REVIEW

Tarhana as a food aid suggestion to the world food program

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Summary

Many regions of the world still suffer from food insecurity, undernourishment and hunger problems. These problems are basically caused by a changing climate, natural disasters, depletion of natural resources, rapid population growth, lack of knowledge, conflicts and wars. Governments and United Nations institutions aim to prevent undernourishment and hunger by direct transportation of adequate, safe and nutritional foods via food aid. Tarhana food could be an alternative idea for providing food aid with mixed food materials obtained from various sources, such as animal and vegetal, instead of a single type of food, including a single source such as grain or milk. In this way, they can help to solve nutritional problems of people suffering from hunger and nutritional deficiencies. Tarhana is a traditional, nutritious, easy-to-prepare and digestible mixed food material obtained by fermenting cereals and dairy products with some vegetables and spices. The inclusion of tarhana to food aid packages can be a solution to hunger and nutritional deficiency problems and it can also be a transition point of passing to solid food. This review aimed to reveal some properties of tarhana and the idea of the inclusion of tarhana in food aid packages prepared for people suffering from undernourishment and hunger.

Keywords

hunger; undernourishment; malnutrition; food security; food aid; tarhana

One of the most important problems of society is food supply because its production depends on natural conditions. Food security is defined as enough food production and/or supply. The term of food security means that an individual can always reach its healthy food needs in order to lead a healthy, active and good life. Food security has been defined in 4 basic dimensions and as a multilayered concept, namely, the availability of food and access to it physically and economically, the use of food suitable for cultural and dietary needs and the stability of the food supply [1–3]. Food must be continuously available in enough quantities in order to ensure food security and economic opportunities must also be sufficient to supply the food. However, natural disasters, increasing with the effect of the changing climate, affect natural resources and thereby people more than in the past. In addition, while rapid population growth increases the pressure on natural resources, conflicts and wars cause mass migration by making it difficult for people to continue their daily lives. Such factors force people to compete more for natural resources and that increases conflicts as well as social problems [4, 5]. In addition, insufficient education in these regions causes ineffective use of limited natural and financial resources and deficiency in food production skills. It is believed that improving and strengthening education programs will have a great impact on food security [6].

Undernourishment and hunger are the main factors in many diseases, causing the death of five million children under the age of 5 in developing countries every year [7]. While undernourishment is stated as insufficiency in amount of food or vitamin, mineral and other nutritional components of consumed food because of insufficient purchase of nutritious foods, hunger is defined as a lack of food intake providing the necessary energy to maintain basic life functions [1–3]. Undernourish-

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ment decreases productivity and efficiency by negatively affecting the physical and mental state. In addition, undernourishment influences child development in this respect and causes to continue negatives from generation to generation. Undernourishment occurring in the first 2 years of life results in irreversible damage together with prevention of growth, shorter stature to normal adults, difficulties in education and low income in adult life. Additionally, it may affect the behaviour, acquiring bad habits and affect mental health of children [8, 9]. In this case, the adequate amount and quality of mother and child nutrition will solve existing problems and prevent future problems [10]. Adequate and balanced nutrition by consuming a variety of foods is important for normal growth, development, learning and productivity for children.

Food aid is food supplements delivered through governments and the United Nations (UN) institutions to regions in need to reduce these negative and undesirable effects. The food aid program aims at delivering adequate, safe and nutritious food directly to regions and individuals in need in the event of and after a humanitarian crisis [5, 11]. One of the most important problems to be solved for direct food aid is to provide food aid in the amount and variety meeting the requirements for energy, protein, fat, vitamins and minerals for each individual [12]. If food aid is made with mixed food materials obtained from various sources such as animal and vegetal instead of one type of food obtained from a single source such as grain or milk, this assistance will provide a stronger opportunity to solve the nutritional problems of people suffering from hunger and undernourishment in a more effective way.

Tarhana is a traditional mixed food with high nutritional value. It is made as semi-ready for consumption after fermenting flour and yogurt with some vegetables and spices [13]. As can be understood from the definition of tarhana, it comes from various vegetal and animal sources and its nutritional value as well as digestibility are increased by fermentation, while the content of non-nutritive compounds, such as phytic acid, is decreased. It has a long shelf life because it is dry and can be easily prepared as a soup. It has been evaluated that tarhana can be added to food aid packages as a new product type depending on its mentioned properties.

This review aimed to state some properties of tarhana and the appropriateness of the inclusion of tarhana in food aid packages prepared for regions of the world suffering from undernourishment and hunger.

Food aid

There are numerous organizations and institutions in the world providing food aid to regions with food security and hunger problems. The Food and Agriculture Organization (FAO) is a UN agency that leads international efforts to fight hunger and prevent poverty in developing countries [14]. FAO was established in 1945 to find solutions for elimination of hunger, guarantee food security and solve undernourishment problems and it still carries out studies in this direction. Although progress has been made in reducing malnutrition and improving the health of individuals since 1990, caused by a changing climate, natural disasters, depletion of natural resources, rapid population growth, lack of knowledge, conflicts and wars. Approximately 700 million people suffer from chronic hunger and approximately 2×10^9 people are suffering from undernourishment today [15]. The number of people suffering from undernourishment in the world and their ratio to the world population are given for each continent in Tab. 1.

World Food Program (WFP) is another UN agency for humanitarian aid, established to overcome hunger and undernourishment. WFP was adopted as a full-fledged UN program in 1965 and has saved the lives of many people all over the world. It provides direct food aid to 80 million people in approximately 80 countries by working with the relevant communities in emergencies today [12]. WFP determines the content and size of food aid packages according to climate conditions, consumption preferences, needs and diseases of the aided region. It is taken into consideration that the prepared food aid packages provide 8 786 kJ of energy per person daily and contain 10–12 % protein, 17 % fat together with various vitamins and micronutrients such as iron, zinc and iodine. These food aid packages usually consist of basic food products such as wheat flour, rice, legumes, vegetable oils fortified with vitamins A and D, iodized salt and sugar. WFP is also using special mixture of fortified foods in food aid packages prepared for preventing general nutritional deficiency and protecting mother-child health. These fortified food mixes contain a minimum of 18 % protein and 6 % fat, and are prepared for consumption by cooking with water. Additionally, ready-to-use supplements are designed by WFP for nutrition of undernourished children, in addition to breast milk, and these contain 12–13 % protein. These foods, containing vegetable oil, skim milk, sugar and whey, are considered more appropriate than fortified mixed foods in meeting the nutritional needs of young

Tab. 1. Number of people suffering from undernourishment in the world and its ratio to the world population.

		Africa	Asia	Oceania	South America	North America	World
2005	Number of people [$\times 10^6$]	192.6	574.7	1.9	48.6	NR	825.6
	Ratio [%]	21.0	14.4	5.6	8.7	< 2.5	12.6
2010	Number of people [$\times 10^6$]	196.1	423.8	2.0	39.6	NR	668.2
	Ratio [%]	18.9	10.1	5.4	6.7	< 2.5	9.6
2015	Number of people [$\times 10^6$]	216.9	388.8	2.2	38.8	NR	653.3
	Ratio [%]	18.3	8.8	5.5	6.2	< 2.5	8.9
2016	Number of people [$\times 10^6$]	224.9	381.7	2.4	42.4	NR	657.6
	Ratio [%]	18.5	8.5	5.9	6.7	< 2.5	8.8
2017	Number of people [$\times 10^6$]	231.7	369.7	2.4	43.5	NR	653.2
	Ratio [%]	18.6	8.2	6.0	6.8	< 2.5	8.7
2018	Number of people [$\times 10^6$]	236.8	385.3	2.4	46.6	NR	678.1
	Ratio [%]	18.6	8.4	5.7	7.3	< 2.5	8.9
2019*	Number of people [$\times 10^6$]	250.3	381.1	2.4	47.7	NR	687.8
	Ratio [%]	19.1	8.3	5.8	7.4	< 2.5	8.9
2030**	Number of people [$\times 10^6$]	433.2	329.2	3.4	66.9	NR	841.4
	Ratio [%]	25.7	6.6	7.0	9.5	< 2.5	9.8

The ratio to the world population for each continent is given. Potential impacts of the COVID-19 pandemic are not included in table.
* – values to update, ** – estimated values, NR – not reported (the number of people was not reported as the ratio was lower than 2.5 % [15]).

children (6–9 months). WFP has contributed to the solution of undernourishment problems of more than 10 million children under the age of 5 and 6 million pregnant and breastfeeding mothers with these foods [12]. It is thought that those who do research on food science and technology have the responsibility of developing new strategies and producing new foods to solve the problems of food security, undernourishment and hunger. It is very important that the products developed by these studies should be produced and stored with basic technologies and low-cost [6]. When considering the content of the food aid packages created by WFP, the designed foods and their intended purposes, tarhana is compatible with these definitions and intended purposes because it is a nutrient-rich and economical product, which is easily produced traditionally in Turkey. It can be also easily prepared as a soup for feeding of vulnerable groups such as pregnant and breastfeeding mothers, children and elderly and it is thought that it can be a key food in solving the problems caused by undernourishment and hunger.

Tarhana

Tarhana is basically produced by kneading crushed pasteurized vegetables and spices with flour and yogurt, and then subjecting them to lactic and alcoholic fermentation for 4–5 days at room temperature. The mixture is then dried and ground into powder. It is mostly used for soup preparation. The properties and types of tarhana are specified in TS 2282 standard [16]. According to this standard, four types of tarhana are described as flour, göce, semolina and mixed tarhana. These tarhana types are determined depending on the use of wheat flour, crushed wheat or semolina for its production. Tarhana can be stored in different shapes and sizes and consumed as a soup or snack. Wet tarhana is also produced without drying but it is not common because of having shorter shelf life than the other variants [17]. These forms vary according to the region and have different sensorial and nutritional properties depending on the different sources of grains, dairy products, vegetables and spices used in dough formulations [18–20]. According to the description of WFP, these can be considered as fortified blended foods. Additionally, there is a ready-to-use form of tarhana called tarhana chips or cracker, which are produced by drying in a thin layer [21, 22]. These can be consumed as a snack similar to tortilla chips [22].

Composition and nutritional content of tarhana

The nutritional value of tarhana varies depending on the raw materials used for its production. In addition to the ingredients used, the production process also significantly affects its composition. It is known that fermentation and drying processes applied to foods help preserve the nutritional, microbiological and sensorial quality of foods during storage and transportation [6]. Tarhana is a fermented product and fermentation process ensures some positive chemical, nutritional and sensorial properties to tarhana. It is known that fermentation is a desirable process for the biochemical modification of primary food products, carried out by microorganisms and enzymes. Fermentation is an easy, traditional and economical method for producing and preserving food materials. The sensorial and nutritional properties of the food are developed as a result of fermentation, while its shelf life is extended [23–25]. It is also a natural way to increase the nutritional value of food in terms of essential amino acid and vitamins occurring by microbial synthesis during fermentation. Due to the aforementioned advantages, fermented foods such as tarhana are a cheap, practical and convenient source of nutrition, especially in hunger-fighting regions [26, 27].

In a study of Çalışkan Koç and Özçıra [28], the composition of tarhana was 7.6 % moisture, 14.0 % protein, 63.1 % starch, 3.6 % fat, and 8.7 % ash. In the studies of Daglioglu et al. [29] and Certel et al. [25], the pH value of tarhana was found at a low level of 4.5 thanks to organic acids, such as lactic acid, formed by microorganisms during fermentation [25, 29]. According to TS 2282 standard, dry tarhana should contain at least 12 % protein in the dry matter and the moisture content should be lower than 10 % [16]. The basic composition and pH values of tarhana reported in some studies are given in Tab. 2 [18, 21, 30–42].

Studies showed that tarhana can be safely stored for a year because of its low moisture content and low pH value [25, 43]. It was reported that the moisture content and pH value of tarhana were 9.6 % and 4.13, respectively [44]. These properties ensure a protective environment against pathogens and microorganisms causing spoilage, in this way extending the shelf life of the product [44–46].

Wheat flour, the main component and energy source of tarhana, is poor in essential amino acids lysine and threonine. For this reason, it can be described as a low-quality protein source. However, the other main ingredient of tarhana, yogurt, is rich in these amino acids. Therefore, flour and yogurt balance each other in terms of essential amino acids and become a higher quality protein source together [47]. Additionally, tarhana fermentation causes protein hydrolysis because of the proteolytic activity of lactic acid bacteria and baker's yeast, which increases the free amino acid contents of tarhana [34, 44]. In the study conducted by Erbas et al. [48] it was reported that the total free amino acid contents of tarhana increased by 57 % with fermentation and this increase was due to the enzyme activities of the microorganisms found in the tarhana. Microorganisms hydrolyse the proteins and peptides and convert them into free amino acids [48]. The digestibility and nutritional value of tarhana are high due to organic compounds formed during the long fermentation and due to proteins with high biological value [18, 49]. The amino acid composition of tarhana is given in Tab. 3 [29, 30].

Tab. 2. Basic composition and pH values of tarhana.

Sample	Moisture [%]	Protein [%]	Fat [%]	Ash [%]	Salt [%]	Acidity [%]	pH	Ref.
1	NA	13.7	NA	2.5	NA	1.9	NA	[18]
2	9.0	16.5	NA	1.6	NA	1.1	NA	[21]
3	NA	14.9	2.3	3.0	NA	NA	NA	[30]
4	8.5	14.5	NA	2.3	NA	NA	4.1	[31]
5	NA	16.4	6.1	1.7	NA	2.0	NA	[32]
6	10.6	14.5	6.2	1.4	NA	1.7	4.3	[33]
7	7.7	16.2	3.8	NA	NA	1.8	4.8	[34]
8	8.2	15.0	3.4	1.7	NA	1.4	4.6	[35]
9	NA	15.3	3.6	1.9	NA	NA	NA	[36]
10	11.7	14.9	5.1	4.6	3.9	NA	NA	[37]
11	11.0	5.3	3.5	3.3	4.6	NA	4.2	[38]
12	4.8	14.4	NA	1.6	NA	NA	NA	[39]
13	10.8	12.9	NA	NA	5.7	NA	NA	[40]
14	9.7	17.3	4.5	1.5	NA	1.4	4.5	[41]
15	6.2	15.1	NA	1.7	NA	NA	4.4	[42]
Mean	8.9	14.5	4.3	2.2	4.7	1.6	4.4	

NA - data not available.

The vitamins contents of tarhana varies according to the raw materials used for its preparation. Accordingly, the used flours for producing tarhana can be enriched with other vitamins in addition to ascorbic acid. In a study using wholemeal flour containing a higher proportion of thiamine than white wheat flour for production of tarhana, the thiamine content of produced tarhana was higher compared to that of tarhana prepared with white wheat flour [49]. The water-soluble vitamins contents of tarhana are given in Tab. 4 [25, 50].

The fermentation process also affects the vitamins contents of tarhana in addition to those that come from the ingredients used. It was reported that the content of some water-soluble vitamins in tarhana increased with prolongation of the fermentation period. It was stated that the synthesis of vitamins by lactic acid bacteria might cause this increase [29, 49, 50]. CERTEL et al. [25] reported that the increase in water-soluble vitamin content during fermentation was caused by both lactic acid bacteria and baker's yeast. Although these microorganisms use vitamins for their own development, they may cause an increase in vitamin content at the end of fermentation due to excessive synthesis.

The content of bioavailable minerals in tarhana depends on both ingredients used in the preparation and on its phytic acid content. Phytic acid changes the digestibility and absorption properties of minerals by binding minerals directly or indirectly and, therefore, it is considered as an antinutrient. It was reported that the phytic acid negatively affects the zinc, calcium and iron absorption in 6–24 months children and elderly people. It is naturally found in cereals and legumes, which are the most preferred products in food aid packages. Therefore, its elimination or reduction in products sent to people suffering from undernourishment and hunger food is an important issue [51, 52]. The low pH, long fermentation time and increased yeast usage are factors to reduce phytic acid [33]. The long fermentation time of tarhana, which is rich in minerals, causes an increase in its mineral bioavailability, as it reduces phytic acid, a nutritional inhibiting factor, by 95 % [31, 49, 53]. The mineral contents of tarhana are given in Tab. 5 [18, 21, 30–33, 36]. It is known that lactic acid bacteria and baker's yeast (*Saccharomyces cerevisiae*) are mainly responsible for the characteristic acidic sour taste and aroma of tarhana. Lactic acid bacteria and baker's yeast produce various organic compounds such as lactic acid, ethyl alcohol, aldehydes and ketones during fermentation, and these compounds significantly affect the sensorial properties of tarhana [29, 44].

The food industry has turned towards functional foods and functional food ingredients, in line with the consumer's desire to consume health-promoting food. Functional foods are defined as foods containing vitamins, minerals, dietary fibre and beneficial microorganisms that protect and improve health and contribute to the continuity of good health besides their nutritious properties [54, 55]. Tarhana is defined as a functional food as it contains indigestible carbohydrates with beneficial physiological effects acting as prebiotics, dietary fibre, and is rich in B-group vitamins [25, 56, 57]. In addition to components coming from the ingredients of tarhana, the fermentation process also provides the functionality to tarhana because of activity of lactic acid bacteria and yeasts [58]. The fermentation process ensures high digestibility and bioavailability to tarhana. Proteins, carbohydrates and lipids in tarhana are broken down and hydrolysed by the effect of bacteria and yeasts during

Tab. 3. Amino acid composition of tarhana.

Amino acid	Content [mg·kg^{-1}]	
	[29]	[30]
Alanine	5 700	6 690
Arginine	5 550	7 610
Aspartic acid	14 400	8 794
Cysteine	1 640	1 712
Glutamic acid	53 050	54 118
Glycine	4 570	6 987
Histidine	6 100	4 436
Isoleucine	6 540	8 536
Leucine	11 520	13 050
Lysine	5 810	6 637
Methionine	3 240	3 747
Phenylalanine	7 330	8 837
Proline	60 940	21 303
Serine	11 300	8 175
Threonine	8 560	5 703
Tyrosine	3 920	5 548
Valine	8 510	9 632

Content is expressed per kilogram of dry matter.

Tab. 4. Water-soluble vitamin contents of tarhana.

Vitamins	Content [mg·kg^{-1}]	
	[25]	[50]
Ascorbic acid	NA	16.3
Folic acid	6.1	0.5
Niacin	24.0	18.4
Pantothenic acid	NA	4.8
Pyridoxine	19.4	0.3
Riboflavin	5.2	2.9
Thiamin	10.2	4.4

Content is expressed per kilogram of dry matter.
NA – data not available.

Tab. 5. Mineral contents of tarhana.

Sample	Content [mg·kg-1]								Ref.
	Ca	Cu	Fe	K	Mg	Mn	P	Zn	
1	NA	NA	12.5	5 383	406.0	NA	1 982	12.1	[18]
2	804.4	2.3	NA	5 002	391.3	NA	2 971	9.9	[21]
3	1 412.0	6.4	23.3	3 394	546.8	8.8	2 428	14.9	[30]
4	346.9	NA	NA	3 880	613.2	NA	1 537	9.9	[31]
5	1 004.0	NA	25.2	3 846	610.5	NA	2 462	15.6	[32]
6	NA	NA	19.8	6 523	783.0	5.9	1 660	9.8	[33]
7	927.2	NA	13.7	NA	751.7	NA	2 635	17.5	[36]
Mean	898.9	4.4	18.9	4 671	586.1	7.4	2 239	12.8	

Content is expressed per kilogram of dry matter.
NA – data not available.

fermentation. In addition, some exopolysaccharides formed by bacteria and yeasts during fermentation also contribute to the functionality and viscosity of the product [29, 36, 58]. People living in regions with undernourishment and hunger generally experience digestive problems. Therefore, it is a very important issue that the sources to be used in the case of food aid consist of easily digestible foods such as tarhana.

Preparation of tarhana soup

Tarhana is mainly consumed as a soup. Tarhana soup can be easily prepared from water and powdered tarhana based on 10% dry matter and consumed as a starter before main meals or at breakfast because of its pleasant sensorial properties. Tarhana soup can be cooked by slowly adding 100 g tarhana into 900 ml of water and heated with stirring until it boils. The tarhana soup can be enriched with the addition of oil and various spices.

Economic aspect

Food prices and imbalances in the distribution of income are the important parameters in providing food security [59, 60]. In some cases, even if there is enough food, individuals or society may have difficulty to obtain food because of the low income. Access to enough food in terms of quantity and quality emerges as an economic challenge in regions with limited natural resources and in emergency situations. In order to prevent or reduce these problems, food must be produced from easily found and cheap raw materials by using simple processes with low energy consumption. The tarhana recommended for food aid packages is considered as an economic and nutritionally valuable food as the cost of each of the ingredients used in its production is low. Wheat flour and yogurt, the main raw materials of tarhana, are cheap and easily accessible materials that can be found in many parts of the world. The vegetables such as tomatoes, peppers and onions used in the production of traditionally produced tarhana are also grown in many regions of the world and can be easily found in many food markets at low cost. The fact that the unit prices of these raw materials, easily accessed all over the world and in all seasons, is very low and makes the final product to be qualified as an economical food.

The production process of tarhana, consisting of fermentation and drying, is simple and does not require a long production time, energy consumption and high cost. These parameters represent an economic advantage. Additionally, various preservatives are added to many food products during production in order to preserve their post-production quality or more than one high-cost process is also required during packaging and storage for these types of foods. However, tarhana can maintain its nutritional, sensorial and microbiological stability for a long time without the addition of any preservatives or additional process causing additional post-production costs due to its structure.

CONCLUSION

Tarhana is a mixture of animal and vegetal materials and has the properties of a fermentated food. It is a safe source of energy, protein, vitamins and minerals that are nutritionally well balanced. Therefore, tarhana can be used as a functional food in the nutrition of sensitive groups such as the pregnant and breastfeeding mothers, children and elderly before switching to solid food in regions suffering from hunger in addition to general community nutrition. It is suggested that tarhana food could be an alternative idea for contribution to the nutritional problems in regions suffering from undernourishment and hunger and can be added to food aid packages sent to these regions.

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Received 21 October 2021; 1st revised 24 February 2022; accepted 21 March 2022; published online 9 May 2022.