ABCS HEALTH SCIENCES

ORIGINAL ARTICLE

OPEN ACCESS

Anthropometric evaluation in patients with metabolic syndrome using a beverage enriched with beta-glucan from white oats and dry extract of yerba mate

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ABSTRACT

Introduction: White oat (*Avena sativa* L.) and yerba mate (*Ilex paraguariensis*) have been studied due to bioactive compounds and functional capacities that may be associated with the reduction of cardiovascular risk. **Objective:** To evaluate the effects on anthropometric and clinical parameters of white oat beta-glucan and standardized dry extract of yerba mate in the treatment of metabolic syndrome. **Methods:** Experimental and analytical, prospective, randomized, double-blind clinical trial type. Clinical variables: blood pressure and anthropometric variables weight, BMI, waist, and abdominal circumference were analyzed in patients with Metabolic Syndrome using a drink enriched with oat beta-glucan and standardized dry extract of yerba mate. For the association, a test to compare means was used for samples paired by Student's t-test and ANOVA test. **Results:** The study was completed by 25 participants. Those who used a shake enriched with standardized dry extract of yerba mate and a shake enriched with beta-glucan and standardized dry extract of yerba mate had a reduction in BP; this study did not have a significant impact on body weight, waist and abdominal circumferences, and waist-to-hip ratio. For the evaluation of body muscle mass, the standardized dry extract of yerba mate showed a significant increase in one of the research times. **Conclusion:** The use of beta-glucan from oats and standardized dry extract of yerba mate may be promising for the treatment and risk reduction of MS, since its use had a positive impact on the reduction of systolic and diastolic blood pressure in the participants.

Keywords: *Avena; Ilex paraguariensis*; Noncommunicable Diseases; plants, medicinal; Dietary Supplements; Blood pressure.

How to cite this article: Santos et al. Anthropometric evaluation in patients with metabolic syndrome using a beverage enriched with beta-glucan from white oats and dry extract of yerba mate. ABCS Health Sci. 2026;51:e026214 https://doi.org/10.7322/abcshs.2025025.3201

Received: Feb 26, 2025
Revised: Sep 29, 2025
Approved: Oct 28, 2025

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Declaration of interests: nothing to declare

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INTRODUCTION

Metabolic Syndrome (MS) is a complex disorder characterized by a cluster of cardiovascular risk factors, usually associated with central fat distribution and insulin resistance[1]. This syndrome is considered a global epidemic due to its steadily rising prevalence in both developed and developing countries, and it is a leading cause of morbidity and mortality[2].

Although the etiology of MS remains unknown, several factors may influence its development, such as genetic factors, age, and lifestyle, as well as hormonal levels, a pro-inflammatory state, sleep disorders, and oxidative stress (OS); however, insulin resistance (IR) and obesity have been identified as the most important predisposing factors[3,4].

The main risk factors for the development of metabolic syndrome include a diet high in fat and saturated fatty acids, consumption of carbohydrates with a high glycemic index (GI), and low dietary fiber intake[5]. Therefore, the primary treatment for metabolic syndrome includes a healthy diet and regular physical activity. These practices aim to promote weight loss, improve lipid profile and insulin resistance, and lower blood pressure[1].

In this regard, two traditionally used medicinal plants—white oats (*Avena sativa* L.) and yerba mate (*Ilex paraguariensis*)—have been studied for their bioactive compounds and functional properties, which may be associated with a reduced risk of cardiovascular disease[6,7].

Yerba mate is an underutilized raw material compared to other plant-based products such as coffee or tea; however, it has been studied as a food product, and its bioactive compounds and the constituents of its extract are associated with health benefits, with potential as a functional food[6,8]. Research shows that yerba mate is associated with weight loss and weight management[9], improved serum lipid profiles[10] and improved fasting blood glucose levels[11].

Yerba mate (*Ilex paraguariensis*) offers a hypothetical multifactorial mechanism for lowering blood pressure, centered on its phenolic compounds (e.g., chlorogenic acids, saponins), which promote antioxidant and anti-inflammatory effects, preserve the bioavailability of nitric oxide (NO), and improve endothelial function. Furthermore, evidence suggests that extracts of I. paraguariensis may interfere with the renin-angiotensin system, possibly by partially inhibiting angiotensin-converting enzyme (ACE), thereby reducing the production of angiotensin II, which plays an important vasoconstrictor role. A study shows an association between regular mate consumption and a lower prevalence of hypertension, as well as a reduction in inflammatory markers such as IL-6 and CRP, which reinforces the role of vascular modulation as a relevant mechanism for blood pressure control[11].

In addition, a healthy diet includes dietary fiber, and beta-glucan may help prevent MS. Its consumption is associated with a decrease in appetite, which in turn leads to weight loss and a reduction in the frequency of MS risk factors[5]. Studies link beta-glucan to lower cholesterol levels and a reduced risk of cardiovascular disease[12,13].

Oat β-glucan appears to exert a blood pressure-lowering effect primarily through its ability to increase the viscosity of intestinal contents, thereby reducing the absorption of glucose and lipids, which leads to an improvement in the metabolic profile and insulin sensitivity. These effects are associated with a reduction in systemic inflammation and an increase in the bioavailability of nitric oxide (NO), promoting vasodilation and improved endothelial function. Thus, regular consumption of β-glucan may contribute to lowering blood pressure in individuals at cardiovascular risk[14].

The objective of this study was to evaluate the effects of white oat beta-glucan and standardized dry yerba mate extract on anthropometric and clinical parameters in the treatment of metabolic syndrome.

METHODS

Study Design

This is an experimental, longitudinal, and analytical prospective study designed as a randomized, double-blind clinical trial in which the following clinical variables were analyzed: blood pressure and anthropometric variables—weight, Body Mass Index (BMI), waist and abdominal circumference, body water, body fat, and muscle mass—in patients with metabolic syndrome who consumed a beverage enriched with oat beta-glucan and standardized dry extract of yerba mate.

The project was approved by the UNIJUÍ Research Ethics Committee (CEP) under opinion number 5,090,249/2021, titled "Bioactive compounds from oats and yerba mate as constituents of foods and medications for the treatment of metabolic syndrome: potential for scientific validation and product development." This study is a follow-up to the project: "The use of beta-glucan extracted from oats as a bioactive agent in the treatment of dyslipidemia."

Since this is a clinical trial, the study was registered on the Brazilian Clinical Trials Registry (ReBEC) platform under Universal Trial Number (UTN) U1111-1288-3639.

Participants

The research was conducted in a municipality in the northwestern part of the state of Rio Grande do Sul. The study was carried out from May through October 2022 with 29 volunteers who met the inclusion criteria.

The established inclusion criteria were: patients diagnosed with metabolic syndrome, based on the criteria of the International Diabetes Federation (IDF), who must have an elevated waist circumference - ≥94 cm for men and ≥80 cm for women; and two additional components from the following list: triglycerides ≥150 mg/dL;

HDL cholesterol <40 mg/dL for men and <50 mg/dL for women; blood pressure ≥130/85 mmHg; serum glucose >100 mg/dL[15].

Patients with other comorbidities - such as liver, kidney, urinary tract, or respiratory diseases - as well as pregnant women, breastfeeding women, and patients over the age of 65 were excluded. After this stage, volunteers were recruited through in-person lectures at the university, as well as online, via social media and email, and through invitations sent by the Office of the Provost; they were included in the study after signing the Informed Consent Form (ICF). An initial screening questionnaire was used, collecting data such as name, age, sex, medication use, and presence of chronic disease, to determine whether the volunteer met the study's eligibility criteria. Those who did not meet the inclusion criteria were excluded during the initial contact.

Patients who met the criteria in the initial screening questionnaire were referred to the Unijuí Clinical Analysis Laboratory (UNILAB) for blood collection to confirm, through laboratory testing, the presence of metabolic syndrome. Following this analysis, a new screening was conducted to determine whether or not they qualified for the study. After selection, patients were randomized into groups: 8 in the beta-glucan group, 7 in the standardized yerba mate extract group, 8 in the beta-glucan plus yerba mate extract group, and 6 in the placebo group.

The participants selected for the study were divided into four groups: beta-glucan, yerba mate, beta-glucan + yerba mate, and placebo. All groups were followed for 90 days. There were 79 interested patients, 50 of whom were excluded for not meeting the inclusion criteria. Among those selected, four participants did not complete the 90-day follow-up due to personal reasons. Thus, 25 patients completed the study (Figure 1), which shows the distribution across the groups.

The groups were treated as follows: Group 1—1 g/day of beta-glucan added to a shake; Group 2—2.25 g/day of standardized dry yerba mate extract added to a shake; Group 3—supplementation with 1 g of beta-glucan + 2.25 g of standardized dry yerba mate extract per day, added to a shake; and Group 4—placebo, flavored shake (powdered milk + stevia + flavoring). It should be noted that the beta-glucan dose used in this study was the one that

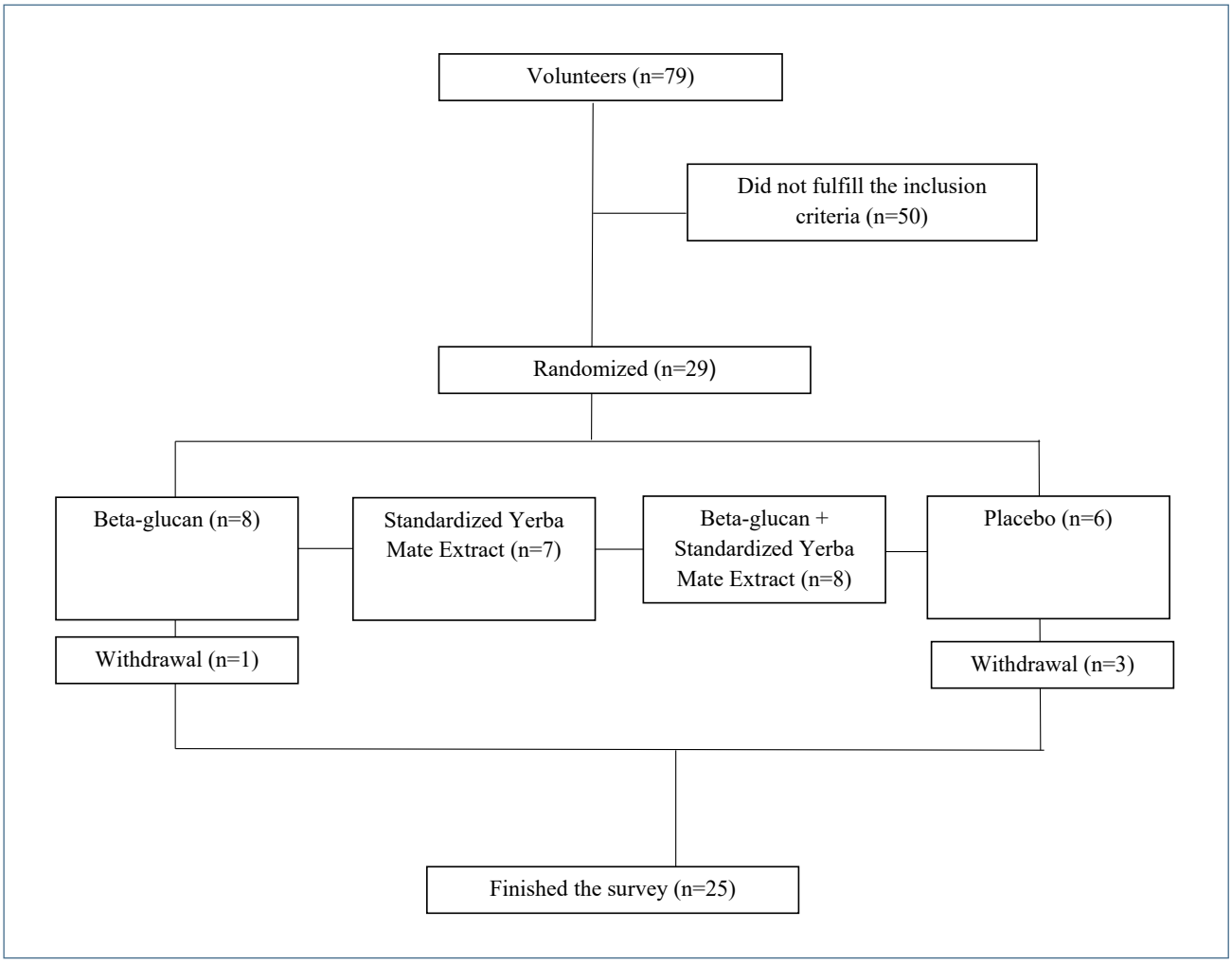


Figure 1: CONSORT 2010 Criteria Flowchart

yielded the best results in the aforementioned previous study, and for standardized yerba mate extract, the dose used was reported in the study by Gebara et al.[11].

Follow-up visits took place at scheduled times, on an individual basis, every fifteen days, at the Faces II Laboratory at Unijuí. The study was conducted by the researcher with the assistance of previously trained students from the university's Pharmacy, Medicine, Nutrition, and Nursing programs. After the research assessments were completed, all data were compiled, and the blinding was lifted to allow for division into treatment groups.

Beta-glucan and Standardized Dry Extract of Yerba Mate

The beta-glucan extracted from oats was supplied by our partner company, Dubai Alimentos, based in Ijuí, Rio Grande do Sul; the extraction was performed in accordance with a protocol previously approved by the UNIJUÍ Institutional Review Board (CEP) under opinion number 4,622,174/2020. The standardized dry extract of yerba mate was supplied by our partner company, Sustentec, based in Pato Bragado, Paraná, and the quality of the raw material supplied was guaranteed.

The shake was produced and prepared at the Unijuí School Pharmacy in accordance with good compounding practices and packaged in a suitable, tightly sealed container to ensure the product's preservation.

The shakes were delivered every 30 days, along with a 10-gram measuring spoon, and patients were instructed, both verbally and in writing, to consume 3 measuring spoons—totaling 30 grams of powder diluted in 200 ml of hot water—daily; the time of day for consuming the drink was left to the patient's discretion.

Interventions

Clinical Variable - Blood Pressure Measurement

The measurement was performed using a G-Tech® manual sphygmomanometer. Blood pressure levels were classified according to the criteria established by the current Brazilian Guidelines for Hypertension, considering systolic blood pressure (SBP) and diastolic blood pressure (DBP) values.

Anthropometric Variables - Weight

A MULTILASER® Bluetooth digital bioimpedance scale with a maximum capacity of 180 kg was used; the subject was weighed without shoes and wearing as little clothing as possible, standing on the platform with both feet and instructed to remain still until the evaluator recorded the weight.

Height

Measured using a portable vertical stadiometer measuring 210 cm, certified by the Institute of Industrial Metrology (IMI); the participant is instructed to be barefoot and without any headwear; the head must be positioned according to the Frankfurt horizontal plane.

Circumferences

Measured with a non-stretchable tape measure at different points: below the breast; waist (smallest circumference observed); 5 cm above the umbilical scar; abdomen (over the umbilical scar); 5 cm below the umbilical scar; 10 cm below the umbilical scar; and hip. These measurements followed the guidelines recommended by the Brazilian Ministry of Health[16].

Water, Fat, and Body Muscle Mass

A MULTILASER® Bluetooth bioimpedance digital scale with a maximum capacity of 180 kg was used. The participant was instructed to stand on the scale over the sensors, hold the handle attached to the scale platform with both hands, as per the user manual, and wait until the device displayed the reading. The analyses followed the guidelines recommended by the Ministry of Health[16].

Anthropometric measurements were taken every 30 days, at Time 0, Time 30, Time 60, and Time 90. Study participants were instructed to continue their normal lifestyle without changing their eating habits or physical activity levels.

Statistical Analysis

For this manuscript, quantitative analysis was performed using SPSS version 20.0, with continuous data described as mean ± standard deviation (SD). To assess the association between quantitative variables, the Student's t-test was used to compare means for paired samples. To assess the difference between group means, a one-way ANOVA was used. A 5% significance level was used for all tests. Analysis of the waist-to-hip ratio (WHR) was performed only in women, as they constituted the larger group of participants and because reference standards for cardiovascular risk differ between the genders.

RESULTS

Twenty-nine volunteers participated in the study; during the course of the study, four dropped out, leaving a total of 25 participants, all of whom had previously been diagnosed with metabolic syndrome (MS). An important risk factor for MS is abnormal blood pressure (BP).

As shown in Table 1, there was no significant difference in systolic blood pressure (SBP) in Groups 1 and 4 when comparing Time 30 (T30), Time 60 (T60), and Time 90 (T90) to Time 0 (T0). Group 2 showed a significant reduction between T0 and after 60 days of follow-up. In Group 3, there was also a significant difference, with a reduction in BP from T0 to the 90-day follow-up.

When the four groups were compared, a difference was observed between Groups 1 and 2 at baseline (T0), with Group 2 showing a higher mean value. In the assessment of diastolic blood pressure (DBP), Group 2 showed a significant difference, with a reduction in blood pressure between T0 and T90, and Group 3 showed a significant difference between T0 and T30. The other intra- and intergroup results were not statistically significant.

With regard to the variables of weight and Body Mass Index (BMI)—since one is dependent on the other—there was no significant difference in any of the study groups, as shown in Table 2. The minimum weight among the study participants was 61.20 kg, and the maximum was 147 kg. Regarding waist and abdominal circumference, as well as the waist-to-hip ratio (WHR), there was no significant difference at any time point or among any of the study groups in Table 3 and Table 4.

Table 5 presents the analysis of body composition by bioimpedance; for body fat, there were no differences at any time point or in any of the intervention groups studied. For body water, Group 4 showed an increase from T0 to T60. As for the assessment of body muscle mass, only Group 2 showed an increase between T0 and T30.

DISCUSSION

As shown, there was a reduction in blood pressure in the groups that consumed shakes enriched with standardized dry extract of yerba mate and shakes enriched with beta-glucan and standardized dry extract of yerba mate. An important bioactive component present in yerba mate is chlorogenic acids (CGAs), which have the ability to exert therapeutic effects against cardiovascular

Table 1: Systolic and diastolic blood pressure variability in patients with metabolic syndrome followed for 90 days while consuming a beverage enriched with standardized dry yerba mate extract and white oat beta-glucan.

Systolic Blood Pressure (SBP)									
	T0	T30	T60	T90	T0	T30	T60	T90	Pb
	Group 1				Group 2				
M	122.86*	127.86	122.86	118.57	144.29*	141.43	131.43*	130.00	* 0.054
SD	12.54	13.50	17.04	10.69	18.12	21.93	13.450	23.80	
Pa		ns	ns	ns		ns	*0.04	ns	
	Group 3				Group 4				
M	135.63*	128.75	132.50	125.00*	120.00	115.00	117.50	115.00	
SD	14.50	11.26	18.32	17.73	8.165	10.00	15.00	5.77	
Pa		ns	ns	*0.042					
Diastolic Blood Pressure (DBP)									
	T0	T30	T60	T90	T0	T30	T60	T90	P
	Group 1				Group 2				
M	80.00	82.14	84.28	75.71	92.86*	87.71	85.71	82.86*	ns
SD	5.77	6.99	5.34	9.76	17.04	7.87	7.87	9.51	
Pa		ns	ns	ns		ns	ns	*0.038	
	Group 3				Group 4				
M	85.00*	78.75*	83.75	78.75	80.00	77.50	75.00	75.00	
SD	9.26	6.41	15.05	9.91	8.16	5.00	5.77	5.77	
Pa		*0.049	ns	ns		ns	ns	ns	

Group 1 – Beta-glucan; Group 2 – dried yerba mate extract; Group 3 – beta-glucan + dried yerba mate extract; Group 4 – placebo; ns – not significant; T0 – day 0; T30 – 30 days; T60 – 60 days; T90 – 90 days; SD – standard deviation; Pa – paired t-test (5% significance level); Pb – one-way ANOVA (5% significance level)

Table 2: Changes in Weight and Body Mass Index (BMI) in patients with metabolic syndrome followed for 90 days while consuming a beverage enriched with standardized dry yerba mate extract and white oat beta-glucan.

	Group 1					Group 2					Group 3					Group 4				
Weight		T0	T30	T60	T90		T0	T30	T60	T90		T0	T30	T60	T90		T0	T30	T60	T90
	M	92.24	91.76	91.47	91.19	**M**	87.53	87.76	87.36	87.49	**M**	87.56	87.55	88.56	89.10	**M**	79.25	78.50	78.98	79.45
	SD	17.00	16.62	15.74	15.75	**SD**	28.34	28.71	28.37	28.84	**SD**	9.98	10.13	9.92	10.50	**SD**	3.66	4.01	4.46	3.56
	P		ns	ns	ns	**p**		ns	ns	ns	**p**		ns	ns	ns	**p**		ns	ns	ns
	Group 1					**Group 2**					**Group 3**					**Group 4**				
BMI (Kg/m²)		T0	T30	T60	T90		T0	T30	T60	T90		T0	T30	T60	T90		T0	T30	T60	T90
	M	36.01	35.64	35.71	35.57	**M**	33.39	33.49	33.44	33.47	**M**	35.08	34.94	35.32	35.48	**M**	32.90	32.60	32.78	32.97
	SD	5.57	5.27	5.29	5.21	**SD**	7.65	7.87	7.69	7.96	**SD**	4.11	3.92	3.78	3.58	**SD**	1.79	1.95	2.07	1.69
	P		ns	ns	ns	**p**		Ns	ns	Ns	**p**		ns	ns	ns	**p**		ns	ns	ns

Group 1 – Beta-glucan; Group 2 – Ilex; Group 3 – Beta-glucan + Ilex; Group 4 – placebo; ns – not significant; T0 – day 0; T30 – 30 days; T60 – 60 days; T90 – 90 days; SD – standard deviation; P – paired t-test (5% significance level); BMI – body mass index

diseases, including hypertension[17]. A study has already demonstrated the potential impact of yerba mate consumption on blood pressure[6]. This may explain the reduction in blood pressure in the groups that consumed standardized dry yerba mate extract—an important finding, given that high blood pressure is a risk factor for metabolic syndrome.

Regarding beta-glucan, a systematic review[5], involving patients with hypertension and hyperinsulinemia showed a significant reduction in systolic blood pressure (-7.5 mmHg) and diastolic blood pressure (-5.5 mmHg) following daily intake of 5.5 g of oat beta-glucan, in the form of cereal, for 6 weeks—a higher dose than that used in the present study. Blood pressure in Group 1 (using only a beta-glucan-enriched shake) showed a reduction of -4.29 mmHg in systolic blood pressure and -4.29 mmHg in diastolic blood pressure, but without a statistically significant difference. The patients in this study were overweight or obese and consequently had high BMIs, which may have hindered blood pressure reduction in individuals who consumed beta-glucan; since these were complex cases, one of the factors that could interfere with the bioactive compound's effectiveness may also be considered in this case, such as the plant's limitations or the dose used.

According to the Brazilian Hypertension Guidelines, the treatment of patients with hypertension aims to achieve blood pressure control by reaching a target blood pressure of less than 140/90 mmHg, but not lower than 120/70 mmHg[18]. This target was achieved in groups 2 and 3, which used standardized dry extract of yerba mate and beta-glucan, combined with standardized dry extract of yerba mate, respectively. Thus, it can be concluded that the use of these bioactive compounds was effective for blood pressure control in patients with metabolic syndrome, representing a potential treatment that can be combined with conventional therapies, such as complementary medicine.

Table 3: Waist and abdominal circumference variables in patients with metabolic syndrome followed for 90 days while consuming a beverage enriched with standardized dry yerba mate extract and white oat beta-glucan.

Waist Circumference (cm)									
	T0	T30	T60	T90	T0	T30	T60	T90	Pb
	Group 1				Group 2				
M	102.44	101.06	101.24	101.47	99.24	99.86	99.77	98.97	ns
SD	9.03	8.08	7.24	7.17	14.79	16.39	17.33	17.30	
Pa		ns	ns	ns		ns	ns	ns	
	Group 3				Group 4				
M	98.45	98.48	98.84	100.17	90.18	94.87	92.38	91.60	ns
SD	6.99	5.26	5.96	5.53	2.12	10.33	5.19	1.79	
Pa		ns	ns	ns		ns	ns	ns	
Abdominal Circumference (cm)									
	T0	T30	T60	T90	T0	T30	T60	T90	Pb
	Group 1				Group 2				
M	110.17	110.17	110.41	111.31	106.66	107.97	106.79	107.31	ns
SD	8.86	10.23	11.09	11.37	18.73	17.21	19.32	20.31	
Pa		ns	ns	ns		ns	ns	ns	
	Group 3				Group 4				
M	104.54	105.01	105.46	106.65	104.65	102.86	99.13	101.5	ns
SD	4.32	3.63	3.54	4.54	8.68	5.36	5.41	4.60	
Pa		ns	ns	ns		ns	ns	ns	

Group 1 – Beta-glucan; Group 2 – Ilex; Group 3 – beta-glucan + Ilex; Group 4 – placebo; ns – not significant; T0 – day 0; T30 – 30 days; T60 – 60 days; T90 – 90 days; SD – standard deviation; Pa – paired t-test (5% significance level); Pb – one-way ANOVA (5% significance level)

Table 4: Waist-to-Hip Ratio (WHR) in female patients with metabolic syndrome who were followed for 90 days while consuming a beverage enriched with standardized dried yerba mate extract and beta-glucan from white oats.

WHR								
	T0	T30	T60	T90	T0	T30	T60	T90
	Group 1				Group 2			
M	0.88	0.85	0.87	0.86	0.89	0.88	0.88	0.88
SD	0.06	0.06	0.07	0.08	0.03	0.04	0.03	0.04
Pa		ns	ns	ns		ns	ns	ns
	Group 3				Group 4			
M	0.83	0.82	0.82	0.87	0.82	0.84	0.82	0.81
SD	0.06	0.05	0.07	0.07	0.04	0.08	0.02	0.01
Pa		ns	ns	ns		ns	ns	ns

Group 1 – Beta-glucan; Group 2 – Ilex; Group 3 – beta-glucan + Ilex; Group 4 – placebo; ns – not significant; T0 – day 0; T30 – 30 days; T60 – 60 days; T90 – 90 days; SD – standard deviation; WHR – waist-to-hip ratio; Pa – paired t-test (5% significance level)

This study did not show a significant impact on body weight and circumferences, a finding consistent with other studies[11], which used standardized encapsulated yerba mate extract (2,250 mg/day) for 4 weeks in 35 male patients (ages 45 to 65); the inclusion criteria were meeting one of the five criteria for metabolic syndrome. Other researchers[18] used decaffeinated green coffee extract (600 mg/day) and a combination of decaffeinated green coffee extract with beta-glucan (600 mg + 5 g/day, respectively) for 20 weeks, evaluating 29 volunteers of both sexes, aged 28 to 59 years. In both studies, the volunteers were instructed to maintain their lifestyle and dietary habits, just as in the present study, which may explain why no changes in body weight measurements were observed throughout the study interventions. Research indicates cardiovascular benefits and a reduction in insulin resistance associated with physical activity in patients with MS[1,19,20] while diet is associated with improved quality of life and a reduced risk of developing chronic noncommunicable diseases[21].

A study conducted on rats showed that treatment with yerba mate extract did not prevent weight gain in the animals, as the group that received a high-fat diet supplemented with yerba mate exhibited a 37% increase in body weight, thus reinforcing the notion that body weight is regulated by a complex system that coordinates food intake and energy expenditure[22]. This corroborates the findings and demonstrates that the bioactive compounds tested have limited use for reducing body measurements or that their results need to be considered in conjunction with other criteria or treatments. Another important point is the caloric density of the shakes used in this study, which was not examined; this may have influenced weight maintenance or gain in the study population.

The waist-to-hip ratio (WHR) is a common measure that indicates the degree of abdominal fat[23]. According to Ferreira et al.[24] the WHR is a better marker for assessing cardiovascular risk. When examining the WHR values, the cardiovascular risk to which the study population is exposed is evident: only group 4 (placebo) had a mean WHR within the normal range; groups 1 and 2 showed a reduction in WHR, though without significant differences; and only group 3 showed an increase in WHR. An increased CRQ is associated with a higher risk of diabetes and hypertension[23].

Ibrahim and Ahsan[23] conducted a study involving healthy individuals who followed a sedentary lifestyle without dietary interventions for 180 days, using a capsule supplement containing

Table 5: Bioimpedance Analysis in Patients with MS.

Bioimpedance - Body Fat (%)								
	T0	T30	T60	T90	T0	T30	T60	T90
	Group 1				Group 2			
M	46.42	46.4	46.36	46.18	43.63	44.91	43.70	45.70
SD	7.94	8.13	7.80	7.81	10.32	11.48	10.89	8.48
p		ns	ns	ns		ns	ns	ns
	Group 3				Group 4			
M	42.93	42.10	42.33	42.9	44.57	45.57	45.75	46.00
SD	11.94	11.13	8.18	10.52	1.17	2.39	2.56	2.10
p		ns	ns	ns		ns	ns	ns
Bioimpedance – Body Water (%)								
	T0	T30	T60	T90	T0	T30	T60	T90
	Group 1				Group 2			
M	42.42	42.60	42.50	42.63	43.4	44.19	43.20	42.12
SD	3.52	3.27	3.17	3.28	4.74	4.89	5.25	3.73
p		ns	ns	ns		ns	ns	ns
	Group 3				Group 4			
M	44.83	45.43	44.05	45.01	42.90*	41.65	41.62*	41.52
SD	5.77	5.73	3.51	5.13	0.80	1.11	1.09	0.93
p		ns	ns	ns		ns	*0,047	ns
Bioimpedance – Muscle Mass (%)								
	T0	T30	T60	T90	T0	T30	T60	T90
	Group 1				Group 2			
M	32.39	32.53	32.47	32.55	32.89*	33.50*	32.70	31.81
SD	2.60	2.42	2.41	2.47	3.73	3.82	4.17	2.52
p		ns	ns	ns		*0,014	ns	ns
	Group 3				Group 4			
M	34.23	34.58	33.48	37.47	32.35	31.30	33.25	31.23
SD	4.74	4.77	2.74	3.34	0.68	0.80	4.10	0.62
p		ns	ns	ns		ns	ns	ns

Group 1 – Beta-glucan; Group 2 – Ilex; Group 3 – beta-glucan + Ilex; Group 4 – placebo; ns – not significant; T0 – day 0; T30 – 30 days; T60 – 60 days; T90 – 90 days; SD – standard deviation; WHR – waist-to-hip ratio; P – paired t-test (5% significance level);

yeast beta-glucan, prebiotics[25], minerals, and S. marianum (milk thistle or silymarin). They concluded that BMI, neck and hip circumferences did not differ between assessments; however, the WHR appeared to decrease slightly over the supplementation period, as was the case in groups 1 and 2 of this study. Therefore, an increased WHR is associated with lifestyle and body fat distribution; given its link to elevated abdominal fat, risk of hypertension, and type 2 diabetes[26], these indicators are already present in the study participants, increasing their predisposition to cardiovascular events.

WHR is considered a practical, accessible, and noninvasive index for identifying risk factors for cardiovascular disease and their effects on metabolism and lipid profile. Thus, the WHR can serve as a useful tool for promoting proper and healthy eating habits and health education among the study population, thereby reducing this risk factor.

When the data are considered as a whole, the bioimpedance results explain the lack of variability in the body measurements of waist circumference, abdominal circumference, and WHR, since body fat levels stabilized from T0 to T90; for body water, a significant difference was observed only in Group 4, though it represented a reduction in body water; and for muscle mass, only Group 2 showed an increase from T0 to T30. In a study conducted with herbal capsules containing Camellia sinensis, Citrus aurantium, and phaseolamine combined with Camellia sinensis, Citrus aurantium, and chromium picolinate, after 60 days of supplementation, the group using Camellia sinensis experienced greater body fat loss. However, this study incorporated dietary and nutritional guidance with individualized meal plans for participants; the researchers state that a balanced diet combined with herbal supplements as adjuncts can yield positive results for individuals[27]. This reinforces the need for specific guidelines for the population to improve overall health, including lifestyle changes (LSC), although this was not the objective of this study.

By combining LSC with dietary interventions and the use of probiotics, prebiotics, and bioactive nutrients, it is possible to transition from an obese state to a metabolically healthy one[28], as observed in this study, despite the absence of significant changes in weight and circumferences; the use of beta-glucan and standardized dry yerba mate extract, combined with LSC, may show promise for the treatment of and risk reduction for metabolic syndrome; however, to confirm this hypothesis, further research is needed, including dietary guidance and physical activity recommendations, for example. It is also necessary to increase the sample size and the doses of bioactive compounds used, given the complexity of patients with metabolic syndrome.

Some may be considered limitations; adherence to the proposed treatment was not assessed, since, given the prolonged duration of the study, participants may have had difficulty consistently consuming the product provided. Another aspect that could be evaluated - particularly after consumption of a beta-glucan-enriched shake is postprandial satiety using a hedonic scale of hunger and satiety. Furthermore, future studies should assess the nutritional composition of the shake and quantify the bioactive compounds present.

Conclusion

It can be concluded that the use of oat beta-glucan and standardized dry yerba mate extract may show promise for the treatment and risk reduction of MS, given that their use had a positive impact on reducing participants' systolic and diastolic blood pressure. The patients in this study presented complex cases and health conditions, which may have influenced the results of this study.

From this perspective, further research is needed to establish new criteria and formulations for beverages enriched with these two important bioactive compounds that are suitable for treating comorbidities associated with metabolic syndrome.

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