVENTICA, Iasi, Romania, June 21-23, 2023. Diploma and Gold Medal.

5.3. SIMINIUC, R., **ȚURCANU, D.** Procedure and composition for obtaining gluten-free bread from soriz flour (*Sorghum Oryzoidum*). In: *The XXVII-th International Exhibition of Inventics,* INVENTICA, Iasi, Romania, June 21-23, 2023. Diploma and Silver Medal.

5.4. SIMINIUC, R., **ȚURCANU, D.** Contributions regarding nutritional eradication of gluten consumption diseases (2021-2023). In: *International Exhibition INVENTCOR 3rd edition,*

Deva, Romania, 15-17.12.2022. 175 p. Diploma and Gold Medal.
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5.5. SIMINIUC, R., **ȚURCANU, D**. REȘITCA, V., CHIRSANOVA, A., POJAR, D., CUJBĂ, R. et al. Personalized nutrition and intelligent technologies for my well-being. PS nr. 20.80095107.10. In: *International Exhibition INVENTCOR 3rd edition*, Deva, Romania, 15-17.12.2022, 176 p. Diploma and Gold Medal.
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5.6. SIMINIUC, R., **ȚURCANU, D**. Compositions and method for producing cozonac with spontaneous flora sourdough. MD 1563. In: *International Exhibition INVENTCOR 3rd edition*, Deva, Romania, 15-17.12.2022, 174 p. Diploma and Gold Medal.
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5.9. SIMINIUC, R., **ȚURCANU, D**. Compositions and method for producing kozonak with sourdough with spontaneous flora. In: *NOVALIMENT International Fair of Inventions and Innovations,* Romania, November 22 - 26, 2021.
https://inovaliment.ro/compozitie-si-metoda-de-obtinere-pentru-kozonak-cu-aluat-din-flora-spontana/

6. Diplomas/mentions obtained at national exhibitions/national contests

6.1. **ȚURCANU, D**. Public Choice Award in the final of the national competition *„My thesis in 180 seconds",* Republic of Moldova, the 3rd edition of the competition organized by the National Office AUF-Moldova, in partnership with the Ministry of Education and Research of the Republic of Moldova and the National Agency for Quality Assurance in Education and Research (ANACEC), June 15, 2022.

6.2. **ȚURCANU, D.** *Government Excellence Scholarship*. Decision of the Government of the Republic of Moldova of February 22, 2023, regarding the granting of the Government Excellence Scholarship and of the Scholarship in scientific fields for doctoral students for the year 2023. Scientific specialty 253.04. Food Security, second year, Doctoral School of the Technical University of Moldova.

7. Scientific projects

7.1. Project on issues of urgent interest: *Exploratory analysis of food security in the Republic of Moldova based on metrics of nutritional and sustainable quality (CNuD) of food products. Project member.*

7.2. National State Project 20.80009.5107.10. *Personalized nutrition and smart technologies for my well-being*. 1.01.2020 – 31.12.2023. *Project member.*

ȚURCANU DINU

NUTRITIONAL SECURITY OF PEOPLE WITH GLUTEN RELATED DISORDERS IN THE REPUBLIC OF MOLDOVA

Scientific Speciality: 253.04 Food Security

Summary of the doctoral thesis in engineering sciences

Approved for printing: 25.07.2023	Paper size 60x84 1/16
Offset paper. RISO printing.	Circulation 50 ex.
Printing sheets: 2,0	Order no. 79

MD-2004, Chisinau mun., 168 Stefan cel Mare si Sfant av., UTM
MD-2045, Chisinau mun., 9/9 Studentilor str., Publishing House "Tehnica-UTM"

CHISINAU, 2023