Educational Intervention Model for Lentil Consumption: A Strategy that Contributes to Sustainable Development

Yoliztli Cecilia Torres Tenorio, [1] ***Claudia Hernández Aguilar*** [1*] ***, Efraín José Martínez Ortíz*** [1]

[1] Sustainable Biophysical Systems for Food, Agriculture and Medicine: Transdisciplinary Perspective, Department of Research and Graduate Education, School of Mechanical and Electrical Engineering (ESIME-Zacatenco-IPN), National Polytechnic Institute. "Adolfo López Mateos" Professional Unit, Lindavista, Gustavo A. Madero, Mexico City. Mexico.

*Corresponding author. E-mail: clauhaj@yahoo.com, clhernandeza@ipn.mx

Received 18 June, 2021; Revised 22 July, 2022; Accepted 22 July, 2022
Available online 23 July, 2022 at www.atlas-tjes.org, doi: 10.22545/2022/00195

It is necessary to propose educational interventions in the population due to economic, social, and environmental situations. Thus, in this research, a transdisciplinary model of an educational intervention to increase lentil consumption was proposed. The population was known based on their lifestyle characteristics, health, and pro-health habits, including lentil consumption. The types of lentils marketed in the Mexico zone were investigated and characterized in terms of their quality attributes: sanitary, physical, and saponins, choosing the best option. Lentil-based foods were formulated to teach their preparation and sensory evaluation preferences. As part of the intervention strategy, food dishes were formulated. The training was provided in their preparation and awareness was raised about the importance of lentil consumption for sustainable development. The changes of the participants were evaluated, and they indicated that their changes were mainly attributed to economic aspects, health reasons, and care for the environment. The lentil dishes were accepted by the focus group.

Keywords: Educational intervention, model TD, sustainable development, Lens culinaris.

1 Introduction

In 2016, the UN established the international year of pulses, to raise awareness of the nutritional benefits as part of sustainable food production (Rios Castillo, 2018) [1]. Among the legumes with a lower glycemic index besides chickpea is lentils (Becerra-Tomás, 2017) [2]. However, in some countries, its consumption was reduced during the pandemic (Pye et al., 2021) [3]. Despite the fact that it would be a suitable food product in the face of the cormobilities that were associated with severe cases of COVID-19 disease (Valdes, 2020; Aquino-Canchari et al., 2020) [4, 5].

This pandemic made evident the need to continue joining efforts in a world in crisis, with declining living standards for some people in some countries, added to the pain that has enveloped so many families because of the losses and the way in which the death occurred. (Perkins, 2021; Sarkis, 2020; Egger et al., 2021) [6, 8]. In relation to available or excess food, we still have a world where two extreme problems persist: malnutrition and overweight and obesity (Domínguez-Hernández et al., 2022; Rue et al., 2017; Tanumihardjo, 2007) [9-11]. In the case of children, statistics show that 150 million children are underdeveloped in height and physical structure. However, approximately 40 million are overweight. The 2030 agenda has zero hunger, food security, sustainable agriculture, and health as part of its objectives. In this sense, promoting consumption of healthy foods among the poor, diabetic, malnourished, and obese population is relevant (Nabarro, 2020; Colglazier, 2015; Boto-Álvarez, 2020) [12-14]. It is necessary to be aware and assume responsibilities, for example, the one that each of us can take in relation to our lifestyle for health. In the case of children, the fathers or tutors be responsible of them for developing nutritional resilience in the face of current and future viruses. In this way, the variety of food is important. This situation was affected in the pandemic in diverse populations and economic levels (Robayo et al., 2022) [15]. Despite the various reasons why it is convenient to consume legumes, intake in Mexico is less than the recommended 1.5-2 servings per day (1 serving = 1/2 cup) (Monge et al., 2019) [16].

Lentil (*Lens culinaris*) consumption in recent years has decreased, and the consumption of other products has increased (this for the population that can access them). INSP (2016) [17] indicated that the adult population consumes lentils, but in urban population and young people this consumption decreases considerably (Monge et al., 2019; INSP, 2016; Gutiérrez et al., 2013) [16-18]. Although in this pandemic season consumption has improved, it still does not meet the necessary requirements for each person.

A critical problem in the country is diabetes, which has one of the highest percentages of diabetic population in the world. In addition, the population needs to educate or re-educate itself to prevent, and or control glucose. By exercising and consuming low glycemic index foods (Carcavilla, 2009). Educating or re-educating the population is of interest to improve the quality of life of society, improve the environment, and the respective economic impact that these actions may have in a changing society and having to adapt to pressing situations, such as the changes left by the pandemic. Some authors point out the importance of promoting legume consumption, thus educational interventions are relevant (Wang et al., 2011; Balázs et al., 2021). The objective of this research is to establish a transdisciplinary model to carry out an educational intervention in a focus group belonging to the area of high valleys in Mexico, raising awareness of the need to change decisions and attitudes for the benefit of oneself, others, and the environment. Changes in human actions should continue to be promoted by the academy since many of them could be detrimental to everyone's life. The consumer benefits may be due to the consumption of lentils, but it has multiple benefits. In the environmental dimension, it could have as well. Among others, is that by consuming lentil protein, meat consumption could be reduced.

It is well known that human decisions and, consequently, human actions produce excess emissions of gases into the atmosphere, which are considered pollutants. Generating an impact on the environment measured through the ecological footprint (De la Torre, 2016) [22], to be aware of the damage done with the actions performed and can prevent affectations (Castillo, 2007) [23].

One of the human activities that generate a significant environmental impact and damage sustainable development is the industry. As it is known, in this industry several transformation actions are carried out, converting raw materials into products (Cardoso et al., 2020) [24]. This human activity is classified according to the type of raw material to be transformed. In the food sector, we have the meat industry, which has 30% of the terrestrial surface destined for its development and production (ONU, 2016) [25].

On the other hand, there is the agricultural industry, which occupies 40% of the surface area (OECD-FAO, 2019) [26], where 70% is destined to the planting of fodder. It is estimated that 11% of the emissions come from this industrial activity. However, 2/3 of the emissions in this sector are a consequence of the planting of fodder for livestock feed (Carmona et al., 2005) [27].

The meat industry produces gases such as CO_2 (9%) and CH4 (20%), which are classified as greenhouse gases according to the UN (Cuatecontzi and Gasca, 2004) [28]. It is important to consider that the more red meat consumption, the more production is required in the meat industry. Consequently, the environmental

impact also increases (Costantini et al, 2018) [29]. Due to the above, it is important to consider food alternatives to red meat.

Red meat consumption is related to several factors. Some people indicate that the preference and high frequency of consumption of red meat is related to the ease and variation of existing dishes (Vilaboa-Arróniz et al., 2009) [30]. Other authors indicate that high consumption is related to the taste and flavor that it generates (Taddei et al., 2012) [31]. However, despite the above, the complexity that exists in the consumer's perception and his or her possibilities of acquiring it for regular consumption depends on several factors (Troy and Kerry, 2010) [32], such as economic level, and cultural aspects, dietary habits.

In general, people are taught the habits and eating styles at home and later at school. In this, the children have their approach to information about foods, identifying and knowing them from a nutritional point of view (Borges et al., 2015) [33]. Although nutrition education varies among countries. In some countries, nutrition and health care are taught in school. In underdeveloped countries, which also have different economic levels, do not have nutritional education and there are several consequences related to diseases. Therefore, educational interventions are required in various dimensions such as food, health, environment, etc. to help sustainable development. In addition, it is necessary to raise awareness of what we eat and the environmental impacts they cause. Awareness of the impact generated by the planting, harvesting and/or production of food.

In this way, it is necessary to carry out educational interventions related to food, the environmental impact of producing it, the cost, the way to prepare dishes, and the benefits that could be obtained. In this sense to lead to changes in habits that improve their own health and that of their ecosystem. In this research as a strategic food for sustainable development, lentils, and their sprouts are proposed as an option to teach the population to adopt changes in eating behavior to decide on this type of food, given their nutritional properties and low environmental impact.

Lentils have an important nutritional contribution for the benefit of the consumer. In countries with micronutrient deficient population, low economic resources and health problems related to food would be a viable option (Hernández et al., 2017; Meléndez-Sosa et al., 2020; Hernández et al., 2020) [34-36]. It is worth mentioning that not all deficiency is linked to malnutrition, but can also occur in obesity, since "hidden hunger", as this deficit is known, is not related to excess or limited food intake, but to the quality ÿ quantity of food (Hernandez et al., 2010; Cintrón et al., 2012) [37, 38].

In view of the points mentioned above, the consumption of legumes has become relevant nowadays due to their nutritional value and medium glycemic index, mainly green legumes (Rebello et al., 2014) [39]. Legume seeds contain a high concentration of protein (15 to 45%), followed by carbohydrates (25 to 60%), oils (7 to 20%), and crude fiber (3 to 15%) (Maya et al., 2013) [40]. In the case of lentils, the presence of antioxidants such as polyphenols (Silva et al., 2010) [41] promotes the proper functioning of the immune system. These could contribute to the reduction of health problems such as diseases related to metabolic syndrome and cancer (Curran, 2012) [42], if they are consumed in an adequate amount. In this sense, there are several dimensions of sustainability that make it necessary to promote educational interventions for lentil consumption.

2 Methodology

The present research is a longitudinal, non-probabilistic study with a sample of 53 people and a focus group of 10 people for convenience.

2.1 Educational Intervention Strategy

In order to carry out an educational intervention related to increasing lentil consumption as an option to sustainable development, a model was developed for such intervention (Figure 1). The model is built based on the transdisciplinary methodology [43], starting by getting to know the subject of study through field research using the survey as an evaluation instrument. In this way, general information is collected, as

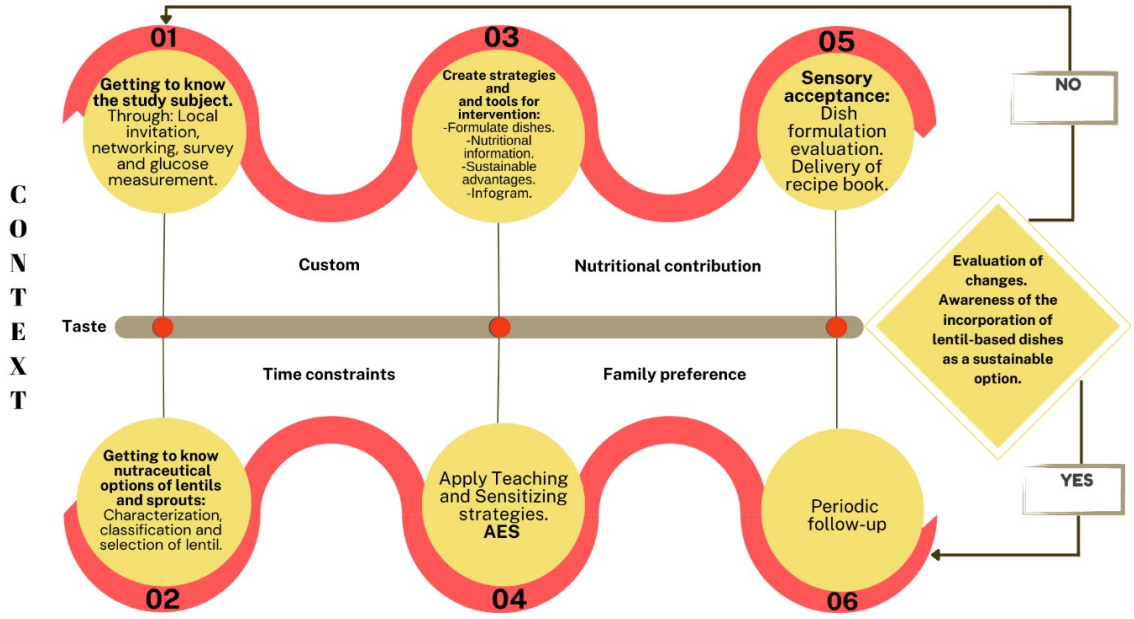


Figure 1: *Educational intervention model for lentil consumption based on a transdisciplinary approach [43].*

well as lentil consumption preferences. The frequency of consumption of lentils and certain foods is also collected in the survey. Finally, the physical activity they perform per week and their state of health.

The information obtained in the survey includes the e-mail, which is a means of contact to make an invitation to the activity that is related to the knowledge of their glycemic response according to their usual diet. They are provided with the general information and objective of the educational intervention, as well as the objective and the process to follow their blood glucose monitoring during the period of one week considering the food menu they consume during that period. The glucose monitoring participants were provided with a glucometer and a monitoring manual. This was to make them aware of the glycemic response after consuming their food, according to their common diet.

In step 2 of the model, it is intended to know the lentils and sprouts as a nutraceutical option. This is achieved according to the information that is investigated in relation to lentils, which allows knowing the physical characteristics and nutritional properties of different varieties of lentil seeds, such as roundness index, volume, density, wet weight, dry weight, germination, nutrients, and saponins. The resulting information is used to select the lentil varieties with the best characteristics for purchase and consumption. In this research, the classification is made by means of principal component analysis.

In the third aspect of the model, strategies and tools are created to carry out the educational intervention. In this stage, the dishes, recipe manual, and Infogram are formulated with important information on lentil consumption: economic, sustainable advantages, and nutritional contributions and its environmental impact compared to meat consumption. Proposals for lifestyle changes are also incorporated. In this way, a local invitation is made via social networks to the population where the importance of eating habits and physical exercise in their lives for the optimal development of their lives is mentioned.

In the next point (4) the educational strategy is applied to the test subjects, knowledge is communicated, and awareness is raised. Lentil-related information is shared and contained in an infogram that is provided to the participants along with the results. As well as the lentil-based food options are presented, the nutritional data of the formulated foods are provided, and the participants are taught how to prepare them and to become aware of their consumption due to the possibility of reducing the impact on the environment. It is proposed to consume lentils as an option to reduce the consumption of meat and thus

the environmental impact or simply to avoid nutritional deficiencies due to lack of protein and improve their health, highlighting the importance of moderation in the consumption of foods that have a medium and high glycemic index.

Subsequently, in step 5 (Figure 1), the tasting of food products with the proposed formulations and their sensory analysis are carried out. The participants are provided with the control dishes (meat-based) with which the lentil-based dishes will be compared. This is so that through their senses they can verify if the lentil-based dish presented is acceptable and preferable to them, using the hedonic scale for the evaluation.

In addition, we continued to provide nutritional knowledge and to sensitize the subjects investigated about the importance of lentil consumption.

A survey was applied to know the frequency of consumption that they would have after the knowledge and awareness were acquired. Afterward, step (4) was retaken, and the lentil-based food recipe booklet was provided. All the above with constant dialogues where doubts are solved. Finally, we propose to evaluate the changes in habits and the introduction of lentil consumption in their daily lives. If the participant has accepted, learned, and become aware of the importance of lentil consumption, we continue with the follow-up strategy (6) to ensure that over time he/she remains motivated and enthusiastic. However, if the participant needs to continue teaching, raising awareness, and providing information, we return to step 1 of the model. It should be noted that the follow-up of participants is a strategic point for them to maintain their adopted habits over time. It is therefore proposed that follow-up, cooperation, teaching, and motivation groups be formed.

2.2 Knowledge of the Subject of Study.

Field research with community members was conducted. A survey on eating habits and tastes, as well as exercise and life routines, was applied. All the above is necessary since the objective is to know (through a first approach with the population) the health situation of the subjects to be investigated. Fifty-three people participated in the survey and were asked to send a formal invitation for the following activities that are part of the educational intervention.

In the application of the educational intervention model, a focus group of 10 test subjects was formed. Of which 2 were men (between 35-40 years old) and 8 women (2 between 15 and 30 years old, and 6 between 30 and 60 years old) (see Table 1). The weight and height of the participants were determined using scales and tape measures and from which it was possible to obtain the body mass index (BMI) according to equation 1 and the basal energy content (eq. 2 and 3) (Calleja et al., 2012 and ISSSTE, 2018). As part of the knowledge of the participants, information was also obtained about their conditions, medications taken, and foods consumed which were classified by their glycemic index.

$$BMI^* = \frac{\text{Weight(kg)}}{\text{height(m)}^2} \quad (1)$$

Woman 9.99*Weight (kg) + 6.25* size(Height-cm)-4.92* age (years)-161 (2)

Man 9.99*Weight (kg) + 6.25* size(Height-cm)-4.92* age (years)+ 5 (3)

2.3 Characterization, Classification and Selection of Lentils.

2.3.1 Characterization of Lentils

Fifteen varieties of lentil seeds commercialized in the municipality of "El Marqués" in the state of Querétaro were used. Of these varieties, 10 were acquired in supermarkets and 5 are marketed in bulk.

2.3.2 Physical Dimension

The tests carried out for lentil knowledge were roundness index, lentil weight, density, and germination.

Roundness index (RI) was obtained from eight replicates of 10 seeds each, to which the equatorial diameter, polar diameter, as well as thickness of these were measured by using a vernier. Dry weight of lentils was determined from 4 replicates of 100 seeds each, placed in aluminum baskets and then dehydrated in an electric oven for 12 hours at 100 °C. Lentil density was obtained from the initial weight and the volume obtained: $\rho = m/V$ (Raviolo et al., 2005) [44]. Volume was obtained by a test tube; the water differential when the seeds were placed at the bottom was measured and used to determine the density (Ortega et al., 2010) [45].

The germination test was performed under two conditions: environmental and under cold stress (at 1°C) for a period of 8 days, which consisted of placing 40 seeds in Petri dishes with moistened blotting paper. Under a randomized complete block experimental design with four replications. Daily monitoring was carried out by counting germinated seeds. Finally, on the last day of planting, seedling length and fresh weight were measured. In an electric oven (Crownful with a capacity of 17.98 lt, weight of 11.34 kg), the seedlings were dehydrated at 60°C for 24 h.

2.3.3 Saponins

The method used to measure the amount of saponins was according to the foam quantity method (Zamora et al., 2010) [46]. This consisted of measuring the foam generated by the extracts of each of the lentil varieties (5 varieties were selected for their attributes: protein, low carbohydrate levels and affordable cost). The raw lentil was first soaked for 30 min in distilled water for 25 g of lentil, then the lentil seed soaking water was filtered. The filtered water is then placed in a test tube, shaken vigorously for 30 s, and left to stand for 15 min. Finally, the height reached by the foam is measured.

2.4 Strategies and Tools for Intervention

2.4.1 Formulation and Nutritional Information of Food Products

Four food products were prepared: two based on lentils (Lentil Bolognese and Lentil Ceviche) and two based on meat (Beef Ceviche and beef Bolognese - controls). The formulation of each food product was established (Table 1), and the nutritional value was calculated according to the table of equivalents (Table A - Annex).

Table 1: Formulation of the 4 dishes made

Ingredients	T0	T1	T0*	T2
	%	%	%	%
Lentils	0	20.66	0	24.64
Salt	2	0.41	0.29	0.49
Pepper	2	0.41	0.29	0.49
White onion	9.05	16.53	11.63	24.63
Tomatoes	21.05	41.33	29.07	49.26
Garlic	0	0	0.58	0.49
Chopped mango	22	20.66	0	0
Ground beef	0	0	58.14	0
Shredded meat	43	0	0	0

2.4.2 Color

The color of the different food products (meat and lentil-based dishes) was determined with a handheld colorimeter (FRU WR-10QC, China). The color parameters corresponding to the CIELAB uniform color space (L*, a* and b*) were obtained directly from the instrument. L* indicates lightness (100=White and 0=Black), "a" indicates greenish-reddish [negative (-a) (green) to red (+a) (positive)] and "b" indicates blue-yellowish [negative (-b) (blue) to yellow (+b) (positive)].

2.4.3 Infogram: Advantages of Lentil Consumption

The purpose of the Infogram is to provide information about lentils to the population in a didactic way. Three dimensions of information was relevant: a) the environmental benefits of lentil consumption, b) the cost and c) the nutritional contribution. In addition to this, a manual of recipes and other information was prepared.

2.5 Apply Strategies: Teaching and Sensitizing

The objective of this educational intervention was to present the benefits of lentil consumption compared to animal protein consumption, due to its impact on health, the economy, and the environment. The study population were people living in the Los Encinos subdivision in the municipality of El Marqués, Querétaro. It has 49 condominiums with approximately 99 houses each, making a total of 4,851.

2.6 Sensory Analysis

The objective of the analysis is to know the sensory preferences of food products formulated with lentils and animal protein. In addition, information was obtained regarding the lifestyle of the participating population. In this sensory analysis, the hedonic scale (Hernández et al., 2021) [47]. was used, with which the participants evaluated the characteristics of these food products using their senses (smell, taste, touch, and sight). The parameters evaluated are chewiness, appearance, flavor, odor, taste, digestive process, and nutritional contribution.

2.6.1 Evaluation of Possible Changes in Lentil Consumption

In this section of the model, an evaluation of the population participating in the educational intervention is carried out. The purpose is to determine whether there is any change in awareness of the benefits of lentil-based dishes, their preference, and frequency of consumption.

2.7 Periodic Follow-up

The follow-up to the population participating in the educational intervention consists of offering support in the preparation of dishes, as well as in the feedback of the information provided with the purpose of increasing the frequency of lentil consumption, providing encouragement and motivation. Create a group that generates a space for the exchange of experiences, etc.

3 Results and Discussion

3.1 Field Research

According to the results obtained through the field research with the 53 participants, data were obtained regarding the monthly frequency of lentil consumption, as well as the consumption of lentil sprouts and their taste for them. The results are shown in Figure 2, where it is indicated that the consumption of lentil

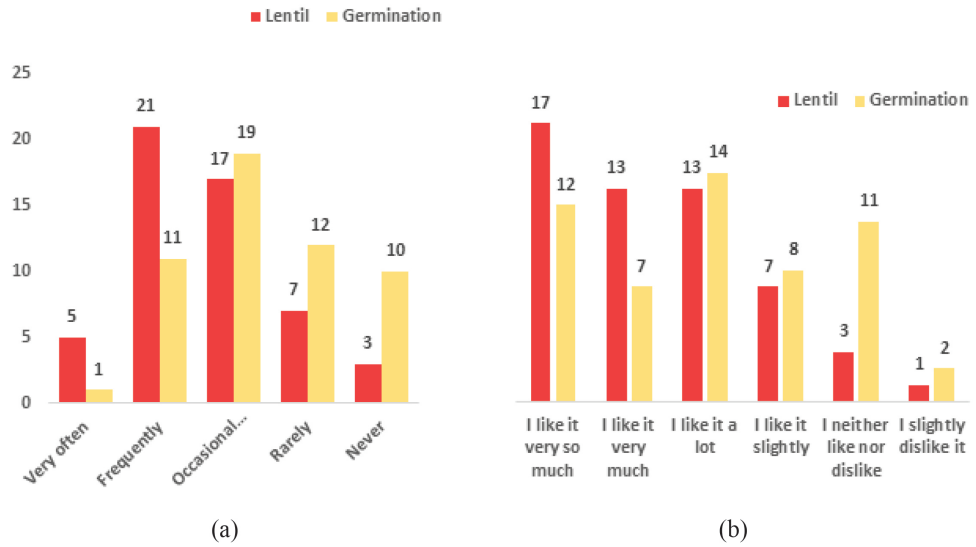


Figure 2: *Results of the survey applied to the population a) Frequency of consumption of lentils and sprouts, and b) Consumption preferences.*

seeds is higher than the consumption of sprouts (Fig. 2a). Likewise, people have a greater taste for lentils than for lentil sprouts. Likewise, people do not have the culture of germinating seeds in general.

For 21 participants the consumption of lentil seed per month is frequent, while for 17 of the 53 participants mentioned that their consumption is occasional. However, only 11 participants mentioned that they consume lentil sprouts frequently. Figure 2b shows that 17 people out of 53 participants indicate that they like lentil seeds very much, while in the case of sprouts; 13 indicate the same level of liking.

In general, from this first approach with the population, it was observed that, of the 53 participants, 26 indicate frequent consumption of lentil seeds per month. While only 12 people consume sprouts frequently. On the other hand, in relation to preferences, 43 of the 53 indicated that the taste for lentil seeds is quite high, while a smaller number of people indicated a taste for lentil sprouts.

3.2 Knowledge of the Subject of Study

Table 2 shows the characteristic results obtained from the intervened study subjects (focus group). Of which 4 are in the normal BMI range. However, 2 are overweight, 3 have type I obesity and one participant has type II obesity. In health subjects, 7 of the 10 participants present a metabolic condition related to eating habits. In the last column we have included the glucose of the participants taken half an hour after having consumed food in their common daily life.

Table 3 served as a support to locate whether people had diabetes, prediabetes, and no diabetes. Comparing the findings found in the population studied and the data provided by the CDC, it was found that 6 of the 10 subjects investigated presented levels that indicated to consider a possible pre-diabetes. This may be related to insulin resistance (Pollak, 2016) [48]. Therefore, people should consume foods with a low or medium glycemic index, such as lentils. Thus, the participants were recommended to visit their physician and perform the pertinent studies to confirm or rule out any diagnosis related to blood glucose levels. They should also be alert to their eating habits. The educational intervention can serve as a support to detect the possibility of preventing diseases to the extent that people become aware of and make decisions about the habits they follow.

Table 2: Characteristics of focus group

Research subject	Sex	Age years	Disease	Weight (kg)	Heigh (cm)	*BMI	Waist (cm)	Calories maintain weight Kcal/día	Calories lose weight Kcal/día	TMB	Medication	Average glucose 30 minutes after consuming food
S1	M	41	Possible diabetes	86	165	31.6 (obesity 1)	93	2,029	1,826.00	1,790	None	191
S2	F	54	None	55	161	21.2	75	1,547	1,425.00	1,219	None	123
S3	F	15	PCOS and insulin resistance	74	164	27.5 (overweight)	90	2,369	2,095	1,590	metformin 500 mg c/12 horas	100
S4	F	60	Hypothyroidism and fatty liver ll.	75	155	30.8 (obesity 1)	112	1,509	1,399	1,372	Eutirox 75 mg.	141
S5	F	29	None	49.5	158	19.5	61	2,029	1,684	1,278	None	101
S6	M	36	None	108	168	38.27 (obesity ll)		2,500	2,100	2,141	None	156
S7	F	40	Hypothyroidism and PCOS	75	158	30 (obesity l)	100	1,766	1,501	1,471	Metformin 500 mg c/12 h.	125
S8	F	35	None	50	149	22.52	65	1709	1,448	1,239	None	115
S9	F	34 años	fatty liver l.	75	174	24.8	88	2,335	2,000	1,519	None	123
S10	M	34	Triglycerides 159 mg/dl	73	90	29.9 (overweight)	80	2,658	2,259	1,933	None	107

PCOS: polycystic ovaries. BMI: Body mass index.

Table 3: Blood sugar levels (mg/dL) - (CDC, 2019) [49].

Health condition with respect to blood sugar level.	Fasting glucose levels (before consuming foods)- (mg/dL)	Glucose levels 2 h after food consumption. (mg/dL)
No diabetes	≤ 99	≤ 140
Prediabetes	100 a 125	140 a 199
Diabetes	≥ 126	≥ 200

3.3 Characterization of Lentils

3.3.1 Physical Dimension

Figure 3 shows an analysis of the main components of lentil seed (according to the 15 varieties studied and the characteristic attributes of density, protein, germination, volume, weight, price, carbohydrates, plumule size and IR). Three clusters were observed (I. 1,3,4,5,6,7,8,9 and 10; II 11,12,13,14 and 15; III 2). The

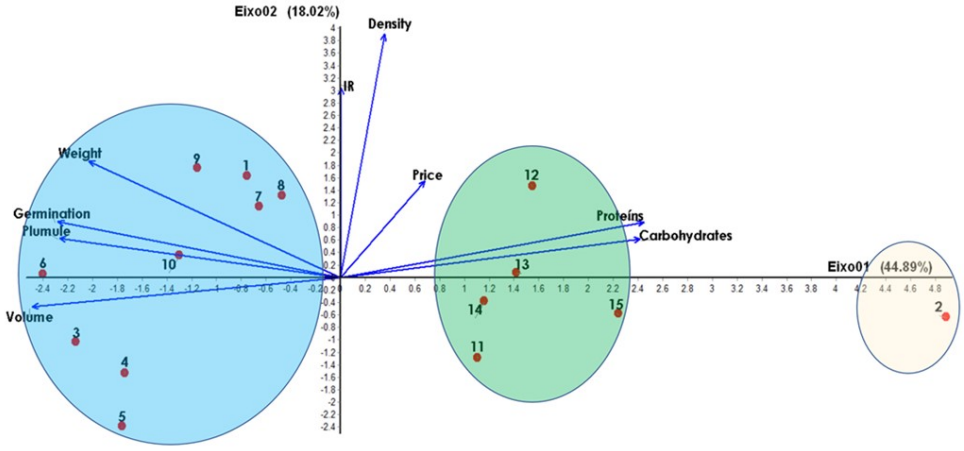


Figure 3: *Principal component analysis of the 15 lentil seed varieties evaluated in this research (density, Price, proteins, carbohydrates, weight, germination, plumule, and volume).*

grouping of the 15 lentil treatments into 3 clusters is due to similarities in characteristics. For cluster I the lentil varieties have similar characteristics in: Weight, germination, plumule and volume. In group II, proteins and carbohydrates are the characteristics that are similar. Finally, in group III is lentil variety 2 whose characteristics are different from the rest of the varieties.

It is possible said that there is a positive correlation for group II for the variables of protein and carbohydrates of lentils and for group III, there is a positive correlation for the variables weight, germination, length of plumule and volume of lentil. The lentil varieties that are part of group II, of which it is agreed that they have affinity between protein, carbohydrate, price, and density. Density is a good indicator of grain quality, Ebru (2008) [50] mentions that the apparent density of lentils is 0.818g/cm^3 and the density obtained in this work was around 1 g/cm^3, so it can be deduced that the quality of the lentil is acceptable, it may be that the storage is adequate or that it has been stored for a short period of time.

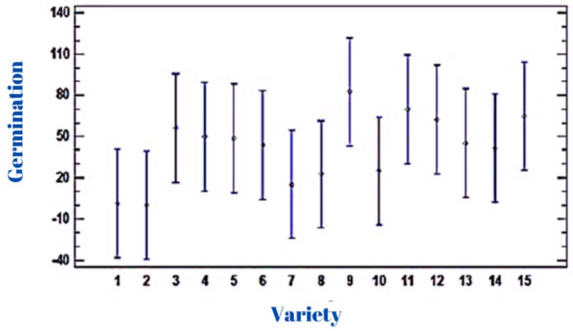


Figure 4: *Germination in 15 varieties of lentils.*

3.3.2 Germination

The 15 lentil varieties were set up to carry out the germination process under stress conditions. This means that the lentil seeds were subjected to different temperatures for periods of time. Figure 4 shows the results

of this process showing a significant difference between varieties 1 and 2 with the rest of the varieties, the latter showing a lower germination percentage. Varieties of Lentil (9: 3, 4, 5, 6, 9, 11, 12, 13, 15) show a higher germination percentage ($\geq 80\%$).

3.3.3 Saponins and Lentil Selection for the Elaboration of Food Products

Based on the knowledge obtained about the 15 lentil varieties, cost, and nutritional intake (carbohydrates and proteins), the most suitable varieties to be consumed by the population were selected (Latham, 2002) [51]. Five varieties were selected whose behavior is similar and suitable for consumer consumption and purchase (See Table 4).

Table 4: Selection of 5 varieties of lentils in relation to certain properties (protein, cost, and carbohydrates), for the preparation of food products.

Varieties	RI*	Density	Weight 1000 g	Cost (500 g)	Protein 100 g	Carbohydrate 100 g	Germination
4	1.01	1.01	30	21.9	9	22	91.25
5	0.94	1.01	30	13.25	9	12	95.62
6	1.01	1.31	40	14.5	9	12	90.00
7	1.24	1.17	30	17.9	21	18	96.25
8	1.05	1.39	40	20.85	23	35	97.50

*RI: Roundness Index.

Table 5: Statistical results of saponin determination.

	Response variable		
Treatment	Fch (cm) Raw lentil	Fch (cm) Raw lentil with turmeric	Fch (cm) Cooked lentil
4	$0.26^{b} \pm 0.153$	$0.16^{b} \pm 0.115$	$1.16^{ab} \pm 0.289$
5	$0.36^{b} \pm 0.231$	$0.10^{b} \pm 0.000$	$1.00^{b} \pm 0.000$
6	$1.23^{a} \pm 0.252$	$0.36^{a} \pm 0.115$	$1.66^{a} \pm 0.577$
7	$1.33^{a} \pm 0.577$	$0.23^{ab} \pm 0.115$	$1.16^{ab} \pm 0.289$
8	$0.56^{b} \pm 0.115$	$0.10^{b} \pm 0.000$	$0.90^{b} \pm 0.173$
C.V.	34.231	49.97	29.172
Significance	0.0024**	0.0453*	0.1588ns
Media	0.753	0.193	1.18
LSD	0.4855	0.1819	0.6481

Means ± standard deviation with different letters in a column are statistically different ($p<0.05$). LSD (LSD: Least Significant Difference) (LSD, a=0.05), C.V.: Coefficient of Variation. Significance: ns; indicates no significance; *: indicates significance; **: high significance.
Fch: foam column heights

Table 5 shows the comparison of means of the foam column heights obtained in the saponin test. The higher the column height, the higher the saponin content. Of the 5 varieties in the three lentil conditions

(1. raw, 2. raw and turmeric, 3. cooked) it was found that the raw and raw lentil conditions added with turmeric have significant statistical differences (p ¡ 0.05) when compared between varieties. In the case of raw lentils and lentils added with turmeric, lentils 6 and 7 had the highest column height with respect to the other lentils. It is important to mention that the addition of turmeric to lentils reduces the saponin content. Therefore, in addition to providing phytonutrients, it also reduces the saponin content. This is convenient for people intolerant to legumes, due to the inflammation produced by saponins. In the present investigation, in the case of lentil 7, it was reduced by more than 50%.

Thus, the type of lentil selected to prepare food products is the variety 7 (Table 6).

Tabla 6: Characteristics of selected lentils

Variety	Cost 500 g ($)	Protein 100 g	Carbohydrate 100 g	Germination (%)	Saponin
7	17.9	21	18	96.25	Lesser amount of lentil grain.

Table 7: Presentation of formulated food products, color and saponins.

Food products	Name	Color			Saponin (measurement of foam-cm)
	1. Beef ceviche (T0)	L*	a*	b*	0
		54.48	4.30	24.51	
	2. Lentil ceviche (T1)	L*	a*	b*	0.2
		54.75	8.81	24.71	
	3. Beef Bolognese (T0*)	L*	a*	b*	0
		74.06	3.28	16.25	
	4. Lentil Bolognese (T2)	L*	a*	b*	0.1
		59.69	6.19	25.38	

3.4 Create Strategies and Tools for Intervention

3.4.1 Formulation of Food Products

Table 7 represents the image of the food products obtained, the name of the dish, the color in the dimensions (L*, a*, b*), and the saponins. The color is related to the nutritional content of the dishes. It is possible to observe that lentil-based foods have a higher value of the color dimension a*. According to the literature, a positive value of a tends to a reddish color (Hernandez et al., 2022) [52]. So, meat-based dishes have lower reddish color intensity. Yellow, orange, and reddish colors are related to carotenoid content. In this research, there is a higher value of a*, so there would be a higher value of carotenoid content when compared to meat-based dishes, but a lower chlorophyll content due to the decrease in green color. Regarding saponins,

the presence of saponins was evident in the lentil-based dishes (the height of the foam column was less than 0.2 cm) and absent in the meat-based dishes.

3.4.2 Implement Strategies: Teach and Raise Awareness Sensory Analysis

Preferences in attributes A1 (Appearance), A6 (Digestive process), A7 (Price) and A8 (Nutritional contribution), showed significant statistical differences ($p<0.05$) when comparing the scores obtained for each of the dishes (Table 8). With respect to appearance (A1), the ceviche based on lentils or meat was preferred over the Bolognese dish (meat or lentils). But there was a greater preference for both dishes which were prepared with lentils.

Table 8: Comparison of response variables (attributes) of 4 food dishes.

	Saucers				Statistical results			
Response variable	1	2	3	4	C.V.	Significance	Media	LSD
A1	$7.10^{ab} \pm 1.287$	$7.70^{a} \pm 0.823$	$7.70^{a} \pm 0.823$	$6.8^{ab} \pm 1.398$	19.469	0.0416*	6.875	1.228
A2	$6.40^{b} \pm 1.430$	$8.00^{a} \pm 0.943$	$6.20^{b} \pm 0.789$	$6.8^{ab} \pm 1.814$	19.965	0.2426ns	6.85	1.254
A3	$7.70^{a} \pm 1.059$	$7.70^{a} \pm 1.059$	$6.20^{b} \pm 0.919$	$6.60^{ab} \pm 1.955$	18.168	0.0981ns	7.05	1.175
A4	$5.90^{b} \pm 1.595$	$8.0^{a} \pm 0.816$	$5.7^{b} \pm 1.494$	$6.9^{ab} \pm 1.595$	22.831	0.1545ns	6.62	1.388
A5	$7.2^{ab} \pm 1.317$	$7.8^{a} \pm 0.919$	$6.3^{b} \pm 1.636$	$6.6^{b} \pm 1.430$	17.982	0.0756ns	6.97	1.150
A6	$5.9^{ab} \pm 1.663$	$7.1^{a} \pm 1.524$	$4.7^{b} \pm 1.160$	$6.9^{a} \pm 1.729$	21.949	0.005**	6.15	1.238
A7	$4.9^{b} \pm 1.729$	$8.5^{a} \pm 0.527$	$4.9^{b} \pm 1.729$	$8.0^{a} \pm 1.414$	20.336	<0.0001**	6.57	1.227
A8	$5.5^{b} \pm 1.269$	$8.4^{a} \pm 0.669$	$5.5^{b} \pm 1.841$	$8.4^{a} \pm 0.669$	14.886	<0.0001**	6.95	0.949

Means ± standard deviation with different letter in a column are statistically different ($p<0.05$). LSD (Least Significant Difference) (LSD, $\alpha=0.05$), C.V.: Coefficient of variation. Significance: ns; indicate that there is no significance; *: indicates that there is significance; **: When there is high significance. Appearance (A1), Chewiness (A2), Flavor (A3), Odor (A4), Taste (A5), Digestive process (A6), Price (A7) and Nutritional contribution (A8).

It is possible to observe, in relation to attribute A6, lentil-based dishes were rated higher for both ceviche and bolognese when compared to meat-based dishes. Similarly, with respect to price (A7) and nutritional contribution (A8), lentil-based foods were rated better than meat-based foods. The highest preferences for lentil were due to its price and nutritional value. Participants are aware of the nutritional value of lentils and sprouts and their low price. Learning other options for dishes and controlling the amount of saponins can be a strategy to opt for more frequent consumption. The participants do not have the same awareness of the possible environmental benefits of consuming lentils and reducing meat consumption.

3.4.3 Evaluation of the Increased Frequency of Lentil Consumption

Figure 5 shows the evaluations obtained from the 10 subjects investigated regarding why they would make changes in their lentil consumption, after having received the transfer of knowledge and sensitization. The dimensions evaluated were P1: Sensory preference, P2: Importance because it could improve digestive processes, P3: Price, P4: Health benefits due to its nutraceutical power, P5: Environmental impact, P6: Savings in protein cooking costs due to the gas used and P7: Reduction of environmental impact-reduction of gases in the atmosphere. The maximum score for the importance of the change to be adopted and the reason for it is 5. The question indicated with question P4 has the highest score (4.8), followed by P3 and P5 (4.7). This means that the participants will make the changes mainly because of the possible benefits to their health for its nutraceutical power, for price and for reducing the environmental impact, being their highest priority of people to decide about their changes.

3.4.4 Periodic Follow-up

The last step of the educational intervention model is the periodic follow-up. This point focuses on people who obtained a positive result in the evaluation of changes in awareness, generating interest in adjusting

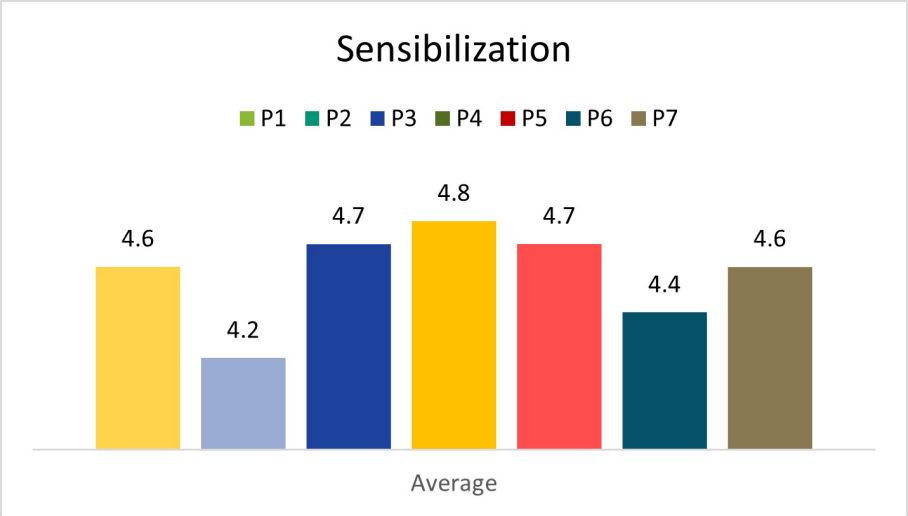


Figure 5: *Importance of factors leading to changes in lentil consumption frequency (Scale 1-5) (P1: sensory preference, P2: importance because it could improve digestive processes, P3: price, P4: health benefits due to its nutraceutical power, P5: environmental impact, P6: gas savings, and P7: reduction of environmental impact-reduction of gases into the atmosphere) .*

their habits to incorporate lentil-based dishes as a sustainable option. The follow-up is offered from a close accompaniment to give advice and guidance, as well as feedback according to individual needs that arise along the way. The discussion was about the importance of forming follow-up groups to encourage and teach each other. In an exercise of mutual learning, as is marked by transdisciplinarity.

3.4.5 Economic Aspects of Food Dishes

Table 9 shows the cost of Mexican pesos for each ingredient involved in the formulation of the four dishes. Dishes T0 and T0* are those prepared with beef (shredded and ground). The costs of these dishes amounted to $230,145 and $240,145, respectively. In the case of T1 and T2 dishes made with lentils, the cost is $40.39 and $22.39 pesos. The costs are calculated for a yield of 4 to 6 servings. In a population with low minimum wages, with the need to choose nutritious foods with a lower glycemic index, as well as to have sustainable development, the option of lentil consumption would be appropriate due to its beneficial social, economic, and environmental impacts.

Table 9: Costs in Mexican pesos of 2 lentil-based and 2 beef-based dishes.

Dishes	Cost in Mexican pesos ($).									
	Image of the dishes	Lentils	Salt	Pepper	White onion	Tomatoes	Garlic	Chopped mango	Ground beef	Shredded beef.
T0		0	0.75	0.64	9	10	0	20	0	190
T1		9	0.75	0.64	9	10	0	20	0	0
T0*		0	0.75	0.64	9	10	2	0	200	0
T2		9	0.75	0.64	9	10	2	0	0	0

T0: Shredded beef ceviche; T1: Lentil ceviche; T0*: Ground beef bolognese; T2: Lentil bolognese.

Sustainable development is one of the imperatives worldwide, one of the foods of the future that have been established among others, is legumes (FAO, 2018) [53]. Lentils not only could be foods of the future but of the present. They are also one of the crops that have a tolerance to various stress conditions (Balboa, 2020) [54].

According to estimates, in the near future (a few years) more than 50% of the world's adult population will be overweight or obese (Sánchez-García et al., 2014) [55]. For this reason, strategies have been sought

to help reduce this percentage and improve health.

One of the strategies is to bring about changes in the population by implementing educational interventions. In general, these cover a set of motivational, pedagogical, methodological, and evaluation actions, whose objective is that the participants reach the points established in the program and make changes in some dimension of their lives (Jordan et al., 2011) [56]

In the present investigation, the purpose of knowing different lentil seeds is to select those with the best nutritional attributes and with an accessible cost for the preparation of dishes. Of the 15 varieties analyzed, it was found that they have differences in relation to the amount of protein, carbohydrates, and cost. In this way, the model used proposes a characterization stage in the process of knowing to choose. In addition, there are bioactive elements in lentils such as saponins. Saponins are glycosidic substances considered as anti-nutrients and are found in the seed shell (Bonilla et al., 2019) [57]. Saponin is the cause of some gastrointestinal problems, such as bloating, diarrhea, and flatulence in some people who consume legumes (Carolina et al., 2014) [58]. Because of the possible discomfort caused in some consumers, alternatives are sought to reduce them. In the present intervention, people were also taught how they could reduce it, through the heating of the lentil, through UV-C radiation, or through the germination process, etc.

In the model used for the intervention, the follow-up stage of the participants is distinguished. Some authors have reported significant results from the follow-up of people in educational interventions (Pimentel et al., 2014) [59]. Follow-ups focused on motivation and accompaniment, as well as providing constant and adequate information according to the doubts that arise help people to generate security and better results (García and Suárez, 2003) [60]. Follow-up in a purposeful environment that allows participants to feel confident in the steps they will take to prevent or treat a health situation according to the required needs gives a better result than just carrying out the educational intervention without any follow-up (Trento et al., 2004) [61]. In fact, there is the opportunity to generate changes over time and not just momentary ones.

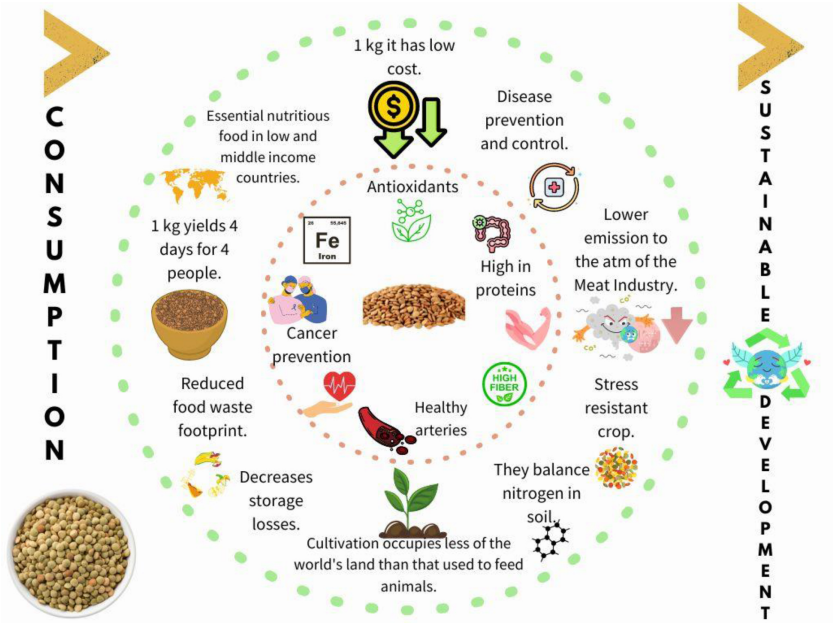


Figure 6: *Lentil consumption, a strategy for sustainable development.*

In this educational intervention, it was found that the main changes people would make would be due to the low cost of lentil-based dishes, health benefits, and environmental protection. In this way, these decisions could have an impact on sustainable development, as shown in Figure 6, impacting due to the invested cost, in the face of populations that cannot afford to invest in meat-based dishes. Opting for lentil consumption leads to a chain of favorable impacts. It would have an impact on a decrease in meat

consumption, a decrease in energy used to cook food (meat takes longer to cook than lentils). The amount of land used to produce foliage for livestock feed would be reduced. In this way, gas emissions into the atmosphere could be reduced. In this chain of impacts, the environment could be improved. Finally, and very relevant is the improvement in the nutritional health of the population.

Thus, an educational intervention model is proposed to increase the consumption of this legume.

4 Conclusions

Almost all the people (71% of whom had an age range between 20 and 40 years and 73.6% had a bachelor's degree) surveyed in the population evaluated were from families with diabetes and arterial hypertension. Of the people surveyed, more than 50% were overweight or obese, no one knew the glycemic index of foods, all consumed a diet with high carbohydrate foods such as bread rolls, sweet bread, fruit, rice, and tortillas, and no one had a culture of periodically self-monitoring their blood glucose, nor did the participating diabetes patients. Knowledge and interest in health issues was scarce. They consumed the meat and knew little about the sustainable benefits of lentil consumption, nor were they accustomed to sprouting lentils for consumption. They also had low consumption of lentils before the intervention. Only 18.86% of the respondents agreed to participate in the educational intervention, forming a focus group with them.

The proposed intervention model could be useful in other populations, since it allowed changes in decisions and preferences in the focus group, people could increase their consumption by becoming aware of the importance of lentil consumption for sustainable development, and could modify their preferences and frequency of consumption by learning about the diversity of lentil-based dishes, have possibilities to choose the most appropriate lentil characteristic and also learn to eliminate saponins from lentils so that they do not produce inflammation.

In the process of lentil characterization, it can be concluded that all varieties have affordable costs with different capacities to germinate, differences in carbohydrates and amount of saponin. The study of lentils allowed to choose the most convenient to be consumed by people and not to impact discomfort (intestinal inflammation) by its consumption.

The 10 people who participated in the sensory analysis indicated liking and surprise for the dishes presented, highlighting their interest in increasing the frequency of lentil consumption. The food dish (T1), named lentil ceviche, was the most accepted. All participants indicated that they wanted the recipe booklet as well as the infographic that was previously explained. People who are interested in knowing their health status mostly look for alternatives to modify their eating habits and economy, since lentil consumption is cheaper than beef, and lentil sprouts increase their nutraceutical properties.

In the intervention strategy, the follow-up of the participants was a relevant element in the intervention. The changes of the participants were mainly due to the cost of lentils, environmental awareness, and their own health benefits.

Acknowledgments

The authors would like to thank to Conacyt, and the "Instituto Politécnico Nacional". The support of the Research to the postgraduate program in Systems Engineering -SEPI-ESIME-Zacatenco, especially the Biophysical systems group for agriculture, food, and medicine under a transdisciplinary vision. Hernandez Aguilar thanks the people of the municipality and others who have agreed to participate in educational interventions in times of pandemic.

Author contributions: YCTT and CHA performed the initial literature search and wrote the manuscript. YCTT prepared visualization elements. CHA proposed the idea of educational intervention. CHA and EJMO secured funding for the research. All authors (YCTT and CHA and EJMO) reviewed and critically edited the text and results, and finally approved the manuscript.

Funding statement: The authors are thankful for the funding provided by the National Polytechnic Institute (SIP 20211699, 20220488).

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Ríos-Castillo, I., Acosta, E., Samudio-Núñez, E., Hruska, A., and Gregolin, A. (2018). Beneficios Nutricionales, Agroecológicos y Comerciales de las Legumbres. *Revista chilena de nutrición*, 45, 8-13. doi.org/10.4067/S0717-75182018000200008

[2] Becerra-Tomás, N., Díaz-López, A., Rosique-Esteban, N., Ros, E., Buil-Cosiales, P., Corella, D., ... and Alba, M. B. (2018). Legume consumption is inversely associated with type 2 diabetes incidence in adults: A prospective assessment from the PREDIMED study. *Clinical Nutrition*, 37(3), 906-913. doi.org/10.1016/j.clnu.2017.03.015

[3] Pye, C., Sutherland, S., & Martín, P. S. (2021). Consumo de frutas, verduras y legumbres en adultos de Santiago Oriente, Chile: ¿Ha influido el confinamiento por COVID-19?. *Revista chilena de nutrición*, 48(3), 374-380. doi.org/10.4067/s0717-75182021000300374

[4] Valdes, M. Á. S. (2020). COVID-19. De la patogenia a la elevada mortalidad en el adulto mayor y con comorbilidades. *Revista Habanera de Ciencias Médicas*, 19(3), 1-12

[5] Aquino-Canchari, C. R., Quispe-Arrieta, R. D. C., & Huaman Castillon, K. M. (2020). COVID-19 y su relación con poblaciones vulnerables. *Revista Habanera de Ciencias Médicas*, 19.

[6] Perkins, K. M., Munguia, N., Ellenbecker, M., Moure-Eraso, R., & Velazquez, L. (2021). COVID-19 pandemic lessons to facilitate future engagement in the global climate crisis. *Journal of Cleaner Production*, 290, 125178. doi.org/10.1016/j.jclepro.2020.125178

[7] Sarkis, J. (2020). Supply chain sustainability: learning from the COVID-19 pandemic. *International Journal of Operations & Production Management*. doi.org/10.1108/IJOPM-08-2020-0568

[8] Egger, D., Miguel, E., Warren, S. S., Shenoy, A., Collins, E., Karlan, D., ... & Vernot, C. (2021). Falling living standards during the COVID-19 crisis: Quantitative evidence from nine developing countries. *Science advances*, 7(6), eabe0997. doi.org/10.1126/sciadv.abe0997

[9] Dominguez-Hernandez, E., Hernández-Aguilar, C., & Hernández, M. E. D. (2022). Sustainability in home garden interventions to improve food security: Results, challenges, and future directions. *Transdisciplinary Journal of Engineering and Science*, 13, 111-140. doi.org/10.22545/2022/00168

[10] Ruel, M. T., Garrett, J. L., & Yosef, S. (2017). Food security and nutrition: *Growing cities, new challenges*. IFPRI book chapters, 24-33.

[11] Tanumihardjo, S. A., Anderson, C., Kaufer-Horwitz, M., Bode, L., Emenaker, N. J., Haqq, A. M., ... & Stadler, D. D. (2007). Poverty, obesity, and malnutrition: an international perspective recognizing the paradox. *Journal of the American Dietetic Association*, 107(11), 1966-1972. doi.org/10.1016/j.jada.2007.08.007

[12] David Nabarro (2020). EL INFORME DE LA NUTRICIÓN MUNDIAL 2020 EN EL CONTEXTO DE LA COVID-19 . https://globalnutritionreport.org/reports/2020-global-nutrition-report/2020-global-nutrition-report-context-covid-19/

[13] Colglazier, W. (2015). Sustainable development agenda: 2030. *Science*, 349(6252), 1048-1050

[14] Boto-Álvarez, A., & García-Fernández, R. (2020). Implementation of the 2030 agenda sustainable development goals in Spain. *Sustainability*, 12(6), 2546. doi.org/10.3390/su12062546

[15] Robayo, C. V., Lara, V. E. G., Cabrera, J., & Delgado, M. D. L. M. (2022). Consumo alimentario durante el confinamiento por Covid-19, en una población de Ecuador y México. *La Ciencia al Servicio de la Salud*, 12(2), 23-35. doi.org/10.47244/cssn.Vol12.Iss2.639

[16] Monge, A.; Macias, L.; Campos, H.; Lajous, M.; Mattei, J. 2019. Perceptions and reasons for legume consumption in Mexico. *Nutr. Food Sci.* 49, 1232–1242 doi.org/10.1108/NFS-01-2019-0033

[17] Instituto Nacional de Salud Pública (2016), "Encuesta nacional de salud y nutrición de medio camino". `https://www.insp.mx/produccion-editorial/publicaciones-anteriores-2010/4669-encuesta-nacional-salud.html`

[18] Gutiérrez, J.P., Rivera-Dommarco, J., Shamah-Levy, T., Villalpando-Hernández, S., Franco, A., Cuevas-Nasu, L., Romero-Martínez, M. and Hernández-Ávila, M. (2013), "Encuesta nacional de salud y nutrición 2012", *Resultados Nacionales, 2nd ed., Instituto Nacional de Salud Pública*, Cuernavaca, México, available at: `ensanut.insp.mx/informes/ENSANUT2012ResultadosNacionales.pdf`.

[19] Carcavilla Urquí, A. (2009). Atención al paciente con diabetes: algo más que insulinas. *Pediatría Atención Primaria*, 11, 217-238

[20] Wang, S., Melnyk, J. P., Tsao, R., & Marcone, M. F. (2011). How natural dietary antioxidants in fruits, vegetables and legumes promote vascular health. *Food Research International*, 44(1), 14-22. doi.org/10.1016/j.foodres.2010.09.028

[21] Balázs, B., Kelemen, E., Centofanti, T., Vasconcelos, M. W., & Iannetta, P. P. (2021). Policy Interventions Promoting Sustainable Food-and Feed-Systems: A Delphi Study of Legume Production and Consumption. *Sustainability*, 13(14), 7597. /doi.org/10.3390/su13147597

[22] De la Torre Martín, J. (2016). La Huella Ecológica: un indicador de sostenibilidad para las actividades humanas. *INDES Revista de Investigación para el Desarrollo Sustentable*, 2(1), 9-17. doi.org/10.25127/indes.20142.58

[23] Castillo, R. M. (2007). Algunos aspectos de la huella ecológica. Intersedes: *Revista de las sedes regionales*, 8(14), 11-25. `https://www.redalyc.org/articulo.oa?id=66615071002`

[24] Cardoso, G. B., Michel, J. R. P., Bautista, M. S. A. O., Peláez, R. M., J. R. P. M., &, S. A. O. B. (2020). ¿Qué es Industria 4?: Definiendo el concepto. no, 8. `http://tecnotrend.delasalle.edu.mx/?n=8&p=90`

[25] ONU, 2016.Recuperado el 15 de febrero 2022: `https://news.un.org/es/story/2006/11/1092601`

[26] OCDE/FAO (2019), OCDE-FAO Perspectivas Agrícolas 2019-2028, *OECD Publishing, París Organización de las Naciones Unidas para la Alimentación y la Agricultura* (FAO), Roma doi.org/10.1787/7b2e8ba3-es

[27] Carmona, Juan C, Bolívar, Diana M, & Giraldo, Luis A. (2005). El gas metano en la producción ganadera y alternativas para medir sus emisiones y aminorar su impacto a nivel ambiental y productivo. *Revista Colombiana de Ciencias Pecuarias*, 18(1), 49-63. Retrieved May 07, 2022, from `http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-06902005000100006&lng=en&tlng=es`

[28] Cuatecontzi, D. H., & Gasca, J. (2004). Los gases regulados por la convención marco de las naciones unidas sobre el cambio climático. Cambio climático: una visión desde México, 87. `https://wwflac.awsassets.panda.org/downloads/cambio_climatico_una_vision_desde_mexico_martinez_bremauntz.pdf#page=85`

[29] Costantini, A. O., Perez, M. G., Busto, M., González, F. A., Cosentino, V. R. N., Romaniuk, R. I., & Taboada, M. A. (2018). Emisiones de gases de efecto invernadero en la producción ganadera. *Asociación Argentina para el Progreso de las Ciencias.* `https://repositorio.inta.gob.ar/bitstream/handle/20.500.12123/4389/INTA_CIRN_InstitutodeSuelos_Costantini_A_Emisiones_gases_efecto_invernadero_produccion_ganadera.pdf?sequence=1&isAllowed=y`

[30] Vilaboa-Arroniz, Julio, & Díaz-Rivera, Pablo, & Ruiz-Rosado, Octavio, & Platas-Rosado, Diego, & González-Muñoz, Sergio, & Juarez-Lagunes, Francisco (2009). Patrones de consumo de carne bovina en la región del papaloapan, veracruz, méxico. *Agricultura, Sociedad y Desarrollo*, 6(2),145-159, ISSN: 1870-5472. `https://www.redalyc.org/articulo.oa?id=360533082001`

[31] Taddei, Cristina, & Preciado, Martín, & Robles, Jesús, & Garza, Cristina (2012). Patrones de consumo de carne en el noroeste de México. Estudios Sociales. *Revista de Alimentación Contemporánea y Desarrollo Regional*, (2),77-96. ISSN. `https://www.redalyc.org/articulo.oa?id=41724972004`

[32] Troy, DJ y Kerry, JP (2010). Percepción del consumidor y el papel de la ciencia en la industria cárnica. *Ciencia de la carne*, 86 (1), 214-226

[33] Borges, E. de M. et al. (2015) 'Percepção dos hábitos alimentares dos estudantes de uma escola de ensino fundamental do município de Jaciara- MT', Revista Monografias Ambientais. Universidad Federal de Santa Maria, 14, pp. 89–100. doi: 10.5902/2236130820440

[34] Hernández, N. G., González, S. R., & Arriola, A. (2017). Hambre oculta. *Acta Pediátrica Hondureña*, 8(1), 739-750. doi.org/10.5377/pediatrica.v8i1.7593

[35] Meléndez-Sosa, M. F., García-Barrales, A. M., & Ventura-García, N. A. (2020). Perspectivas e impacto en la salud del consumo de los alimentos funcionales y nutracéuticos en México. *RD-ICUAP*, 6(1), 114-136

[36] Hernandez-Aguilar, C., Dominguez-Pacheco, A., Palma Tenango, M., Valderrama-Bravo, C., Soto Hernández, M., Cruz-Orea, A., & Ordonez-Miranda, J. (2020). Lentil sprouts: a nutraceutical alternative for the elaboration of bread. *Journal of food science and technology*, 57(5), 1817-1829. doi.org/10.1007/s13197-019-04215-5

[37] Hernandez, A. C., Domínguez, P. A., Cruz, O. A., Ivanov, R., Carballo, C. A., & Zepeda, B. R. (2010). Laser in agriculture. *Int. Agrophys*, 24(4), 407-422. `http://www.international-agrophysics.org/Laser-in-agriculture,106402,0,2.html`

[38] Cintrón, K., Santiago, O., Berdiel, M. J., InBioMed, P., & de Ciencias Médicas, R. (2012) El fenómeno del hambre oculta: El impacto sobre la salud de la deficiencia o insuficiencia crónica de micronutrientes. `https://www.galenusrevista.com/?El-fenomeno-del-hambre-oculta`

[39] Rebello, C. J., Greenway, F. L., & Finley, J. W. (2014). A review of the nutritional value of legumes and their effects on obesity and its related co-morbidities. *Obesity reviews*, 15(5), 392-407. doi.org/10.1111/obr.12144

[40] Maya-Zepeda, L., Hernández-Gobora, J., Rodríguez-Macías, R., García-López, P. M., & Ruiz-López, M. A. (2013). Oligosaccharide content of Mexican wild legume seeds. *Chilean Journal of Agricultural & Animal Sciences*, ex Agro-Ciencia, 29(2), 161-167

[41] Silva-Cristobal, L. et al. (2010) 'Chemical composition, carbohydrate digestibility, and antioxidant capacity of cooked black bean, chickpea, and lentil Mexican varieties Composición química, digestibilidad de carbohidratos, y capacidad antioxidante de variedades mexicanas cocidas de frijol', CyTA - *Journal of Food*. Taylor & Francis, 8(1), pp. 7–14. doi: 10.1080/19476330903119218

[42] Curran, J. (2012) 'The nutritional value and health benefits of pulses in relation to obesity, diabetes, heart disease and cancer', British Journal of Nutrition. Cambridge University Press, pp. S1–S2. doi: 10.1017/S0007114512003534

[43] Hernandez-Aguilar, C. (2018). Transdisciplinary methodological option for initial research process: Training of researchers. *Transdisciplinary Journal of Engineering & Science*, 9. doi.org/10.22545/2018/00108

[44] Raviolo, A., Moscato, M., & Schnersch, A. (2005). Enseñanza del concepto de densidad a través de un modelo analógico. *Revista de Enseñanza de la Física*, 18(2).

[45] Ortega-David, E., Rodríguez, A., David, A., & Zamora-Burbano, Á. (2010). Caracterización de semillas de lupino (Lupinus mutabilis) sembrado en los Andes de Colombia. *Acta agronómica*, 59(1), 111-118. `https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/14094`

[46] Zamora, C., Juárez, B. I., & Aguirre, J. R. (2010). Variación de la concentración de azúcares y saponinas durante la cocción del maguey mezcalero Potosino. *e-Gnosis*, 8. `https://www.redalyc.org/articulo.oa?id=73013006007`

[47] Hernandez-Aguilar, C., Dominguez-Pacheco, A., Valderrama-Bravo, C., Cruz-Orea, A., Ortiz, E. M., Ivanov, R., & Ordonez-Miranda, J. (2021). Photoacoustic characterization of wheat bread mixed with Moringa oleifera. *Current Research in Food Science*, 4, 521-531. doi.org/10.1016/j.crfs.2021.07.008

[48] Pollak, F. (2016). Resistencia a la insulina: Verdades y controversias. *Revista Médica Clínica Las Condes*, 27(2), 171-178. doi.org/10.1016/j.rmclc.2016.04.006

[49] CDC (2019). Manejo de azúcar en sangre. USA. Centro Nacional para la Prevención de Enfermedades Crónicas y Promoción de la Salud, División de Diabetes Aplicada Recuperado de `https://www.cdc.gov/diabetes/spanish/living/manage-blood-sugar.html#:~:text=Antes%20de%20comer%3A%2080%20a,Menos%20de%20180%20mg%2FdL`

[50] Ebru Firatligil-Durmus, E. S. (2008). Image Vision Technology for the Characterisation of Shape and Geometrical Properties of Two Varieties of Lentil Grown in Turkey. *Czech J. Food Sci.*, 109-116

[51] Latham, M. C. (2002). Nutrición humana: en el mundo en desarrollo (Vol. 29). New York, NY, USA: FAO

[52] Hernandez-Aguilar, C., Valderrama-Bravo, C., Dominguez-Pacheco, A., Romero-Galindo, R., Igno-Rosario, O., Contreras-Gallegos, Eder Contreras Gallegos, Rumen Ivanov, and Cruz-Orea, A. (2022). Caracterización colorimétrica, textura y calidad sanitaria de panes adicionados con maíces criollos y Cúrcuma longa. *Superficies y Vacío*, 35, 220407. doi.org/10.47566/2022_syv35_1-220407

[53] FAO. (2016). El papel de la FAO en la ganadería y el medio ambiente. `http://www.fao.org/livestock-environment/es/`

[54] Julián Balboa, Á. (2020). Respuestas genéticas al estrés debido a sequía en lenteja (Lens culinaris medikus). `https://buleria.unileon.es/handle/10612/14730`

[55] Sánchez-García, R., Reyes-Morales, H. and González-Unzaga, M. A. (2014) 'Preferencias alimentarias y estado de nutrición en niños escolares de la Ciudad de México', *Boletín Médico del Hospital Infantil de México*. No longer published by Elsevier, 71(6), pp. 358–366. doi: 10.1016/j.bmhimx.2014.12.002

[56] Jordán Padrón, M., Pachón González, L., Blanco Pereira, M. E., & Achiong Alemañy, M. (2011). Elementos a tener en cuenta para realizar un diseño de intervención educativa. *Revista Médica Electrónica*, 33(4), 0-0. `http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1684-18242011000400017`

[57] Bonilla, H., Carbajal, Y., Gonzales, M., Vásquez, V., & López, A. (2019). Determinación de la actividad insecticida de la saponina de la quinua (Chenopodium quinoa) en larvas de Drosophila melanogaster. *Scientia Agropecuaria*, 10(1), 39-45. doi.org/10.17268/sci.agropecu.2019.01.04

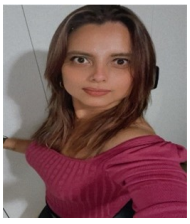
[58] Carolina, A. et al. (2014) 'Efecto de la concentración de saponinas en la actividad hemolítica de extractos de ocho plantas de uso medicinal en Guatemala'. `https://core.ac.uk/download/pdf/35292891.pdf`

[59] Pimentel Jaimes, J. A., Sanhueza Alvarado, O., Gutiérrez Valverde, J. M., & Gallegos Cabriales, E. C. (2014). Evaluación del efecto a largo plazo de intervenciones educativas para el autocuidado de la diabetes. *Ciencia y enfermería*, 20(3), 59-68. doi.org/10.4067/S0717-95532014000300006

[60] García, R., & Suárez, R. (2003). Resultados de un seguimiento educativo a personas con diabetes mellitus tipo 2 y sobrepeso u obesidad. *Revista Cubana de Endocrinología*, 14(3), 0-0

[61] Trento, M., Passera, P., Borgo, E., Tomalino, M., Bajardi, M., Cavallo, F., & Porta, M. (2004). Un estudio controlado aleatorizado de 5 años sobre el aprendizaje, la capacidad de resolución de problemas y las modificaciones de la calidad de vida en personas con diabetes tipo 2 manejadas por atención grupal. *Cuidado de la diabetes*, 27 (3), 670-675

About the Authors



Yoliztli Cecilia Torres Tenorio is a sixth semester student of the Doctorate program in Systems Engineering within the Engineering Systems research line at the National Polytechnic Institute (IPN) of Mexico. She is a chemical engineer by profession with a master of science degree in systems engineering. She has worked in engineering and project areas in the southern industrial zone of Mexico. Her goal is to bring benefits to society through research.

Claudia Hernandez-Aguilar is a professor and researcher of the National Polytechnic Institute, within the Graduate Program in Systems Engineering of ESIME Zacatenco. She is the leader of the Research Group on Sustainable Biophysical Systems for Agriculture, Food and Medicine. She is a member of the Mexican Academy of Sciences and the National System of Researchers (Mexico). Since 2012, she has been a member of the Editorial Committee for the International Agrophysics journal. She has published her research in international journals and has received over 500 citations. Her focus is the use of engineering e.g., sustainable biophysical methods and photothermal techniques to improve society's quality of life and wellbeing. In times of pandemic, she has proposed educational interventions for the consumption of nutraceutical and low glycemic index foods, as well as the care of the other, the other and the others. She has trained young transdisciplinary researchers for the past 15 years, emphasizing the need for awareness, conscience, rigor, and humanism in the research process and of a Transdisciplinary systemic view on the impact obtained from it. Motto: Transform yourself, to transform your world.

Efraín José Martínez Ortiz. Academic Background. Bachelor's Degree in Education and Bachelor's Degree in Mathematics (Universidad Nacional Mayor de San Marcos Lima Peru), Master's Degree in Mathematics (CINVESTAV Mexico). Specialization in Operations Research, Grenoble France. Teaching Experience. Universidad Nacional Mayor de San Marcos. Lima Peru 1968-1970; Universidad Nacional Autónoma de México 1975-1996, Instituto Politécnico Nacional 1973 to date. Instructor in the formation of human resources in Special Projects of SEP and in different universities of the Mexican Republic Academic and/or Administrative Function.