Transdisciplinarity for Sustainable Development: Incorporating Organic Waste into Bread-Making

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Abstract:*This research proposes to take advantage of waste generated in the kitchen to be added into bread-making. The main findings were as follows: 1) family members of the population studied (more than 80%) had diabetes or cancer, their diet is based on high glycemic index foods, including bread. It is necessary to modify its characteristics through fiber and bioactive compounds. 2) Bread added with wastes showed changes in the color (L*a*b*). Those that presented the highest difference with respect to (control) were coriander (30.5), cabbage (30.8) and parsley (22.1) breads; followed by tomato bread (19.6). The porosity increased with the addition of waste, presenting the highest in the breads added with parsley and coffee grain. The bread with lowest hardness after control was the tomato bread, and this was also the of highest sensory acceptance. 3) Bronfenbrenner model was proposed for the evaluation of impacts and self-change to use waste.*

Keywords:Transdisciplinary Methodology, waste, bread, self-change

1 Introduction

The transdisciplinary perspective has been proposed to address sustainability issues (Nicolescu Basarab, 2012) [1]. Several authors emphasize the similarities between research for sustainability and the characteristic features of transdisciplinarity (TD) as that must be oriented to concrete issues in specific problem situations, consider the knowledge of the people involved and their needs and interests, locate processes and specifically where changes are required to be established. Additionally, it is required to establish how to carry out the transformation process in the specific problem in question (Hadorn et al. 2006) [2]. In several of the sustainability issues, society can participate in making changes and then also be agents of change.

In the case of sustainable food systems, one of the key factors is to reduce food waste (Soma and Maclaren, 2020) [3], which has been increasing (Jenkins et al., 2022) [4]. Fruits and vegetables contribute more than 42% of the world's total food waste (Ganesh et al., 2022) [5]. Waste is generated in various levels of society, including in consumers' homes (Abadi et al., 2021) [6]. Consumer behavior, habits, decisions, and awareness are, among other factors, relevant causes of the increase in food waste. For this reason, the transdisciplinary perspective is useful to address this relevant problem and to work on some alternatives for a better use of household waste. Educational institutions could have an impact on this process, thus contributing to progress towards sustainable development.

The generation and non-utilization of food waste represents a complex and relevant problem, currently, there are an estimated 1.3 billion tons of food waste annually (Awasthi et al., 2020) [7]. The total monetary value of food lost or wasted reaches $1 trillion (FAO, 2019) [8]. It is estimated that almost half of horticultural products (fruits, vegetables, and tubers) are wasted worldwide, sometimes as much as 60% (Hussain et al., 2020) [9]. In some countries, urban waste is taken care of by government authorities and is often dumped in landfills or burned, leading to environmental and health problems (Paritosh et al., 2017; Khan et al., 2022) [10,11], as well as economic ones.

Consumers could play an important role in reducing and reusing the organic waste generated in their homes and contribute to solving the waste problem. For this, several programs and/or campaigns have been developed in various countries carrying out educational interventions to raise awareness about the love of food and not waste (Jenkins et al., 2022) [4]. It is necessary to be aware of the situation of food waste in the world, in our countries, but also in our homes. Every human being generates some kind of waste (Balwan et al., 2022) [12]. In the case of some delegations of Mexico City, such as Gustavo A Madero, it has been reported an amount of waste of up to 2.8 kg of organic waste. In a city with food insecurity due to the existing economic differences and health problems, it could be beneficial to take advantage of organic waste in its various components and improve the nutritional quality of staple foods such as bread.

Bread is a food that provides energy to the consumer, but has a low nutritional level, fiber, and antioxidant capacity, and on the other hand has a high glycemic index [13, 14]. Therefore, it is necessary to continue adding ingredients that help to potentiate its functional effect and/or fiber and overcome the weaknesses of this product for consumption by the population, mainly in populations with obesity and diabetes problems such as Mexico, United States and Brazil. In case of Mexico is a population characterized by low vegetable consumption and increased diabetes (Ensanut, 2020) [15]. In this context, we propose to take advantage of organic home waste to be added to wheat bread (mold) in such a way as to improve its nutraceutical power, evidenced through the color changes of the food prototype, and to maintain acceptable texture and porosity measures. This proposal could have an impact on Sustainable Development Goal 12 "Ensure sustainable consumption and production patterns", whose goal is to halve global food waste by 2030 [16]. Furthermore, goals 2 and 3, on zero hunger and health and well-being.

In this sense, they are being integrated and sensitized in the same process to develop this change of attitudes, in this case from the home, where young people and their capacity for change and adaptation play a very important role in moving from a transdisciplinary perspective towards a sustainable world. Likewise, an important role is played by educational institutions at different levels of education, since it is the place that could support to carry out the processes of dehydration and conversion of the raw material to be added to food, in this case to the bread.

Some of the wastes that have been used to be added to bread and/or bakery products include apple pomace, banana peels, tomato pomace, coffee hulls among many others (Masoodi and Chauhan, 1998; Jannati et al., 2018; Mehta et al., 2018; Guglielmetti et al., 2019) [17, 18, 19, 20]. In the case of the addition of coffee hulls it was reported that when added to the bread it can modify the postprandial response (Guglielmetti et al., 2019) [20], which is an important response in diabetes prevention and control.

2 Methodology

We report a part of a research project that works under the transdisciplinary methodology [21], in the 4R's of the Research (4I's, in Spanish): 1. **R**esearch: contextual, field, and documental, 2. **R**esearch: the subject conducting the research, 3. **R**esearch: experimental, and 4. **R**esearch: impacts. The research began by locating the context of its application as established in mode 2 for the generation of knowledge Gibbons et al. (1997) [22]. In this sense, field research was carried out using as an evaluation instrument a survey to know the eating habits of the target population. As is known, it is a tortilla-consuming population, but it was sought which other foods are more frequent in this sample population, since the purpose is to make use of waste generated in the kitchens of the homes of students and family members.

2.1 Research of field

2.1.1 Instrument of evaluation

A field investigation was carried out to learn about habits, eating habits and health care. The sample size was defined using a 90% confidence value with an error percentage of 9%, for an infinite population (Equation 1) [23].

$$n = \frac{z^2pq}{e^2} \tag{1}$$

where: n=sample size; p=estimated percentage of positive variability (50 %), q=percentage of negative variability (100-p), e=allowed error or precision of estimation (5 %) and Z=confidence level (Z of tables=1.96). The survey consists of 36 multiple choice questions, divided into three sections (1. general data, 2. eating habits (likert scale description), 3. health care habits (likert scale description)). This survey was carried out in Mexico City in the facilities of the National Polytechnic Institute (workers, students, and teachers). The Google documents tool called ChartExpo was used for the analysis of the Likert-scale variables.

2.1.2 Study subjects

The survey was applied to the population aged 15 years and older, being applied to 83 subjects, of which 43 were male and 40 females, whose main occupations were students, housewives and employees. The average age of the respondents was 23 years old.

2.2 Research of the subject that investigate (Self-Research)

2.2.1 Focal group to collect organic wastes

Focus group composed of some internal and external students of the ESIME-Zacatenco (Institution of Higher Education in Mexico) located in the Gustavo A Madero delegation, was invited to collect organic waste from their kitchen. The students, in turn, invited their teachers and families, who live in Mexico City and the State of Mexico. Likewise, to carry out self-research tasks for self-transformation leading to the incorporation of a change of thinking, towards systemic, scientific, and transdisciplinary attitudes based on continuous reflection [24,25]. Consequently, transdisciplinary training is a way to incorporate new habits, in this case that allow the use of organic waste from their kitchens, moving towards mutual learning among participants; in the experience of being "all teachers and all students". Raising awareness

Table 1: Characteristics of the interviewed population.

Variables	**N**	**%**
Sex		
M	43	51.81
F	40	48.19
Age		
< 30	68	81.92
> 30	12	14.45
They did not indicate their age	3	3.63
BMI		
Low weight	1	1.20
Normal	44	53.01
Overweight	33	39.75
Slight obesity	3	3.61
Moderate obesity	0	0
Severe obesity	0	0
Information of family member with diabetes or cancer disease	66	80%

N: Number of people, BMI: Body mass index, M: Male, F: Female

among other aspects that when food is wasted, it is not only the food itself, but the whole set of resources, personnel, knowledge, and time invested to obtain it (Jellil et al., 2018) [26].

2.3 Research Experimental

2.3.1 Organic waste

Once the organic wastes were delivered, they were processed and converted into nutraceutical powder. The wastes received were mainly cilantro (*Coriandrum sativum*), purple cabbage (*Brassica oleracea var. capitata*), parsley (*Petroselinum crispum*), black radish (*Raphanus Sativus*) peels, tomato peels (*Lycopersicum esculentum Mill.*), and coffee (*Coffea arabica L.*) grains. These wastes were washed and disinfected.

2.3.2 Dehydration Process

The powder of each of the organic wastes collected in this research was prepared from the stems (coriander and parsley), peels (tomato and black radish), the external part of purple cabbage and the leftover grain from the preparation of instant coffee. These were neatly placed in a dehydrator during 8 hours at 130 °F and then pulverized in a Hamilton Beach grinder.

2.3.3 Bread Formulation

The formulations for the preparation of box bread were adapted from Hernandez et al. (2022) [27], which can be observed in Table 1. It is possible to appreciate the ingredients used to make the dough in percentages (water, milk, egg, salt, sugar, olive oil, yeast, wheat flour). The wheat breads were added with organic waste powders at 5%, according to the sensory preferences reported by some authors. The process carried out is also the same as reported for bread making by the authors in different articles making bread added with moringa, corn, lentil germ, etc. [27, 28, 29].

The solid ingredients were incorporated into the mixer bowl, while yeast was allowed to stand in 150 g of warm water. The fermented water was added together with 150 g of warm milk forming a mixture to

Table 2: Formulations of 8 types of breads with added bio-products from the kitchen

Ingredients	P0	P1	P2	P3	P4	P5	P6	P7
"Boxed bread" added with organic wastes (%)								
Wheat flour	-	86.7	81.7	81.7	81.7	81.7	81.7	81.7
Oil	-	3.46	3.46	3.46	3.46	3.46	3.46	3.46
Eggs	-	7.21	6.54	6.54	6.54	6.54	6.54	6.54
Salt	-	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Sugar	-	0.57	0.57	0.57	0.57	0.57	0.57	0.57
Yeast	-	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Powder (P1)	-	0	0	0	0	0	0	0
Coriander	-	0	0	5	0	0	0	0
Purple cabbage	-	0	0	0	5	0	0	0
Black radish peel	-	0	0	0	0	5	0	0
Tomato peel	-	0	0	0	0	0	5	0
Coffee grain	-	0	0	0	0	0	0	5

P0: Commercial bread, P1: non-added formulation, P2: bread added with coriander, P3: purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee grains

form the bread dough. This mixture was kneaded in a mixer with a dough hook (spiral) for 10-15 min. Then, it was placed in a box loaf pan previously greased with olive oil, where it was allowed to grow in volume until before 1 cm of the height of the loaf pan. The mold was covered with a damp cloth and allowed to stand for approximately 50-60 min. A similar procedure was carried out for each of the 8 types of bread, including the control bread (which was not added with powder from organic waste).

Once the time had elapsed, the bread was baked in an electric oven (Black & Decker), preheated (15 min) at 180 °C, for 50 min. After baking, the bread was allowed to cool to room temperature and was sliced using an electric knife (Hamilton Beach).

2.3.4 Bread Color

The color of the 8 types of bread was measured by means of a precalibrated manual colorimeter (FRU WR-10QC, Shenzhen Wave Optoelectronics Technology Ltd, China). Prior to the measurements the meter was calibrated. Thus, the color parameters in CIELAB 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)]. Additional color parameters such as whiteness index (WI) and yellowness index (YI) were calculated (Rhim et al., 1999; Pathare et al., 2013) [30, 31]. Finally, color differences in CIELAB space were determined between commercial bread and breads made with and without organic residues (Melendez et al., 2007) [32].

2.3.5 Texture profile analysis (TPA)

Texture profile analysis for the 8 bread formulations was performed with the texture analyzer (Brookfield Model CT3 25 K, USA) in a 25 kg load cell. After slicing the bread, 5 slices were selected from the center and stored in polyethylene bags for preservation prior to measurement. The analysis was performed for two compression cycles, at 20%, using a TA TA25/1000 general test kit with a cylinder diameter and length of 50.8 and 20 mm, at a speed of 2 mm/s and 1 g preload. The parameters obtained were hardness, elasticity index, cohesiveness, and chewiness. The TPA analysis began 18 hours after the bread was made, for two consecutive days; five repetitions of each sample were performed at a temperature of 24 ± 1°C.

2.3.6 Bread Porosity

The porosity of the bread was determined by image processing: a) original image of commercial bread, made without the addition of residue and with the addition of cooking residue, b) image in gray scale, c) binarized image with the percentages associated with porosity. The original images were cropped to a size of 1800 x 1800 pixels and converted to gray scale with intensity values between 0 and 1. Adaptive binarization was used to calculate a threshold for each pixel from local average intensity around the pixel neighborhood [33]. For this purpose, the Matlab (2019) function Binary according to Hernandez (2022) [27] was employed. Then, by applying the aforementioned function, the binary image is obtained, which allows the visualization of areas corresponding to the pores. From that, a count of the pixels with value 1 is made and divided by the total area of the image, to finally obtain the percentage of porosity.

2.4 Research Impacts

2.4.1 Bronfenbrenner-based impact Model

The ecosystemic model is based on a multi-level perspective of behavioral impacts of individuals towards their ontosystem, microsystem, mesosystem, etc. (Bronfenbrenner, 1992) [34]. The ecosystemic model proposed by Bronfenbrenner (1917-2005), points out that the behavior of individuals is influenced by several holistic levels: a) the microsystem - the close influences of the individual with others in direct relationships, b) the mesosystem - the relationships between the members of the microsystem; c) exosystems: these are the elements independent of the individual, but represent part of the environment of some element of the microsystem; d) macrosystem: these are the elements or variables external to the macro level such as culture, race, geographical distribution, economic, political, social situation, etc.; e) the chronosystem: these are the events that emerge in time and that can influence the individual (Boulet et al., 2021; Principato et al., 2018) [35, 36]. In addition, some authors have added external level (globosystem) and internal level (nanosystem), these are related to global aspects and particular aspects that each individual (sex, health, genetics), etc. (Stanger, 2011) [37].

3 Results and Discussions

3.1 Field Research. Food Habits and Dietary Customs

In the present investigation, with the population sample investigated belonging to the academic environment, interest in the prevention of the disease was found, with 87% of the population surveyed expressing their agreement (Figure 1). As indicated above, 80% of the population lives with patients with either diabetes or cancer. The interest in opting for preventive attitudes may be because they are related to situations of family illness and have been sensitized to this situation, in this process of awakening awareness of living with sick patients and what it entails in terms of quality of life. Perhaps if other strata of society without this family experience or belonging to other vulnerable sectors were investigated, perhaps their concerns would be of a different type. Likewise, they also showed interest in balanced diets, expressing their agreement (45%) and total agreement (40%), making a total of 85% of the surveyed population in favor of dietary care. In relation to the consumption of fruits and vegetables, they also agree (67%) and totally agree (15%) in their consumption and their attitude towards the consumption of water is neutral (93%). However, they agree and strongly agree in the consumption of fast food, in a total of 60% of the respondents.

Likewise, their habits of opting for the consumption of high carbohydrate foods such as high glycemic index fruits like banana (52%) and orange (38%); and rice (65%) and bread (51%) is high (Table 3). In the case of consumption of apples (65%) is important mention that is one of the fruits with the highest glycaemic index, among the lowest level fruits. It should be noted that this depends on the state of maturity and type of apple consumed, i.e. the glycaemic index of the apple could increase, placing it in the medium or high glycaemic index category, especially if the peel of the apple is not eaten and if the apple is not green. In this sense, fiber consumption decreases the glycaemic impact. In a population such as that of

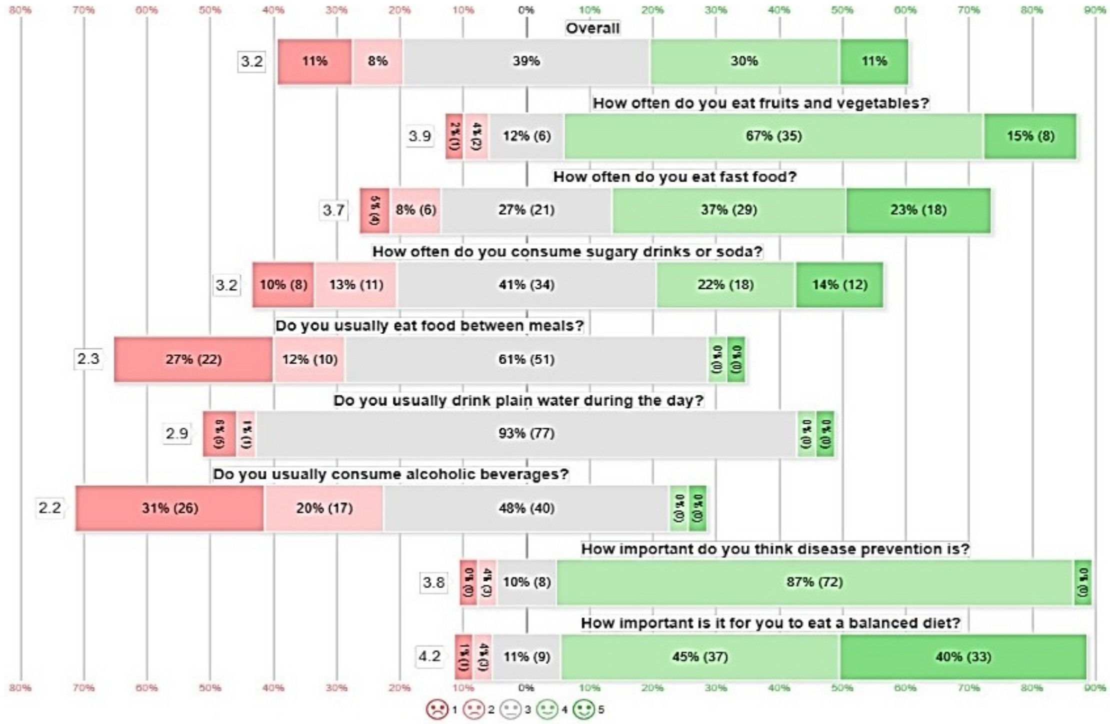

Figure 1: Food habits and interest in balanced diet and health prevention.

Mexico City and in the country in general; it is important to opt for basic foods such as "tortillas", rice, and bread, but with added fiber to modify their glycemic response, as well as their moderate consumption. In this sense, the population could take advantage of the fiber in their food husks and consume more of them, thus reducing the glycemic impact in their staple foods, such as bread. According to their dietary habits, it can be observed that people consume various vegetables and fruits, which could be used in their entirety and at the same time reduce the waste generated by them.

In relation to the consumption of low glycemic index fruits such as strawberries (13%) and pears (11%), a lower percentage of the population consumes them. Consumption data and consumption frequencies in the field research suggest that people do not have a low glycemic index diet. Then they could opt for low glycemic index diets.

High percentages of family members with diabetes or cancer have been reported in various studies (Jenkins et al., 1988; Ludwig, 2002; Hu et al., 2013; Zafar et al. 2019) [38-40]. In a study conducted in Iowa, a corn-producing area, cancer was reported to be highly associated with the consumption of high glycemic load foods in non-diabetic women (Folsom et al., 2003) [41]. It is advisable for individuals with both diseases to reduce their intake of foods high in carbohydrates.

Hence the importance of adding fiber to staple foods, to modify their glycemic index. In the case of utilization of some organic waste generated in the kitchen, it could be useful for this purpose. As reported by some authors, the addition of fiber or nutraceutical foods modifies the glycemic response of staple foods such as bread. Of course, it can also be modified when bread is made with other types of flour, such as almond and coconut flour. In this research, it has been proposed to add to the bread food residues generated in the kitchen that represent fiber. In the face of a serious waste generation problem (Jungowska et al., 2021) [42], it is proposed here to make the most of it.

Table 3: Dietary customs

What is your daily diet?	N	%	What fruits do you normally consume?	N	%
Meat	63	75.9	Melon	23	27.71
Chicken	65	78.31	Watermelon	32	38.55
Fruits	57	68.67	Apple	65	78.31
Vegetables	59	71.08	Banana	52	62.65
Fish and seafood	14	16.87	Pineapple	12	14.46
Bread	43	51.81	Guava	23	27.71
Egg	49	59.04	Orange	38	45.78
Beans	38	45.78	Strawberry	13	15.66
Rice	54	65.06	Papaya	23	27.71
Pasta	37	44.58	Pear	11	13.25
Cheese	32	38.55	Grape	23	27.71
Milks	39	46.99	Mango	18	21.69
Desserts	26	19.28	Grapefruit	3	3.61
Sweets	27	20.48	Peach	9	10.84
Sausages	19	22.89	Other	11	13.25
Frequency of consumption of sugar-sweetened beverages or sodas					
Always	12	14.46			
Frequently	18	21.69			
Occasionally	34	40.96			
Rarely	11	13.25			
Never	8	9.63			

N: Persons number

3.2 Experimental Research

3.2.1 Color, Porosity, and Texture

In this research it is possible to observe significant statistical changes in color, when comparing the formulated breads with respect to the commercial bread in the dimensions L*, a*, b*, YI, WI and ΔE as shown in Table 4.

The characteristic of Luminosity L* in the breads had a higher value behavior in the white breads apparently, both the commercial box bread (P0) and the white bread P1 elaborated with the formulation used in the present investigation, with values of 58.45 and 56.75. The other breads had lower values since their brightness decreases when some type of dust from kitchen waste is incorporated. The lowest brightness values were for breads P2 (38.17), P5 (39.94) and P7 (31.3), corresponding to the breads added with powders from coriander, black radish, and coffee bean waste, with a difference in percentage with respect to P0 of 34.6, 31.6 and 46.4%, respectively. These values coincide with what is reported in the literature, since the addition of organic powder decreases the brightness of the bread. This means that the bread retains bioactive elements that can benefit the consumer. In the case of color dimension, a*, all the breads increased their value except for P4, which showed a slight decrease. In the color dimension b*, most of the breads tended to increase in this variable, except for bread P3. Likewise, in the YI variable, higher values are expressed for all types of breads; the formulated and the added ones when compared with commercial bread. The breads with the lowest YI yellowness index values were P0 (23.33) and P1(37). The whiteness index is related to the brightness value found as expected, which decreases in the formulated

Table 4: Color, porosity, and structural characteristics of bread added with organic wastes

	Color variables						Porosity (%)	Texture variables			
	L*	**a***	**b***	**WI**	**YI**	**ΔE**	**Porosity**	**Hardness**	**Cohesiveness**	**Elasticity**	**Chewiness**
P0	58.45	1.137	9.54	57.35	23.33	0	0.17	323	0.83	2.58	3.7
P1	56.75	1.247	14.7	54.28	37	5.43	2.26	761	0.78	3.29	18.3
P2	38.17	3.443	38.8	26.91	146.1	30.5	11.34	727	0.81	2.74	15.5
P3	47.25	4.043	9.32	46.28	28.18	30.8	9.18	675	0.81	3.09	15.3
P4	43.79	1.07	30.9	35.83	101.3	22.1	17.51	746	0.79	3.58	22.5
P5	39.94	2.927	12	38.68	43.22	19.4	23.73	737	0.8	3.3	8.57
P6	49.78	6.937	28.5	41.82	81.64	19.6	3.75	453	0.84	3.13	8.57
P7	31.3	5.953	30.1	24.77	137.2	18.6	30.44	750	0.79	2.68	16.1

P0: Commercial bread, P1: non-added formulation, P2: bread added with coriander, P3: purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee bean, YI: yellowness index, WI: whiteness index

and added breads in relation to P0. Another color parameter of interest was the color differences as a function of the variables L*, a* and b*. It is possible to observe that the breads that presented the greatest differences in color are P2, P3 and P4, which correspond to the breads added with cilantro, purple cabbage, and parsley.

Figure 2 shows another perspective of the bread color changes on day 1, where the "xy" coordinates are plotted to locate the color tone region of the eight bread samples P0, P1, P2, P3, P4, P5, P6, and P7. The "x" axis moves towards red color and the "y" moves towards green color (Hernandez et al., 2022) [27]. It is observed that the P0 bread is located at the lowest values of the "x" and "y" coordinates in the CIE chromatic triangle. The loaves closest to P0 are loaves P1, P3 and P5 located in the "x" (0.35 to 0.375) and "y" (0.35-0.375) coordinates. As it is possible to observe, breads P2, P4, P6 and P7, are in other coordinates further away from those previously mentioned (x = 0.425-0.475 and y= 0.4 -0.45). This indicates that these breads would have greater changes of bioactive components when compared to breads P0 and P1.

Figure 3 shows histogram with scales in "x" 0 - 255 (value at the center of 128) and in "y" 0-4000. The breads with the highest luminosity level P0 (58.45), P1(56.75) and P6(49.78), and are the breads that reach a level of intensity "x" in higher coordinates. As the bread was added, it is observed that it occupies lower levels in "x", being the bread P7 the one with the lowest level in "x". The blue component of the breads is found in lower values for breads P2, P4 and P7 followed by P5 and P6.

3.2.2 Texture Analysis

The variables of hardness, chewiness, elasticity, and cohesiveness showed significant statistical differences when compared between the commercial bread P0 and the formulated breads (P1, P2...P7) and between P1 (formulated and not added with powder from organic waste) and the added breads (P2, P3, P4, P5, P6, and P7).

Figure 4 shows the changes in the characteristics of hardness, chewiness, elasticity, and cohesiveness. In the case of hardness, when compared with the control (P0-commercial bread), all the breads increased in value, although to a lesser extent the hardness of the tomato bread (P6) increased by only 40%. The other breads showed a similar behavior in hardness, with an average increase of more than 100% with respect to the control. Hardness on the second day decreased in the case of the control bread and P2; the others

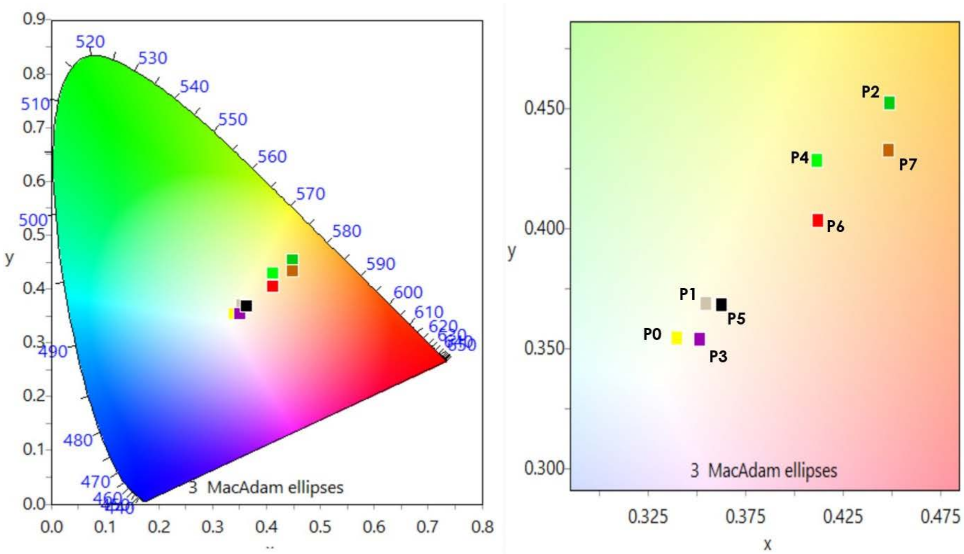

Figure 2: Hue of bread samples in the CIE chromatic triangle (neutral achromatic point x=0.333, y=0.333), a) scale x= 0-0.8, y=0-0.9 and b) scale x=0.275-0.475 and y=0.3-0.475. P0: Commercial bread, P1: Non-added formulation, P2: Bread added with coriander, P3: Purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee grains.

showed a tendency to increase with different percentages of increase when compared to the commercial control sample (P0), such as bread P1 (29%), P3 (45%), P6 (53.6%) and P7 (108%). Similarly, in the case of chewiness, it increased in all the formulated breads, both P1 (without adding organic waste) and all the others with additives, with the least affected being the tomato bread with an increase of 129%. Chewiness and hardness have a direct relationship, although the breads show greater changes in the chewiness variable. With respect to the measurement made on the third day, it is possible to observe how P0 presents a small decrease (35%). However, P1 (28%), P3 (102%), P4 (16%), P5 (6%), P6 (75.27%) and P7/38.5%) tend to increase except for P2 which decreases (4.76%) with respect to the measurement taken on the first day.

In the variable elasticity, the breads tend to increase on the first day in all cases. The lowest changes were observed for breads P2 (6.61%) and P7 (4.28%). In the comparison of the respective types of bread measured on the first day and the third day, it was found that for breads P0 (6.6%), P4(28.49%), P5 (19.14%) and P6 (17%) the elasticity decreased. Cohesiveness was the variable that showed the least changes when comparing the formulated and control breads (P0). The breads with the highest value of cohesiveness are P0 (0.825) and P6 (0.85). In other studies, texture variables have been modified.

In relation to porosity according to the results obtained, all the breads increase their porosity when compared to the porosity of white commercial bread. The most porous breads are parsley, purple cabbage, and coffee bean bread (Figure 5).

Finally, it is possible to observe in Figure 6 a heat map, where the color changes found for days 1, 3 and the bread in dehydrated conditions are observed. As can be seen, the breads with the highest changes were due to the change of condition from fresh to dehydrated bread for the variables L*, a* and b*. Breads P0 and P1 showed the least changes in luminosity. Bread P1 showed the least changes in the color dimension a*.

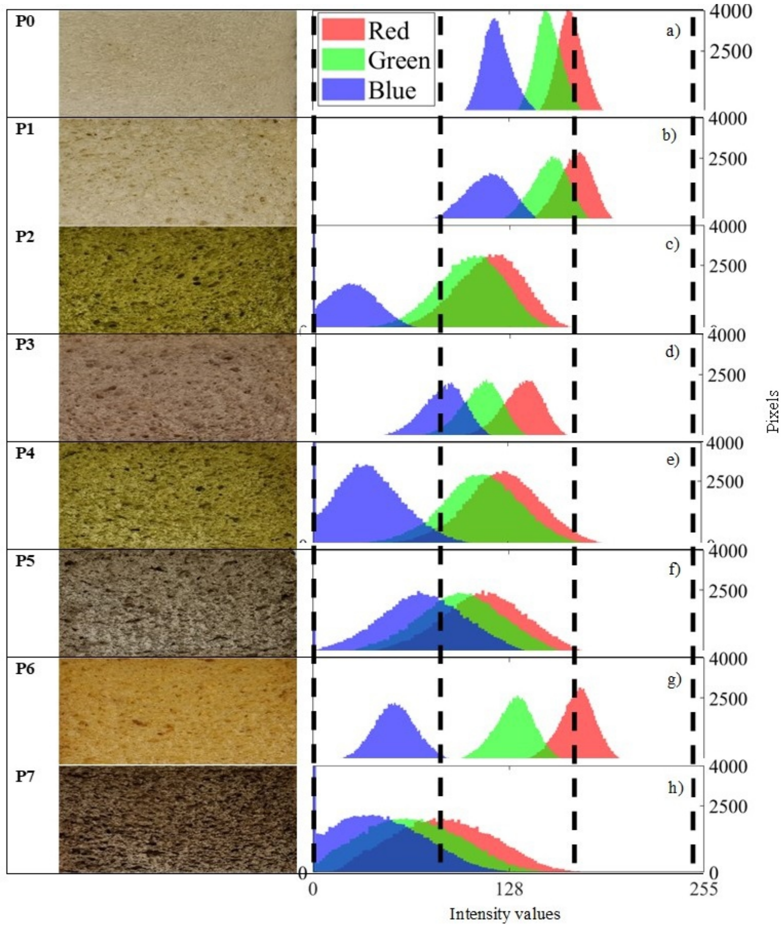

Figure 3: RGB of bread samples (P0: Commercial bread, P1: Non-added formulation, P2: Bread added with coriander, P3: Purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee grounds).

3.3 Impacts Research and auto-Research

3.3.1 Modelo de Bronfenbrenner

Bronfenbrenner's ecosystemic model [34] is based on analyzing the development of an individual as a function of external influences from different holistic levels (Globe, macro, meso, micro, onto, and chrono-system) (Figure 7). However, it is also possible to visualize it in an inverted way. From the center of the model, where the individuals are located; (students, teachers, friends, relatives) towards the different holistic levels, outside the onto-system. That could be a kind of wave that expands. This means that it is possible to influence the change of attitudes in the different holistic levels, at the level of micro-system, meso-system, macro-system, chrono-system, and globo-system. In this sense, students, teachers, workers, etc. belonging to educational institution, could be transcendental elements since they would go beyond the academic limits to impact their holistic multi-levels, being detonating entities of attitude change, in their close environment: family, teachers, church.

In this sense, in the ecosystemic model of proposals in each one of the holistic levels it could be considered: 1). Onto-system. Self-observation, self-transformation, attention to health care, to know our psycho-emotional factors that must be worked on and advanced, the level of spirituality that can be enriched with continuous actions that lead to resilience, tolerance, peace and will, perseverance in changes, openness to learning how to use waste from their household kitchens, development of new food products,

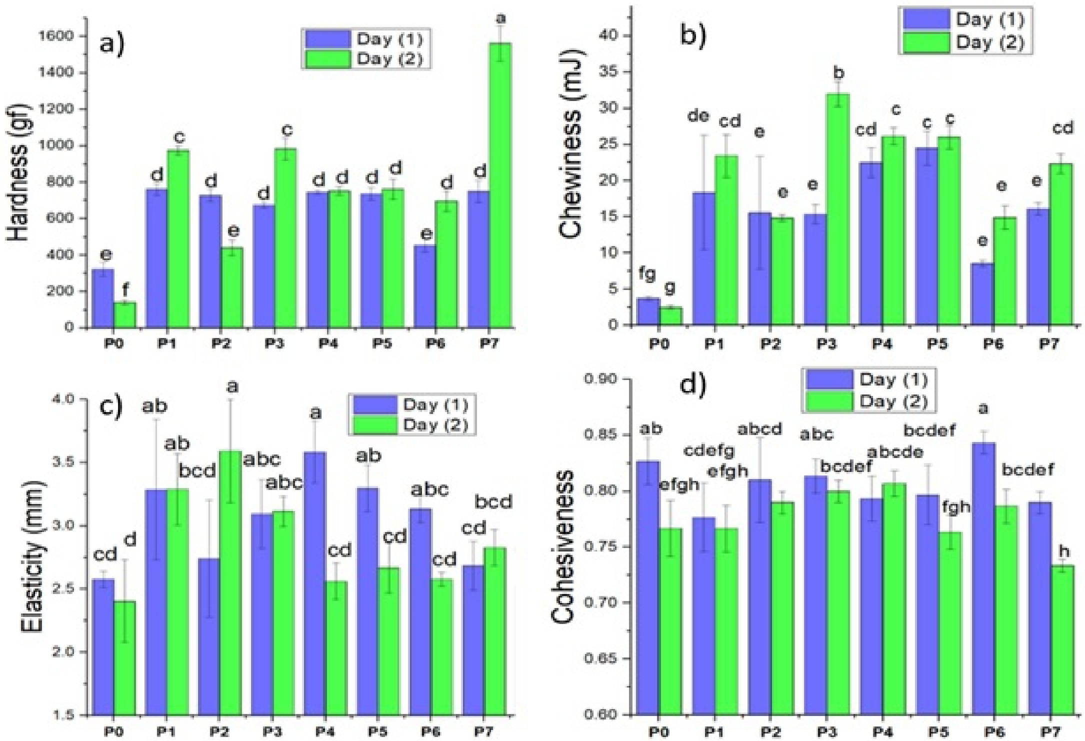

Figure 4: Structural analysis of the 8 types of bread a) Hardness, b) Chewiness, c) Elasticity and d) Cohesiveness. (P0: Commercial bread, P1: Non-added formulation, P2: Bread added with coriander, P3: Purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee grounds).

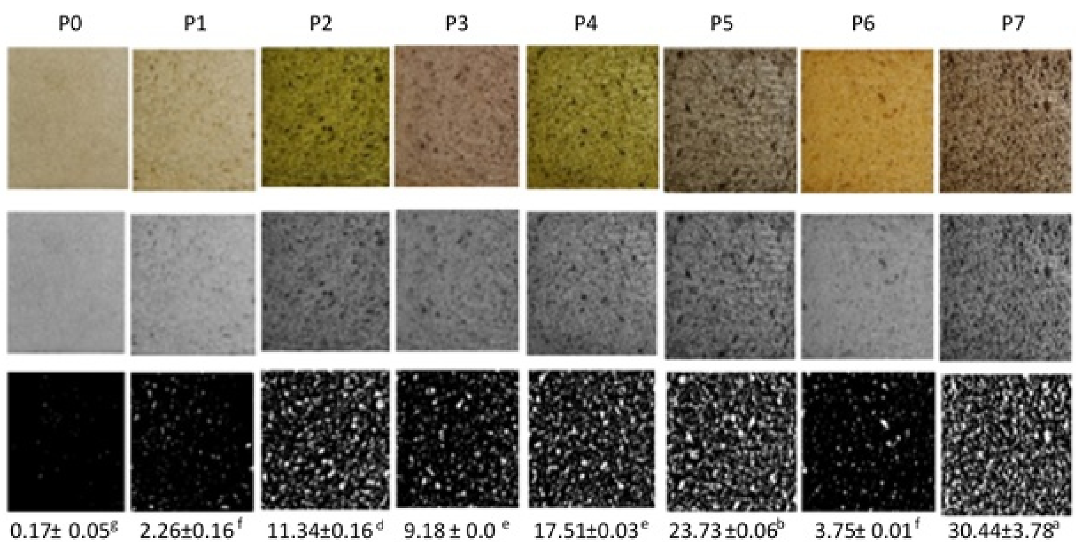

Figure 5: Porosity of bread (P0: Commercial bread, P1: Non-added formulation, P2: Bread added with coriander, P3: Purple cabbage, P4: parsley, P5: black radish, P6: tomato, P7: coffee grounds).

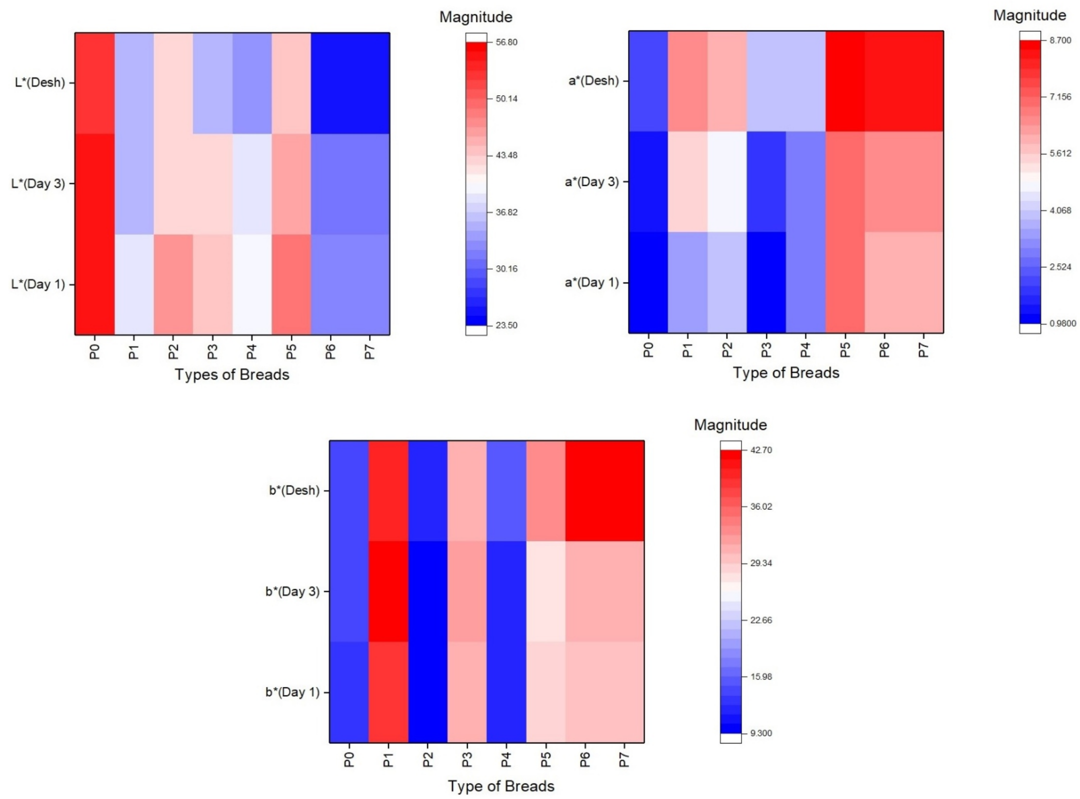

Figure 6: Heat map of color components for breads on days 1,2 and under dehydrated (Desh) conditions.

etc. A key aspect is self-observation, to know oneself, to be thought about others (environment) and the others (population, society, humanity). 2). Micro-system. Knowledge of the elements of its microsystem, the main elements, to make the exercise of knowing outside of its onto-system, to know outside of itself to understand and accept the diverse evolutionary levels, to tolerate and to dialogue, developing a shared vision. 3). Meso-system. Co-participate with individuals, co-construct spaces for change, co-teach, co-sensitize, co-learn, co-operate, connect in digital and non-digital media (face-to-face with the population), co-create collaborative, participatory and enthusiastic spaces. Not to hinder, but to facilitate with their possible connections, as well as rather to be enthusiastic among the elements of the microsystem. In general, in the relationships between the elements of the microsystem, knowledge transfer and re-education will be established between all those connected at this level. 4) Exo-system. This level corresponds to the links between social environments that do not involve the individual in the process of change (in this case, towards the use of waste from the kitchen). In this sense, it is necessary to create awareness between the relations of this and the independent relations to the mesosystem. It is could be knowing the influence that it can have and that the interaction that it has in the individual in process of change does not generate some type of demotivation, on the contrary it generates a permanent environment to persevere in the changes and to join little by little all in this shared vision, with changes in chain in a dynamic. Through the respective dissemination of knowledge at all other levels, independent of the individual (student, teacher, administrative). 5) Macro-system and globo-system. Plans and programs, incentives, dissemination of information to population and educational institutions, which in turn impart it to young people, but those young people in turn request it from the authorities. Presence of world organizations in schools, through their presence in governments, following up on the fulfillment and incorporation of strategies to

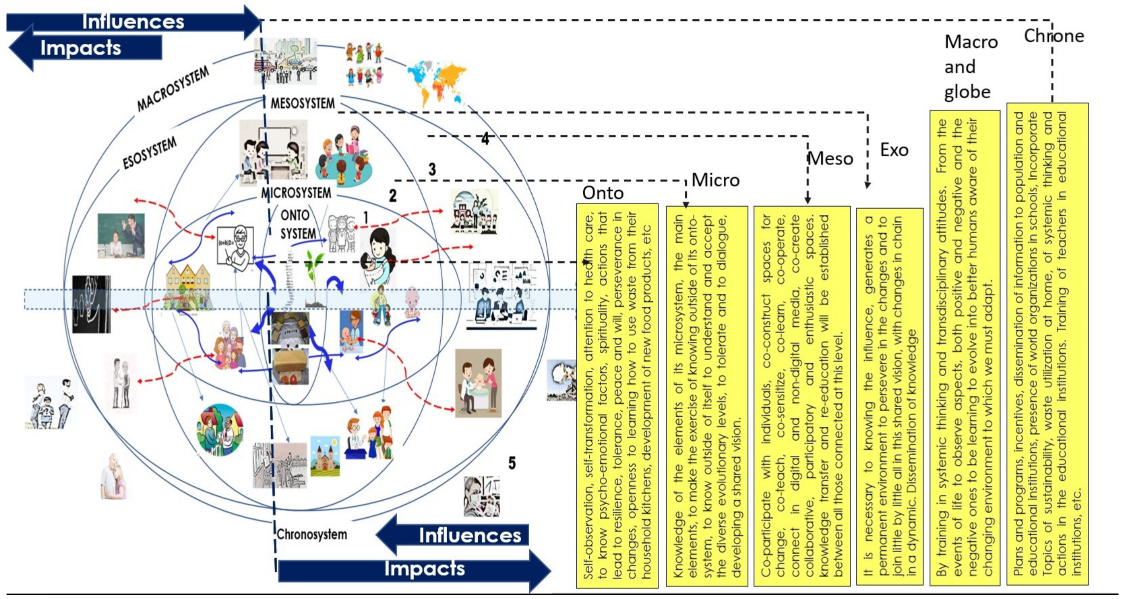

Figure 7: Ecosystem model, adapted from Brofenbrenner [34].

achieve sustainable goals. Incorporate subjects of sustainability, waste utilization at home, of systemic thinking and actions in the educational institutions, that in the world forums the systemic formation is also strengthened in the leaders, As well as in the training of teachers in educational institutions, etc. 6. Chrone-system. Educate in learning and awareness of life experiences. Through training in systemic thinking and transdisciplinary attitudes. From an early age to observe the consequences of our actions and their impact on others. Life events serve to observe aspects, both positive and negative and the negative ones to be learning to evolve into better humans aware of their changing environment to which we must adapt.

From this, students could be influential individuals in their microsystem, according to Bronfenbrenner's model [34]. The development of the individual is influenced by different holistic levels. But we individuals could also influence our environment, starting with our own ontosystem and microsystem and thus impact the various holistic levels. Each one of us being seeds germinating with our own changes and thus being detonators towards the changes of others, teachers and our own or neighboring families, friends, and later friends among other friends, neighbors with other neighbors, teachers with other individuals and so on in a multiplying effect. Reflecting, the problem of facing the challenges of sustaining changes over time, retaining self-determination and self-regulation (Kwasnicka et al., 2016) [43], at every point in time to overcome it and sustain changes over time. To add up the changes to participate in evolutionary processes necessary in today's society, to which science must serve but in the sense of transferring knowledge, sensitizing and raising awareness of the various problems that are experienced. Where the population can do a lot, in this case a use of household kitchen waste for which educational institutions could play a determining role as support and seed of these processes of change.

This paper addresses the experimental activities carried out in the utilization of organic waste obtained from home kitchens of students, teachers, and respective family members to elaborate nutraceutical and/or lower glycemic index bread. In a survey applied to graduate students in systems engineering, who took the subject of experimental methodology or meta-methodologies, asking if they use waste from their homes. The students answered 65% that they did, but not frequently. If they did use it, most of them used it for compost. No one reused it to add to food. They did not know how to do it, nor did they have any ideas for this. Nor did they know the benefits of adding it to their staple foods, and none knew about the glycemic index of foods. In some studies, in Poland, it has been pointed out that people do not use their organic wastes in food because they do not know how to transform them and have no ideas for what to make.

But not only that is the problem, sometimes there is resistance to consume something that is mentioned that is waste. It is important to clarify that the product to be used must maintain the necessary hygiene aspects so that it can be consumed with confidence by the leftovers normally used in the preparation of their food. In this way generate new added products and join in the reduction of waste in the community, in society and in the country. Finally, the individual changes in this chain of changes are relevant. Do not wait for everyone to do it, but with patience and perseverance, each one should do his or her own thing. As Mahatma Gandhi said (1869-1948):

"I tried to change the world and I couldn't, I changed myself and I changed the world."

4 Conclusions

In the context of application, according to the field research it was found that the most consumed high glycemic index foods in the surveyed population are rice (65.06%) and bread (51.81%). Likewise, the population opting for the consumption of fruits of high carbohydrate i.e. high glycemic index as banana (52%), and orange (38%). Consumption of low glycemic index fruits such as strawberries (13%) and pears (11%) were found less. In the case of apples, it is one of the most widely consumed fruits (65%) in the population studied. It is important to mention that it is one of the fruits with the highest glycaemic index among the lower level fruits.

Diet followed by the population is not based on a low glycemic index diet, which would be advisable in view of the data found, more than 80% of people with diabetic or cancer patients in their family.

Breads with the highest yellowness index (YI) were P2, P4, P7 and P6 located at the coordinates of the CIE chromatic triangle within the points on the scale, y =0.4-0.455 and at x=0.4-0.45. Highest changes in the color dimension were obtained in the dehydrated bread, except for the control bread, which maintained the luminosity variable constant. In general, for all breads, the L* variable was decreased except for the P1 and P2 breads, which showed no changes on day 3 and the dehydrated bread.

Variables of hardness, chewiness, elasticity, and cohesiveness showed significant statistical differences when compared between the commercial bread P0. In the case of hardness, when compared with the control (P0-commercial bread), all the breads increased in value, although to a lesser extent the hardness of the tomato bread (P6) increased by only 40%. In the case of chewiness, it increased in all the formulated breads, both P1 (without adding organic waste) and all the others with additives, with the least affected being the tomato bread with an increase of 129%. Chewiness and hardness have a direct relationship, although the breads show higher changes in the chewiness variable.

Authors' Contribution: CHA had the idea for the research, proposed the methodology and carried out the research and manuscript preparation. DAS collaborated in field research and manuscript preparation, ADP and OIR collaborated in color research and performed some illustration development and manuscript preparation, MCVB collaborated with texture analysis and, RI collaborated in color research and manuscript revision, JEVH collaborated in sample collection, dehydration, and characterization, MFC collaborated in research and EJMO collaborated in mathematical analysis. All authors critically revised and edited the text and results, and finally approved the manuscript.

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References

1. Basarab N. (2012). *Transdisciplinarity and sustainability.* Edited by Basarab Nicolescu. Lubbock, Texas: TheATLAS Publishing.

2. Hadorn, G. H., Bradley, D., Pohl, C., Rist, S., & Wiesmann, U. (2006). Implications of transdisciplinarity for sustainability research. *Ecological economics,* 60(1), 119-128.

3. Soma, T., Li, B., & Maclaren, V. (2020). Food waste reduction: A test of three consumer awareness interventions. *Sustainability,* 12(3), 907.

4. Jenkins, E. L., Brennan, L., Molenaar, A., & McCaffrey, T. A. (2022). Exploring the application of social media in food waste campaigns and interventions: A systematic scoping review of the academic and grey literature. *Journal of Cleaner Production,* 132068.

5. Ganesh, K. S., Sridhar, A., & Vishali, S. (2022). Utilization of fruit and vegetable waste to produce value-added products: Conventional utilization and emerging opportunities-A review. *Chemosphere,* 287, 132221.

6. Abadi, B., Mahdavian, S., Fattahi, F., (2021). The waste management of fruit and vegetable in wholesale markets: intention and behavior analysis using path analysis. *J. Clean. Prod.,* 279, 123802 `https://doi.org/10.1016/j.jclepro.2020.123802`.

7. Awasthi, S. K., Sarsaiya, S., Awasthi, M. K., Liu, T., Zhao, J., Kumar, S., & Zhang, Z. (2020). Changes in global trends in food waste composting: Research challenges and opportunities. *Bioresource Technology,* 299, 122555.

8. FAO (Food and Agriculture Organisation of the United Nations) (2019). Global Initiative on Food Loss and Waste Reduction. Available online: `http://www.fao.org/3/a-i4068e.pdf`

9. Hussain, S., Jõudu, I., & Bhat, R. (2020). Dietary fiber from underutilized plant resources—A positive approach for valorization of fruit and vegetable wastes. *Sustainability,* 12(13), 5401.

10. Paritosh, K., Kushwaha, S. K., Yadav, M., Pareek, N., Chawade, A., & Vivekanand, V. (2017). Food waste to energy: an overview of sustainable approaches for food waste management and nutrient recycling. *BioMed research international,* 2017.

11. Khan, M. K. I., Asif, M., Razzaq, Z. U., Nazir, A., & Maan, A. A. (2022). Sustainable food industrial waste management through single cell protein production and characterization of protein enriched bread. *Food Bioscience,* 46, 101406.

12. Balwan, W. K., Singh, A., & Kour, S. (2022). 5R's of zero waste management to save our green planet: A narrative review. *European Journal of Biotechnology and Bioscience,* 10(1), 7-11.

13. Hernandez-Aguilar, C., Palma-Tenango, M., Miguel-Chavez, R. S., Dominguez-Pacheco, A., Soto-Hernandez, M., del Carmen Valderrama Bravo, M., ... & Ordoñez-Miranda, J. (2022). Induced changes of phenolic compounds in turmeric bread by UV-C radiation. *Journal of Food Measurement and Characterization,* 16(2), 1012-1028.

14. Borczak, B., Sikora, M., Sikora, E., Dobosz, A., & Kapusta-Duch, J. (2018). Glycaemic index of wheat bread. *Starch - Stärke,* 70(1-2), 1700022.

15. Shamah-Levy T, Vielma-Orozco E, Heredia-Hernandez O, Romero-Martinez M, Mojica-Cuevas J, Cuevas-Nasu L, Santaella-Castell JA, Rivera-Dommarco J. (2020). Encuesta Nacional de Salud y Nutrición 2018-19: Resultados Nacionales. México: Instituto Nacional de Salud Pública.

16. Bengtsson, M., Alfredsson, E., Cohen, M., Lorek, S., & Schroeder, P. (2018). Transforming systems of consumption and production for achieving the sustainable development goals: moving beyond efficiency. *Sustainability science,* 13, 1533-1547.

17. Masoodi, F. A., & Chauhan, G. S. (1998). Use of apple pomace as a source of dietary fiber in wheat bread. *Journal of Food Processing and Preservation,* 22(4), 255-263.

18. Jannati, N., hojjatoleslamy, M., Hosseini, E., Mozafari, H. R., & Siavoshi, M. (2018). Effect of apple pomace powder on rheological properties of dough and sangak bread texture. *Carpathian Journal of Food Science & Technology,* 10(2).

19. Mehta, D., Prasad, P., Sangwan, R. S., & Yadav, S. K. (2018). Tomato processing by product valorization in bread and muffin: Improvement in physicochemical properties and shelf life stability. *Journal of food science and technology,* 55(7), 2560-2568.

20. Guglielmetti, A., Fernandez-Gomez, B., Zeppa, G., & del Castillo, M. D. (2019). Nutritional quality, potential health promoting properties and sensory perception of an improved gluten-free bread formulation containing inulin, rice protein and bioactive compounds extracted from coffee byproducts. *Polish Journal of Food and Nutrition Sciences,* 69(2).

21. Hernandez-Aguilar, C. (2018). Transdisciplinary methodological option for initial research process: Training of researchers. *Transdisciplinary Journal of Engineering & Science,* 9.

22. Gibbons M, Limoges C, Nowotny H, Schwartzman, S, Scott P, Trow M (1997). La nueva producción del conocimiento. *La dinámica de la ciencia y la investigación en las sociedades contemporáneas.* Ediciones pomares-corredor, Barcelona. ISBN:84-87682-28-6.

23. Renteria-Gomez, I., Santiago, M. A. L., Dominguez-Pacheco, F. A., Hernandez-Aguilar, C., & Zepeda-Bautista, R. (2018). Evaluación de la rentabilidad de la producción de tortilla de maíz en el Estado de México. *Revista Chapingo Serie Zonas Aridas,* 17(1), 1-13.

24. Hernandez-Aguilar, C., Dominguez-Pacheco, A., Martinez-Ortiz, E. J., Ivanov, R., Bonilla, J. L. L., Cruz-Orea, A., & Ordonez-Miranda, J. (2020). Evolution and characteristics of the transdisciplinary perspective in research: a literature review. *Transdisciplinary Journal of Engineering & Science,* 11.

25. Gooding, H., Lattanzio, S., Parry, G., Newnes, L., & Alpay, E. (2023). Characterising the transdisciplinary research approach. *Product: Management and Development,* 20(2), 0-0.

26. Jellil, A., Woolley, E., Rahimifard, S., 2018. Towards integrating production and consumption to reduce consumer food waste in developed countries. *Int. J. Sustain. Eng.,* 11, 294–306. `https://doi.org/10.1080/19397038.2018.1428834`.

27. Hernandez-Aguilar, C., Valderrama-Bravo, C., Dominguez-Pacheco, A., Romero-Galindo, R., Igno-Rosario, O., Contreras-Gallegos, E., ... & Cruz-Orea, A. (2022). Caracterización colorimétrica, textura y calidad sanitaria de panes adicionados con maíces criollos y Cúrcuma longa. *Superficies y Vacío,* 35, 220407.

28. 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.

29. Hernandez-Aguilar, C., Dominguez-Pacheco, A., Palma Tenango, M., Valderrama-Bravo, C., Soto Hernandez, 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.

30. Rhim, J. W., Wu, Y., Weller, C. L., & Schnepf, M. (1999). Physical characteristics of a composite film of soy protein isolate and propyleneglycol alginate. *Journal of food science,* 64(1), 149-152.

31. Pathare, P. B., Opara, U. L., & Al-Said, F. A. J. (2013). Colour measurement and analysis in fresh and processed foods: a review. *Food and bioprocess technology,* 6, 36-60.

32. Melendez-Martinez, A. J., Vicario, I. M., & Heredia, F. J. (2007). Rapid assessment of vitamin A activity through objective color measurements for the quality control of orange juices with diverse carotenoid profiles. *Journal of Agricultural and Food Chemistry,* 55(8), 2808-2815.
33. Bradley, D., & Roth, G. (2007). Adaptive thresholding using the integral image. *Journal of graphics tools,* 12(2), 13-21.
34. Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental psychology,* 22(6), 723.
35. Principato, L., Pratesi, C. A., & Secondi, L. (2018). Towards zero waste: An exploratory study on restaurant managers. *International Journal of Hospitality Management,* 74, 130-137.
36. Boulet, M., Hoek, A. C., & Raven, R. (2021). Towards a multi-level framework of household food waste and consumer behaviour: Untangling spaghetti soup. *Appetite,* 156, 104856.
37. Stanger, N. R. (2011). Moving "eco" back into socio-ecological models: A proposal to reorient ecological literacy into human developmental models and school systems. *Human Ecology Review,* 167-173.
38. Jenkins, D. J., Wolever, T. M., Buckley, G., Lam, K. Y., Giudici, S., Kalmusky, J., ... & Wong, G. S. (1988). Low-glycemic-index starchy foods in the diabetic diet. *The American journal of clinical nutrition,* 48(2), 248-254.
39. Ludwig, D. S. (2002). The glycemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. *Jama,* 287(18), 2414-2423.
40. Hu, J., La Vecchia, C., Augustin, L. S., Negri, E., De Groh, M., Morrison, H., ... & Canadian Cancer Registries Epidemiology Research Group. (2013). Glycemic index, glycemic load and cancer risk. *Annals of oncology,* 24(1), 245-251.
41. Zafar, M. I., Mills, K. E., Zheng, J., Regmi, A., Hu, S. Q., Gou, L., & Chen, L. L. (2019). Low-glycemic index diets as an intervention for diabetes: a systematic review and meta-analysis. *The American journal of clinical nutrition,* 110(4), 891-902.
42. Folsom, A. R., Demissie, Z., & Harnack, L. (2003). Glycemic index, glycemic load, and incidence of endometrial cancer: the Iowa women's health study. *Nutrition and cancer,* 46(2), 119-124.
43. Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016). Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health psychology review,* 10(3), 277-296.

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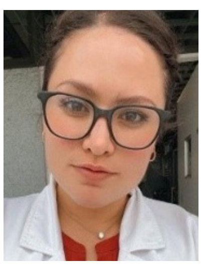

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