

Standardization and Glycemic Index of a Traditional Oat (*Avena sativa*) Beverage

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Abstract A traditional beverage from oats is popularly consumed in Mexico to treat obesity, diabetes *mellitus* and cardiovascular disorders. Certain dietary components in oats experimentally prove qualities which support their use in the chronic management of such diseases. However the traditional beverage lacks of *macronutrient characterization and glycemic index*. Both parameters are useful in determining the safety in long term use in chronic ill patients. The purpose of this study was to provide a standardization of the traditional method. Then the macronutrient and microbiological content from the resulted beverage was assessed and the glycemic index was also determined. After a factorial design a reproducible beverage is recovered through blending 65 g of oat flakes in 250 ml of water and resting it at 4 °C for 6 h. No significative differences was found in carbohydrate ($P=0.085$) and fiber content ($P=0.811$) compared to raw oats flakes. It also remains microbiological safe until 48 hrs post elaboration and is suitable for consumption. Moreover the resulted glycemic index was 38, which means a decrease from 78 in raw oats. Thus we conclude that according to macronutrient composition and glycemic index; the traditional oat beverage is safe and suitability in the management of chronic diseases. Additionally it's decreased effect in postprandial glucose response along with its equally fiber content when compared with oats, meet the criteria to considered it as a functional food, thus the development of a functional beverage from the traditional method is also discussed.

Keywords: *oats, standardization, glycemic index, glycemic load, functional foods*

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1. Introduction

The prevention or management of chronic diseases is a major health care priority since they account for nearly 60% of all deaths worldwide (WHO). Nutrition has important long-term consequences for health since it can contribute with chronic disease development and progression particularly type 2 diabetes and cardiovascular diseases [1].

Such increased awareness between nutrition and health, has accordingly rise the population demands for healthy foods [2]. Foods that provide a health benefit beyond basic nutrition are denominated functional foods [3] and is estimated that a 20% reduction in healthcare expenditure could be achieved through their widespread consumption. Thus nutrition, through functional foods is an attractive therapeutic alternative to deliver dietary components

capable of managing chronic disease, especially in light of the increasing cost of health care [4].

In Mexico, chronic diseases are commonly treated with traditional medicine [5], which include a beverage from oats. Oat bran (*Avena sativa*) and oats derived products are considered functional foods, because has proven to be helpful in the treatment of diabetes and cardiovascular disorders preventing glucose and sterol absorption in the intestine therefore slowing down intestinal transit and gastric emptying [6]. Most of such properties are attributed to their fiber content, especially the soluble fiber called β -glucan, however is also a good source of B complex vitamins, and protein [7,8].

Raw oat flakes posses a glycemic index of 78, considered high [9]. The glycemic index is a system that ranks foods according to their effects on the postprandial glucose response [10]. The importance of it is based on observational studies, were a diet producing high glycemic index results associated with a significant increased

chronic disease risk. In addition, avoidance of dramatic fluctuation of blood glucose is critical for the management of chronic ill patients, and the glycemic index help to adjust such responses [11].

Therefore is necessary to provide a reliable value for the glycemic index of the traditional oat beverage, because processed products modify their value and are not representative of the source food [12]. In addition their *macronutrient characterization* is also necessary to support its safety in obesity, diabetes mellitus and cardiovascular disorders [11]. *Finally to allow reproducibility, a standardization of the traditional method is mandatory.* Thus the purpose of this study was to provide empirical support for the traditional oat beverage as a therapeutic option in chronic diseases.

2. Material and Methods

2.1. Oat Beverage Standardization

Traditionally used, oats are placed in a jar which is then filled to the top with water, tightly lidded and allowed to steep for 4-10 hours. Then, is decanted and consumed (a cup or more), and the remainder is refrigerated to remain suitable for consumption. Thus we tried to preserve this process in the standardization and add some minor modifications. In brief; oats were purchased from a local superstore unprocessed oat flakes (*Avena sativa*) and purified water. Then, 65g of oat flakes in 250 mL of water were blended for 40 sec at 29,000 rpm (Total Blender Classic, BlendTec®). Those grams from oats were need it to recover a portion of beverage containing 50 g of carbohydrates (proximal analysis is showed below), necessary for glycemic index tests.

Optimal conditions to keep nutritional and microbiological properties in oat beverage were subjected to an experimental factorial design – shakes were incubated for 3 time periods (6, 8 or 10 hours), at two temperatures (21°C or 4°C), closing to ambient temperature and refrigeration conditions. Following, resulted beverage was recovered by decanting it.

2.2. Proximal and Microbiological Analysis

Ash, protein, fat, fiber and carbohydrate content were analyzed with proximate analysis by the AOAC method [13] in 100 g of dry weight of unprocessed oat flakes and beverages obtained by the six conditions. Microbiological analyses of the oat beverage obtained at 4°C for 8 h were carried out at 0, 8, 24 and 48 hours to check for the presence of *mesophilic* aerobic bacteria, *coliforms*, and *yeasts-molds* accordingly to *Norma Oficial Mexicana* (NOM-110-SSA1-1994) [14]. All standardization assays for oat-based beverage optimal production conditions were performed in *triplicate*.

2.3. Subjects

Healthy participants were recruited for the present study by means of advertisements, flyers and personal communication. Before inclusion into the study, potential participants were briefed on all aspects of the experiment and were given the opportunity to ask questions. Following the subjects' consent, a health assessment was

performed, which included anthropometric measurements and a health questionnaire (giving details of food allergies/intolerance, metabolic diseases, special dietary needs, and smoking habits). Participants who met the following inclusion criteria were enrolled in the study: age (21-30 years), (BMI $\leq 25\text{kg/m}^2$), fasting blood glucose (70-100 mg/dL); glycosylated hemoglobin (4.0-6.0%), total cholesterol (≤ 200 mg/dL) and total triglycerides (≤ 150 mg/dL) not on prescription medication; non-smoker; no genetic, neoplastic, metabolic or autoimmune diseases diagnosed, or who were recently suffered from infection. Pregnant women were excluded from the present study. Weight, height and BMI were determined in a measuring station (Seca-763). Written informed consent was obtained from all eligible subjects before participation and ethical approval for the study (Project code 13-FASPYN-SA-30) was obtained from the Ethical Committee of FASPYN.

2.4. Postprandial Study

Enrolled subjects visited the Center for Research in Nutrition and Public Health at FASPYN in two occasions. Subjects were asked to arrive at 8 am after a 10 h fasting period. On the first visit a postprandial challenge was performed to determine subjects' response to a standard food (white bread) and water (250 mL) and to determine the standard food glycemic index. Venous blood samples were collected at baseline (fasting), 15, 30, 45, 60, 90 and 120 min in sodium fluoride containing tubes. The same protocol was performed in the second visit, using the standardized oat-based beverage (containing 50 g of carbohydrates) as a postprandial challenge instead of the standard food and water.

2.5. Calculation of the Glycaemic Index and Glycaemic Load

The total blood glucose response was expressed as the incremental area under the blood glucose response curve (IAUC), ignoring the area beneath the baseline, and was calculated geometrically using the trapezoidal rule. The mean, and the IAUC of each subject's repeated reference food (50 g of carbohydrate from white bread) were calculated. The IAUC of oat beverage by each subject was expressed as a percentage of the mean IAUC of the reference food eaten by the same subject. The glycemic index value (GI) of the oat beverage was taken as the mean for the whole group [15]. With GI and the number of grams in a portion of the beverage, is possible to assess its glycemic load (GL). This concept quantify the overall glycemic effect of a standard portion size of food [16].

2.6. Data Processing and Statistical Analysis

Statistical analyses were performed using the statistical package IBM SPSS version 23 for Windows. The results of the proximate analyses were subjected to a one way ANOVA, and SNK posthoc test, and are expressed as means \pm SD. A *P* value of 0.05 was selected as level of significance in all performed test. Descriptive statistics were realized for the studied population characteristics (weight, height, age, BMI, fasting blood glucose, glycosylated hemoglobin, total cholesterol, and total triglycerides). Results are expressed as means \pm SD.

3. Results

3.1. Proximate Analyses

Results from six experimental conditions shown significant differences in ash, protein, fat and fiber, except in carbohydrate content *P* value of 0.000 (Table 1).

Table 1. Proximate analysis of oat beverage (100g of oat flakes in 250ml of water)

Conditions		Composition of 100g of dry weight				
°C	h	Ash*	Protein*	Fat*	Fiber*	Carbohydrate
4	6	1.66 ± 0.31	9.68 ± 0.18	7.60 ± 0.80	1.85 ± 0.29	81.04 ± 0.91
4	8	1.62 ± 0.22	9.44 ± 0.12	7.33 ± 0.34	1.83 ± 0.10	81.60 ± 0.27
4	10	1.62 ± 0.47	9.45 ± 0.27	6.96 ± 0.38	1.42 ± 0.19 †	81.95 ± 0.36
21	6	1.63 ± 0.57	9.53 ± 0.33	6.66 ± 0.71	1.76 ± 0.12	82.16 ± 0.62
21	8	1.55 ± 0.55	9.04 ± 0.32	7.28 ± 0.30	1.98 ± 0.10	82.11 ± 0.29
21	10	1.51 ± 0.41	8.81 ± 0.24	7.90 ± 0.33	1.51 ± 0.17	81.75 ± 0.58

* Proximate analyses were subjected to a one way ANOVA. † SNK posthoc test, *P* = 0.05 was selected as level of significance.

Proximal analysis of the Oat Beverage prepared at 4°C for 6 h containing 50 g of carbohydrate.

Table 2. Proximate analysis of oat beverage (65.5 g Oats in 250ml water, resting 6 h at 4 °C)

Composition 100 g of dry weight	%	g
Ash	1.5	1
Protein	12.5	8.2
Fat	7.8	5.1
Fiber	1.8	1.2
Carbohydrate	76.3	50

In order to test the GI is a prerequisite to assess the grams of flakes need it to obtain a portion of beverage equivalent to 50 g of carbohydrates. Proximate analysis

Although higher fiber content was maximal at 21°C for 8 hrs; due spontaneous fermentation refrigerated incubations were preferred (data not shown). Among the 3 conditions tested at 4 °C, the incubation for 10 hr had a significant decline in fiber content *P* value of 0.000. Thus, we selected 4 °C for 6 hours which is the shortest period of incubation

shows that through blending 65.5 g of oats flakes in 250 mL and with an incubation of 4°C for 6 hr was sufficient to obtain 50 g of available carbohydrates (Table 2).

Proximal analysis of the Oat Beverage versus unprocessed oat flakes.

Criteria to assess functionality is that foods contain similar or enhanced quantities of the nutrient (s) that are related with the health benefits. Oat fiber is the main responsible for its functional properties, thus we compare beverage content of fiber versus the present in oat flakes. In Table 3 data for the comparison between macronutrients are provided. Neither significant differences in fiber nor in carbohydrate content were found (*P* value of 0.085 and 0.811 respectively).

Table 3. Proximate analysis of beverage and raw oat flakes

Sample	Composition of 100 g of dry weight				
	Ash	Protein	Fat	Fiber	Carbohydrate
Oat beverage	1.60 ± 0.23	9.36 ± 0.13*	7.69 ± 0.09*	1.82 ± 0.12	77.65 ± 0.04
Unprocessed oat flakes	1.69 ± 0.20	11.54 ± 0.32	9.58 ± 0.92	1.74 ± 0.89	77.08 ± 1.12

* Proximate analyses were subjected to a one way ANOVA, *P* = 0.05 was selected as level of significance.

3.2. Microbiological Analyses

Microbiological analyses were carried out at 0, 8, 24 and 48 hours in the oat beverage obtained at 4°C for 8 h. No detectable growth until 24 hours *mesophilic* aerobic bacteria and *yeasts*-molds were detected at ≤200 UFC/g. At 48 hrs those number increase to ≤1000 UFC/g, however none exceed upper limits of NOM-110-SSA1-1994 [14] even at this time. No coliforms were detected in any of times measured. Further assessment was avoided because the volume prepared of the beverage is typically consumed a day after elaboration.

3.3. Glycemic Index of the Standardized oat Beverage

3.3.1. Subjects Characteristics

Ten female volunteers comprised the final studied population for glycemic index value calculation (Table 4).

3.3.2. Glycaemic Index and Glycaemic Load Calculation

Table 4. Participant characteristics

n=10	Mean	SD
Age (y)	24.4	± 1.77
Weight (kg)	58.6	± 7.35
Height (m)	1.62	± 5.50
BMI (kg/m ²)	22.3	± 2.17
Fasting blood glucose (mg/dL)	84.5	± 3.20
Glycosylated hemoglobin (mg/dL)	4.8	± 0.32
Total cholesterol (mg/dL)	161.0	± 25.08
Total triglycerides (mg/dL)	63.3	± 15.57

Values are provided as means ± standard deviation (SD)

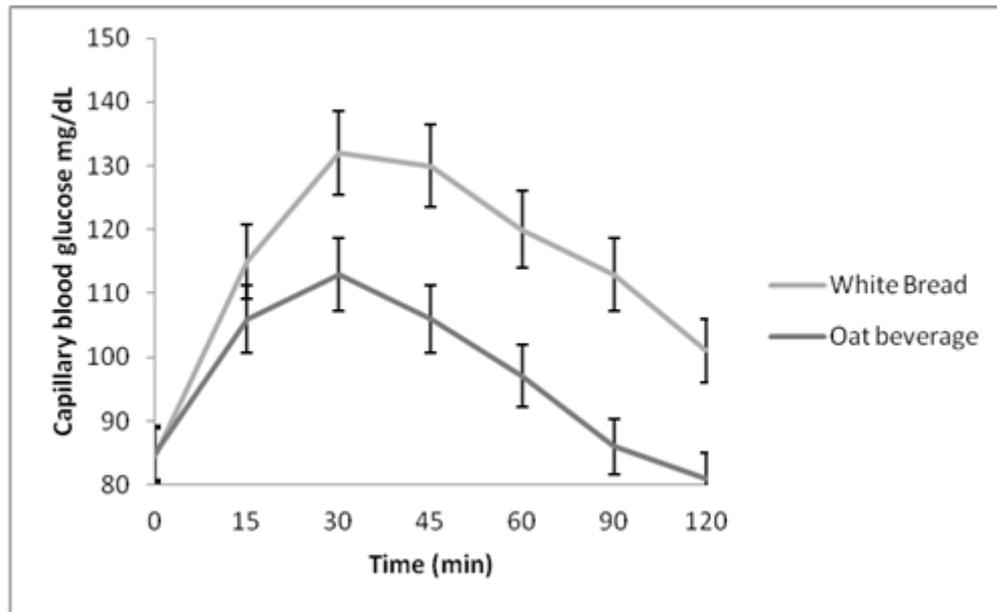


Figure 1. Mean fasting and postprandial capillary blood glucose responses to the reference meal and the oat beverage over 120 min

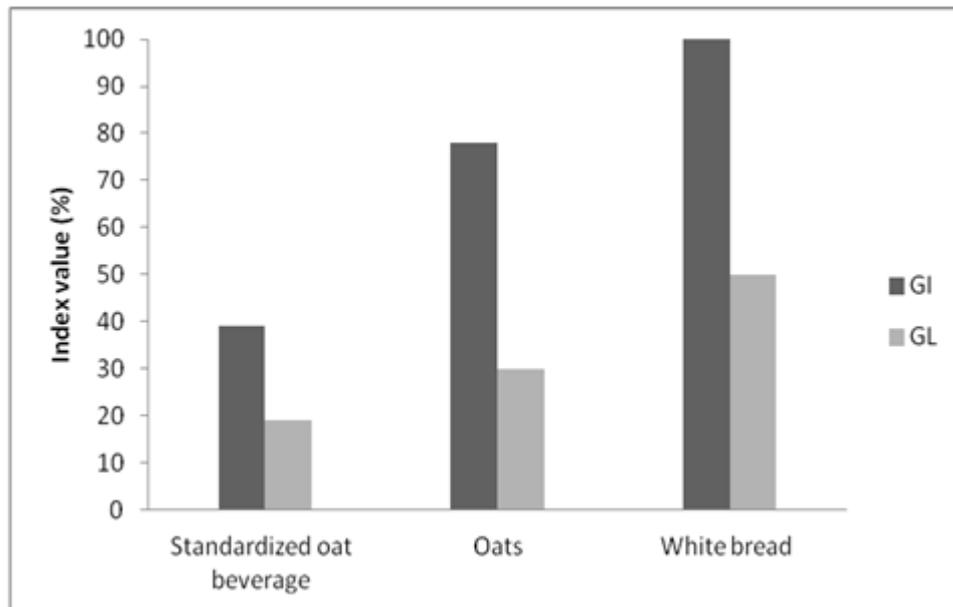


Figure 2. Comparison of the glycemic index (GI) and glycemic load (GL) of the standardized oat beverage, the raw oats and the reference food (white bread). Values are expressed as means

4. Discussion

To our knowledge this is the first report of a non-processed beverage from oats. We demonstrated that blending 65 g of oat flakes in 250 mL of purified water and resting it at 4°C for 6 h recovered a beverage with 50 g of carbohydrates, 1 g of fiber, 8 g of protein and 5 g of fat. Fiber content shows no significant differences, thus according to definition [17], the traditional oat beverage can be considered a functional beverage. Furthermore, it remains microbiological safe at refrigeration even after 48 h of elaboration keeping numbers of *mesophilic* aerobic bacteria, *coliforms*, and *yeasts*-molds under upper limits [14].

The oat beverage can be easily prepared at home, with the use of raw materials from supermarket and a domestic refrigerator and blender, it also showed to be suitable for management or chronic disease patients as expected by the

widely traditional used and purpose. We can safely argue the above because we found that glycemic index of the standardized oat beverage was 38.6 ± 8.7 and the glycemic load was 19.3 ± 4.4 using bread as standard. Thus, accordingly with ranks, its GI is low and the GL is medium [9].

As expected, the beverage modifies their GI value compared with oats [12]. The reported GI from oats is 78 and its GL 30 (using the same method and reference food) [9].

Thus, the recovered beverage has a decreased effect in postprandial glucose response and might be even more suitable than raw oat flakes in managing chronic diseases. Among the best described functionalities of oats are their capability to attenuate the postprandial glycemic [11] and insulin responses of foods when consumed at the same time [18,19]. Different composition of oat products, e.g. oat meal, oat bran etc. pre-treated by different methods,

e.g. extrusion, autoclavation or even untreated when used in diets, shown their beneficial effects [20]. This decrease in GI compared with raw oat flakes can be at least partially explained by the mechanical effect of blender in oat flakes and the 6 h incubation with water, which altogether might potentially maximizing gel formation due increased availability of the water soluble fiber (β -glucans among them) [18] and delaying gastric emptying [21].

Beverages are the most profitable functional food in the market because of customer demands and their convenience [22]. Although dairy beverages are the most common [23], cereals are rising as the better candidate to substitute them [8]. In part due the increased concern of their association with chronic degenerative diseases [24], lactose intolerance, and high caloric-cholesterol content [25].

Currently, published developments of beverages from oats are through fermentation process [7,8,26]. In spite of being health the main focus of the study, neither glycemic index nor macronutrient content is reported and, both data are highly relevant in the management of cardiovascular and diabetic patient [11,27]. However through determination of antioxidant, polyphenol and β -glucan content health claims are supported. Moreover addition of lactobacillus inoculums and the production of health related metabolites as well as the organoleptic improvements obtained are referred. Although the standardized traditional oat beverage reported here, lacks of the aforementioned determinations and a fermentation process, we argue that is an attractive starting point to develop a functional beverage due nowadays nonthermal processing techniques are endorsed to unmodify natural food sources, due many of the functional properties are sensitive to the manufacturing process [22]. Overall, results from the traditional oat beverage might endorse its regular consumption, but new studies must be carried out to test anthropometric and biochemical parameters regarding their functional properties. Moreover, nutraceutical content and consumer acceptance must be assessed for its future viability as a functional beverage in the marketplace. Clinical trials of the original and from a fortified version of the traditional oat beverage are currently performed in Center for Research in Nutrition and Public Health at FASPYN in patients diagnosed with metabolic syndrome, from which health claims will be sustained.

5. Conclusion

The standardization of the traditional oat beverage and its characterization were the first steps towards assessing its therapeutic potential, and to consider it as a functional beverage. The traditional oat beverage reported posses a macronutrient profile and glycemic index which support their safety use in the long term management of chronic diseases. Moreover the functional properties of oats are enhanced in the standardized beverage due its decreased effect in postprandial glucose response.

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Statement of Competing Interest

The authors have no competing interest.

List of Abbreviations

AOAC (Official *Methods* of Analysis)
 CFU (*colony*-forming unit)
 FASPYN (Facultad de Salud Pública y Nutrición)
 GI (Glycemic index value)
 GL (Glycemic load)
 IAUC (Incremental area under the blood glucose response curve)
 NOM (Norma Oficial Mexicana).

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