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Traditional Mushroom Consumption Associated to Lower Levels of Triglycerides and Blood Pressure in an Indigenous Peasant Community from Oaxaca, Mexico

María Eugenia Meneses,[a,b,*,†] María Galicia-Castillo,[c,†] Aleyda Pérez-Herrera,[b,d] Rosalva Martínez,[e] Hugo León,[e] & Daniel Martínez-Carrera[a]

[a]Centro de Biotecnología de Hongos Comestibles, Funcionales y Medicinales (CB-HCFM), Campus Puebla, Colegio de Postgraduados (CP), Boulevard Forjadores de Puebla No. 205, Puebla 72760, Puebla, México; [b]Consejo Nacional de Ciencia y Tecnología (CONACYT), Avenida Insurgentes Sur No. 1582, Colonia Crédito Constructor, Benito Juárez, C.P. 03940, México City, México; [c]Universidad Popular Autónoma del Estado de Puebla (UPAEP), 21 Sur No. 1103, Barrio de Santiago, Puebla 72410, Puebla, México; [d]Instituto Politécnico Nacional, CIIDIR, Unidad Oaxaca, Hornos No. 1003, Colonia Noche Buena, Santa Cruz Xoxocotlán, Oaxaca 71230, México; [e]Instituto Tecnológico del Valle de Oaxaca (ITVO), Ex Hacienda de Nazareno, Xoxocotlán, Oaxaca 71230, México

*Address all correspondence to: María Eugenia Meneses, CONACYT-Colegio de Postgraduados, Centro de Biotecnología de Hongos Comestibles, Funcionales y Medicinales (CB-HCFM), Campus Puebla, Colegio de Postgraduados (CP), Boulevard Forjadores de Puebla No. 205, Puebla 72760, Puebla, México; Tel./Fax: +52-2222852162, E-mail: meneses.eugenia@colpos.mx

†These authors contributed equally to this work.

ABSTRACT: Traditional consumption of edible mushrooms is supported by ethnomycological studies worldwide. However, the potential impact of mushroom consumption on the nutritional and health status of remote rural communities has not yet been studied. We carried out these initial standard studies in the indigenous peasant community of Benito Juárez, Oaxaca, Mexico. Participant adults (45) were grouped as follows: optimal body mass index (BMI: 17.8%), overweight (48.9%), obesity type I (24.5%), obesity type II (4.4%), and obesity type III (4.4%). A high proportion of women (90.3%) and men (64.3%) had a high risk of cardiovascular disease (WHI: waist/hip index). Most women (93.6%) and men (57.1%) showed abdominal obesity. In biochemical parameters, subjects had hypertriglyceridemia (75.6%), hypercholesterolemia (26.7%), hyperglycemia (53.3%), and hypertension (46.7%). There was an excessive intake in the diet of energy, proteins, carbohydrates, sugar, and lipids, as well as a deficiency in the consumption of several vitamins and minerals. A high frequency of mushroom consumption (> 3 times per week) was significantly correlated to lower energy, lipids, saturated fatty acids (SFA), and sodium intake, as well as to higher intake of cobalamin and zinc. The levels of triglycerides and diastolic blood pressure were significantly lower in adults consuming edible mushrooms every day. Total cholesterol also tended to be lower. These associations allow to promote healthier diets in remote indigenous communities by keeping or increasing the consumption of edible mushrooms, either wild or cultivated. Edible mushrooms can play a more important role in community nutrition and health, considering their unique functional and medicinal properties.

KEY WORDS: blood pressure, dietary intake, edible and medicinal mushrooms, health status, indigenous community, Mexico, nutritional status, triglycerides

ABBREVIATIONS: BMI, body mass index; **HDL-c**, high-density lipoproteins; **LDL-c**, low-density lipoproteins; **TC**, total cholesterol; **TG**, triglycerides; **WHI**, waist/hip index

I. INTRODUCTION

In a global perspective, the Mexican population is undergoing a nutritional transition, characterized by giving up native foods and adopting the Western diet containing highly atherogenic ingredients.[1,2] Genetic studies have found that Mexicans are prone to develop alterations in the level of blood lipids, due to the presence of specific polymorphisms. The most studied polymorphisms of *ABCA1* and *APOA5* genes have been associated with increasing levels of total cholesterol and LDL-c, and a decreasing level of HDL-c.[3]

Recent studies estimated accordingly that 28% of the Mexican population suffers from hypercholesterolemia, 25.5% hypertension, and 10.3% diabetes, which are critical factors for the development of cardiovascular diseases. Furthermore, around 72.5% of the Mexican population shows a combination of overweight and obesity, although the prevalence of overweight in rural areas is 11.6% higher than that in urban areas.[4] Chronic degenerative diseases increasingly affect not only the urban population, but also rural communities as they are giving up local foods relevant for healthy traditional diets.

In the State of Oaxaca in southern Mexico, chronic diseases related to food and diet are a public health challenge. An important strategy being developed by the authors consists of recovering important elements of the traditional Mexican diet, particularly those foods having functional properties. We have focused research efforts on cultivated edible mushrooms.[5] Many species of wild mushrooms have been traditionally consumed by indigenous communities since pre-Hispanic times. At present, increasing evidence shows the functional and medicinal properties of edible mushrooms.[6–8] The consumption of edible mushrooms, mushroom products, or bioactive compounds has been shown to effectively reduce serum cholesterol using *in vivo* models, as well as clinical trials.[9–12] Preventive effects in alterations of glucose levels,[13] hypertension control,[14] and prebiotic effects[9,15] have also been reported.

The State of Oaxaca has a great diversity of edible mushrooms, and their traditional use and management is well documented in ethnomycological studies.[16–18] However, there are no studies on the nutritional and health status of remote rural communities and its association with mushroom consumption, including the intake of macronutrients and micronutrients in the diet. In this study, we carried out a diagnosis on the state of nutrition and health, as well as the intake of nutrients, for assessing their association with mushroom consumption in the indigenous peasant community of Benito Juárez, located in the Northern Mountains of Oaxaca, Mexico. Data analyses indicated that keeping or increasing the consumption of edible mushrooms can help to prevent chronic degenerative diseases in remote rural communities of Mexico, considering their functional and medicinal properties.

II. MATERIALS AND METHODS

A. Studied Mushrooms

The Zapotec community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico, is located at 2,895 m altitude, and surrounded by coniferous forest. Wild and cultivated edible mushrooms consumed by this community were recorded and identified taxonomically. Species authorities are according to the *Index Fungorum* (www.indexfungorum.org). Common names were also registered. Main species cultivated in the region were *Pleurotus ostreatus* (Jacq.) P. Kumm., *Agaricus bisporus* (J.E. Lange) Imbach, and *Ustilago maydis* (DC.) Corda. Main wild species gathered by peasants during the rainy season were *Agaricus campestris* L., *Amanita caesarea* (Scop.) Pers., *Cantharellus cibarius* Fr., *Laccaria laccata* (Scop.) Cooke, *Neolentinus lepideus* (Fr.) Redhead & Ginns, *P. ostreatus*, and *Tricholoma magnivelare* (Peck) Redhead.

B. Recruitment of Volunteers

Two community workshops to become aware of healthy eating patterns were carried out for attending volunteers at the Community Health Center from Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico. After each workshop, participants were encouraged to participate in this study, and volunteers registered. The inclusion criteria were (1) adult person from Benito Juárez, 18 to 74 years old; and (2) written approval of participation in the study, signing the informed consent form. The exclusion criteria were (1) younger (< 18 years old) or older (> 74 years old) person from Benito Juárez; (2) pregnant woman; (3) person using heart pacemaker; (4) person being prescribed a modification of usual food intake or a strict diet used for specific pathologies; (5) person allergic to mushrooms; and (6) patient under pharmacologic treatment for hyperlipidemia, including statins.

C. Clinical and Dietary Histories

A validated clinical history was obtained during nutritional consultation.

D. Eating Habits

A 24-hour reminder and a food frequency questionnaire were applied, containing main food groups, including cereals and tubers; fruits and vegetables; products of animal origin; fats and oils; and industrialized or sugar-rich food products (e.g., sugary drinks). The frequency of consumption of wild and cultivated edible mushrooms, including their preferred culinary preparations, were recorded in a specific section of the food frequency format.

E. Diagnosis of Nutritional and Health Status

Volunteers were assessed in a fasting state of 8–10 h. Weight, percentage of body fat: Volunteers were measured with the Omron scale and a body monitor with seven indicators, Omron HBF-514C (Omron Healthcare, Inc., Illinois, USA). Reference values for the body mass index (BMI) were taken from the World Health Organization: underweight (< 18.50), normal weight (18.50–24.99), overweight (≥ 25.00), pre-obesity (25.00–29.99), obesity class I (30.00–34.99), obesity class II (35.00–39.99), obesity class III (≥ 40.00).[19] Reference values for the percentage of body fat were as follows: (1) thin: men < 8.0%, women < 1 5.0%; (2) optimal: men 8.1–15.9%, women 15.1–20.9%; (3) slight overweight: men 16.0–20.9%, women 21.0–25.9%; (4) overweight: men 21.0–24.9%, women 26.0–31.9%; and (5) obese: men ≥ 25.0%, women ≥ 32.0%.[20]

Body height: measurements were taken using a Bame 430 mechanical scale meter.

Body circumferences: measurements were taken using the Lufkin Executive tape (Lufkin Industries, Inc., Texas, USA). Reference values for the waist/hip index (WHI) were: ICC = 0.71–0.84 normal for women; ICC = 0.78–0.94 normal for men. Reference values from the International Diabetes Federation were used for waist circumference,[21] as follows: < 80 cm for women, and < 90 cm for men.

Biochemical parameters: glucose, triglycerides (TG), and total cholesterol (TC) parameters were assessed in capillary blood by the Accutrend® Plus Roche equipment (Roche Diagnostics Ltd., Switzerland).

Blood pressure: an Omron HEM-7130 baumanometer (Omron Healthcare, Inc., Illinois, USA) was used for assessing this parameter. Reference values were systolic pressure 130/diastolic 85 mm Hg.

F. Macronutrients and Micronutrients Intake Analysis

The current intake of macronutrients (carbohydrates, proteins, lipids) and micronutrients (vitamins, minerals) was calculated on the basis of data from the 24-hour reminder, through the Nutrikcal Vo software program (2016) developed for Mexican conditions (Consifo, S.C., Mexico). The percentage of adequacy was compared with the daily average of nutrient intake in relation to the reference dietary recommendations.[22]

G. Data Analysis

The comparisons between two groups were analyzed by Student's *t*-test using Prism statistical software (GraphPad Prism for Mac OSX v.7, USA). Differences were considered significant at $p < 0.05$.

III. RESULTS AND DISCUSSION

In this study, we analyzed the nutritional and health status, dietary intake of macronutrients and micronutrients, as well as their association with mushroom consumption by participant adults (45) from the remote indigenous peasant community of Benito Juárez, Oaxaca, Mexico.

A. General Characteristics of Subjects

Participants in the study comprised 45 volunteers: 31 women (68.9%) and 14 men (31.1%). There were no withdrawals or dropouts during the research period. The average age for women was 47.20 ± 13.35 years old, while for men was 50.57 ± 15.81 years old. Average general characteristics of subjects (BMI, waist and hip circumferences, WHI; glucose, triglycerides, total cholesterol levels; body fat, blood pressure) are shown in Table 1. A variety of traditional local foods consumed by the community were recorded, such as *tlayudas*, the main cereal food (a sort of maize pancake made by hand and cooked on a hot plate), vegetables (tomatoes, carrots, zucchinis, green beans, diverse wild plants), fruits (bananas, apples, pears, peaches, seasonal blackberries), and legumes (mainly black beans). The diet was unbalanced, as there was a tendency to eat an excess of *tlayudas*, while the consumption of fruits and vegetables was below recommendations for adults, i.e., 400 g per day (WHO-FAO). Increasing consumption of nontraditional foods is leading to overweight and obesity, as participants expressed consumption of soft drinks (22.2%), sugar (35.6%), and industrialized bread (55.5%) two or three times per day or daily.

B. Evaluation of Nutritional and Health Status

Anthropometric measurements and biochemical parameters were used to determine the nutritional and health status.

1. Anthropometric Measurements

Only 17.8% of the participant adults had an optimal BMI; 48.9% were overweight, 24.5% obesity type I, 4.4% obesity type II, and 4.4% obesity type III. When compared by gender, only 9.7% of women had

TABLE 1: Average baseline characteristics of participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Variable	Total (*n* = 45)	Women (*n* = 31)	Men (*n* = 14)
Age (years)	48.27 ± 14.08	47.20 ± 13.35	50.57 ± 15.81
Body mass index (BMI)	28.69 ± 4.56	30.10 ± 4.47	25.56 ± 3.00
Waist circumference (cm)	93.37 ± 9.42	94.03 ± 10.24	91.89 ± 7.44
Hip circumference (cm)	101.56 ± 10.95	104.94 ± 11.10	94.07 ± 5.82
Waist/hip index (WHI)	0.92 ± 0.07	0.90 ± 0.05	0.98 ± 0.06
Body fat (%)	38.41 ± 11.46	44.51 ± 6.65	24.91 ± 7.62
Glucose (mg/dL)	101.36 ± 35.50	100.13 ± 36.09	104.07 ± 35.32
Triglycerides (TG, mg/dL)	199.02 ± 65.44	205.99 ± 57.70	183.57 ± 80.23
Cholesterol (TC, mg/dL)	186.64 ± 32.06	183.16 ± 32.36	194.33 ± 31.16
Systolic blood pressure (mm Hg)	125.26 ± 21.43	123.07 ± 20.60	130.31 ± 23.28
Diastolic blood pressure (mm Hg)	79.63 ± 19.00	80.53 ± 22.27	77.54 ± 7.61

optimal BMI; 48.5% were overweight, 29.0% obesity type I, 6.4% obesity type II, and 6.4% obesity type III. By contrast, a greater proportion of men had optimal BMI (35.7%); 50.0% were overweight, and 14.3% obesity type I (Fig. 1A).

The body fat parameter showed that only 3.2% of adult women had the recommended level of fat, while 96.8% had obesity. A greater proportion of men (14.3%) had optimal level of fat, 14.3% slight overweight, 21.4% overweight, and 50.0% obesity (Fig. 1B). The WHI showed that 90.3% of women and 64.3% of men have high risk of a cardiovascular disease (Fig. 1C). The waist circumference indicated that 93.6% of women have abdominal obesity (> 80 cm), as well as 57.1% of men (> 90 cm) (Fig. 1D).

2. Biochemical Parameters

Participant adults had a high risk of cardiovascular disease due to the high prevalence of hypertriglyceridemia. Most subjects (75.6%) included in the study, as well as 83.9% of women and 57.1% of men had high levels of triglycerides, i.e., > 150 mg/dL (Fig. 2A). The prevalence of hypercholesterolemia was also high, 26.7% of the subjects studied, 25.9% of women and 28.6% of men showing levels of cholesterol > 200 mg/dL (Fig. 2B). There was also a high prevalence of hyperglycemia, as it was recorded in 53.3% of adults studied, with 51.6% of women and 57.1% of men showing high glucose levels, i.e., > 100 mg/dL (Fig. 2C). There were significant differences between subjects, men and women, having optimal ranges of blood biochemical parameters, and those showing abnormal ranges, as well as symptoms of hypertriglyceridemia, hypercholesterolemia, and hyperglycemia (Fig. 3).

3. Blood Pressure

About half of participant adults (46.7%) had hypertension; 48.4% of women and 57.1% of men (Fig. 2D). There were significant differences between subjects having optimal systolic and diastolic blood pressure, men and women, in comparison with those showing hypertension symptoms (Fig. 3).

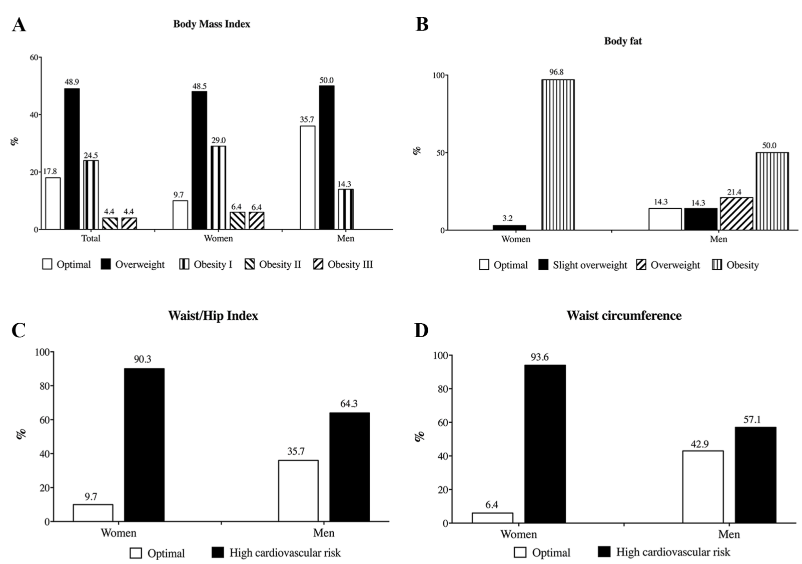

FIG. 1: Categories based on anthropometric measurements of participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico. (A) Body mass index (BMI); (B) body fat; (C) waist/hip index (WHI); (D) waist circumference.

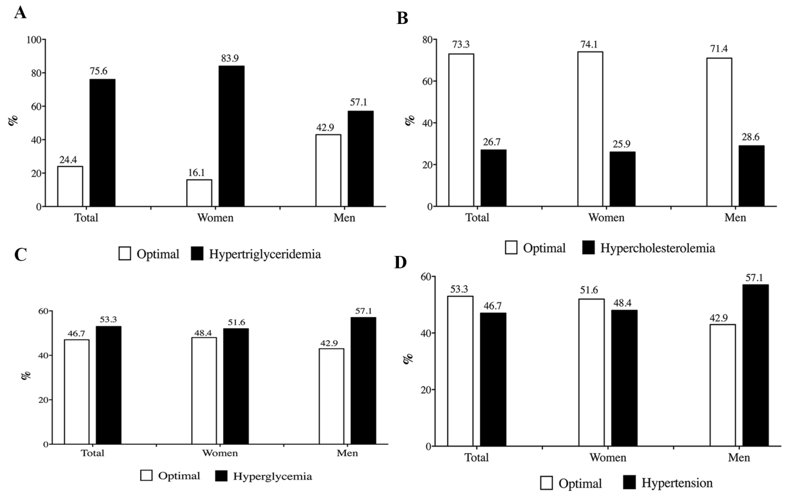

FIG. 2: Categories based on biochemical parameters, as well as blood pressure, of participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico. (A) Hypertriglyceridemia; (B) hypercholesterolemia; (C) hyperglycemia; (D) hypertension.

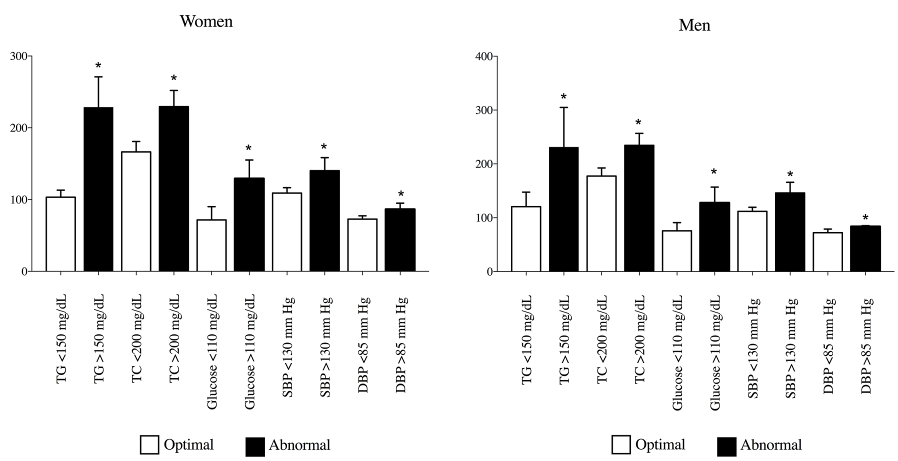

FIG. 3: Biochemical parameters and blood pressure of participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico. Optimal and abnormal values of triglycerides (TG), total cholesterol (TC), glucose, systolic blood pressure (SBP), and diastolic blood pressure (DBP). Differences were considered significant at $p < 0.05$, according to Student's *t*-test.

4. Analysis by Age Group

The BMI showed that subjects considered healthy in this parameter varied from 13% to 22% (Table 2). The prevalence of overweight in the age group of 20 to 29 years old (60%) was greater than the rest of the groups (22% to 58%). The greatest proportion of obesity type I was recorded in the age group of > 60 years old (45%), for obesity type II in the age group of 20–29 years old (20%), and for obesity type III in the age group of > 60 years old (11%). The age group with the greatest proportion of subjects having high average

TABLE 2: Body mass index (BMI) and biochemical parameters studied by age group of participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Age (years)	BMI					Biochemical parameters		
	Optimal	Overweight	Obesity type I	Obesity type II	Obesity type III	Glucose > 100 mg/dL	TG > 150 mg/dL	TC > 200 mg/dL
20–29	0%	60%	20%	20%	0%	60%	75%	20%
30–39	13%	50%	37%	0%	0%	62%	75%	14%
40–49	18%	55%	18%	9%	0%	45%	44%	9%
50–59	17%	58%	17%	0%	8%	42%	82%	45%
> 60	22%	22%	45%	0%	11%	67%	86%	50%

TG, triglycerides; TC, total cholesterol.

levels of glycemia (> 100 mg/dL), triglycerides (> 150 mg/dL), and total cholesterol (> 100 mg/dL) was > 60 years old (Table 2).

In terms of nutritional status, there was 82.2% combined prevalence of overweight and obesity (women: 90.3%; men: 64.3%), data above the national average reported as 72.5% for the total population (women: 75.6%; men: 69.4%). Data also showed that the prevalence of obesity in women (41.8%) is higher than men (14.3%), again above the national trend (women: 38.6%; men: 27.7%). These data are in agreement with the National Survey of Health and Nutrition (ENSANUT MC 2016),[4] which found prevalence of overweight in rural localities 11.6% higher than in urban localities. Likewise, the prevalence of overweight and obesity is increasing over time in Mexican rural areas, particularly in women.[23]

Participant adults belonging to the young age group (20–29 years) did not show optimal BMI, indicating that this is the most vulnerable group of the nutritional transition taking place in the Mexican population, due to changes in eating patterns. Moreover, volunteers showed a high prevalence of abdominal obesity, particularly women, whose proportion (93.6%) was greater than the national trend (87.7%). In the case of men, the proportion (57.1%) was slightly lower than the national trend (65.4%). There was a high prevalence of hypertriglyceridemia in participant adults (75.6%), which is important as high levels of triglycerides are directly associated with inflammation and cardiovascular disease.[24] Moreover, about a quarter of volunteers studied had hypercholesterolemia (26.7%); 25.9% in women and 28.6% in men. This prevalence is similar to the national trend (women: 28.4%; men: 27.4%).[4] A high proportion (15.5%) of participant adults in this study had previous diagnosis of diabetes mellitus, higher than the national trend (9.4%). This was also the case for high prevalence of hypertension (46.6%), in comparison with the national trend (25.5%).[4]

C. Macronutrients and Micronutrients Intake

The median percentage adequacy for energy consumption, proteins, carbohydrates, sugar, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), fiber, cholesterol, thiamine (vitamin B_1), riboflavin (vitamin B_2), iron, magnesium, sodium, and phosphorus, was above recommended standards. However, deficiencies were observed in the intake of vitamins and minerals, mainly in retinol (vitamin A), pantothenic acid (vitamin B_5), folic acid (vitamin B_9), cobalamin (vitamin B_{12}), niacin (vitamin B_3), potassium, selenium, and zinc (Table 3). There was an excess in the consumption of energy, proteins, carbohydrates, sugar, and fat in terms of diet quality, but a deficiency in several vitamins and minerals. Similar results have been found in a previous study showing poor diet quality of the Mexican population. The median intake of fruits and vegetables was approximately half of the recommended

TABLE 3: Median percentage of adequacy of daily consumption of macronutrients and micronutrients in participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Energy or nutrient	IR	Intake (50 percentile)	Percentage of adequacy (50 percentile)	CI (95%)
Energy (kcal)	1,978.15	2,017.00	102.76	98.53–112.39
Macronutrients				
Proteins (g)	51.44	74.30	142.67	132.05–161.15
Carbohydrates (g)	277.15	333.51	121.23	112.19–130.27
Lipids (g)	72.79	70.62	95.06	87.05–103.07
Saturated fatty acids (SFA, g)	< 7.10	11.57	159.53	134.71–184.35
Monounsaturated fatty acids (MUFA, g)	12.74	19.50	151.61	132.48–170.73
Polyunsaturated fatty acids (PUFA, g)	< 4.90	10.80	210.29	187.25–233.34
Fiber (g)	27.69	36.50	133.96	118.20–146.41
Sugar (g)	25.00	46.29	185.15	162.67–207.62
Micronutrients				
Cholesterol (mg/day)	< 200	233.62	116.81	94.14–139.48
Retinol, vitamin A (μg/day)	500.00	490.00	98.00	98.98–153.25
Thiamine, vitamin B_1 (mg/day)	0.90	1.63	175.11	157.70–192.52
Riboflavin, vitamin B_2 (mg/day)	0.90	1.20	131.11	113.93–140.35
Niacin, vitamin B_3 (mg/day)	11.07	10.89	95.36	91.48–107.25
Pantothenic acid, vitamin B_5 (mg/day)	5.00	2.49	49.82	43.51–56.13
Pyridoxine, vitamin B_6 (mg/day)	1.10	1.14	92.31	84.23–112.50
Folic acid, vitamin B_9 (μg/day)	320.00	233.59	73.00	60.23–85.76
Cobalamin, vitamin B_{12} (μg/day)	2.00	1.50	75.09	55.45–94.73
Calcium (mg/day)	1,100	1,033.91	97.30	86.28–108.32
Iron (mg/day)	7.00	11.28	167.62	145.80–189.44
Potassium (g/day)	4.70	2.79	59.41	53.55–65.27
Magnesium (mg/day)	289.56	355.28	124.00	109.79–138.21
Sodium (g/day)	2.20	2.80	127.60	108.24–146.96
Phosphorus (mg/day)	580.00	832.15	143.47	123.41–163.54
Selenium (μg/day)	52.11	33.78	65.46	56.79–74.13
Zinc (mg/day)	7.55	4.52	61.17	53.40–68.94

IR, average of international recommendation; CI, confidence interval.

standard, and there was a high intake of sugary drinks in the northern and southern parts of the country.[25] Other studies reported inadequate intakes of complex B vitamins in rural areas of Mexico.[26,27]

D. Frequency of Consumption of Edible Mushrooms

The consumption of wild and cultivated mushrooms is frequent in the community of Benito Juárez, Oaxaca. Mushroom gathering, preparation, cooking, consumption, and selling are traditional activities in the community culture. Traditional knowledge has been transmitted orally through many generations. Most participant

TABLE 4: Frequency of consumption of wild and cultivated edible mushrooms by participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Mushroom	Frequency (number of times consumed)											
	Never or < 1/month		1–3/month		1/week		2–4/week		5–6/week		Daily	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Wild	16	36	2	4	2	4	7	16	4	9	14	31
Cultivated	9	20	19	42	5	11	10	22	0	0	2	5

adults (64%) expressed that they consume wild edible mushrooms during summer, in the rainy season (June–August). The consumption of cultivated mushrooms was more frequent than that of wild mushrooms, as stated by most adults (80%). Participant adults (31%) reported consumption of wild edible mushrooms daily during the rainy season, while others (16%) 2–4 times per week, or less than 1 time per week or never (36%). Cultivated edible mushrooms were consumed by 42% of adults 1–3 times per month, followed by 22% for 2–4 times per week, 20% for less than 1 time per week or never, 11% for 1 time per week, and 5% daily (Table 4). The average amount of cooked mushrooms was 260 g per day when consumed.

Wild edible mushrooms highly consumed by the participants were *Amanita caesarea*, known locally as *hongo coloradito* or *hongo rojo*; *Cantharellus cibarius*, known as *baya dee* or *hongo amarillo*; and *Agaricus campestris*, known as *hongo de burrito*. Cultivated edible mushrooms widely consumed were *Pleurotus ostreatus*, known commercially as *setas*; *Agaricus bisporus*, known as *champiñón*; and *Ustilago maydis*, known as *huitlacoche*. Other important edible mushrooms, such as *Neolentinus lepideus* (local name: *hongo de venado*, *baya yeri*) and *Tricholoma magnivelare* (local name: *hongo de ocote*, *hongo blanco*), are also shown in Table 5. A variety of cooking preparations were recorded for wild and cultivated mushrooms in Benito Juárez, Oaxaca, such as roasting with herbs, frying with cheese and eggs, and stewing with tomato, onions, spices, and hot chili. The State of Oaxaca possesses a great cultural and biological diversity. This study confirmed that wild and cultivated edible mushrooms are an important part of cultural traditions from the community of Benito Juárez. Important mushroom species found were *A. caesarea*, *C. cibarius*, *A.*

TABLE 5: Mushroom species and their common names, which are widely consumed by participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Species	Common names	*n*	%
Wild mushrooms			
Agaricus campestris	*Hongo de burrito*	12	27
Amanita caesarea	*Hongo coloradito*, *hongo rojo*	27	60
Cantharellus cibarius	*Baya dee*, *hongo amarillo*	13	29
Laccaria laccata	*Hongo patita de pajarito*	4	9
Neolentinus lepideus	*Hongo de venado*, *baya yeri*	4	9
Pleurotus ostreatus	*Seta silvestre*	10	22
Tricholoma magnivelare	*Hongo de ocote*, *hongo blanco*	3	7
Cultivated mushrooms			
P. ostreatus	*Seta cultivada*	36	80
Agaricus bisporus	*Champiñón*	24	53
Ustilago maydis	*Huitlacoche*	20	44

campestris, *P. ostreatus*, *A. bisporus*, *U. maydis*, and *L. laccata*, which have also previously been reported in various mycological studies.[16,28]

E. Macro- and Micronutrients Intake Associated to Edible Mushrooms

Participant adults reporting a high frequency of mushroom consumption (> 3 times per week) had a significant lower intake of energy, lipids, fatty acids (SFA, MUFA, PUFA), and sodium, as well as significant higher intake of cobalamin and zinc. There was also a tendency to consume lower amounts of proteins, carbohydrates, cholesterol, iron, ascorbic acid (vitamin C), vitamin E, calcium, potassium, and selenium, as well as higher amounts of niacin, retinol, thiamine, folic acid, pantothenic acid, magnesium, and phosphorous (Table 6). Micronutrient intake improved in participants consuming greater amounts of mushrooms, as their average nutritional value (*Agaricus*, *Lentinus*, *Pleurotus*) on a dry weight basis has been studied regarding vitamins (A, B_1, B_2, B_3, B_6, B_{12}, C, D_2, D_3, niacin, D_2 pro-vitamin), minerals (Fe, K, P, Cu, Se, Ca, Mg, Mn, Zn), and dietary fiber (27.9–47.3 g/100 g).[5,28] The high content of dietary fiber, polyunsaturated fatty acids, and the apparent absence of trans isomers of unsaturated fatty acids make mushrooms an important functional food capable of reducing risk of cardiovascular diseases.[10] This hypocholesterolemic effect is achieved by decreasing very-low-density lipoproteins, improving lipid metabolism, inhibiting the 3-hydroxy-3-methyl-glutaryl-CoA reductase (HMG-CoA, the rate-controlling enzyme of the mevalonate pathway that produces cholesterol and other isoprenoids), and promoting the excretion of fecal bile acids and cholesterol.[9]

F. Nutritional and Health Status in Relation to the Consumption of Edible Mushrooms

Analysis of anthropometric measurements and biochemical parameters, based on the frequency of mushroom consumption, indicated significant difference in parameters studied in 45 participant adults. This was so for lower triglycerides (TG) in blood and diastolic blood pressure associated to a high frequency of mushroom consumption (Table 7). Total cholesterol (TC) level and systolic blood pressure tended to be lower in participant adults reporting high frequency of the consumption of edible mushrooms (daily). These parameters are indicators of lower cardiovascular risk. This positive effect of mushrooms, including species here reported as widely consumed, is well documented. Previous research has shown that their bioactive compounds decrease cholesterol and triglyceride levels in both animal models and clinical trials. β-glucans, which represent 4–13% of the total dietary fiber in mushroom species, inhibit cholesterol and triglycerol absorption.[10,29] In this study, daily consumption of fiber by participant adults was higher (36.50 g) than that of recommended intake (27.69 g).

Participant adults reporting high frequency of mushroom consumption (> 3 times per week) showed a positive tendency of several health parameters, namely (1) lower intake of energy, lipids (SFA, MUFA, PUFA), and sodium; (2) higher intake of cobalamin, and zinc; (3) lower consumption of carbohydrates and cholesterol; (4) higher intake of niacin, retinol, thiamine, folic acid, and pantothenic acid; and (5) lower waist circumference, hip circumference, triglycerides (TG), and cholesterol (TC) levels. These results are similar to previous research work, in which it was shown that the consumption of edible mushrooms 3 times per week (8 oz) can help to reduce total energy and fat intake, as well as to improve body composition and several indicators, such as blood pressure, TC, LDL cholesterol, and HDL cholesterol.[30] Clinical studies have shown the lipid lowering effect of oyster mushrooms in diabetic patients, where *P. ostreatus* intake lowered total cholesterol and triglycerides in blood plasma.[31]

IV. CONCLUSIONS

Edible mushrooms are traditionally consumed by the indigenous community of Benito Juárez, Oaxaca, Mexico. Main wild and cultivated species were *Agaricus bisporus*, *A. campestris*, *Amanita caesarea*,

TABLE 6: Intake of macronutrients and micronutrients in relation to the frequency of consumption of edible mushrooms, wild and cultivated, by participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Energy or nutrient	High frequency of consumption (> 3 times/week) (*n* = 26)	Low frequency of consumption (< 3 times week) (*n* = 19)	*p**
Energy (kcal)	1,899 ± 103.50	2,307 ± 169.30	0.03*
Macronutrients			
Proteins (g)	71.77 ± 4.90	82.79 ± 6.82	0.18
Carbohydrates (g)	316.70 ± 16.63	356.50 ± 23.54	0.16
Lipids (g)	48.77 ± 4.13	69.99 ± 7.24	< 0.05*
Saturated fatty acids (SFA, g)	10.19 ± 1.05	13.98 ± 1.58	< 0.05*
Monounsaturated fatty acids (MUFA, g)	16.12 ± 1.44	24.13 ± 2.42	< 0.05*
Polyunsaturated fatty acids (PUFA, g)	9.26 ± 0.68	12.91 ± 1.25	< 0.05*
Fiber (g)	37.19 ± 2.77	37.08 ± 3.76	0.98
Sugar (g)	42.05 ± 3.37	39.71 ± 4.16	0.66
Micronutrients			
Cholesterol (mg/day)	197.10 ± 30.74	267.90 ± 42.35	0.17
Retinol, vitamin A (μg/day)	1.65 ± 0.12	1.58 ± 0.12	0.71
Thiamine, vitamin B_1 (mg/day)	1.65 ± 0.12	1.58 ± 0.12	0.71
Riboflavin, vitamin B_2 (mg/day)	1.19 ± 0.07	1.24 ± 0.13	0.74
Niacin, vitamin B_3 (mg/day)	12.52 ± 1.02	11.52 ± 1.048	0.50
Pantothenic acid, vitamin B_5 (mg/day)	2.64 ± 0.23	2.38 ± 0.22	0.43
Pyridoxine, vitamin B_6 (mg/day)	1.17 ± 0.12	1.17 ± 0.13	0.99
Folic acid, vitamin B_9 (μg/day)	254.10 ± 27.24	221.30 ± 32.86	0.44
Cobalamin, vitamin B_{12} (μg/day)	2.05 ± 0.30	1.24 ± 0.18	< 0.05*
Ascorbic acid, vitamin C (mg/day)	78.10 ± 10.91	100.60 ± 14.57	0.21
Vitamin E (mg/day)	3.21 ± 0.29	3.76 ± 0.62	0.39
Calcium (mg/day)	985.90 ± 85.56	1,257.00 ± 126.80	0.07
Iron (mg/day)	19.51 ± 1.56	23.18 ± 1.69	0.12
Potassium (mg/day)	2,703.00 ± 198.90	2,915.00 ± 224.60	0.48
Magnesium (mg/day)	371.60 ± 27.06	369.70 ± 40.04	0.96
Sodium (mg/day)	2,245.00 ± 171.70	3,078.00 ± 406.50	< 0.05*
Phosphorus (mg/day)	847.80 ± 82.92	810.70 ± 97.78	0.77
Selenium (μg/day)	32.160 ± 3.10	36.00 ± 3.59	0.42
Zinc (mg/day)	5.136 ± 0.39	3.88 ± 0.45	< 0.05*

*Significant difference, $p < 0.05$.

Cantharellus cibarius, *Laccaria laccata*, *Neolentinus lepideus*, *Pleurotus ostreatus*, *Tricholoma magnivelare*, and *Ustilago maydis*. In this community, where subjects were diagnosed as having hypertriglyceridemia

TABLE 7: Anthropometric measurements and biochemical parameters associated to the frequency of mushroom consumption by participant adults from the community of Benito Juárez, Santa Catarina Lachatao, Oaxaca, Mexico

Parameter	Mushroom consumption		*p**
	High frequency (daily; *n* = 9)	No consumption (*n* = 9)	
Age (years)	57.00 ± 15.12	51.33 ± 9.19	0.350
Body mass index (BMI)	28.86 ± 3.95	26.93 ± 3.50	0.290
Waist circumference (cm)	91.67 ± 4.79	90.06 ± 7.70	0.601
Waist/hip index (WHI)	0.92 ± 0.07	0.90 ± 0.04	0.419
Triglycerides (TG, mg/dL)	143.30 ± 26.30	207.10 ± 53.59	0.005*
Total cholesterol (TC, mg/dL)	167.90 ± 14.35	180.60 ± 36.18	0.343
Glucose (mg/dL)	93.11 ± 13.26	89.44 ± 19.40	0.646
Systolic blood pressure (mm Hg)	123.10 ± 19.61	124.20 ± 18.79	0.903
Diastolic blood pressure (mm Hg)	73.00 ± 5.80	79.67 ± 5.24	0.021*

*Significant difference.

(75.6%), hypercholesterolemia (26.7%), hyperglycemia (53.3%), and hypertension (46.7%), the levels of triglycerides (143.30 mg/dL) and diastolic blood pressure (73 mm Hg) were significantly lower in adults consuming edible mushrooms daily. Total cholesterol was also lower (167.90 mg/dL). Lower intake of energy, macronutrients (lipids, saturated fatty acids), and micronutrients (sodium), as well as higher intake of cobalamin and zinc, were significantly correlated to a high frequency of mushroom consumption (> 3 times per week). Results from the present study show that edible mushrooms should be integrated as functional food to public policies, community workshops, and nutritional guides for promoting consumption, as well as healthy eating patterns. Further mushroom research work is being carried out, including gene expression, genomic analysis, and nutritional intervention to provide additional evidence for the association between mushroom consumption and the nutritional and health status in remote indigenous peasant communities.

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