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Reformulation of the total liquid diet increases the acceptability of the food by hospitalized patients

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Abstract
Health improvement of the hospitalized patient is largely conditioned by the food supplied, which must meet the nutritional requirements. However, it has been reported that modified texture diets, especially total liquid diet (TLD), have low acceptance due to their sensory attributes, which leads to a low intake that affects health recovery and prolongs the hospital stay. The aim of this study was to reformulate the TLD provided by the food service of a hospital institution, with a focus on nutritional and sensory quality. The intake of 33 patients with TLD indication was evaluated, then, 10 menus of TLD were reformulated and the acceptance of 26 patients with TLD prescription was analyzed. It was found that patients with TLD indication ate 50% of the diet supplied by the hospital due to low sensory acceptance. The patients had adequate acceptance of the reformulated TLD and whole of the patients refer that they would frequently eat the reformulated menus. In conclusion, there is an improvement in acceptance of the TLD when it is reformulated with a nutritional and sensory quality approach.

Keywords: reformulation, fortification, total liquid diet, sensory quality, nutritional quality, acceptance

1. Introduction
Hospital Malnutrition (HM) is a process of physiological deterioration with multiple etiology in which the nutritional status is negatively affected [1]. This condition affects between 30% and 50% of the hospitalized population worldwide [2]. In Europe, Asia, North America and Australia HM has a prevalence between 20% and 45%, being higher in critical and elderly patients, while in Argentina, Peru, Venezuela and Colombia the prevalence is higher than 45% [3].
HM increases the morbidity and mortality of the patients, the hospital stays length and hospital readmission rate, which represents a high economic cost for the hospital [4]. In addition, inadequate intake raises the food losses and waste, which also implies economic losses for the institution [5].
On the other hand, HM has different etiologies, such us the clinical status of the patient, the influence of anorexigenic drugs, diagnostic and therapeutic procedures, hospitalization length, prescription of restrictive diets, oral health, eating habits, emotional factors of hospital environment and an inadequate intake [1, 6]. A determining factor of inadequate intake is the low acceptance for hospital food. The patients have the perception that it has sensory characteristics that do not meet their expectations [7], especially the texture modified diets [8].
Therapeutic modification in the diets texture affects its nutritional contribution, which do not reach the nutritional requirements of the patients due to their composition and texture [9, 10]. An inadequate nutritional contribution of texture modified diets, such as the total liquid diet (TLD), added to the reduced intake due to low palatability, leads to a risk of malnutrition in hospitalized patient [11, 13]. In this way, strategies such as reformulation and fortification of diets, allow to produce texture modified diets that meet the nutritional contribution and sensory quality expectations by patients [14, 15]. Therefore, the aim of this study was to reformulate the total liquid diet supplied by a hospital food service (HFS), with a nutritional and sensory quality approach.

2. Materials and Methods
The study was carried out during the second semester of 2018 and was divided into four stages: characterization of the diets offered by the HFS, intake assessment of the TLD, reformulation of the TLD and sensory analysis.

2.1 Characterization of diets offered by the HSF
A database was created with the information of the hospitalized patients during the months of May through July of 2018, those with TLD prescription were selected. The variables analyzed were percentage distribution of the diets provided by the hospital, percentage of patients with TLD (normal TLD or with nutritional derivation), sex, age, clinical condition, and length of hospital stay.

2.2 Intake assessment of the TLD
A semi-structured intake control questionnaire was applied to 33 elderly patients hospitalized with a TLD indication greater than 24 hours. Five mealtimes were evaluated, determining the percentage consumption of each menu component. In addition, the reason for diet prescription, the reason for non-consumption of the diet and the clinical condition of the patient were evaluated. Hospitalized patients in pediatrics, obstetrics, psychiatry, intensive care units and those who had nutritional support therapy were excluded.

2.3 Reformulation of the TLD
A reference subject was created to determine the nutritional target. The weight and height data of the reference subject were obtained from studies conducted in hospitalized elderly patients [16, 18]. To determine the nutritional target, the total caloric value, fat, protein, carbohydrates, calcium, iron, vitamin A and sodium were considered. The food

groups included for the design of the menus were: cereals, roots, tubers and plantains, fruits and vegetables, milk and dairy products, meats, eggs, legumes, fats and sugars. The menus were fortified with a whey protein isolate and soy protein powder (Abbott Lafrancol) and hybrid palm oil (*Elaeis oleifera x Elaeis guinnensis)* (HPO) (Nolí – Del Llano Alto Oleico). Then, a five-day menu cycle was designed including the mealtimes of breakfast, lunch, dinner, and other small meals. Menu recipes were standardized by triplicate.

2.4 Sensory analysis

This analysis was performed with 26 elderly hospitalized patients with TLD indication who signed an informed consent. Patients with radiation and nutritional support therapy, and those who did not agree to sign the informed consent were excluded. The menus were cooked in the HFS. The fluidity of the preparations was evaluated by the fork test [19]. The acceptance of the TLD was assessed using a affective scaling method (1-5 points) for sensorial attributes (appearance, smell and taste), where 1 reflected "I dislike it a lot" and 5 indicated "I like it a lot.". The sensory analysis evaluated 9 breakfast menus and 9 lunch menus, both from the TLD provided by the hospital and from the reformulated one. Between each sample the patients performed a mouth wash with drinking water. A consumption attitude test was applied to the patients asking how often they would eat the preparation offered, having as options: frequently (once a week), occasionally (once two weeks) or never [20].

2.5 Statistical analysis

Descriptive statistics (averages, frequencies, and percentage distributions) were used for the characterization of the diets offered by the HFS stage. A *t-Student* test was applied to evaluate the relationship between the intake and sex of the patients, for the intake assessment of TLD stage. Finally, a multiple correspondence analysis was performed for the sensory analysis stage. The data was analyzed using SPSS software version 21.

2.6 Ethical Statement

This research was approved by the Nutrition Department of the hospital institution.

3. Results & Discussion

3.1 Characterization of diets offered by the HSF

The institution has an outsourcing food service and a satellite-type distribution system with kitchens on each floor. The hospital managed an average of 363 diets offered per mealtime, of which 21% were texture modified diets. Out of the total of these diets, the 29% were TLD.

The TLD offered by the HFS were classified as normal and with nutritional derivation. The former with a percentage of 75% and the latter with 25% per mealtime. Patients with TLD prescription had an average length of hospital stay of 3 days. Figure 1 shows the distribution according to the sex and age of the patients who have a normal TLD prescription. It was found that 75% of the patients are older than 60 years, showing that elderly patients were the target population of TLD.

3.2 Intake assessment of the TLD

The results of consumption of TLD per mealtime and per day are shown in Figure 2. The average intake of TLD per day was 50%, being higher in the breakfast (57%) and lower in the late morning (48%). The *t-Student* test did not show significant differences ($p < 0.005$) in relation to sex and patient intake (data not shown).

The main indication for the prescription of TLD was to present difficulty in chewing or swallowing, followed by a high risk of choking and surgical procedures. The most frequent pathology in these patients was chronic obstructive pulmonary disease (COPD), followed by cancer. The results of why the patients do not eat the whole TLD offered by the HFS are shown in Figure 3. The main reason for non-consumption was dislike for the hospital food. Different studies have shown that a low sensory quality of hospital feeding decreases the intake of patients [5, 14]. It is important to highlight the risk of nutritional insufficiency that patients with low intake have, because they are not receiving all the necessary nutrients for their health recovery [21]. The deterioration of nutritional status increases the risk of morbidity and mortality, hospital stay length and the rate of hospital readmission [22].

3.3 Reformulation of the TLD

The theorical reference subject used for the nutritional target determination of the TLD is shown in Table 1, the nutritional target of the reformulated TLD and the percentage distribution of the total caloric value per mealtime are shown in Table 2 and 3, and the reformulated TLD menu cycle is shown in Table 4. Some international preparations could be observed within the menus.

Figure 4 shows a comparison between a TLD breakfast provided by the HFS and a reformulated TLD breakfast. There is an evidence of the reduction of volume and number of menu components due to an increase in nutritional density of the reformulated TLD. In addition, there is an improvement of the appearance due to ta different colors combination. Due to the high risk of nutritional insufficiency that patients with low intake have, it is important to increase the nutritional density of the menus so that in a low volume they contribute all the necessary nutrients for the patient's health recovery, considering the low intake found in patients [23]. Scientific evidence has shown that fortification of therapeutic diets improves their nutritional quality, contributing to the prevention of HM [5, 10, 24]. For this reason, fortification was used as a strategy to increase the fat and protein content of the TLD. The evidence showed that achieve the nutritional contribution of fat and protein content is critical in texture modified diets, and due to the importance, that these nutrients have in the recovery of patients, it is necessary to ensure their intake from fortification [10, 25, 26].

The improvement of protein absorption is important in elderly patients since at this age there is a redistribution of body mass, with an increase in fat mass and a decrease in muscle mass [27]. The protein chosen in the current study could prevent the muscle mass loss due to its animal and vegetable protein blend [28, 29]. The whey protein is rapidly absorbed and soy protein is slowly absorbed, in this way, the protein powder used has an average absorption rate, allowing an increase in the postprandial protein, promoting its absorption [27, 29, 33].

Considering the physiological characteristics of the target population (elderly patients), it is important to contribute to the improvement of their health status from the nutritional quality of the menus. HPO provided palatability to the

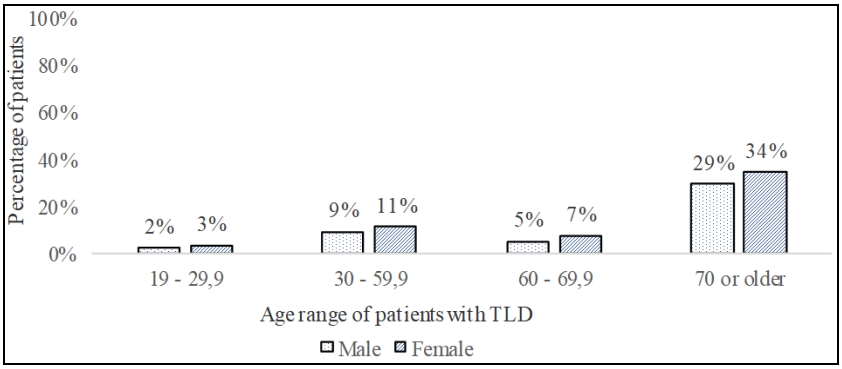
preparations and highlight the appearance due to its color. This oil has an adequate oxidative stability against other vegetable oils, thus allowing the preservation of its high content of monounsaturated fatty acids and vitamin E (especially the tocotrienol isoform) [34, 35]. According to studies, due to its nutritional content, HPO contributes to an improvement of the antioxidant plasma activity, brain health through neuroprotection, this due to its high content of tocotrienols, which improve the cognitive health [36, 37]. Also, it provides visual health benefits due to its high vitamin A content and promotes cardiovascular health from the control of LDL cholesterol and arterial compliance due to its high monounsaturated fatty acid content (high oleic acid content) [34, 38].

3.4 Sensory analysis

The results of the multiple correspondence analysis are shown in Figures 5, 6 and 7, for the attributes of appearance, odor, and flavor, respectively. For all the sensorial attributes, there was evidenced a similar behavior, with a low acceptance by the TLD provided by the hospital, evidenced mostly as "3 - I don't like it nor dislike it" and "2 - I dislike it" rating. The results for the reformulated TLD tend towards the "5 - I like it a lot" rating. With these results there is an evidence of the rejection by the TLD provided by the HFS and an acceptance by the reformulated TLD. The results obtained from the consumption attitude test are shown in Figure 8. The 11% of the patients referred that they would frequently eat the TLD menus provided by the hospital, in contrast, 100% of patients said that they would frequently eat the menus of the reformulated TLD. These results showed that the reformulated TLD had greater acceptance by the patients.

Sensory analysis results showed that the reformulated TLD has a higher acceptance by the patients compared to the TLD provided by the hospital, with a "5 - I like it a lot" rating for most of the sensorial attributes of the reformulated menus. Most of the menus provided by the hospital had the "3 - I don't like nor dislike" rating, showing inadequate acceptance by patients. The results of the sensory analysis are consistent with those obtained in the consumption attitude test, in which patients indicated that they would frequently eat all the menus from the reformulated TLD. The design of menus with a focus on sensory quality based on the attributes of appearance, odor and flavor, has an influence on the patient eating behavior [14, 24].

The sensory characteristics of the menus, such as odor and flavor, have been associated with physiological responses that affect the appetite. However, it is important to maintain a balance between these two attributes, because if the odor is more intense than the flavor, appetite suppression can be induced [39]. This shows the importance of following the standardization of recipes to replicate the sensory characteristics of each menu without affecting the relationship of these sensorial attributes [40, 41].



Abbreviations:
TLD: Total Liquid Diet

Fig 1: Percentage distribution of patients with TLD prescription according to sex and age

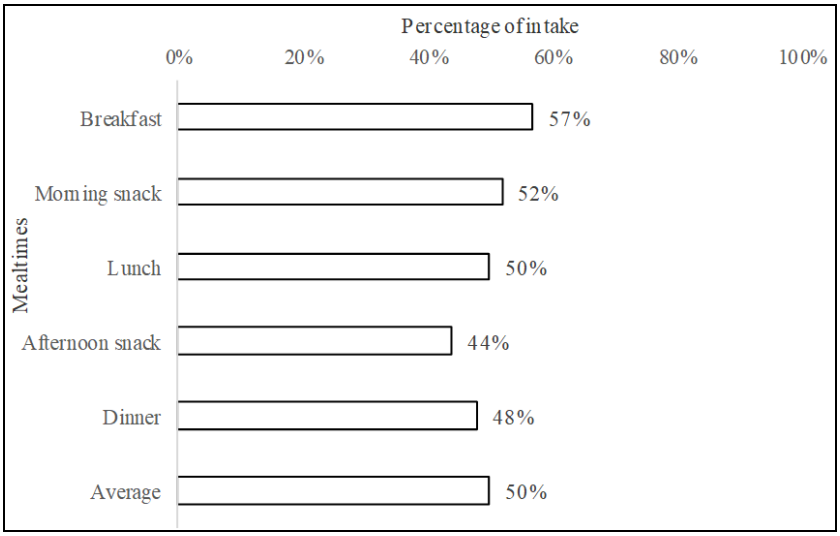
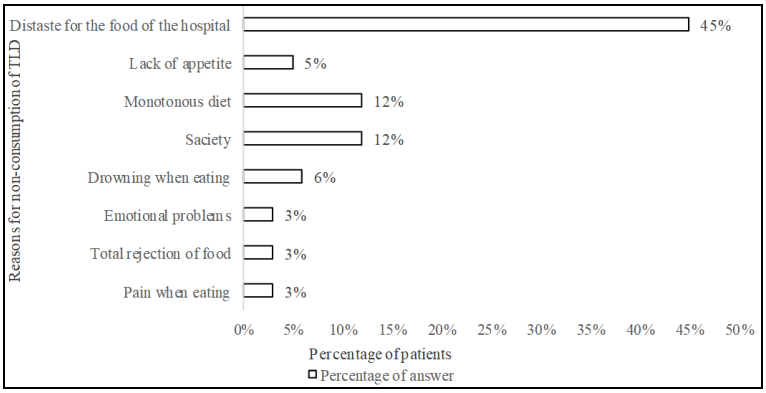


Fig 2: Percentage of intake of patients with TLD prescription



Abbreviations:
TLD: Total Liquid Diet

Fig 3: Reasons for non-consumption of the TLD

Table 1: Characteristics of target Population for the Reformulated TLD

Age[1]	Sex	No. people[2]	Height[3]	Weight[4]	BMI[5]	% Participation[6]
19 – 29,9	Male	13	1,701	66,9	23,1	2%
	Female	15	1,569	56,6	23,0	3%
30- 59,9	Male	54	1,673	71,5	25,5	9%
	Female	69	1,549	61,2	25,5	11%
60 – 69,9	Male	28	1,593	64,9	25,6	5%
	Female	42	1,478	60,0	27,5	7%
≥ 70	Male	174	1,611	65,7	25,3	29%
	Female	207	1,478	54,7	25,0	34%
			Total			100%

[1]Age is measured in years.
[2]Number of people included to determine the target population.
[3]Height is measured in meters.
[4]Weight is measured in kilograms.
[5]BMI: Body Mass Index. The BMI is measured in kilograms per square meter.
[6]Percentage of participation with respect to the total number of people included.

Table 2: Daily Energy Value

Daily Energy Value (Kcal)	1800	
Daily Energy Value Distribution per mealtime[1]		
Mealtime	Minimum value	Maximum value
Breakfast	21%	27%
Morning snack	8%	14%
Lunch	27%	33%
Afternoon snack	8%	14%
Dinner	21%	27%

[1]The distribution of the Daily Energy Value was carried out in five mealtimes, the distribution percentage is shown in the table.

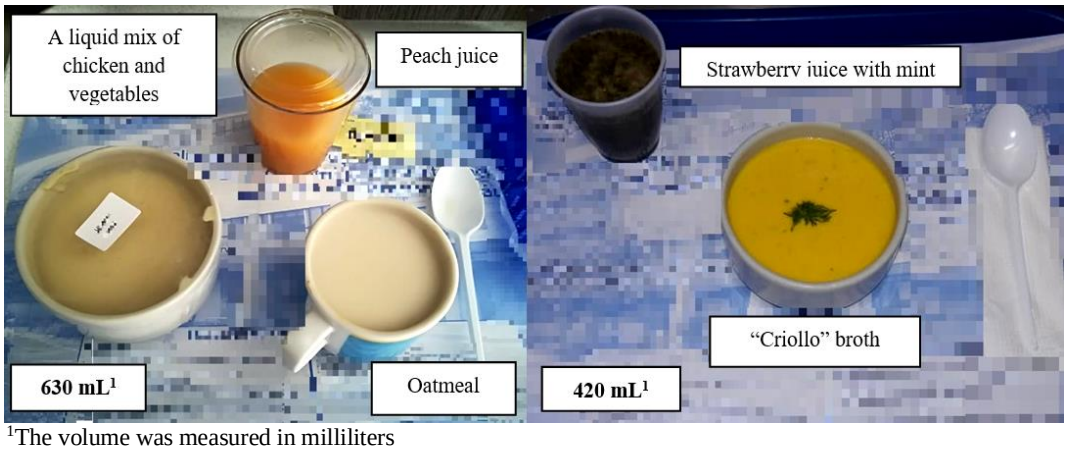
Table 3: Nutritional Target of the TLD

Macronutrients[1]			Micronutrients		
	Minimum value	Maximum value		AI[2]	UL[3]
Protein	14%	20%	Calcium[4]	941	2125
Fat	25%	30%	Vitamin A[5]	704	3000
Carbohydrates	50%	55%	Iron[6]	8,8	45,0
			Sodium[7]	1287	2300

[1]The macronutrient ranges were established from the Acceptable Macronutrient Distribution Range, implemented in Resolution 3803 of 2016 of Colombia.
[2]AI: Adequate Intake, implemented in the intake, energy and nutrients recommendations of Colombia.
[3]UL: Tolerable Upper-Level Intake, implemented in Resolution 3803 of 2016 of Colombia.
[4]The calcium was taken in milligrams.
[5]The Vitamin A was taken in micrograms.
[6]The iron was taken in milligrams.
[7]The sodium was taken in milligrams.

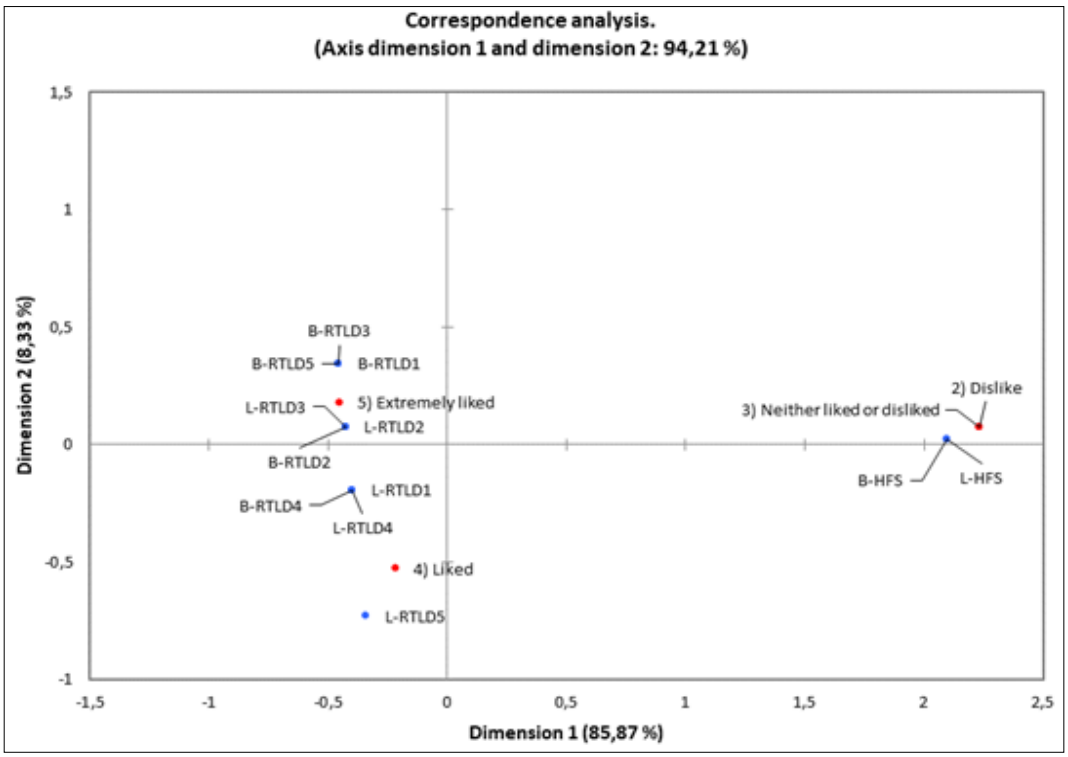
Table 4: Menu cycle of the reformulated TLD

Mealtime	Day 1	Day 2	Day 3	Day 4	Day 5
Breakfast	Mango and banana smoothie	Strawberry juice with mint and "criollo" broth	Fruit explosion smoothie	Hot oatmeal in milk with potato, meat and vegetable broth	Blackberry juice and "candil"
Morning snack	Oatmeal with vanilla and cinnamon powder	Curuba shake	Mango shake	Strawberry shake	Soursop shake
Lunch	Refreshing green smoothie, Mexican tortilla soup, and creamy vanilla and red berries	Banana juice with strawberry, onion cream in the French style and blackberry flan	Carrot and pineapple juice, tomato cream and strawberry flan	Tropical juice, country carrot cream and vanilla mousse with blackberry jam	Papaya and pineapple juice, "sancocho" and passion fruit flan
Afternoon snack	Strawberry shake99)	Feijoa shake	Cornstarch with milk	Curuba shake	Blackberry shake
Dinner	Carrot and pineapple juice and tomato cream	Tropical juice and country carrot cream	Papaya and pineapple juice and "sancocho"	Banana juice with strawberry and Mexican tortilla soup	Refreshing green smoothie and onion cream in the French style



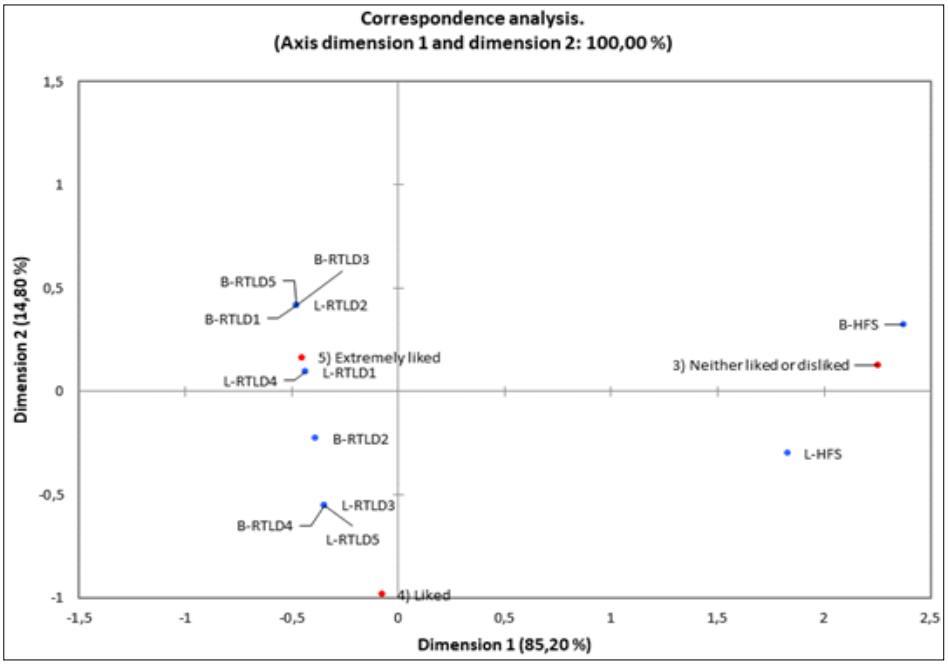
[1]The volume was measured in milliliters

Fig 4: Comparison of current TLD breakfast and reformulated TLD breakfast



Abbreviations:
B-HFS: Breakfast offered by the Hospital Food Service
B-RTLD: Breakfast of the Reformulated Total Liquid Diet
L-HFS: Lunch offered by the Hospital Food Service
L-RTLD: Lunch of the Reformulated Total Liquid Diet

Fig 5: Perceptual map of multiple correspondence analysis for the appearance attribute



Abbreviations:
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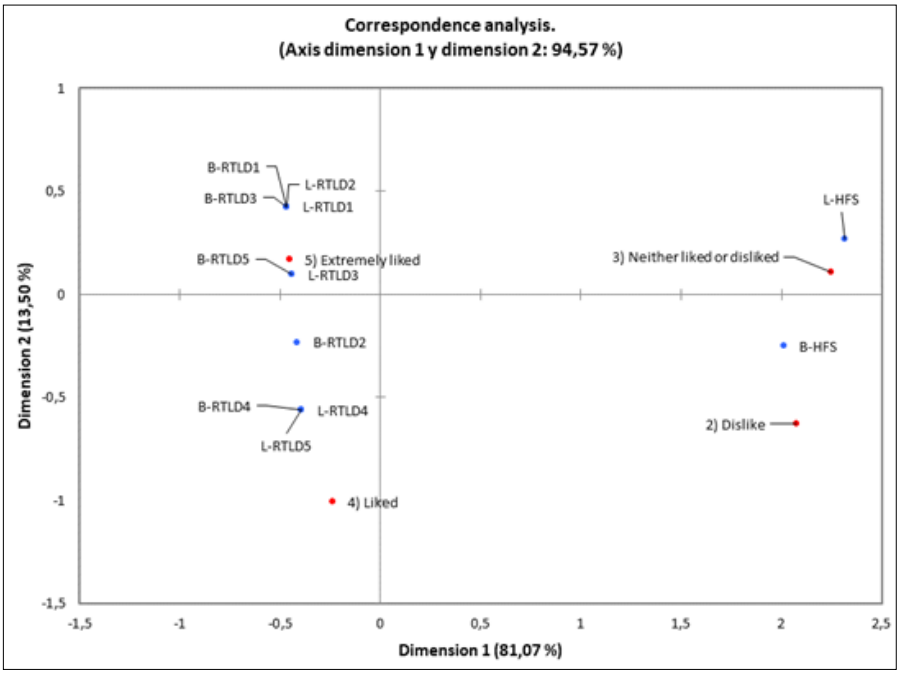
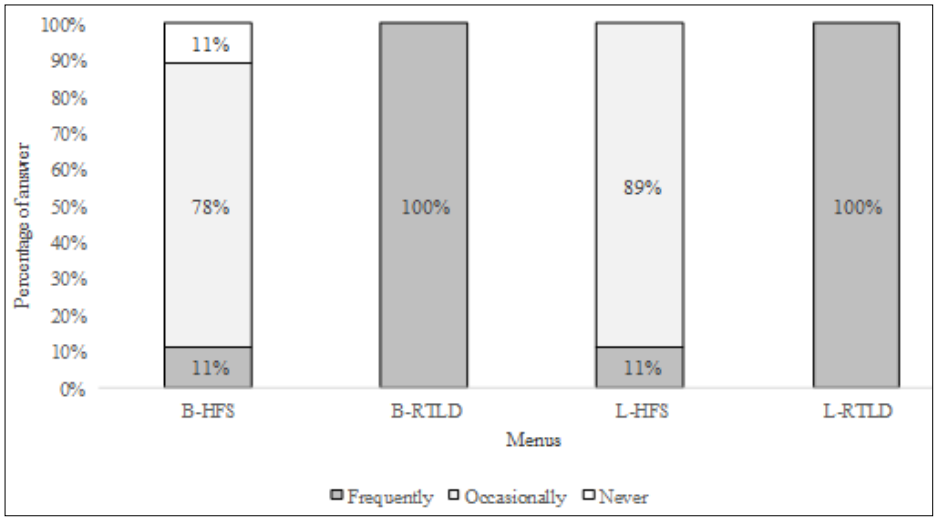
B-RTLD: Breakfast of the Reformulated Total Liquid Diet
L-HFS: Lunch offered by the Hospital Food Service
L-RTLD: Lunch of the Reformulated Total Liquid Diet

Fig 6: Perceptual map of multiple correspondence analysis for the odor attribute



Abbreviations:
B-HFS: Breakfast offered by the Hospital Food Service
B-RTLD: Breakfast of the Reformulated Total Liquid Diet
L-HFS: Lunch offered by the Hospital Food Service
L-RTLD: Lunch of the Reformulated Total Liquid Diet

Fig 7: Perceptual map of multiple correspondence analysis for the flavor attribute



Abbreviations:
B-HFS: Breakfast offered by the Hospital Food Service
B-RTLD: Breakfast of the Reformulated Total Liquid Diet
L-HFS: Lunch offered by the Hospital Food Service
L-RTLD: Lunch of the Reformulated Total Liquid Diet

Fig 8: Consumption Attitude Test

7. Conclusions

In the current study, it was found that the hospitalized target population with TLD prescription were elderly patients. These patients ate half of the hospital food and the main reason for non-consumption was dislike for the sensory attributes of the menus. Therefore, through fortification as a strategy to reformulate the total liquid diet with a nutritional and sensory quality approach, it was possible to increase the nutritional density of the menus in a lower volume, highlighting the sensory attributes of the food. Fortification allowed to increase the contribution of high-quality protein, monounsaturated fatty acids, and vitamin E of the diet, improving its nutritional quality. The reformulation increased the acceptance of the diet by patients and could potentially contribute to the improvement of their nutritional and health status.

The reformulation of therapeutic diets in hospital food services could be an effective strategy that contribute to the improvement of HM. Considering the call of the 2030 agenda, especially with the United Nations Sustainable Development Goals 2, 3 and 11, the raise of sensory quality in hospital feeding could be a tool to reduce food waste, and to improve the nutritional and health status of hospitalized population. For this reason, is important to continue in the research of hospital feeding innovation from different disciplinary fields.

8. Acknowledgments

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