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VOL 67 **SEPTIEMBRE 2017** **N° 3**

Contenido

Páginas

ARTICULOS GENERALES

WHO body mass index for age charts overestimate thinness and overweight compared to international and US charts applied to indigenous and non-indigenous Mexican children.
Erik Ramírez, Juan E. Ramos Salas, Martha Barrera Bustillos, Luis Ricardo González Franco, Elena Flores Guillen, Alfredo Pérez Jacome, Mauro E. Valencia..... 159

Suplementos nutricionales como modificadores de morbimortalidad en pacientes con cáncer
Annette Faria, Jeanette Coriat, María Camila Rueda-Rodriguez, Camilo Castañeda-Cardona, Diego Rosselli..... 169

PERSPECTIVA

Comparison of nonnutritive artificial sweetener consumption among university students in Latin American: Multicentric Study
Samuel Durán Agüero; María del Pilar Rodríguez Noel; Karla Cordón Arrivillaga; Julieta Salazar de Ariza; Jiniva Record Cornwall; María del Pilar Cereceda Bujaico; Sonia Antezana Alzamora; Sissy Espinoza Bernardo; Claudia Encina Vega. 178

Ingredients of mayonnaise: Future perspectives focusing on essential oils to reduce oxidation and microbial counts
Izabela Alves Gomes; Flávia dos Santos Gomes; Otniel Freitas-Silva; Janine Passos Lima da Silva..... 187

TRABAJOS DE INVESTIGACION

Riesgo Cardiometabólico

Cintura e índice de masa corporal: los mejores predictores antropométricos en la reducción y progresión de la agregación de factores de riesgo cardiometabólicos
Giovanna Valentino; María José Bustamante, Samuel Durán Agüero, Lorena Orellana, Marcela Adasme, Fernando Baraona, Gastón Chamorro, Jorge Jalil, Carlos Navarrete y Mónica Acevedo 200

Ciencia de Alimentos

Influence of extraction solvent on phenolic content and antioxidant capacity level of a commercial food supplement from *Moringa oleifera* leaves
Vania Urías-Orona, Guadalupe Gutiérrez-Soto2, Jahir Ruiz-Bautista, Raúl Flores-Alonso, Isac Montiel-Ramos, Guillermo C. G. Martínez-Ávila, Juana Aranda-Ruiz, Guillermo Niño-Medina..... 211

The effect of foliar fertilization with organic products on some nutritional value during post-harvest storage of tomatoes (*Lycopersicon esculentum* Mill)
Dinu Maria, Soare Rodica, Dumitru Mihaela Gabriela 218

Tecnología de Alimentos

Análisis proximal, de textura y aceptación de las galletas de trigo, sorgo y frijol
Norma Soler Martínez, Octelina Castillo Ruíz, Guadalupe Rodríguez Castillejos, Adriana Perales-Torres, Ana Luisa González Pérez.. 227

FE DE ERRATAS..... 235

INFORMACION PARA LOS AUTORES..... 236

Archivos Latinoamericanos de Nutrición

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VOL 67 **SEPTEMBER 2017** **N° 3**

Contents

Pages

GENERAL ARTICLES

WHO body mass index for age charts overestimate thinness and overweight compared to international and US charts applied to indigenous and non-indigenous Mexican children.
Erik Ramírez, Juan E. Ramos Salas, Martha Barrera Bustillos, Luis Ricardo González Franco, Elena Flores Guillen, Alfredo Pérez Jacome, Mauro E. Valencia..... 159

Nutritional supplements as modifiers of morbidity and mortality in cancer patients
Annette Faria, Jeanette Coriat, María Camila Rueda-Rodriguez, Camilo Castañeda-Cardona, Diego Rosselli..... 169

PERSPECTIVE

Comparison of nonnutritive artificial sweetener consumption among university students in Latin American: Multicentric Study
Samuel Durán Agüero; María del Pilar Rodríguez Noel; Karla Cordón Arrivillaga; Julieta Salazar de Ariza; Jiniva Record Cornwall; María del Pilar Cereceda Bujaico; Sonia Antezana Alzamora; Sissy Espinoza Bernardo; Claudia Encina Vega. 178

Ingredients of mayonnaise: Future perspectives focusing on essential oils to reduce oxidation and microbial counts
Izabela Alves Gomes; Flávia dos Santos Gomes; Otniel Freitas-Silva; Janine Passos Lima da Silva..... 187

RESEARCH PAPERS

Cardiometabolic Risk

Waist and body mass index: The best anthropometric predictors in the reduction and progression of the aggregation of cardiometabolic risk factors
Giovanna Valentino; María José Bustamante, Samuel Durán Agüero, Lorena Orellana, Marcela Adasme, Fernando Baraona, Gastón Chamorro, Jorge Jalil, Carlos Navarrete y Mónica Acevedo 200

Food Science

Influence of extraction solvent on phenolic content and antioxidant capacity level of a commercial food supplement from *Moringa oleifera* leaves
Vania Urías-Orona, Guadalupe Gutiérrez-Soto2, Jahir Ruiz-Bautista, Raúl Flores-Alonso, Isac Montiel-Ramos, Guillermo C. G. Martínez-Ávila, Juana Aranda-Ruiz, Guillermo Niño-Medina..... 211

The effect of foliar fertilization with organic products on some nutritional value during post-harvest storage of tomatoes (*Lycopersicon esculentum* Mill)
Dinu Maria, Soare Rodica, Dumitru Mihaela Gabriela 218

Food Technology

Nutritional, texture and sensory profile of cookies from wheat, sorghum and bean
Norma Soler Martínez, Octelina Castillo Ruíz, Guadalupe Rodríguez Castillejos, Adriana Perales-Torres, Ana Luisa González Pérez.. 227

ERRATUM..... 235

INFORMATION FOR AUTHORS 236

ARCHIVOS LATINOAMERICANOS DE NUTRICIÓN
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Vol. 67 N° 3, 2017

WHO body mass index for age charts overestimate thinness and overweight compared to international and US charts applied to indigenous and non-indigenous Mexican children.

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SUMMARY: Assessments of whether children are thin (low body mass index for age) or overweight are based on body mass index (BMI for age and sex) charts published by the World Health Organization (WHO), the International Obesity Task Force (IOTF), and the US Centers for Disease Control and Prevention (CDC). We aimed to determine whether these charts indicated different prevalence of thinness and overweight (obesity included) in indigenous and non-indigenous school aged children from different regions and ethnic groups in Mexico. A probability proportional to size, cluster sampling method was employed in four regions of the country. We recruited 1,731 children aged 7.0-9.9 (507 indigenous from six ethnic groups and 1,224 non-indigenous). BMI was calculated according to age, and thinness and overweight classifications were compared according to cutoff values in the WHO, IOTF, and CDC references. The WHO reference generated the highest rates for thinness (12.5%) and overweight (30%) in children across regions and ethnic groups. The CDC reference estimated the lowest rates of thinness in children (5.5%), and the IOTF reference estimated the lowest rates of overweight (24.7%). Estimates of both thinness (8.3%) and overweight (13.4%) rates were lower in indigenous than non-indigenous groups (14.3% and 37.5%, respectively). The WHO BMI for age chart estimated higher rates of thinness and overweight in children compared to the CDC and IOTF charts. Because thinness as indicator of undernutrition status is relatively new, differences in body composition among indigenous and non-indigenous children may justify the need for more appropriate screening criteria to compare the growth status.

Key words: Overweight, references, Mexican indigenous, Mexican mestizos, children.

RESUMEN. La referencia de IMC para la edad de OMS sobreestima la delgadez y el sobrepeso en comparación con las referencias IOTF y CDC en niños indígenas y no indígenas mexicanos. La clasificación del estado nutricio de los niños con delgadez o con sobrepeso se realiza empleando el índice de masa corporal (IMC para la edad y el sexo) con las tablas de la OMS, IOTF y CDC. El objetivo de esta investigación fue determinar si estas referencias resultan en diferentes prevalencias de delgadez y sobrepeso (obesidad incluida) en niños escolares indígenas y no indígenas de diferentes regiones de México. Se empleó un muestreo por conglomerados en cuatro regiones del país. Se reclutaron 1,731 niños con edades entre 7,0-9,9 (507 indígenas de cinco grupos étnicos y 1,224 no indigenas) durante 2006 y 2008. El IMC se calculó y se clasificó como delgadez y sobrepeso con los puntos de corte sugeridos por las referencias internacionales. Cuando se compararon las clasificaciones, la referencia de OMS generó la prevalencia más alta de delgadez (12,5%) y sobrepeso (30%) en niños de todas las regiones y grupos étnicos. La referencia de los CDC estimó las prevalencias más bajas de delgadez (5,5%) y la referencia IOTF produjo las proporciones más bajas de sobrepeso (24,7%). Las proporciones de delgadez (8,3%) y sobrepeso (13,4%) fueron más bajas en niños indígenas que en los no indígenas (14.3% y 37.5%, respectivamente). La referencia de la OMS del IMC para la edad produjo las prevalencias más altas de delgadez y sobrepeso en comparación con los estándares de CDC y IOTF. Dado que la delgadez como indicador de desnutrición en niños es de uso reciente, las diferencias encontradas entre indígenas y mestizos pueden justificar el contar con mejores herramientas de tamizaje en estudios de crecimiento.

Palabras clave: Sobrepeso, delgadez, referencias, niños indígenas, mestizos, México

INTRODUCTION

Developing countries and regions are currently facing a twofold burden of malnutrition; at the same time, the prevalence of underweight and obesity has risen in different regions. Nationally aggregated data hide disparities among regions and among different ethnic and socioeconomic groups. For example, in Mexico, stunting affects more than 30 percent of children aged one to four years in rural areas of southern regions (1). In contrast, the overall prevalence of overweight status has risen in school children of the northern and central regions (2).

Recently, many countries have assessed overweight status in children and adolescents based on the body mass index (BMI), which is classified as high or low compared to normal ranges for a given sex and age, according to national or international standard references. Likewise, BMI has been used to assess thinness (low BMI for a given age) with specific references and cutoff points (3-6). In 2007, the WHO recommended a new growth reference chart for school aged children (aged 5-19 y) (3). Previously, in 2000, the IOTF had published reference tables based on BMI, age, and sex to define overweight and obesity classifications (4). In 2007, IOTF released complementary reference data to define thinness (5). In 2000, the CDC recommended new growth charts for US children aged $\geq$ 2 y (6); these continue to be used in some developing countries (7, 8). The use of three references (WHO, IOTF, and CDC charts) may generate different prevalence rates of overweight status in preschool and school aged children, which implies that they are not necessarily equivalent.

Studies in school-aged children have rarely compared different prevalences of thinness estimated with WHO, IOTF, and CDC references. A recent review and meta-analysis only compared the prevalence of overweight and obesity in children among those references (9). In particular, some countries, like Mexico, have broad socioeconomic, geographic and ethnic diversities; thus, it is important to test the estimations derived from these three references to determine whether they are adequate for use in public health policies. The IOTF has been reported to produce a lower rate of overweight children than that estimated with CDC reference (9, 10). This suggested that the prevalences of overweight and thinness in children may be underestimated or overestimated compared to the latest WHO reference.

Thus, this study aimed to determine whether the WHO reference might produce different estimates of thinness and overweight prevalences compared to the IOTF and CDC charts. We studied school aged children within four geographic regions and different ethnic groups in Mexico. The study assessed the BMI in Mexican children aged 7.0 -9.9 y, and determined the prevalence of overweight and thinness according to the WHO, IOTF, and CDC references.

MATERIALS AND METHODS

Design and subjects

This study was conducted according to the guidelines laid down by the Declaration of Helsinki; the Ethical Committee of the (Centro de Investigación en Alimentación y Desarrollo, A.C), approved all procedures involving human subjects. Written, informed consent was obtained from all subjects and/or their parents. Only there were included children who agreed to participate in the study and those without physical disabilities. This study was adapted from the cross-sectional protocol proposed by the European Childhood Obesity Group (11). We assessed 1,731 children, aged 7.0-9.9 y during 2006–2008. This age range was chosen for practical and physiological reasons. At this age, schooling is usually obligatory; thus, confounding factors, like variations in the age of puberty, did not affect selection.

Selection of the Sample

We analyzed data from the main geographic and socioeconomic areas of Mexico (northern,

central, and southern regions) (12). The term "indigenous" was defined as a community with a strong cultural identity that spoke a language different from Spanish. The term "ethnic group" could be applied to either an indigenous or non-indigenous population (13). Each geographic area comprised two states that represented the majority of two indigenous populations. The states were Sonora and Chihuahua (north), Puebla and Hidalgo (central), and Chiapas and Yucatan (south). Due to its population and its unique demographic and socioeconomic conditions, Mexico City (District of Coyoacan) was considered a separate region (14).

In each state, we selected municipalities with indigenous people that comprised at least 40% of the population. We studied six indigenous populations, including Mayo and Tarahumaras (north); Nahuas-Otomies (central), and Mayas and Tzotziles (south). Near the municipalities with high proportions (40%) of indigenous populations, we selected a second group of municipalities with populations that predominantly comprised non-indigenous Mexican people. These included capital cities and other towns. A total of 308 municipalities (80 with high proportions of indigenous people) were considered for the study.

After selection of geographic areas and municipalities, in each region, a probability proportionate to size, multistage cluster sampling method was used to select the participants. The sample size was determined based on census data obtained from the Ministry of Education, which indicated 567,106 children aged 7.0-9.9 years enrolled in the schools of selected areas. The overall prevalence of obesity was estimated to be 15% (11) with a 95% confidence level and an error of ± 4%. The rate of homogeneity was set at 0.02 for proportions of illness in general. For the present study, the cluster size was set at a minimum of 45 subjects per day. Each cluster corresponded to one school, and there were 39 schools (sampling units); this gave a total sample of 1,755 children. The municipalities were stratified by the proportion of indigenous or non-indigenous populations. Depending on the size of the schools and the age group, classrooms were randomly selected to form the clusters. The selection of subjects in each cluster was performed with random sampling. Random numbers were generated using Excel. Ethnicity was confirmed with the schoolteachers and the children's parents. We finally assessed 1,731 children from different regions and ethnic groups of Mexico. Twenty-four children were excluded because of missing values.

Anthropometric measurements

The anthropometric assessment was conducted from 07:30 to 10:30 AM in a classroom, library, or other suitable area. In each state, two trained technicians made all measurements according to standardized techniques (15). Height was measured with a stadiometer (Seca 225; Seca, Hamburg, Germany). Body weight was measured with a digital electronic scale (Seca 882; Seca). The technical error of measurement was 0.11 g for body weight and 0.12 cm for height, assessed as described by de Onis et al (15).

Analysis and cutoff points

Statistical analysis was performed with the statistical program NCSS 8 (NCSS 2012, LLC. Kaysville, Utah, USA). Characteristics of subjects were reported as the mean and standard deviation (SD). Prevalence data were expressed as percentages with a 95% confidence interval (95% CI). Both thinness and overweight status (obesity included) between indigenous and non-indigenous children were compared with a Chi-squared test. BMI was calculated as the ratio of weight to height squared (kg/m2). Z scores of BMI for age were computed for all children with WHO AthroPlus software (16). Percentiles of BMI for age were calculated with CDC Epi Info, Version 6 software (17). BMIs that corresponded to the adult cutoff points were calculated with the IOTF

LmsGrowth software (18). We used equivalent classifications to compare the three references, defined as thinness and overweight (obesity included). For school aged children, according to the WHO reference, thinness was defined as < -2 Z score from the mean value of the reference population. The IOTF criteria defined thinness (level 1) as a BMI < 18.5 kg/m^2. The CDC reference classified underweight as a BMI for age below the 5th percentile of the reference population. Overweight was defined by the WHO as > 1 Z score and obesity was defined as > 2 Z score from the mean value of the reference population. The IOTF criterion defined overweight as > 25 kg/m^2 and obesity as > 30 kg/m^2. The CDC classified risk of overweight as ≥ 85th percentile and overweight as ≥ 95th percentile of the reference population. Crosstabs test for related samples was used for differences between the three matched sets of frequencies.

RESULTS

Descriptive data (Table 1) showed that, with the WHO reference, the mean height for age Z score was < -1.0 in indigenous children from southern and central regions. In general, the rates of stunting (height for age Z score < -2.0) were higher in indigenous children than in non-indigenous children (22.8% vs. 4.1%). The mean BMI for age Z score was above the median (>0; WHO reference) in all ethnic groups.

Overall, the highest rates of thinness and obese children were generated with the WHO reference in both ethnic groups across all regions ($p < 0.05$; Tables 2 and 3). The largest difference between assessments of thinness was observed with the WHO and CDC references, in both indigenous and non-indigenous children (4% and 8.2%, respectively). The largest difference between overweight assessments was observed with the

TABLE 1. Basic characteristics of Mexican school-aged children of indigenous and non-indigenous populations

Variable	North				Central				South				Mexico city	
	Mayo-Tarahumara		Non-indigenous		Nahua-Otomie		Non-indigenous		Maya-Tzotzil		Non-indigenous		Non-Indigenous	
N	153		285		176		318		178		273		348	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age, y	8.5	0.9	8.4	0.9	8.4	0.7	8.5	0.8	8.3	0.8	8.4	0.8	8.6	0.8
Height/age, Z-score*	-0.60	1.05	0.09	0.98	- 1.04	1.00	-0.29	1.03	-1.70	0.98	- 0.55	0.98	0.11	1.02
BMI/age, Z-score*	0.02	0.9	0.44	1.45	0.10	0.99	0.67	1.43	0.13	0.97	0.51	1.54	0.77	1.56
BMI, kg/m^2	16.1	1.7	17.3	3.5	16.3	2.0	17.7	3.4	16.3	2.0	17.4	3.4	18.4	3.9
Females, %	49.7		46.0		51.1		51.9		47.8		50.6		51.6	
Height/age Z score <-2.0, % (n)*	8.5 (13)		2.8 (8)		19.9 (35)		5.4 (17)		39.9 (71)		5.9 (16)		2.3 (8)	

Abbreviations: SD; standard deviation.
* WHO Growth Child Standards.

TABLE 2. Prevalence (%) of thinness in children, assessed by CDC, IOTF, and WHO criteria

Region and reference†	Indigenous % (CI)	Non-indigenous % (CI)	All % (CI)
All Regions			
WHO	8.3 (2.0 - 21.0)	14.4 (9.6 - 20.5)	12.6 (8.5 - 17.8)
IOTF	7.1 (1.2 - 20.8)	12.2 (7.4 - 18.6)	10.7 (6.6 - 16.1)
CDC	3.9 (0.1 - 23.2)	6.2 (2.0 - 14.2)	5.5 (1.9 - 12.1)
North			
WHO	9.2 (0.5 - 36.6)	14.7 (5.7 - 29.0)	12.8 (5.4 - 24.4)
IOTF	8.5 (0.3 - 37.1)	11.9 (3.4 - 27.6)	10.7 (3.5 - 23.2)
CDC	3.3 (0.1 - 56)	5.6 (0.1 - 29.3)	4.8 (0.1 - 23.9)
Center			
WHO	8.5 (0.4 - 34.4)	12.0 (3.8 - 26.7)	10.7 (3.9 - 22.3)
IOTF	6.8 (0.1 - 36.5)	9.1 (1.7 - 25.7)	8.3 (2.0 - 21.2)
CDC	4.0 (0.1 - 46.3)	4.7 (0.03 - 29.2)	4.5 (0.1 - 22.8)
South			
WHO	7.3 (0.2 - 35.5)	16.1 (6.8 - 30.3)	12.6 (5.3 - 24.1)
IOTF	6.2 (0.1 - 37.5)	15.8 (6.5 - 30.1)	12.0 (4.8 - 23.7)
CDC	4.5 (0.0 - 43.2)	8.4 (1.0 - 27.6)	6.8 (0.9 - 21.9)
Mexico City			
WHO		14.9 (6.5 - 27.5)	
IOTF		12.4 (4.3 - 26.0)	
CDC		6.3 (0.4 - 25.4)	

Categorical variables are presented as percentages and confidence interval (CI). P values among ethnic groups were calculated using Chi square test: $p < 0.001$.
† Comparisons between references were analyzed with a crosstabs test for related samples: $p < 0.05$.

WHO and IOTF references, in both indigenous and non-indigenous children (4.9% and 5.4%, respectively). Therefore, the lowest prevalence of thinness in children was estimated with the CDC reference ($p < 0.05$). On the other hand, the lowest prevalence of overweight children was estimated with the IOTF reference.

Based on the WHO growth reference, both thinness and overweight status were more prevalent among non-indigenous than among indigenous children (thinness: non-indigenous 14.4%, indigenous 8.3%; $p < 0.001$; overweight: non-indigenous 38.2%, indigenous 13.4%; $p < 0.001$; Tables 2 and 3).

TABLE 3. Prevalence (%) of overweight (obesity included) children, assessed by CDC, IOTF, and WHO criteria

Region and reference†	Indigenous % (CI)	Non-indigenous % (CI)	All % (CI)
All Regions			
WHO	13.4 (6.4 - 23.8)	38.2 (33.8 - 42.8)	31.0 (27.1 - 35.1)
IOTF	8.5 (2.2 - 21.1)	32.8 (28.2 - 37.6)	25.7 (21.7 - 30.0)
CDC	9.3 (2.3 - 21.4)	34.8 (30.3 - 39.5)	27.3 (23.3 - 31.6)
North			
WHO	10.5 (1.0 - 35.9)	31.6 (22.2 - 42.3)	24.2 (16.4 - 33.5)
IOTF	7.2 (0.1 - 38.9)	24.6 (15.1 - 36.4)	18.5 (10.1 - 28.7)
CDC	8.5 (0.3 - 37.1)	27.7 (18.2 - 38.9)	21.0 (13.2 - 30.7)
Center			
WHO	16.5 (0.3 - 37.1)	39.3 (30.7 - 48.4)	31.2 (24.0 - 39.2)
IOTF	10.2 (1.1 - 33.6)	33.7 (24.8 - 43.5)	25.3 (18.0 - 33.9)
CDC	10.8 (1.4 - 33.5)	34.6 (25.8 - 44.3)	26.1 (18.8 - 34.6)
South			
WHO	12.9 (2.7 - 33.4)	34.4 (24.9 - 44.9)	25.9 (18.2 - 34.8)
IOTF	7.9 (0.3 - 34.9)	28.9 (19.2 - 40.2)	20.6 (12.9 - 30.2)
CDC	8.4 (0.4 - 34.3)	31.9 (22.3 - 42.8)	22.6 (14.9 - 31.9)
Mexico City			
WHO		45.7 (37.8 - 53.8)	
IOTF		42.0 (33.4 - 50.4)	
CDC		43.1 (35.1 - 51.4)	

Categorical variables are presented as percentages and confidence interval (CI). P values among ethnic groups were calculated using Chi square test: $p < 0.001$.
† Comparisons between references were analyzed with a crosstabs test for related samples: $p < 0.05$.

DICUSSION

This study showed that the WHO BMI for age reference estimated higher rates of thinness and overweight status than IOTF and CDC charts between 1,731 indigenous and non-indigenous from different geographic regions.

Comparison of the prevalence of thinness

Few studies have compared other references with the WHO reference for estimating thinness in school children from developing countries. It has been reported that the WHO reference estimated higher rates of low BMI for age than either the CDC (7, 10) or IOTF reference in children of Seychelles (19). Even compared with weight for height NCHS (National Center for Health Statistics) reference, the WHO BMI for age yielded twice the rate of thinness in 11 low income countries (7). In the present study, we found that indigenous children had low rates of

underweight status compared to non-indigenous children (BMI for age < -2 Z score: 8.3% vs.14.4%, respectively). This prevalence was similar to that reported for children in Burkina Faso (8.7%) and Mali (8.6%) (7). For centuries, regions with large indigenous populations have had the worst socioeconomic, educational, and health conditions in Mexico. Therefore, it might be expected to find that indigenous children would have the highest rates of low BMI for age. To stablish the clinical implication about using one or the other standard of reference, it is necessary to evaluate in prospective studies children that are thin, but not wasted, compared to those that are both thin and wasted (7). BMI differences among thin children can be due to differences in body composition. Therefore, BMI values among children should be interpreted with caution (20). In Mexico, like other countries, the use of thinness as an indicator of undernutrition status in children is relatively new. In addition, the use of terms like "wasting" (low weight for height) and "underweight" (low weight for age) should not be confused by adopting the term "thinness" (low body mass index for age) (21).

Comparison of the prevalence of overweight

As have other researchers, WHO reference yielded the highest rates of overweight status in children from developing and developed. In children from Nigeria, Canada, and the Czech Republic, the WHO reference produced the highest estimates of overweight status when compared to either CDC or IOTF references. In those studies, the prevalences of overweight children were different by 8.6% to 1%, when comparing WHO and CDC references (8, 22) and by 10.7% to 3.9%, when comparing WHO and IOTF references (8,23). In addition, the IOTF criteria always produced the lowest rates of overweight status. However, few studies have reported interethnic comparisons within a single country. We observed the greatest differences in overweight prevalence between WHO and IOTF in non-indigenous children (5.4%). Cut offs for overweight and obesity were analyzed separately, and in all cases (data not shown), the direction of the estimates were similar when comparing the three references for different regions or different ethnic groups (indigenous or non-indigenous children). Previous evidence indicated that the prevalence of overweight children varied according to region in Mexico (24, 25). However, that data was not consistent, because different references were used in different studies. The National Health Survey (ENSANUT) in Mexico and other research groups adopted the IOTF reference in 2006 and retained the CDC reference to assess stunting (24). A recent review and meta-analysis of the role of standard references suggest that a given reference may be more suitable for one country than others. The IOTF reference is used by researchers and policy makers for descriptive and comparative purposes. The 2000 CDC Growth Charts, and the WHO charts are used for clinical use in monitoring children's growth (9).

The differences in the prevalence of thinness and overweight estimates made with different references may have arisen due to differences in the datasets, smoothing methods, and analytical approaches (3, 5, 6). Although the WHO and IOTF references may be more useful than the CDC reference for international comparisons, it is uncertain whether their cut-off points are appropriate in non-represented countries. IOTF used Brazil to represent Latino children, but Brazil is probably the least representative of the ethnic diversity found in Latin America. Nevertheless, any country would not be the perfect representation of the region.

When the IOTF and CDC databases and cutoffs were used to detect overweight status and obesity in Swiss children, the IOTF system showed lower sensitivity, but higher specificity,

than the CDC reference (26). According to Cole et al (27), the IOTF obesity cutoffs had lower sensitivity (and high specificity) than the CDC cutoffs, because the cutoffs were closer to the high extreme of the distribution, which logically led to a lower prevalence of obesity. There are no well-established BMI cutoffs for assessing thinness in school children. Nevertheless, WHO and IOTF references have proposed different categories for evaluating thinness. The WHO reference defines thinness as < -2 Z score and severe thinness as <-3 Z score; the IOTF criteria defines thinness level 1 as < 18.5 kg/m2, thinness level 2 as < 17 kg/m2, and thinness level 3 as < 16 kg/m2. Further studies are necessary to clarify the health significance of the different definitions of underweight status proposed by the WHO and IOTF references.

It may be that, in Mexico, the adoption of the WHO reference for research could increase the prevalence of overweight and thinness, which may prematurely alarm the national health system. Evidence shows that the WHO reference produced higher rates of overweight and thinness than native growth charts (23). This was exemplified in a study in Hong Kong, which suggested that it was necessary to retain local references to prevent overdiagnosis and a probable increase in clinical workload (28). If the WHO 2007 reference were applied in China, there would be increases in the prevalence of short stature and underweight status, and 5.8 million additional children would be diagnosed as affected with both conditions (28). The CDC and IOTF references have been the most widely used in Mexico, but no standardized reference has been adopted. Since indigenous population represents almost twelve million people, the current inclusion of indigenous children in the national nutrition surveys could produce a misleading interpretation of the overall prevalence of overweight and underweight status; therefore, one of the most important issues in Mexico is to provide the best data reference system and the highest possible consistency over time for proper evaluations of nutritional status and intervention programs. We recommend that future studies analyze the prevalence of thinness and obesity using the WHO and IOTF references. Because thinness as indicator of undernutrition status in children is relatively new, differences in body composition among indigenous and non-indigenous children may justify the need for more appropriate screening criteria to compare the growth status. Future studies should clarify the health significance of the different categories of underweight and overweight status in both ethnic groups. In addition, further studies are necessary to test the sensitivity and specificity of the growth references regarding ethnicity and biomarkers.

In this study, different municipalities represented different geographic regions and different ethnic groups in Mexico. However, the sample was not representative of the school children, regions, or indigenous groups for all of Mexico. In addition, due to logistic constraints, information about the socioeconomic status of the families was not included. This study did provide new information about the importance of considering the reference criteria, the classification systems, the ethnicity, and the environments in a sample when reporting the overall prevalence of thinness and overweight status in children.

CONCLUSIONS

In conclusion, the WHO BMI for age reference generated higher rates of overweight and thinness than those found with the CDC and IOTF charts indigenous and non-indigenous school aged children from different regions and ethnic groups in Mexico. The IOTF reference generated the lowest prevalence of overweight status and the CDC reference generated the lowest prevalence of underweight status. Care must be taken when the WHO reference is used to estimate the growth status in indigenous and non-indigenous Mexican school children.

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REFERENCES

1. Kennedy G, Nantel G, Shetty P: Assessment of the double burden of malnutrition in six case study countries. In The double burden of malnutrition. Case studies from six developing countries. Edited by FAO. Rome; FAO Food Nutr Pap 2006, 84:1-18.
2. Secretaria de Salud: Acuerdo Nacional para la Salud Alimentaria: Estrategia contra el sobrepeso y la obesidad. Secretaría de Salud: México; 2010.
3. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J: Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007, 85:660–667.
4. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH: Establishing a standard definition for child overweight and obesity: international survey. BMJ 2000, 320:1240–1243.
5. Cole TJ, Flegal KM, Nicholls D, Jackson AA: Body mass index cut offs to define thinness in children and adolescents: international survey. BMJ 2007, 335:1–8.
6. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF, Johnson CL: 2000 CDC Growth Charts for the United States: Methods and development. Vital Health Stat 2002, 246:147–148.
7. Rousham EK, Roschnik N, Baylon MA, Bobrow EA, Burkhanova M, Campion MG, Adle-Chua T, Degefie T, Hilari C, Kalengamaliro H, Kassa T, Maiga F, Mahumane BJ, Mukaka M, Ouattara F, Parawan AR, Sacko M, Patterson DW, Sobgo G, Khandaker IU, Hall A. A comparison of the National Center for Health Statistics and new World Health Organization growth references for school-age children and adolescents with the use of data from 11 low-income countries. Am J Clin Nutr 2011, 94:571–577.
8. Fetuga MB, Ogunlesi TA, Adekanmbi AF, Alabi AD: Growth pattern of schoolchildren in Sagamu, Nigeria using the CDC standards and 2007 WHO standards. Indian Pediatr 2011, 48:523–528.
9. Ghanbari S, Ayatollahi SM. Comparing the role of standard references on the prevalence of Iranian children and adolescents' overweight and obesity: A systematic review and meta-analysis. J Res Med Sci 2016, 21:121.
10. Kain J. Uauy R, Vio F, Albala C. Trends in overweight and obesity prevalence in Chilean Children: comparison of three definitions. Eur J Clin Nutr; 2002:56:200-204.
11. Lehinge Y: The European Childhood Obesity Group (ECOG) project: the European collaborative study on the prevalence of obesity in children. Am J Clin Nutr 1999; 70(Suppl):166¬168.
12. Programa de las Naciones Unidas para el Desarrollo: Informe sobre desarrollo Humano México 2002. México; 2003.
13. Navarrete F. Los pueblos indígenas de México: CDI., México; 2008. 7–9.
14. Yamamoto-Kimura L, Posadas-Romero C, Posadas-Sánchez R, Zamora-González J, Cardoso-Saldaña G, Méndez Ramírez I: Prevalence and interrelations of cardiovascular risk factors in urban and rural Mexican adolescents. J Adolesc Health 2006, 38:591–598.
15. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R: Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food Nutr Bull 2004, 25(Suppl 1):27–36.

16. WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. Geneva; 2009. (http://www.who.int/growthref/tools/en/).
17. Dean AG, Dean JA, Coulombier D, Brendel KA, Smith DC, Burton AH, Dicker RC, Sullivan K, Fagan RF, Arner, TG: Epi Info, Version 6: a word processing, database, and statistics program for public health on IBM-compatible microcomputers. Centers for Disease Control and Prevention, Atlanta, Georgia, U.S.A; 1996.
18. Pan H, Cole TJ: lmsGrowth, a Microsoft Excel add-in to access growth references based on the LMS method. Version 2 .2., 2007. (www.healthforallchildren.co.uk /).
19. Bovet P, Kizirian N, Madeleine G, Blössner M, Chiolero A: Prevalence of thinness in children and adolescents in the Seychelles: comparison of two international growth references. Nutr J 2011, 10:65.
20. Freedman DS, Wang J, Maynard LM, Thornton JC, Mei Z, Pierson RN, Dietz WH, Horlick M: Relation of BMI to fat and fat-free mass among children and adolescents. Int J Obes 2005, 29:1–8.
21. WHO. Measuring Change in Nutritional Status; Guidelines for Assessing the Nutritional Impact of Supplementary Feeding Programmes for Vulnerable Groups: Geneva; 1983.
22. Shields M & Tremblay MS: Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. Int J Pediatr Obes 2010, 5:265–273.
23. Kunešová M, Vignerová J, Pařízková J, Procházka B, Braunerová R, Riedlová J, Zamrazilová H, Hill M, Bláha P, Steflová A: Long-term changes in prevalence of overweight and obesity in Czech 7-year-old children: evaluation of different cut-off criteria of childhood obesity. Obes Rev 2011, 7:483–491.
24. Moraes SA, Beltrán Rosas J, Mondini L, Freitas IC: Prevalence of overweight and obesity, and associated factors in school children from urban area in Chilpancingo, Guerrero, Mexico. Cad Saude Publica 2004, 22:1289–1301.
25. Villa-Caballero L, Caballero-Solano V, Chavarría-Gamboa M, Linares-Lomeli P, Torres-Valencia E, Medina-Santillán R, Palinkas LA: Obesity and socioeconomic status in children of Tijuana. Am. J. Prev. Med 2006, 30:197–203.
26. Zimmermann MB, Gübeli C, Püntener C, Molinari L: Detection of overweight and obesity in a national simple of 6-12-year-old Swiss children: accuracy and validity of reference values for body mass index from the US Centers for Disease Control and Prevention and International Obesity Task Force. Am J Clin Nutr 2004, 79:838–843.
27. Cole TJ, Flegal K, Dietz WH: Detecting obesity based on skinfold thincknesses. Am J Clin Nutr 2005, 81:196–197.
28. So HK, Nelson EA, Sung RY, Ng PC: Implications of using the World Health Organization growth reference (2007) for identifying growth problems in Hong Kong children aged 6 to 18 years. Hong Kong Med J 2011, 3:174–179.

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Suplementos nutricionales como modificadores de morbimortalidad en pacientes con cáncer

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RESUMEN: La caquexia, un síndrome multifactorial caracterizado por la pérdida de masa muscular con o sin pérdida de tejido adiposo que no puede ser revertido con soporte nutricional convencional, es frecuente en pacientes con enfermedades crónicas como cáncer, en quienes empeora notablemente su estado de salud. El objetivo de esta revisión fue estudiar el impacto que tienen los suplementos nutricionales en la morbimortalidad de los pacientes con caquexia secundaria a cáncer. Se realizó una búsqueda de literatura en las bases de datos Embase y Medline (Pubmed), sobre los suplementos y desenlaces clínicos en pacientes con caquexia secundaria a cáncer. Se excluyeron revisiones de literatura no sistemáticas, y aquellos que se centraran en otros desenlaces. Se seleccionaron 42 artículos, y se revisó su versión en texto completo. Se encontró que los ácidos grasos poliinsaturados aumentan el peso corporal; los antioxidantes podrían reducir la progresión del cáncer; selenio, zinc, hierro y cobre mejorarían el sistema inmunológico; y las proteínas y suplementos calóricos podrían reducir la lipólisis y proteólisis. Dentro de las limitaciones del estudio se encuentra la referencia a múltiples tipos de cáncer, con diferencias significativas en el tratamiento y el pronóstico de los pacientes. Se concluye que el soporte con suplementos nutricionales que contengan ácidos grasos poliinsaturados (EPA y DHA), micronutrientes (Fe, Cu, Zn, Se, vitamina E y C) y aminoácidos (l-arginina, l-glutamina, y b hidrometilbutirato), puede mejorar la morbimortalidad y por lo tanto la calidad de vida en pacientes con caquexia secundaria a cáncer.

Palabras clave: Cáncer, suplementos nutricionales, caquexia.

SUMMARY: Nutritional supplements as modifiers of morbidity and mortality in cancer patients. Cachexia, a multifactorial syndrome characterized by the loss of skeletal muscle mass with or without loss of fat mass that cannot be reversed by conventional nutrition support, is frequently present in patients with chronic diseases such as cancer, in whom the health status deteriorates markedly. The objective of this review was to study the impact of nutritional supplements on morbidity and mortality of patients with cachexia secondary to cancer. A literature search was conducted (Embase and Medline-Pubmed) looking for references that described associations between supplements and morbidity or mortality in patients with cachexia secondary to cancer. Non-systematic literature reviews, or studies with other non-clinical outcomes were excluded. A total of 42 articles were selected, and their full text version reviewed. We found that polyunsaturated fatty acids increase body weight; antioxidants reduce cancer progression; selenium, zinc, iron and copper improve the immune system and proteins and caloric supplements prevent lipolysis and proteolysis. Within the limitations of the study is the reference to multiple types of cancer, which in themselves present significant differences in treatment and prognosis of patients. As a conclusion, nutritional support with nutritional supplements containing polyunsaturated fatty acids (EPA-DHA), micronutrients (Zn, Se, Cu, Fe, vitamins C and E) and amino acids (l-arginine, l-glutamine and b hidroxymethylbutyrate) , can improve morbimortality and therefore quality of life in patients with cachexia secondary to cancer.

Key words: Cancer, nutritional supplements, cachexia.

INTRODUCCIÓN

La caquexia es un síndrome multifactorial asociado a una enfermedad subyacente, caracterizado por la pérdida de masa muscular con o sin pérdida de masa grasa que no puede ser revertido con soporte nutricional

convencional. Involucra un balance energético y proteico negativo producto de la combinación de disminución en la ingesta de alimentos y metabolismo anormal. En pacientes con cáncer como enfermedad de base se encuentra una afección del desempeño habitual y calidad de vida, e incluso una mayor tasa de mortalidad cuando se asocia a anorexia y pérdida involuntaria de peso de hasta un 30% (1,2).

Este proceso metabólico se asocia a carencia de componentes nutricionales, déficit anabólico para la formación de tejidos, resistencia a la insulina y aceleración catabólica secundaria a citoquinas inflamatorias como IL-1 e IL-6 y a factores tumorales como TNF alfa (1,3-5).

El estado caquéctico requiere de una terapia nutricional adecuada, por lo tanto se ha evaluado el uso de suplementos nutricionales para este fin. Entre los nutrientes estudiados se encuentran los ácidos grasos poliinsaturados como ácido eicosapentaenóico (EPA) y ácido docosahexaenóico (DHA) que ayudan a disminuir dichos componentes inflamatorios (6,7); el zinc (Zn), selenio (Se), cobre (Cu) y hierro (Fe) que actúan como cofactores para mejorar el metabolismo y a su vez el sistema inmune del huésped; los antioxidantes como las vitaminas C y E que disminuyen la concentración de los componentes tumorales, y los suplementos proteicos que revierten la marcada proteólisis que sufren los pacientes con caquexia (8,9).

El tratamiento que ha demostrado mejores resultados es el uso de suplementos proteicos haciendo énfasis en los aminoácidos esenciales como glutamina, la administración de lípidos y el uso de micronutrientes antioxidantes como Se, Cu, Fe, Zn y vitaminas C y E (10).

La caquexia se presenta con alta frecuencia en los pacientes con cáncer, con una prevalencia de aproximadamente 20 a 40% al momento de diagnóstico, y que aumenta con la progresión de la enfermedad hasta afectar a un 80% de los pacientes (9). El presente estudio busca revisar la evidencia en la literatura sobre el papel de los suplementos nutricionales mencionados para disminuir o revertir el deterioro nutricional.

MATERIALES Y MÉTODOS

Se hizo una búsqueda en la literatura de estudios clínicos que relacionaran los ácidos grasos Omega-3 (EPA y DHA), Se, Zn, Fe, Cu, suplementos energéticos y antioxidantes, con estado nutricional y caquéctico, pérdida de peso y morbimortalidad de los pacientes con caquexia secundaria a cáncer. Para ello, se emplearon las bases de datos Pubmed y Embase.

Los términos empleados en la búsqueda de Pubmed fueron: ("cachexia" OR "dietary supplements") AND ("neoplasms/therapy"). En Embase, las búsquedas se hicieron con los siguientes términos: dietary supplements'/exp OR 'dietary supplements' AND 'cancer' AND 'cachexia' AND ('article'/it OR 'article in press'/it OR 'review'/it).

Los artículos encontrados, fueron transferidos al programa de manejo de referencias Mendeley. Se excluyeron las revisiones de literatura no sistemáticas, y aquellos cuyo contenido no evaluara la relación entre suplementos nutricionales y caquexia.

Se seleccionaron ensayos clínicos, revisiones sistemáticas de la literatura, metanálisis, estudios de cohortes, estudios de casos y controles y estudios transversales. Se obtuvo la versión de texto completo de los artículos seleccionados, y se recogió la información sobre la intervención/exposición, el desenlace medido, la forma en que se midió el desenlace y el resultado principal de cada estudio.

RESULTADOS

Del total de 725 referencias filtradas, se encontraron 10 duplicadas, 3 fueron excluidas

por no encontrarse en texto completo y 670 por su contenido, finalmente se seleccionó un total de 42 artículos y se adquirió la versión en texto completo de los mismos. Los artículos encontrados exponen cómo los suplementos nutricionales influyen en la mejoría de la morbimortalidad y estado general y nutricional de los pacientes con caquexia secundaria a cáncer.

Dentro de los ensayos clínicos aleatorizados revisados se encontraron beneficios del suplemento con Zn y Se en pacientes con cáncer, mejorando el estado general y desacelerando en cierto modo la evolución de la enfermedad. El estudio de Federico et al (11) realizado en Italia suministró 200 mcg/día de Zn y 21 mg/día de Se, por un periodo de 50 días a un grupo 60 pacientes con diagnóstico de cáncer de tracto digestivo y reportó una mejoría en el estado general de la totalidad de pacientes, con aumento del apetito y disminución de la astenia, mientras en los no tratados la caquexia aumentó en un 80%.

En cuanto al efecto de este suplemento en la morbilidad asociada al tratamiento de cáncer, el estudio de Sieja et al (12) en Polonia, evaluó 31 pacientes con cáncer de ovario en suministro de Se en dosis de 200 mcg/día con disminución de la caída del cabello, astenia y dolor abdominal, aumento del apetito y del recuento leucocitario. De la misma manera el estudio de Muecke et al (13) en Alemania, con 81 pacientes con cáncer de cuello uterino suplementados con Se (300-500 mcg/día) encontró una posible mejoría de los efectos adversos de la radioterapia, con presencia de diarrea secundaria en el 20,5% de los pacientes tratados, comparado con un 44,5% en los pacientes de control, lo que concuerda con lo reportado por el estudio de Lin (14), en un estudio realizado en China con 100 pacientes con cáncer de cabeza y cuello con disminución considerable de la mucositis tras el suministro de Zinc (100 mg/día).

El uso de los antioxidantes también tiene un papel relevante, el estudio de Hanson (15) realizado en Suecia, reportó la ayuda de éstos en la inmunomodulación con aumento de linfocitos Natural Killer (NK) e interferón gama en 13 pacientes suplementados con 750 mg/día de Vitamina E. Por otro lado, los estudios de Joniau et al (16) y Grainger et al (17) con 100 y 41 pacientes respectivamente, incluyen el suplemento con vitamina E (25-30 mg/día) en pacientes con cáncer prostático, obteniendo disminución del antígeno prostático (PSA) hasta en un 35% (16-18)

Con respecto al suplemento con ácidos grasos (EPA/DHA) se ha descrito mejoría en el gasto energético basal de pacientes con cáncer, con regulación de la respuesta metabólica; adicionalmente se planteó que puede haber cierta influencia de los mismos en los factores de crecimiento tumoral, contribuyendo al pronóstico de la entidad (18-20). Barber (21), Read (22), Bauer (23), Weed (24), y Mantovanni (25) en sus estudios de 23, 200, 32, 20 y 332 pacientes respectivamente, determinaron que estos suplementos mejoran el estado nutricional de los pacientes con caquexia al aumentar el apetito, ganancia y estabilidad en peso, energía y masa corporal, aportados a una dosis promedio de 1 g/día, similar a lo reportado por Barber (26) y Yoshii (27) quienes indican que el uso de ácidos grasos contribuye al anabolismo y la modulación de síntesis de proteínas.

El estudio de Barber (28) realizado en el Reino Unido con 16 pacientes con cáncer de páncreas y caquexia asociada, sugiere que a pesar de los efectos benéficos que puede tener el EPA (2 g/día), el uso de este componente por sí solo no tiene un impacto significativo sobre la progresión de la enfermedad de estos pacientes .

Van der Meij (29), Mocellin (Brazil, 30), Finocchiaro (31) y Gómez (32) en sus estudios acerca del efecto de los suplementos con ácidos grasos (EPA) con una dosis mínima de 600 mg

y máxima de 1,5 g/día, en pacientes con cáncer de pulmón y colorrectal respectivamente, concluyeron que el grupo tratado tuvo una disminución en marcadores inflamatorios mejorando así su estado general. A su vez, Senkal (33), en su estudio llevado a cabo en Alemania, con 40 pacientes llegó a concluir que los suplementos con ácidos grasos a 3,7 g/día en pacientes con cáncer gastrointestinal mejoraban la incorporación de los lípidos a los tejidos (hígado 1.3% vs 0,4%, colon 0,8% vs 0,3%), y se asociaba con una mejor modulación inmunológica.

El estudio de Trabal (34), en España, evaluó la tolerabilidad a la quimioterapia en 13 pacientes con cáncer colo-rectal que recibían suplementos con ácidos grasos (6,1 g/día), demostrando que aquellos que recibían los suplementos tenían menos interrupciones en las quimioterapias por la disminución de los efectos adversos (0/6 vs 4/7 en grupo no tratado) y adicionalmente mayor ganancia de peso (aumento de 4.94 Kg vs pérdida de 1.17 Kg); lo anterior medido indirectamente a través encuestas de calidad de vida, con diferencia hasta de 10 puntos en el grupo tratado y haciendo énfasis en el control del dolor y disminución de la fatiga.

El estudio de Murphy (35,36), en Canadá, con 45 pacientes en quimioterapia, concluyó que el suplemento con aceite de pescado (2,5 g EPA+DHA) mejora la respuesta al tratamiento siendo esta de 60% en pacientes suplementados y 25,8 % en controles. El estudio de Pastore (37) en Brasil, evaluó el mismo efecto en pacientes con cáncer de pulmón y gastrointestinal y determinó que administrar 2,2 g al día de EPA en las primeras 72 horas posteriores a quimioterapia durante 4 semanas, no tenía un gran efecto y que al parecer el momento ideal para hacerlo no es antes de la quimioterapia, debido posiblemente a fallas en la adherencia.

A pesar de los estudios que sugieren los efectos benéficos de los suplementos nutricionales con ácidos grasos Omega-3, los estudios de Bruera (38) y Zuidjgeest (39), con 60 y 17 pacientes, sugieren que los suplementos con ácidos grasos tienen poco efecto en el estado nutricional y en la lipólisis de los pacientes con cáncer

Otros estudios evaluaron el efecto de los suplementos con aminoácidos esenciales como arginina, glutamina y el cuerpo cetónico b hidroxi butirato (40). El estudio de May (41), realizado en Estados Unidos con 33 pacientes concluyó que la administración de aminoácidos esenciales Hidroximetilbutirato (3 g/día), L-arginina (14 g/día), L-glutamina (14 g/día) en los pacientes con cáncer aumenta el peso corporal secundario a síntesis de grasa y disminución de proteólisis (aumento promedio de 0,95 Kg comparado con pérdida de 0,26 Kg).

Akutsu et al (42) en un estudio de casos y controles en Japón evaluaron el suplemento con Zn y Se en adición de Fe y Cu a dosis variables en 18 pacientes con cáncer esofágico, obteniendo buenos resultados en la homeostasis nutricional.

Inoue (43) en un estudio de cohortes en Estados Unidos con 2218 pacientes estableció que el uso de la vitamina E se asocia con menor riesgo de muerte por sus propiedades antioxidantes, con un 85% de los supervivientes en el grupo suplementado.

Kazi et al (44) en un estudio transversal en Pakistán, compararon los niveles de elementos de traza y tóxicos (arsénico y cadmio) en pacientes sanos y con cáncer hepático (n=144) antes y después del tratamiento con Se y Zn y concluyeron que el tratamiento es benéfico para la homeostasis metabólica en ambos casos (44).

Las revisiones sistemáticas revisadas acerca del uso de ácidos grasos arrojan resultados similares a los descritos anteriormente, recalcando efectos positivos de los suplementos nutricionales en la ganancia o mantenimiento del peso, se recomendó una dosis de ácidos grasos mayor a 1,5 g/día (45-46).

DISCUSIÓN

Los resultados obtenidos sugieren que los suplementos nutricionales tienen un impacto positivo en los pacientes con cáncer caquécticos y en no caquécticos, pues contribuye a mejorar su condición clínica, pronóstico y calidad de vida, haciendo énfasis en estabilidad en el peso e índice de masa corporal, mejoría de gasto energético, aumento del apetito, mejores niveles plasmáticos de proteínas y elementos de traza e incluso mejoría en efectos secundarios de la quimioterapia, dolor y fatiga.

Al analizar cada componente por separado, se observó que los suplementos con ácidos grasos poliinsaturados (EPA y DHA), los cuales son uno de los más utilizados en los estudios, mejoran las reservas energéticas de los pacientes con cáncer, así como su metabolismo evitando la disminución de peso y por lo tanto de masa corporal (18,19). Adicionalmente tienen efectos importantes en reducir el avance de las enfermedades neoplásicas al disminuir los factores proinflamatorios como IL-1 e IL-6 e interferir con la producción del factor potenciador de cadenas ligeras kappa de las células B (NF-kB), promotor de neoplasia (20,29-32,41). Sin embargo, una minoría de estudios no reportaron beneficios significativos de esta conducta, lo que sugiere la necesidad de ampliar la información acerca de la utilidad de los suplementos con ácidos grasos teniendo en cuenta el estadío de la enfermedad y el tipo de cáncer (39,47).

Otros suplementos incluidos en el análisis son los elementos de traza como zinc, selenio hierro, cobre y las vitaminas que actúan como catalizadores de procesos enzimáticos, específicamente el sistema antioxidante, reduciendo de esa manera las lesiones oxidativas de procesos inflamatorios que conducen a carcinogénesis. Múltiples estudios determinaron que estos componentes influyen positivamente en el sistema inmunológico y por lo tanto en la pronta recuperación de los pacientes. Se sustentó que la deficiencia de zinc y selenio está implicada en la patogénesis y progreso de esta enfermedad, y por lo tanto este tratamiento representaría una mejoría del estado general, así como una mayor tolerancia de los efectos adversos asociados al tratamiento de cáncer (11-13,44,48). Adicionalmente, se observó que el uso de hierro y cobre también tiene efectos positivos sobre los pacientes pues ayudan a establecer la homeostasis nutricional, evitando una desnutrición severa; lo anterior abriría campo al uso de micronutrientes desde el momento del diagnóstico de la enfermedad y en lo posible, su suministro simultáneo al tratamiento planteado (42).

Con respecto a vitaminas antioxidantes como la vitamina E y la C, se evidenció un rol importante de los mismos al disminuir la expresión de radicales libres y modular el sistema inmunológico, lo cual podría impactar positivamente el curso de la enfermedad, haría falta la realización de estudios que impliquen un seguimiento a largo plazo para estandarizar esta conducta (15,48).

Por último, se analizaron los beneficios de los aminoácidos esenciales como Hidroximetilbutirato, L-arginina y L-glutamina. Se infiere que estos suplementos promueven la síntesis proteica, aumentando la masa corporal que es lo que pierden esencialmente los pacientes con caquexia (40,42).

De manera general, en los estudios revisados se observó que cada elemento contenido en los suplementos tiene un efecto relevante en la salud de los pacientes con estas condiciones, evidenciándose mejoría en peso corporal, reservas energéticas, reducción de la progresión de la enfermedad, mejoría del sistema inmunológico, recuperación del estado nutricional y tolerancia al tratamiento complejo que requieren las personas con estas enfermedades; sin embargo, cabe mencionar

que muchas veces las dosis suprafisiológicas de estos suplementos pueden tener efectos contrarios. Dentro de las limitaciones del estudio se encuentra la referencia a múltiples tipos de cáncer, los cuales por sí mismos presentan diferencias significativas en el tratamiento y el pronóstico de los pacientes.

Cabe resaltar que la variabilidad en los resultados obtenidos tras el análisis de la información podría atribuirse a las diferentes posologías manejadas en los estudios, además de la diferencia en el tiempo de seguimiento, tamaño de muestra y en la medición de gasto energético y medidas ponderales.

CONCLUSIONES

Los resultados observados en esta revisión de la literatura sugieren un beneficio con el uso de suplementos nutricionales como Vitamina C y E, elementos traza (Cu, Zn, Se, Fe), aminoácidos esenciales y ácidos grasos poliinsaturados como modificadores de la morbimortalidad en pacientes con caquexia secundaria a cáncer. Sin embargo, no se tiene suficiente información para definir en qué momento de la enfermedad deben admnistrarse. Estos suplementos no sólo ayudan en los aspectos nutricionales, sino que además influyen positivamente en la calidad de vida, se asocian con menor cantidad y severidad de efectos adversos en el tratamiento, específicamente quimioterapia y al parecer podrían retrasar la progresión de la enfermedad.

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REFERENCIAS

1. Donohoe C, Ryan A, Reynold J. Cancer cachexia: mechanisms and clinical implications. Gastroenterol Res Pract. 2011; 2011:1-13.
2. Fearon K, Strasser F, Anker SD, Bosaeus I, Bruera E, Fainsinger RL, et al. Definition and classification of cancer cachexia: an international consensus. Lancet Oncol. 2011; 12(15):489-95.
3. Mazzotta P, Jeney CM. Anorexia-cachexia syndrome: a systematic review of the role of dietary polyunsaturated fatty acids in the management of symptoms, survival, and quality of life. J Pain Symptom Manage. 2009; 37(6):1069–77.
4. Campo J, García-Luna P, Pereira J. Causas e impacto clínico de la desnutrición y caquexia en el paciente oncológico. Nutr Hosp. 2006; 21(3):10-6.
5. Baviera T, Ferriols F. El síndrome caquéctico en el paciente oncológico: fisiopatología, manifestaciones clínicas y tratamiento farmacológico. Farm Hosp. 2003; 27:308-16.
6. Barber MD. Cancer cachexia and its treatment with fish-oil-enriched nutritional supplementation. Nutrition. 2001; 17:751–75.
7. Planas M, Puiggrós C, Redecillas S. Contribución del soporte nutricional a combatir la caquexia cancerosa. Nutr Hosp. 2006; 21(3):21-7.
8. Gill C. The role of nutritional supplements in the treatment of cachexia in cancer patients [Internet]. 2007 [consultado julio de 2016]. Disponible en: http://www.touchoncology.com/system/files/private/articles/1253/pdf/onco7607.pdf
9. Lancheros-Páez L, Merchán-Chaverra R, Martínez-Anaya L. Tamización del riesgo nutricional en el paciente oncológico. Rev Fac Med. 2014; 62(1):57-64.
10. Murphy RA, Yeung E, Mazurak VC, Mourtzakis M. Influence of eicosapentaenoic acid supplementation on lean body mass in cancer cachexia. Br J Cancer. 2011; 105 (10):1469-73.
11. Federico A, Lodice P, Federico P, Del Río A, Mellone MC, Catalano G, et al. Effects of selenium and zinc supplementation on nutritional status in patients with cancer of digesive tract. Eur J Clin Nutr. 2001; 55(4):293-7.
12. Sieja K, Talerczyk M. Selenium as an element in the treatment of ovarian cancer in women receiving chemotherapy. Gynecol Oncol. 2004; 93(2):320–7
13. Muecke R, Micke O, Schomburg L, Buentzel J, Glatzel M, Baaske D, et al. Impact of treatment

planning target volumen (PTV) size on radiation induced diarrhoea following selenium supplementation in gynecologic radiation oncology - a subgroup analysis of a multicenter, phase III trial. Radiat Oncol. 2013; 8:72.

14. Lin Y-S, Lin L-C, Lin S-W, Chang C-P. Discrepancy of the effects of zinc supplementation on the prevention of radiotherapy-induced mucositis between patients with nasopharyngeal carcinoma and those with oral cancers: subgroup analysis of a double-blind, randomized study. Nutr Cancer. 2010; 62(5):682–91.
15. Hanson MG V, Özenci V, Carlsten MC, Glimelius BL, Frödin JE, Masucci G, et al. A short-term dietary supplementation with high doses of vitamin e increases NK cell cytolytic activity in advanced colorectal cancer patients. Cancer Immunol Immunother. 2007; 56(7):973–84.
16. Joniau S, Goeman L, Roskams T, Lerut E, Oyen R, Van Poppel H. Effect of nutritional supplement challenge in patients with isolated high-grade prostatic intraepithelial neoplasia. Urology. 2007; 69(6):1102–6.
17. Grainger EM, Schwartz SJ, Wang S, Unlu NZ, Boileau TW-M, Ferketich AK, et al. A combination of tomato and soy products for men with recurring prostate cancer and rising prostate specific antigen. Nutr Cancer. 2008; 60(2):145–54.
18. Moses WG, Slater C, Preston T, Barber MD, Fearon KCH. Reduced total energy expenditure and physical activity in cachectic patients with pancreatic cancer can be modulated by an energy and protein dense oral supplement enriched with n-3 fatty acids. Br J Cancer. 2004; 90(5):996–1002.
19. Barber MD, Fearon KC. Tolerance and incorporation of a high-dose eicosapentaenoic acid diester emulsion by patients with pancreatic cancer cachexia. Lipids. 2001; 36(4):347–51.
20. Fahrmann JF, Ballester OF, Ballester G, Witte TR, Salazar AJ, Kordusky B, et al. Inhibition of nuclear factor kappa B activation in early-stage chronic lymphocytic leukemia by omega-3 fatty acids. Cancer Invest. 2013; 31(1):24–38.
21. Barber MD, Ross J, Voss C, Tisdale MJ, Fearon KC. The effect of an oral nutritional supplement enriched with fish oil on weight-loss in patients with pancreatic cancer. Br J Cancer. 1999; 81(1):80–6.
22. Read J, Beale PJ, Volker DH, Smith N, Childs A, Clarke SJ. Nutrition intervention using an eicosapentaenoic acid (EPA)-containing supplement in patients with advanced colorectal cancer. Effects on nutritional and inflammatory status: A phase II trial. Support Care Cancer. 2007; 15(3):301–7.
23. Bauer J, Capra S, Battistutta D, Davidson W, Ash S. Compliance with nutrition prescription improves outcomes in patients with unresectable pancreatic cancer. Clin Nutr. 2005; 24(6):998–1004.
24. Weed H, Ferguson M, Gaff R, Hustead D, Nelson JN, Voss N. Lean body mass gain in patients with head and neck squamous cell cancer treated perioperatively with a protein and energy-dense nutritional supplement containing eicosapentaenoic acid. Head Neck. 2011; 33(7):1027–33.
25. Mantovani G, Macciò A, Madeddu C, Serpe R, Massa E, Dessì M, et al. Randomized phase III clinical trial of five different arms of treatment in 332 patients with cancer cachexia. Oncologist. 2010; 15(2):200–11.
26. Barber MD, Preston T, McMillan DC, Slater C, Ross J a, Fearon KCH. Modulation of the liver export protein synthetic response to feeding by an n-3 fatty-acid-enriched nutritional supplement is associated with anabolism in cachectic cancer patients. Clin Sci. 2004; 106(4):359–64.
27. Yoshii R, Yokoyama J, Ohba S, Fujimaki M, Kojima M, Ikeda K. Impact of EPA nutritional approach on cachexic patients with advanced hypopharyngeal cancer treated by induction chemotherapy. Surg Oncol. 2014; 6(2):2–5.
28. Barber MD, McMillan DC, Preston T, Ross J, Fearon KC. Metabolic response to feeding in weight-losing pancreatic cancer patients and its modulation by a fish-oil-enriched nutritional supplement. Clin Sci. 2000; 98(4):389–99.
29. Van der Meij B, Langius J, Smit E, Spreeuwenberg M, Von Blomberg BM, Heijboer AC, et al. Oral nutritional supplements containing (n-3) polyunsaturated fatty acids affect the nutritional status of patients with stage III non-small cell lung cancer during multimodality treatment. J

Nutr. 2010; 140(10):1774-80.

30. Mocellin M, Pastore e Silva J, Camargo C, Fabre M, Gevaerd S, Naliwaiko K, Moreno Y, Nunes E, Trindade E. Fish oil decreases C-reactive protein/albumin ratio improving nutritional prognosis and plasma fatty acid profile in colorectal cancer patients. Lipids. 2013; 48(9):879–88.
31. Finocchiaro C, Segre O, Fadda M, Monge T, Scigliano M, Schena M, et al. Effect of n-3 fatty acids on patients with advanced lung cancer: a double-blind, placebo-controlled study. Br J Nutr. 2012; 108(2):327–33.
32. Gómez-Candela C, Villarino Sanz M, Horrisberger A, Loria Kohen V, Bermejo L, Zamora, Auñón P. Evaluación de la eficacia de un suplemento oral en polvo enriquecido con ácido eicosapentaenoico en un grupo de pacientes con cáncer. Nutr Hosp. 2011; 26(6):1385–93.
33. Senkal M, Haaker R, Linseisen J, Wolfram G, Homann H-H, Stehle P. Preoperative oral supplementation with long-chain Omega-3 fatty acids beneficially alters phospholipid fatty acid patterns in liver, gut mucosa, and tumor tissue. J Parenter Enteral Nutr. 2005; 29(4):236–40.
34. Trabal J, Leyes P, Forga M, Maurel J. Potential usefulness of an EPA-enriched nutritional supplement on chemotherapy tolerability in cancer patients without overt malnutrition. Nutr Hosp. 2010; 25(5):736–40.
35. Murphy R, Mourtzakis M, Chu Q, Baracos V, Reiman T, Mazurak V. Supplementation with fish oil increases first-line chemotherapy efficacy in patients with advanced nonsmall cell lung cancer. Cancer. 2011; 117(16):3774–80.
36. Murphy R, Mourtzakis M, Chu Q, Baracos VE, Reiman T, Mazurak VC. Nutritional intervention with fish oil provides a benefit over standard of care for weight and skeletal muscle mass in patients with nonsmall cell lung cancer receiving chemotherapy. Cancer. 2011; 117(8):1775–82.
37. Pastore C, Orlandi S, Gonzalez M. Introduction of an Omega-3 enriched oral supplementation for cancer patients close to the first chemotherapy: May it be a factor for poor compliance? Nutr Cancer. 2014; 66(8):1285–92.
38. Bruera E, Strasser F, Palmer JL, Willey J, Calder K, Amyotte G, et al. Effect of fish oil on appetite and other symptoms in patients with advanced cancer and anorexia/cachexia: a double-blind, placebo-controlled study. J Clin Oncol. 2003; 21(1):129–34.
39. Zuijdgeest-Van Leeuwen SD, Dagnelie PC, Wattimena JL, Van den Berg JW, Van der Gaast A, Swart GR, et al. Eicosapentaenoic acid ethyl ester supplementation in cachectic cancer patients and healthy subjects: effects on lipolysis and lipid oxidation. Clin Nutr. 2000; 19(6):417–23.
40. Madeddu C, MacCiò A, Astara G, Massa E, Dessì M, Antoni G, et al. Open phase II study on efficacy and safety of an oral amino acid functional cluster supplementation in cancer cachexia. Med J Nutrition Metab. 2010; 3(2):165–72.
41. May PE, Barber A, D'Olimpio JT, Hourihane A, Abumrad NN. Reversal of cancer-related wasting using oral supplementation with a combination of beta-hydroxy-beta-methylbutyrate, arginine, and glutamine. Am J Surg. 2002; 183(4):471–9.
42. Akutsu Y, Kono T, Uesato M, Hoshino I, Murakami K, Fujishiro T, et al. Are additional trace elements necessary in total parenteral nutrition for patients with esophageal cancer receiving cisplatin-based chemotherapy? Biol Trace Elem Res. 2012; 150(1-3):109–15.
43. Inoue-Choi M, Greenlee H, Oppeneer SJ, Robien K. The association between postdiagnosis dietary supplement use and total mortality differs by diet quality among older female cancer survivors. Cancer Epidemiol Biomarkers 2014; 23(5):865–75.
44. Kazi TG, Kolachi NF, Afridi HI, Kazi NG, Sirajuddin, Naeemullah, et al. Effects of mineral supplementation on liver cirrhotic/cancer male patients. Biol Trace Elem Res. 2012; 150(1-3):81–90.
45. Martinez-Alonso M, Dusso A, Ariza G, Nabal M, Porta-Sales J, Alonso A, et al. The effect on quality of life of vitamin D administration for advanced cancer treatment (VIDAFACT study): protocol of a randomised controlled trial. BMJ Open. 2014; 4:e006128–e006128.
46. Colomer R, Moreno-Nogueira JM, García-Luna P, García-Peris P, García-de-Lorenzo A, Zarazaga A, et al. N-3 fatty acids, cancer and cachexia: a systematic review of the literature. Br J Nutr. 2007; 97(5):823–31.
47. Burns CP, Halabi S, Clamon G, Kaplan E, Hohl

RJ, Atkins JN, et al. Phase II study of high-dose fish oil capsules for patients with cancer-related cachexia: A cancer and leukemia group B study. Cancer. 2004; 101(2):370–8.

48. Fuchs-Tarlovsky V, Bejarano-Rosales M, Gutiérrez-Salmeán G, Casillas MA, López-Alvarenga JC, Ceballos-Reyes M. Efecto de la suplementación con antioxidantes sobre el estrés oxidativo y la calidad de vida durante el tratamiento oncológico en pacientes con cáncer cérvico uterino. Nutr Hosp. 2011; 26(4):819–26.

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Comparison of nonnutritive artificial sweetener consumption among university students in Latin American: Multicentric Study

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SUMMARY: The Objective this study is to compare the consumption of artificial sweeteners by sex and BMI status among university students in Peru, Chile, Guatemala and Panama. Survey of consumption of artificial sweeteners containing foods was designed and applied, adapted for each country with pictures of surveyed foods. After the survey application, a total of 1,229 participants male and female both university students from 4 different Latin American countries: Chile (n=473); Panama (n=300); Guatemala (n=253); Peru (n=204) were submitted to a anthropometry measeurement. Over 80% of students ate at least 1 food that contained artificial sweeteners, acesulphame-k, sucralose, and aspartame had the highest levels of consumption. Females in Chile and Guatemala ate the most sucralose (25.7 (6.6-50.9), p<0.05; 38.3 (15.1-82.5). Males in Panama ate the most acesulphame-k, (35.3 (11.5-91.5), p<0,05). Females had a positive correlation between artificial sweetener consumption and BMI for: acesulphame-k, aspartame and cyclamate. Males had a negative relationship between acesulphame-k, aspartame and BMI (p<0.05). We found a high consumption of artificial sweeteners among both male and female Latin Americ an university students, with differences by country, sex and BMI status.

Key words: Artificial sweeteners, estimated intake, nutritional status, acesulphame-k, saccharin.

RESUMEN: Comparación en el consumo de edulcorantes no nutritivos en estudiantes universitarios latinoamericanos: Estudio Multicéntrico. El objetivo del estudio es comparar el consumo de edulcorantes artificiales no nutritivos por sexo y estado nutricional (IMC) entre los estudiantes universitarios en Perú, Chile, Guatemala y Panamá. Se diseñó y aplicó una encuesta de consumo de alimentos que contienen edulcorantes artificiales no nutritivos, adaptado para cada país con fotos de alimentos encuestas. Posteriormente se aplicó la encuesta y una evaluación antropometrica entre 1.229 estudiantes universitarios en 4 diferentes países de América Latina: Chile (n = 473); Panamá (n = 300); Guatemala (n = 253); Perú (n = 204). Más del 80% de los estudiantes comía al menos 1 alimento que contiene edulcorantes artificiales, acesulfamo-K, sucralosa, aspartame y tenían los niveles más altos de consumo. Las mujeres en Chile y Guatemala comsumieron más sucralosa (25,7 (6,6-50,9), p <0,05; 38,3 (15,1-82,5). Los hombres de Panama comsumían más acesulfamo-K, (35,3 (11,5-91,5), p <0,05) Las mujeres tenían una correlación positiva entre el consume de edulcorante artificial y el IMC para: acesulfamo-K, aspartamo y ciclamato hombres tenían una relación negativa entre el acesulfamo K, aspartamo y el IMC (p <0,05). Encontramos un alto consumo de edulcorantes artificiales entre los estudiantes de ambos sexos en las universidades de América Latina, con diferencias por país, sexo e IMC.

Palabras clave: Edulcorantes no nutritivos, ingesta estimada, estado nutricional, acesulfame-k, sacarina.

INTRODUCTION

Artificial sweeteners are food additives that have the ability to simulate the presence of sugar in food (1). These sweeteners are available across the primary food markets of the world and are added to many different types of foods.

Additionally, because these sweeteners have little or no calories they have high consumer acceptance, as many consider them to be healthy and help maintain weight (2). Artificial sweeteners have been available since the late 1800s. More recently the consumption of these types of sweeteners has increased in many countries. Saccharin, cyclamate, aspartame, acesulphame-k (or acesulphame potassium), sucralose, neotame, alitame and stevia are among the most common artificial sweeteners.

The first three substances: saccharin, cyclamate, aspartame are known as first generation sweeteners. After which came second generation sweeteners , which include acesulphame-k, sucralose, neotame, alitame that have different market inflection points(3).

Cyclamate was discovered in the United States in 1937. This sweetener is sodium and calcium cyclamic acid and has high water solubility. It is 30-50 times sweeter than sugar. As it is a less intense sweetener, it is mixed with sodium saccharin in order to increase its sweetening effect (3).

Saccharin is the oldest artificial sweetener. Saccharin is a sulphonamide, whose hydrogen atom is somewhat acidic and readily forms salts. Sacchairne is approximately 300 times sweeter than sugar and has zero calories (1).

Aspartame was discovered in 1965. It is an artificial sweetener comprised of a methyl ester of a dipeptide formed by the L - aspartic acid and L - phenylalanine. It is 180 to 200 sweeter than sugar and has 4 calories per gram (4).

Acesulphame-k is 200 times sweeter than sugar. It was discovered in 1967 and chemically composed of the potassium salt of 6-methyl-1,2,3-oxathiazine-4 (3H)-one 2,2-dioxide. It is a stable sweetener that has good water solvability, although at high concentrations it has a bitter taste. It cannot be metabolized and is thus secreted, without any change, in the urine (4).

Sucralose is an artificial sweetener discovered in 1976 composed of 1.6 dichloro - 1,6 dideoxy - β-D-fructofuranosyl - 4 - chloro - 4 deoxy - αD - galactopyranoside obtained by selective halogenation of the sucrose molecule. It is 600 times sweeter than sugar and has no calories (4).

Stevia is a subtropical jungle plant from the highlands of Paraná is also native to the northeast region of Misiones, Paraguay where the indigenous people use it for medicinal purposes. The stevia plant produces a natural sweetener, 300 times stronger than sucrose with no calories. Its leaves can be used in a natural form and because of its strength as a sweetener only a small amount is needed (5, 6).

The use of artificial sweeteners has been associated with health lifestyles, including maintaining weight within the normal range. Advertisements for healthy foods that contain artificial sweeteners have increased and have the power to influence young consumers, who use these sweeteners for weight maintenance and because of family environment (7).

Despite the increase in use of artificial sweeteners in food, little or nothing is known about the consumption of artificial sweeteners among young people in Latin America. The aim of the study was to compare the consumption of artificial sweeteners among a sample of university students in Peru, Chile, Guatemala and Panama.

MATERIAL AND METHODS

Cross-sectional studies. We studied 1,229, male and female university students (public and private universities) between the ages of 18-26; among which 472 were from Chile (private), 300 from Panama (private), 253 from Guatemala (public) and 204 from Peru (public), the implementation of the surveys was between June and November 2014. The sample size for each country was calculated based on a study by Arcella (8) with a 95% confidence interval and

90% power and precision calculated as observed sample size – recommended value. The study had a non-probabilistic.

The criteria of inclusion used in the study were; being a university student with metabolic diseases and type 1 diabetes and those who did not complete the data entry forms were excluded (were excluded students for not having completed all information). Students were asked to sign an informed consent and over 27 years old. The study protocol was reviewed and approved by the IRBs at the different university sites. The study was developed following the Helsinki Declaration with respect to studies conducted with human subjects and was approved by the local ethics committee beings. Finally the compliance with STROBE has been addressed in this study.

Foods that contain artificial sweeteners and liquid and powdered sugar substitutes were sampled in each country through visits to markets. Each product was photographed and numbered. The survey contained sweetener a)milk products (yogurt, milk, etc), b)breakfast cereals, granola bars, c) liquid and powdered juices, d) carbonated beverages and energy drinks, e)cookies, f) flan/ custard, jello, and g) sugar substitutes used to sweeten coffee and tea (tablet and liquid forms). A total of 122 products were sampled in Chile, 109 in Panama, 29 in Guatemala, and 124 in Peru.

To determine the consumption of artificial sweeteners, a survey of weekly food consumption was adapted for each country (only foods that contain artificial sweeteners were asked).

The survey was analysed using Excel. For the analysis of the survey, we considered type and amount of each artificial sweetener determined by the additives listed on the nutritional label per 100 g or ml.

Weight was measured using an electronic precision scale (GAMMA ®) with sensitivity of 0.1 kg, which allowed consumption per kilo of weight to be calculated. Height was measured with a stadiometer attached to the scale. Nutritional status was determined using body mass index (BMI), calculated as weight (kg) / height^2 . Normal BMI was defined as 18.5-24.9; overweight 25.0-29.9; and obesity >= 30 kg/m^2.

Data were analysed using an Excel spreadsheet and SPSS 19.0. To evaluate the normality of

TABLE 1. Comparison of anthropometric variables in Latin American university students

	Chile Mean ± SD	Peru Mean ± SD	Guatemala Mean ± SD	Panama Mean ± SD
Females	n=317	n=140	n=217	n=216
Age (years)	20.9 ± 2.5	22.0 ± 2.2	22.3 ± 3.2	24.8 ± 7.9
Weight (k)	58.8 ± 7,7^{b}	57.1 ± 9,0^{a}	57.3 ± 9.5^{c}	61.5 ± 11.6^{a,b,c}
Height (m)	1.61 ± 0.05^{a}	1.57 ± 0.06^{a,b,c}	1.59 ± 0.06^{b}	1.60 ± 0.06^{c}
BMI (k/m^2)	22.6 ± 2.5^{a}	22.8 ± 3.2	22.3 ± 3.6^{b}	23.7 ± 4.2^{a,b}
Males	n=155	n=64	n=36	n=84
Age (years)	21.2 ± 2,6	22.6 ± 2,9	22.3 ± 3.2	23.6 ± 6.5
Weight (k)	73.5 ± 11.1	69.1 ± 12.3^{a}	74.2 ± 12.6	77.1 ± 16.4^{a}
Height (m)	1.73 ± 0.07	1.70 ± 0.08^{a}	1.74 ± 0.07^{a}	1.72 ± 0.08
BMI (k/m^2)	24.4 ± 2.9	23.8 ± 2.8^{a}	24.2 ± 3.2	25.7 ± 4.9^{a}

Anova and Bonferroni post-hoc test. A,b,c, same letters indicate significant differences (p<0,05)

continuous variables (age, weight, height, and consumption of artificial sweeteners) we used the Shapiro Wilk goodness of fit test. For comparisons by sex we used Student t or Mann-Whitney for normally and non-normally distributed variables, respectively. To compare by country we used either ANOVA or Kruskal-Wallis tests. For correlations we used Pearson or Spearman correlations depending on the normality of the variable. For all tests $p<0.05$ was considered statistically significant.

RESULTS

The sample consisted of 1,229 university male and female students of different majors: health, education, engineering, law. Over 80% of the sample consumed at least 1 food per day that contained an artificial sweetener. The sweeteners with the highest intake were acesulphame-k, sucralose, and aspartame (Figure 1,2 and 3), 9.3% of students in Peru consumed stevia, compared to 1.9% in both Panama and Chile. Cyclamate and saccharin were only consumed in Chile, among 23% and 25.8% of students, respectively.

Comparing consumption (Table 2,3) between countries (kilos of weight), we found significant differences women in Guatemala have the highest consumption of acesulphame-k ($p<0.05$), Chile women show the highest consumption of sucralose ($p<0.05$), Panama women show the highest consumption of aspartame ($p<0.05$). For Panama men have the highest consumption of acesulphame-k and aspartame ($p<0.05$).

We found differences by sex and country only between Chile and Guatemala, with Chilean females consuming the most acesulphame-k, sucralose, and cyclamate ($p<0.05$) and Guatemalan females consumed more aspartame, acesulphame-k and sucralose ($p<0.05$).

We found no significant correlation among males in Chile and Panama between consumption (per kilo of weight) and BMI. Among males in Peru and Guatemala, however, consumption

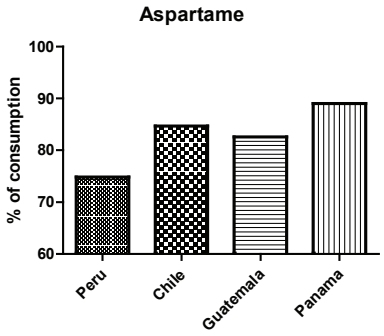

FIGURE 1. Prevalence of consumption of aspartame by country.

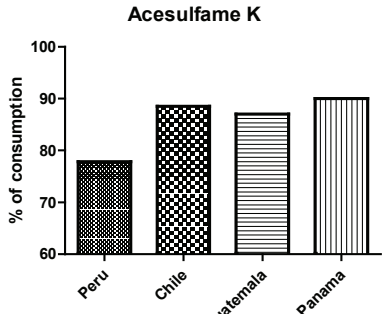

FIGURE 2. Prevalence of consumption of acesulfame k by country

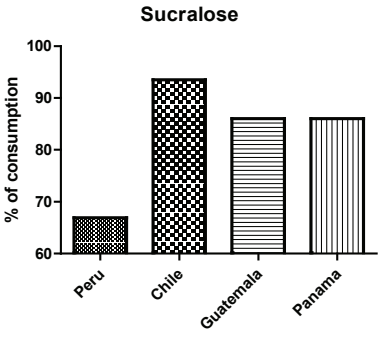

FIGURE 3. Prevalence of consumption of sucralose by country

TABLE 2. Comparison of artificial sweeteners consumption by sex

	Mean ± SD		P-value
Chile	Males	Females	
Acesulphame-k Kg/ wt	0.3 (0.03-0.8)	0.8 (0.1-1.03)	0.018
Aspartame kg/ wt	0.7 (0.07-1.8)	1.0 (0.9-2.3)	0.108
Sucralose kg/wt	0.3 (0.09-0.8)	0.6 (0.2-1.5)	0.001
Cyclamate kg/wt	0.0 (0.0-0.0)	0.0 (0.0-0.02)	0.009
Saccharin kg/wt	0.0 (0.0-0.0)	0.0 (0.0-0.01)	0.046
Peru			
Acesulphame-k Kg/ wt	0.2 (0.0-1.4)	0.1 (0.0-1,1)	0.58
Aspartame kg/ wt	0.6 (0.0-3.7)	0.3 (0.01-3.3)	0.886
Sucralose kg/wt	0.3 (0.0-0.9)	0.3 (0.0-1.2)	0.63
Guatemala			
Acesulphame-k Kg/ wt	0.1 (0.04-0.6)	0.8 (0.1-1.8)	0.001
Aspartame kg/ wt	0.4 (0.1-1.7)	2.1 (0.1-4.7)	0.014
Sucralose kg/wt	0.04 (0.1-0.6)	0.5 (0.2-1.1)	0.017
Panama			
Acesulphame-k Kg/ wt	0.4 (0.1-0.9)	0.3 (0.1-0.9)	0.729
Aspartame kg/ wt	0.9 (0.3-2.3)	0.9 (0.3-2.8)	0.579
Sucralose kg/wt	0.09 (0.01-0.4)	0.1 (0.04-0.4)	0.065

Mann Whitney test

TABLE 3.Comparison of artificial sweeteners consumption by countries

Mens	Chile Mean ± SD	Perú Mean ± SD	Guatemala Mean ± SD	Panama Mean ± SD
Acesulphame-k Kg/ wt	0.3 (0.03-0.8)	0.2 (0.0-1.4)	0.1 (0.04-0.6)	0.4 (0.1-0.9)#
Aspartame kg/ wt	0.7 (0.07-1.8)	0.6 (0.0-3.7)	0.4 (0.1-1.7)	0.9 (0.3-2.3)#
Sucralose kg/wt	0.3 (0.09-0.8)	0.3 (0.0-0.9)	0.04 (0.1-0.6)	0.09 (0.01-0.4)
Cyclamate kg/wt	0.0	(0.0-0.0)	-	-
Saccharin kg/wt	0.0	(0.0-0.0)	-	-
Women	Chile Mean ± SD	Perú Mean ± SD	Guatemala Mean ± SD	Panama Mean ± SD
Acesulphame-k Kg/ wt	0.8 (0.1-1.03)	0.1 (0.0-1,1)	0.8 (0.1-1.8)#	0.3 (0.1-0.9)
Aspartame kg/ wt	1.0 (0.9-2.3)	0.3 (0.01-3.3)	2.1 (0.1-4.7)	0.9 (0.3-2.8)#
Sucralose kg/wt	0.6 (0.2-1.5)#	0.3 (0.0-1.2)	0.5 (0.2-1.1)	0.1 (0.04-0.4)
Cyclamate kg/wt	0.0 (0.0-0.02)			
Saccharin kg/wt	0.0	(0.0-0.01)		

different from other county ($p<0.05$), test used Anova post hoc Bonferroni

of aspartame and acesulphame-k and BMI were negatively correlated. We found positive correlations among females in Peru, Chile and Guatemala between BMI and total consumption, consumption per kilo of weight of acesulphame-k, aspartame and cyclamate (only in Chile).

Acceptable daily intake of sucralose is between 0-15, 0-40 for aspartame, 0-7 for cyclamate, 0-5 of saccharin, 0-15 of acesulphame-k and (11). For acesulfame-k, no student surpassed this amount, with the highest consumption being 58.7% of acceptable daily intake. Consumption of cyclamate beyond daily acceptable intake levels was reported by 1 Chilean student and 2 Chileans reported consuming above acceptable levels of sucralose.

DISCUSSION

The intake of artificial sweeteners has greatly increased across Latin America, as was shown in our study and other research conducted in Latin America. Among a sample children and adolescents in Chile report that 99.6% of elementary school children sampled ate food with artificial sweeteners (9), attributed mostly to consumption of zero calorie, inexpensive, carbonated drinks, whereas a multicenter study which was carried out on Latin American University Students which evaluated the intake of sugarless beverages showed that 80% of the students consumed at least 1 cup of a beverage without sugar per day (10).

In a study conducted among Brazilian adults, Zanini et al (11) found 22.7% of females and 13.9% of males ate foods with non-nutritive sweeteners. A study conducted in the U.S. that used the National Health and Nutrition Examination Survey (NHANES) (12), found that 15% of the population consumed artificial sweeteners present in food and drinks. It is important to mention that comparisons between countries should be evaluated with caution because of differences in methods, instruments used, study populations and time period evaluated.

The high levels of artificial sweeteners consumed in our study can be attributed to the intake of carbonated beverages, juices (ready-made and powder forms), and sweetened milk products (i.e. flavour yogurt).

Artificial sweeteners are typically used as a nutritional aid to those who need to reduce their consumption of sugar or calories or need to manage their weight (13). Our differing results for men and women related to BMI and consumption of artificial sweetener is important to highlight, where BMI was positively related to sweetener intake in women, but not men. This may be related to advertisement that focuses primarily on the female consumer. Higher education level is also related to higher artificial sweetener intake, which may be related to an increased concern among persons of higher education levels to maintain a healthy weight. Another explanation may be that foods containing nonnutritive sweeteners (light or diet foods) are considered healthy products and that persons with greater education have higher access to these foods which are generally more expensive.

Among the surveyed countries, Chile was the only one in which cyclamate and saccharin were consumed on a daily basis. Very little was consumed or these particular sweeteners are not available in the other countries surveyed. There is a tendency to replace cyclamate and saccharin for other no nutritive sweeteners (9) included sucralose, aspartame, acesulfame-k and stevia (natural sweetener), possibly because of studies conducted in animal models showing an increased risk of bladder cancer (14) indicating that cyclamate and saccharin may negatively affect health. The role of artificial sweeteners in cancer risk has been widely debated since 1970, when researchers found an increased risk of bladder cancer among rodents given extremely high doses of saccharin (14). Later epidemiological studies also found increased risk among humans

(14), although more recent studies do not find such association (15). Boselli and colleagues (16), for example, found no association between consumption of saccharin and risk of mouth, pharynx, oesophagus, larynx, breast, colon, rectal, kidney, ovarian, or prostate cancer. Later is was shown that the carcigenic effect of saccharin was specific to certain species (17). Despite these findings, consumer groups are against the use of saccharin and especially cyclamate in food products.

Traditionally it is thought that substituting artificial sweeteners for sugar can be an effective strategy to control weight, although findings are mixed (13). A modelling study recently published shows that a decrease of 40% of free sugars added to sweetened beverages for more than 5 years would result in an average reduction in energy consumption of 38.4 kcal per day (95% CI: 36.3-40.7) at the end of the fifth year. This would lead to an average reduction of 1.20 kg (1.12 - 1 .28) in steady-state body weight in adults, which would result in a decrease of 1.0 percent(from 35.5% to 34.5%) in overweight and 2.1 percent in obesity (from 27.8% to 25.7%) (18).

That artificial sweeteners do not satisfy appetite as well as sugar does is another issue under debate. It is even suggested that artificial sweeteners stimulate hunger and activate pleasure receptors, leading to eating in excess and an addiction to sweet foods (19).

Recent findings demonstrate an increase in the expression of transporters utilized in the intestinal absorption of glucose (SGLT1) and the induction and translocation of glucose transporters (GLUT2) in the membrane border when consuming artificial sweeteners. The increase of these changes could facilitate absorption and metabolism of ingested sugars (20). In the case of consumption of artificial sweeteners, however, since these changes are not accompanied by sugar intake, they may increase energy consumption. Additionally, a recent study has shown changes in the microbiota when consuming sweeteners. This is the case with a consumption equivalent to the IDA, favoring glucose intolerance (21). However, other studies show inconsistent results (22).

Studies in humans have documented the activation of different neural pathways in the hypothalamus when caloric sweeteners are consumed compared to artificial sweeteners, indicating that differences in sweeteners can be detected (23). Taken as a whole, these findings advance the hypothesis that the consumption of sweet, but non-caloric, foods produce significantly different effects compared to the consumption of sugar sweetened foods. These effects could, over time, contribute to a positive energy balance and an increase in body weight.

It is important that artificial sweeteners—the amount of each sweetner per serving size and for each 100 g or mls of prepared food—be listed on nutritional labels. Additionally, the daily recommended amount in mg/kg of body weight per WHO/FAO recommendations should also be noted.

The consumption of artificial sweeteners may be increased in Latin America, due to an increment in taxes on sugary drinks as is currently happening in Mexico, Ecuador and Chile as well as the new food labeling standards for foods high in sugars and other nutrients associated to health risks, conducted in Chile, which has lead to the change from sugar to artificial sweeteners in food and beverages by the food industry.

Within the limitations is possible to name the sample y not aleatory and is a transversal study, in no possibility to name of causality only association. It is neither possible to realize sensibility and specificity analysis of the survey, and can mention this the a low sample of men, since in general the majority of the students was of the area of the health. The strength we can is a first study in different countries in Latin America,

use a validate food survey and in not a secondary data.

The current study demonstrated heterogeneous behaviour among the countries surveyed. Overall we observed high consumption of artificial sweeteners, especially among females. We also found that increased BMI was related to increase consumption among females, with the opposite being true in males. And finally, findings indicate consumption of artificial sweeteners within the daily recommended levels according to WHO/FAO standards. New products that contain artificial sweeteners arrive to markets daily, making the task of monitoring appropriate levels of consumption of these sweeteners difficult.

REFERENCES

1. Roberts JR. The paradox of artificial sweeteners in managing obesity. Curr Gastroenterol Rep. 2015;17(1):423.
2. Popkin BM, Nielsen SJ. The sweetening of the world's diet. Obes Res. 2003;11(11):1325-32.
3. Chattopadhyay S, Raychaudhuri U, Chakraborty R. Artificial sweeteners - a review. J Food Sci Technol. 2014;51(4):611-21.
4. Polyak E, Gombos K, Hajnal B, Bonyar-Muller K, Szabo S, Gubicsko-Kisbenedek A, et al. Effects of artificial sweeteners on body weight, food and drink intake. Acta Physiol Hung. 2010;97(4):401-7.
5. Wilinski B, Opoka W, Somogyi E, Piotrowska J, Wilinski J. Stevia, cyclamate and saccharin - natural and artificial sweeteners - exert no effect on sulfane levels in tissues. Folia Med Cracov. 2013;53(3):37-42.
6. Geuns JM. Stevioside. Phytochemistry. 2003;64(5):913-21.
7. Weihrauch MR, Diehl V. Artificial sweeteners--do they bear a carcinogenic risk? Ann Oncol. 2004;15(10):1460-5.
8. Arcella D, Le Donne C, Piccinelli R, Leclercq C. Dietary estimated intake of intense sweeteners by Italian teenagers. Present levels and projections derived from the INRAN-RM-2001 food survey. Food Chem Toxicol. 2004;42(4):677-85.
9. Duran Aguero S, Onate G, Haro Rivera P. Consumption of non-nutritive sweeteners and nutritional status in 10-16 year old students. Arch Argent Pediatr. 2014;112(3):207-14.
10. Duran Aguero S, Record Cornwall J, Encina Vega C, Salazar de Ariza J, Cordon Arrivillaga K, Cereceda Bujaico Mdel P, et al. Consumption of carbonated beverages with nonnutritive sweeteners in Latin American university students. Nutr Hosp. 2015;31(2):959-65.
11. Zanini R, Araújo C, Martínez-Mesa J. Use of diet sweeteners by adults in Pelotas, Rio Grande do Sul State, Brazil: a population-based study. Cad Saúde Pública. 2011;27:924-934.
12. Mattes RD, Popkin BM. Nonnutritive sweetener consumption in humans: effects on appetite and food intake and their putative mechanisms. Am J Clin Nutr. 2009;89(1):1-14.
13. Position of the American Dietetic Association: use of nutritive and nonnutritive sweeteners. J Am Diet Assoc. 2004;104(2):255-75.
14. Howe GR, Burch JD, Miller AB, Morrison B, Gordon P, Weldon L, et al. Artificial sweeteners and human bladder cancer. Lancet. 1977;2(8038):578-81.
15. Andreatta MM, Munoz SE, Lantieri MJ, Eynard AR, Navarro A. Artificial sweetener consumption and urinary tract tumors in Cordoba, Argentina. Prev Med. 2008;47(1):136-9.
16. Bosetti C, Gallus S, Talamini R, Montella M, Franceschi S, Negri E, et al. Artificial sweeteners and the risk of gastric, pancreatic, and endometrial cancers in Italy. Cancer Epidemiol Biomarkers Prev. 2009;18(8):2235-8.
17. Belpoggi F, Soffritti M, Padovani M, Degli Esposti D, Lauriola M, Minardi F. Results of long-term carcinogenicity bioassay on Sprague-Dawley rats exposed to aspartame administered in feed. Ann N Y Acad Sci. 2006;1076:559-77.
18. Ma Y, He FJ, Yin Y, Hashem KM, MacGregor GA. Gradual reduction of sugar in soft drinks without substitution as a strategy to reduce overweight, obesity, and type 2 diabetes: a modelling study. Lancet Diabetes Endocrinol. 2016;4(2):105-14.
19. Ma J, Bellon M, Wishart JM, Young R, Blackshaw LA, Jones KL, et al. Effect of the artificial

sweetener, sucralose, on gastric emptying and incretin hormone release in healthy subjects. Am J Physiol Gastrointest Liver Physiol. 2009;296(4):G735-9.

20. Pepino MY. Metabolic effects of non-nutritive sweeteners. Physiol Behav. 2015;152(Pt B):450-5.
21. Suez J, Korem T, Zeevi D, Zilberman-Schapira G, Thaiss CA, Maza O, et al. Artificial sweeteners induce glucose intolerance by altering the gut microbiota. Nature. 2014;514(7521):181-6.
22. Spencer M, Gupta A, Dam LV, Shannon C, Menees S, Chey WD. Artificial Sweeteners: A Systematic Review and Primer for Gastroenterologists. J Neurogastroenterol Motil. 2016;22(2):168-80.
23. Smeets PA, de Graaf C, Stafleu A, van Osch MJ, van der Grond J. Functional magnetic resonance imaging of human hypothalamic responses to sweet taste and calories. Am J Clin Nutr. 2005;82(5):1011-6.

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Ingredients of mayonnaise: Future perspectives focusing on essential oils to reduce oxidation and microbial counts

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SUMMARY: Low-acid mayonnaise produced with raw egg is a product rich in oil, almost a home-made product, but it is susceptible to lipid oxidation and microbial contamination by *Salmonella Enteritidis*, which results in deterioration of the product and forms undesirable components such as free radicals and reactive aldehydes. A better understanding of the factors that affect and can prevent lipid oxidation and microbial growth is essential to improve the product's lifetime. This review presents information on the factors that influence lipid oxidation and can accelerate the proliferation of microorganisms. Monitoring these possible factors can reduce the induction period that accelerates rancidity and ensure microbiological safety of the product, possibly increasing shelf life. The most effective means to slow lipid oxidation in mayonnaise and ensure its safety is the use of antioxidants and antimicrobials. Currently, several synthetic additives are being replaced by natural products such as essential oils. Therefore, to provide a better base for the food industry, an effective antioxidant and antimicrobial system must be designed for mayonnaise.

Key words: Mayonnaise; oil autoxidation, *Salmonella,* natural antioxidants, natural antimicrobials, essential oils.

RESUMO: Ingredientes para maionese: perspectiva do uso de óleos essenciais para redução da oxidação e da contaminação microbiana. A maionese de baixa acidez é um produto similar a maionese caseira, produzida com ovo *in natura* é um produto rico em óleo, susceptível à oxidação lipídica e contaminação microbiana por *Salmonella Enteritidis*, o que resulta em deterioração do produto e a formação de componentes indesejáveis, tais como os radicais livres e aldeídos reativos. Uma melhor compreensão dos fatores que afetam e que podem prevenir a oxidação de lipídios e multiplicação microbiana é essencial para melhorar o tempo de vida do produto. Esta revisão apresenta o conhecimento dos fatores que influenciam a oxidação lipídica e que podem acelerar a multiplicação de microrganismos. O acompanhamento destes fatores possíveis pode reduzir o período de indução que aceleram o ranço e garantir a segurança microbiológica do produto o que poderia aumentar o tempo de prateleira da maionese. Os meios mais eficazes para retardar a oxidação lipídica na maionese e garantir a sua segurança é a utilização de antioxidantes e antimicrobianos. Atualmente, diversos aditivos sintéticos estão sendo substituídos por produtos naturais, como os óleos essenciais. Portanto, para proporcionar uma melhor base para a indústria alimentar um sistema antioxidante e antimicrobiano eficaz deve ser concebido para maionese.

Palavras-chave: Maionese; auto-oxidação de óleos; *Salmonella*; antioxidantes naturais; antimicrobianos naturais; óleo essencial.

INTRODUCTION

Mayonnaise is a semisolid sauce formed by mixing vegetable oil, egg yolk, vinegar and salt and other optional seasonings (1). In the past 100 years it has been considered the most used sauce in the world (2). Its structure, creaminess, appearance, rheological behavior and stability parameters are of great importance for its sensory properties and texture, and hence consumers' choice and satisfaction (3).

From a colloidal point of view, mayonnaise is an oil-in-water emulsion with low pH, characterized by having very high oil content,

ranging from 65 to 85%, depending on the formulation (3).

Because of its acid taste, conventional manufactured mayonnaise has started to be rejected by some consumers and is being replaced by home-made mayonnaise, prepared with raw eggs and generally mixed with boiled potatoes and other vegetables, also known as low-acid mayonnaise (LAM) (4). However, the low acidity, consumption of this mayonnaise can pose a risk of microbial contamination. Nevertheless, many people choose to consume it because of its sensory characteristics (5).

The vegetable oil in the formulation of low-acid mayonnaise has nutritional and economic importance. Its unsaturated and saturated fatty acid composition will determine the oxidative stability of the final product. Soybean oil, for example, is more susceptible to oxidation than many other vegetable oils due to its high linoleic acid content, so the presence of antioxidants is necessary to ensure its oxidative stability (6).

There are several factors that can accelerate the lipid oxidation process of low-acid mayonnaise: the presence of transition metals (even in small amounts), which can accelerate oxidation, reducing the oil induction period and making it more susceptible to oxidation; storage temperature (higher temperatures accelerate the oxidation process); exposure to light, which can cause photolytic self-oxidation; pH; composition (oil concentration); and the use or not of antioxidants (1).

In all segments of the food industry, conservation of food is extremely important and mainly involves controlling the multiplication of microorganisms, which are responsible for the generation of risks to health and food spoilage. Microbial contamination has a significant influence on the quality of food. It can compromise safety due to the presence of pathogenic bacteria as well as conservation status by the multiplication of spoilage bacteria that reduce shelf life (7). Mayonnaise is particularly subject to microbial contamination by *Salmonella* spp.

There have been several reports in the international literature of health problems caused by homemade mayonnaise produced with raw egg (8). The composition of the mayonnaise and the pH are the factors that most influence its microbiological safety. Therefore, the industry has been using additional barriers to ensure the microbiological quality of mayonnaise as well as its stability. However, the additives used as "barriers" are not pleasing to many consumers, who prefer foods without artificial chemicals, generating a strong demand for products with fewer additives as well as natural substitutes (9).

Mayonnaise consumers are increasingly concerned about synthetic or artificial additives, so "healthier" versions have been developed (10). Butyl hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), are the most commonly used synthetic antioxidants, and show high efficacy, but their use in food has been partially restricted due to their adverse effect on the enzymes in human organs. Accordingly, there is currently great interest throughout the world in finding new antimicrobials and antioxidants from natural sources (11). The main alternatives that have been studied include plant extracts (12). Since the middle ages, essential oils have been widely used in medicinal and cosmetic applications due to their bactericidal, virucidal, fungicidal and insecticidal activities. With the growing preference of consumers for "natural" products, interest in these oils in the pharmaceutical, agricultural and food sectors is growing (13).

Essential oils (EO) are liquid mixtures of volatile compounds derived from aromatic plants, usually by steam distillation. They

constitute what is called the "essence" of plants and usually have pleasant fragrances. Essential oils have been used for millennia because of their perceived health benefits and beneficial cosmetic effects, well documented in ancient literature. Some of the beneficial properties described are antiseptic, antioxidant, antimicrobial and anti-inflammatory (14).

Essential oils are complex mixtures of individual compounds. Each of these compounds contributes to the beneficial and adverse effects of these oils. Therefore, knowledge of the essential oil composition allows better applications (15).

Regarding antimicrobial and antioxidant properties, several studies have been performed using different bacteria and fungi. The chemical activity is caused by the presence of terpenes and their oxygenated compounds. Each compound contributes to the biological activity of the essential oil (16). The antimicrobial activity of phenolic compounds present in essential oils increases with acid pH, which makes it essential to find oils suitable for use in low-acid mayonnaise (17,18).

Thus, it is relevant to investigate the possibility of replacing synthetic antioxidants and antimicrobials with essential oils in formulating mayonnaise.

This article focuses on knowledge of the physico-chemical parameters of low-acid mayonnaise, showing the influence of these parameters on the start of lipid oxidation, and the effect of essential oils on lipid oxidation and microbial growth, as well as the causes of deterioration if low-acid mayonnaise, by means of a review of the literature in the SciELO and ScienceDirect databases.

LIPID OXIDATION

Oxidation of unsaturated fatty acids has been the main focus of research into the instability of emulsions. Like all high-fat foods, low-acid mayonnaise is susceptible to deterioration due to self-oxidation of unsaturated fats in the oil (1).

Lipid oxidation is responsible for the development of unpleasant tastes and odors, making improper for consumption. It also causes other changes that affect not only the nutritional quality due to degradation of fat-soluble vitamins and essential fatty acids, but also integrity and food safety, through the formation of potentially toxic polymeric compounds (18).

Autoxidation is the main mechanism of oxidation of oils and fats. There is a sequence of interrelated reactions to explain the autoxidation process of lipids (19). This autoxidation is associated with the reaction of oxygen with unsaturated fatty acids and occurs in three stages: initiation, propagation and termination. During initiation, the formation of free radicals of fatty acid occurs due to the withdrawal of an allyl carbon hydrogen in the fatty acid molecule in favorable conditions of light and heat. In propagation, free radicals, which are readily susceptible to atmospheric oxygen attack, are converted into other radicals, producing the primary oxidation products (peroxides and hydroperoxides), whose structure depends on the nature of the fatty acids present. The free radicals formed act as reaction propagators, resulting in an autocatalytic process. At the end, the two radicals combine with the formation of stable products (secondary oxidation products) obtained by scission and rearrangement of peroxides (volatile and non-volatile epoxides) (18).

This lowers the nutritional value of food products as well as changes the color, texture and other sensory and physiological properties. The resulting lipid peroxidation from the reaction between the unsaturated fatty acids and molecular oxygen is a serious problem for the oil and fat industry. It not only deteriorates the quality of fatty foods and fatty acids, causing chemical damage, but also produces free and reactive oxygen radicals that are associated with carcinogenesis, mutagenesis, inflammation,

aging and cardiovascular disease. Because of this, consumers do not accept oxidized foods, causing losses to food producers (20).

For the purpose of inhibiting or retarding lipid oxidation of oils, fats and fatty foods, chemical compounds known as antioxidants are employed. However, although hundreds of compounds have been proposed to inhibit oxidative deterioration of oxidizable substances, only some can be used in products for human consumption (18).

FACTORS THAT INFLUENCE LIPID OXIDATION AND MICROBIAL GROWTH

Mayonnaise composition

Since 1756, various mayonnaise formulations have been described. Although the basic ingredients have always been the same, many other lesser ingredients can be used (2).

Mayonnaise can be divided according to the function of its components into three phases: oil phase, spice phase and egg yolk phase. The oil phase comprises the vegetable oil used in mayonnaise preparation. Among the most common oils used to make mayonnaise are soybean oil and sunflower oil. The spice phase consists of various seasonings, together with water-soluble food additives and water. The egg yolk phase acts as the emulsifier (21). Table 1 summarizes the various mayonnaise compositions found in the literature. The preparation is carried out with the mixture of egg, vinegar and then all other ingredients except the oil in a mixer or blender until they are homogeneous. Then the oil is gradually added until the sauce begins to thicken (22). Some formulations include ingredients such as mustard, pepper and corn starch. Brazilian law allows other ingredients to be added, provided there is no adulteration of the product (23). U.S. law (21 CFR §169,140) allows the use of spices and monosodium glutamate as long as mayonnaise color is not modified (24).

The use of vinegar in mayonnaise preparation is recommended since, in the pH range observed in this food, acetic acid presents a greater number of molecules than coupled citric acid. Furthermore, the addition is suggested of mustard in a concentration from 0.30 to 1.50%, along with garlic, due to the antimicrobial effect of the allyl isothiocyanate and allicin present in these spices, respectively. Vegetables such as carrots can also be added, resulting in absorption of acetic acid by the plant and, consequently, reduced bactericidal effect (27).

TABLA 1. Mayonnaise composition

Ingredients	Quantity (%)	References
Water	44	
Soy oil	20	
Dried egg	9	
Vinegar	9	21
Corn starch	9	
Sugar	4	
Salt	3	
Modified corn starch	2	
Corn oil	70	
Whole egg	19.1	
Salt	1.0	
Sugar	0.6	22
Lemon juice	1.6	
Vinegar	5.6	
Mustard	1.8	
White pepper	0.3	
Salt	2	
Sugar	1	
Mustard	1	25
Potassium sorbate	0.1	
Sodium benzoate	0.1	
Lemon juice	0.1	
Soy oil	76	
Egg yolk	7.7	
NaCl solution (10%)	3.95	26
EDTA solution 1%	0.54	
Vinegar 4% (acetic acid)	10.9	

Egg yolk is the most problematic ingredient of mayonnaise formulation, since eggs and egg-based products are often associated with outbreaks of food poisoning by *Salmonella*. The foods most often involved are mayonnaise, ice cream and other cold desserts that are prepared and consumed after addition of raw egg (28).

The yolks have a more favorable environment for bacteria than the whites due to pH and lipid content. Fresh egg yolk has pH values around 6.0, varying very little even in prolonged storage conditions. The physical and chemical changes in the viscosity of the white and permeability of the vitelline membrane is exacerbated by aging. Increased permeability allows *Salmonella* to reach the yolk. The penetration through the yolk vitelline membrane in experimentally infected eggs can occur after 24 hours at 25 °C. Once in the yolk, *Salmonella* can multiply at temperatures between 10 to 25 °C, and the number of bacteria increases rapidly at 25 °C (27).

Vertical transmission and horizontal transmission are possible routes by which *Salmonella* spp. can contaminate intact eggs. Several authors have reported that in birds, the serotype enteritidis can be transmitted vertically. Contamination of eggs by vertical transmission occurs when *Salmonella Enteritidis* bacteria enter the eggshell during or after oviposition, and contaminate the internal contents (27). It is difficult to completely avoid contact between the egg shell and chicken feces. The extent of fecal contamination of the shell determines the contamination level. Externally contaminated eggs have a risk of internal contamination through horizontal transmission and can cause cross-contamination of other foods in the kitchen (28).

Vinegar is one of the ingredients most often used to form an antimicrobial barrier. It is the most common acid used in the preservation of mayonnaise because it has antiseptic value and also helps prevent deterioration and rancidity (21). Vinegar is usually added together with other acids such as lactic acid to keep the pH of the mayonnaise low (between 3.3 and 3.8). The use of other acids avoids an overly strong acid taste caused by vinegar (29).

Salt improves the taste of the mayonnaise and acts as a preservative. Because salt is dissolved only in the aqueous phase, which is much smaller than the oil phase, it ends up having high concentration, and thus hinders microbial growth (30).

Water activity (Aw)

One of the main components of most foods is water. Water activity (Aw) is a parameter that measures the amount of free water in the food, being defined as the ratio between the partial water vapor pressure contained in the solution or in the food and the standard-state partial vapor pressure of water at a given temperature (31). Just like water activity, the moisture content of a food is very important because it is related to its stability, quality and composition, and can be affected during storage (32). Foods with excessive moisture or water activity near 1 are subject to rapid deterioration. This is the case of low-acid mayonnaise, which has water activity ≈ 0.97, where the emulsion formed is not sufficient to ensure low water activity, making this an essential parameter to determine the survival and growth of pathogens. Control of water activity is one of the oldest techniques of food preservation (33).

The temperature x Aw binomial is also extremely important to control microbial growth, since the exposure of *S. Enteritidis* to water activity of 0.95 at 21 °C increases the thermal resistance of this bacterium (27).

Hydrogen potential (pH) and acidity

The pH of low-acid mayonnaise varies from 3.6 to 4.0. The best viscoelasticity and stability are observed when the pH is near the isoelectric point of the egg yolk (34). Monitoring pH is essential to ensure the quality of mayonnaise, since a decrease in pH can have pro-oxidant effect,

breaking the existing bonds between the proteins of the egg yolk and iron. Subsequently, the iron becomes more accessible to oxidation. Also, the distribution of secondary oxidation products is pH-dependent (35). Low-acid mayonnaise, despite a better taste, degrades quickly at low pH (21). The main risk of low pH is multiplication of *Salmonella*, since the yolk is a natural culture medium, facilitating survival of the pathogen.

In the refining process, the acidity of vegetable oils is reduced as a quality control measure. With the occurrence of the non-enzymatic oxidation, oil acidity increases. The decrease in mayonnaise pH (increased acidity) during storage can be attributed mainly to the activity of microorganisms that are tolerant to acids, such as the lactic acid bacteria that are present in the aqueous phase in mayonnaise. In addition, these increases can be also be caused by the activity of hydrolytic and oxidative enzymes present in eggs (2).

ESSENCIAL OILS

Antioxidant activity of essential oils

Spices and herbs are excellent sources of antioxidants and have a long history of use. More than 5,000 years ago, the ancient Egyptians used spices and herbs (cumin, cinnamon and onions, among others) in their food, for medicinal purposes and for mummification. Several studies have shown that spices and herbs such as rosemary, sage and oregano, with their high content of phenolic compounds, serve as strong antioxidants (36).

Antioxidants are compounds that inhibit or delay the onset of oxidation and can be classified as natural or synthetic. Due to their components, spices and herbs are excellent sources of antioxidants for food preservation (36).

Due to market requirements, the use of synthetic antioxidants is being replaced more and more by natural antioxidants from plant sources. Many sources of antioxidants of vegetable origin have been studied in recent years, and numerous types of plants have been identified with various antioxidant activities (37).

It has been clearly demonstrated that plant-derived phenolic compounds have antioxidant properties. Research has demonstrated the strong phenolic character of essential oils from oregano (*Origanum vulgare*), thyme (*Thymus vulgaris L.*), wild thyme (*Thymus serpyllum L.*), rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*), nutmeg (*Myristica fragrans*), cinnamon (*Cinnamomum verum*), clove (*Syzygium aromaticum*), allspice (*Pimenta dioica*), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*) and paprika (*Capsicum annuum*) (10,37).

Even essential oils with low antioxidant activity can serve as intermediates in forming other compounds with antioxidant activity, such as linalool, which can be obtained from the essential oil of ho-sho. Linalool can be employed as an intermediate in synthesis of vitamin E, which has high antioxidant activity (38).

The antioxidant mechanism of phenolic compounds in lipids has not yet been fully explained (37).

Rosmarinic acid, caffeic acid, coumaric acid, quercetin, thymol and carvacrol are some of the compounds responsible for antioxidant activity of various essential oils (19). Laguori and Boskou (39) concluded that inhibition of oxidation of essential oils of oregano species is highly dependent on carvacrol and thymol content.

Table 2 presents some studies of antioxidant activity in the DPPH test, showing the IC50 (which is the concentration of essential oil required to reach 50% antioxidant activity) of some plants of interest. The larger the IC50, the lower the antioxidant activity of the oil is. In the DPPH test, the essential oil's ability to act as a donor of hydrogen atoms or electrons in the transformation of DPPH in the reduced form of DPPH - H (diphenyl picryl hydrazine) is measured spectrophotometrically. The DPPH is a free radical stable at room temperature, producing

TABLE 2. Main essential oils with antioxidant activity properties

Common name of the essential oil	Scientific name of the plant source	IC_{50} μg.mL-1	References
Garlic	*Allium sativum.* L.	88.14	36
Araticum	*Annona crassiflora* Mart	49.18	40
Cagaita	*Eugenia dysenterica* DC.	14.15	40
Lemon balm	*Melissa officinalis* L.	7.58	41
Guava	*Psidium guajava* L.	33.57	42
Guaco	*Mikania glomerata* Spreng.	1283.88	42
Basil	*Ocimum basilicum* L.	0.39	43
Oregano	*Origanum vulgare* L.	0.17	36,43
Capsicum	*Capsicum annuum* L.	906.08	42
Thyme	*Thymus vulgaris* L.	0.19	43

a violet solution in ethanol. In the presence of antioxidant compounds, the DPPH is reduced, producing a clear ethanol solution.

Table 3 summarizes the antioxidant compounds isolated from herbs and spices and their mode of action to inhibit or delay the oxidation of fats and oils in foods. Some antioxidants derived from spices and herbs react with the free radicals created during the early autoxidation stage. Others form complexes with metal ions (36).

Antimicrobial activity of essential oils

The antimicrobial effects of essential oils have been investigated against a wide range of microorganisms over the years, but the mechanism of action is still not completely understood (44). Essential oils typically contain many bioactive molecules and can consist of up to 45 different compounds. This structural diversity allows the presence of different modes of action that are responsible for acting in different cellular targets. Essential oils have various modes of action that can result in cell death, including cell wall disorders of bacteria by forming pores that result in increased permeability of the membrane and allow the release of cell components, reduction of intracellular pH and changes in the intracellular

TABLE 3. Antioxidants isolated from herbs and spices (36)

Spice/herb	Scientific name	Mode of action
Rosemary	*Rosemarinus officinalis*	Scavenge superoxide radicals, lipid antioxidant and metal chelator
Clove	*Eugenia caryophyllata*	
Cumin	*Cumimum cymimum*	Free radical scavenger, metal chelator
Sage	*Salvia officinalis* L.	
Oregano	*Origanum vulgaris*	
Thyme	*Thymus vulgaris* L.	Free radical scavenger
Ginger	*Zingiber officinale*	
Turmeric	*Curcuma domestica* L.	
Black pepper	*Piper nigrum* L.	
Chili pepper	*Capsicum frutescens* L.	

concentration of adenosine triphosphate (ATP) (7, 44). The presence of oxygenated monoterpenes, monoterpene hydrocarbons and aldehyde essential oils has the ability to inhibit the process of breathing and movement of ions and consequently leads to destruction of the bacterial cell (45).

The antimicrobial activity of an essential oil is due to the interaction effect between the major and minor compounds of the oil (15). Therefore, one of the most important factors in the study of their applicability is the chemical composition, which can vary within the same plant due to biological factors (genetics, nutrition and development stage) and edaphoclimatic factors (local climate and soil type) (46).

Antimicrobial agents such as essential oils and most antibiotics have hydrophobic character and can easily penetrate Gram-positive bacteria cell walls because this type of bacterium is rich in mucopolysaccharides and protein and low in phospholipids (15,38). The lipopolysaccharides (LPS) present on the surface of the outer membrane of Gram-negative bacteria have a repellent effect on the hydrophobic components of EO, hindering its entry through the cell wall. However, in a study by Dorman and Deans (47), carvacrol and thymol were able to cause disintegration of the outer membrane of Gram-negative bacteria, releasing lipopolysaccharides (LPS) and increasing the permeability of the cytoplasmic membrane to ATP (48).

The presence of divalent ions such as Mg^{2+} in LPS will increase the crosslink between molecules, thereby reducing the pore size and further limiting the passage of bioactive compounds (7). Table 4 shows the principal essential oils with microbial activity described in the literature.

The inappropriate use of antimicrobials results in the selection and the consequent spread of resistant strains of various microorganisms (27). The emergence of resistance of microorganisms such as *Salmonella* to antimicrobial drugs constitutes a double threat to humans and animals, due to the intense use of antimicrobials in human and veterinary medicine, requiring the use of other products that prevent the multiplication of microorganisms. The essential oils from oregano, thyme and cinnamon, among others, have significant antimicrobial potential (11).

In low-acid mayonnaise, the use of essential oils can be regarded as an additional obstacle to the survival and proliferation of Salmonella. However, their use in foods for preservation is limited due to the intense flavor and odor they give when used at effective doses. The addition of oregano essential oils (thymol and isotimol) at a sensorially acceptable concentration of 0.70% is a natural alternative that contributes to the intrinsic safety of mayonnaise, acting synergistically with low pH and low storage temperature (27).

CONCLUSION AND FUTURE PERSPECTIVES

Lipid oxidation in food products, along with the growth of undesirable microorganisms, results in the development of rancidity and spoilage, making the products unacceptable for human consumption. This review analyzed important factors affecting lipid oxidation and microbial growth in mayonnaise. With the monitoring of these parameters, it is possible to slow the lipid oxidation and increase the shelf life of low-acid mayonnaise. Other strategies to prevent oxidation should also be considered, such as reducing the concentration of oxygen in food (vacuum packaging) and decreasing the storage temperature. However, the exclusion of oxygen in a food is difficult, so one of the most effective means of delaying lipid oxidation in mayonnaise is to incorporate antioxidants.

Parallel to this, to prevent microbial contamination of low-acid mayonnaise, effective measures are the use of pasteurized egg yolk, refrigerated storage, modified atmosphere (carbon dioxide), control of acidity in the aqueous phase, proper choice of acid used, control of pH, type and quantity of used, and educational and

TABLE 4. Main essential oils with antimicrobial activity

Common name of the essential oil	Scientific name of the plant source	Major components	Composition (%)	References
Rosemary	*Rosmarinus officinalis*	1,8-cineol α-pinene Acetate bornila Camphor	3-89 2-25 0-17 2-14	49
Anise	*Illicium verum*	(E)-anetol Limonene Methyl-chavicol α –pinene	90.4 2.6 1.3 Traces	46
Cinnamon	*Cinnamomum zeylandicum*	Trans-cinnamaldehyde	65	11, 50
Shin-sassafras	*Ocotea odorífera*	Methyl eugenol Safrole Camphor 1,8-cineol	81.2 10.6 5.87 0.64	46
Lemongrass	*Cymbopogon citratus*	Citronelal limonene mirceno	5-48 2-16 1-8	51
Coriander (immature leaves)	*Coriandrum sativum*	Linalool E-2-decanal	26 20	52
Coriander (seeds)	*Coriandrum sativum*	Linalool	70	52
Clove	*Syzygium aromaticum*	Eugenol Acetate eugenila	75-85 8-15	53
Mentrasto	*Ageratum conyzoides*	precocene (E)-caryophyllene β-cubebeno, α-humuleno	87 7.10 Traces Traces	44
Ho-Sho	*Cinnamomum camphora* Ness	Linalool Caryophyllene Oxide Linalool oxide (trans) β- caryphyllene Oxide linalool (cis)	91.98 2.11 1.51 1.43 1.36	39
Oregano	*Origanum vulgare*	Carvacrol Thimol α-Terpinene p-Cimene	80 64 52 52	9, 46
Long pepper	*Piper hispidinervum*	Safrole α-terpinolene 3-carene	82.4 13.38 1.30	44
Sage	*Salvia officinalis* L.	Camphor 1,8-cineool β-pinene α-pinene	6-15 6-14 2-10 4-5	54
Thyme	*Thymus vulgaris*	Thimol p- Cimene α-Terpineno Carvacrol	10-64 10-56 2-31 2-11	55

informational measures directed to the preparation of the product, among others.

Similarly, the sale of mayonnaise at room temperature is an aspect that needs to be reviewed in Brazil by the National Health Surveillance Agency. Refrigeration would minimize the possible occurrence of contamination of egg yolks by *Salmonella* spp..

The use of essential oils in phytotherapy is related to activities of secondary metabolites, which have antimicrobial, spasmolytic, anti-viral and anti-carcinogenic activities, among others. In addition, many essential oils and isolated compounds of them have recently been recognized as powerful natural antioxidants, which could be used as potential substitutes for synthetic antioxidants.

In relation to conventional control methods employing synthetic antimicrobials and antioxidants with broad spectrum of action, the use of natural products such as essential oils stands out by showing good results.

As people become more concerned with their health, there is a global trend of using natural antioxidants and antimicrobials in food products. Several species can be used as sources of natural antioxidants and antimicrobials.

However, more studies need to be performed to evaluate the efficacy and safety of these products. In the particular case of mayonnaise, since contains a variety of different components, there is still a lack of knowledge about the influence of these components on the effectiveness of natural resources with antioxidant and antimicrobial activity. In addition, the elucidation of the mechanism of oxidation in mayonnaise and a better understanding of action and efficacy of such natural products with antioxidant and antimicrobial activity is of great technological importance to the food industry.

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REFERENCES

1. Gorji SG, Smyth HE, Sharma M, Fitzgerald M. Lipid oxidation in mayonnaise and the role of natural antioxidants: a review. Trends Food Sci Tech, 2016; 56: 88-102.
2. Kishk YFM, Elsheshetawy HE. Effect of ginger powder on the mayonnaise oxidative stability, rheological measurements, and sensory characteristics. Ann Agric Sci, 2013; 58 (2): 213-220.
3. Mattia C, Balestra F, Sachetti G, Neri L, Mastrocola D, Pittia P. Physical and structural properties of extra-virgin olive oil based mayonnaise. Food Sci Technol-LEB, 2015; 62 (1): 764-770.
4. Elias SO, Tomasco PV, Alvarenga VO, Sant'ana AS, Tondo EC. Contributor factors for the occurrence of salmonellosis during preparation, storage and consumption of homemade mayonnaise salad. Food Res Int, 2015; 78: 266-273.
5. Malheiros OS, De Paula CMD, Tondo EC. Cinética de crescimento de *Salmonella Enteritidis* envolvida em surtos alimentares no RS: uma comparação com linhagens de outros sorovares. Ciênc e Tecnol de Aliment, 2007; 27 (4):751-755.
6. Masuchi MH, Celeghini RMS, Gonçalves LAG, Grimaldi R. Quantificação de TBHQ (Terc Butil Hidroquinona) e avaliação da estabilidade oxidativa em óleos de girassol comerciais. Quím Nova, 2008; 31 (5): 1053-1057.
7. Danneberg GS, Funck GD, Mattei FJ, Silva WP, Fiorentini, AM. Antimicrobial and antioxidant activity of essential oil from pink pepper tree (*Schinus terebinthifolius Raddi*) in vitro and in cheese experimentally contaminated with *Listeria monocytogenes*. Innov Food Sci and Emerg Tech, 2016; 36: 120-127.

8. Luca ANB, Koerich GMD. Perfil Epidemiológico dos Surtos de DTA Causados por *Salmonella* sp. em Santa Catarina, Brasil, Notificados no SINAN NET de 2006 A 2008. 2009. 20 f. Monografia (Especialização) - Curso de Especialização em Microbiologia, Departamento de Microbiologia, Pontifícia Universidade Católica do Paraná, Curitiba, 2009.
9. Elias SO. Modelagem dos Parâmetros Cinéticos de Multiplicação de *Salmonella Enteritidis* SE 86 em Maionese Caseira e Práticas de Preparo, Estocagem e Consumo desse Alimento no Rio Grande do Sul. 2014. 104 f. Dissertação (Mestrado) - Programa de Pós Graduação em Microbiologia Agrícola e do Ambiente, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2014.
10. Nakatani N. Phenolic antioxidants from herbs and spices. Biofactors, 2000; 13: 141-146.
11. Santurio JM, Santurio DF, Pozzatti P, Moraes C, Franchini PR, Alves SH. Atividade antimicrobiana dos óleos essenciais de orégano, tomilho e canela frente à sorovares de *Salmonella* enterica de origem avícola, Ciênc Rural, 2007; 37 (3): 803-808.
12. Bakkali F, Averbeck S, Averbeck D. Biological effects of essential oils – A review. Food Chem Toxicol, 2008; 46 (2): 446-475.
13. Amorati R, Foti MC, Valgimigli L. Antioxidant activity of essential oils. J Agric Food Chem, 2013; 61: 10835-10847.
14. Lahlou M. Methods to study the phytochemistry and bioactivity of essential oils. Phytother Res, 2004; 18: 435-448.
15. Bouchekrit M, Laouer H, Hajji M, Nasri M, Haroutounian SA, Akkal S. Essential oils from Elaeoselinum asclepium: Chemical composition, antimicrobial and antioxidant properties. Asian Pac J Trop Biomed, 2016; 6 (10): 851-857.
16. Bajpai VK, Baek KH, Kang SC. Control of Salmonella in foods by using essential oils: A review. Food Res Int, 2012; 45: 722-734.
17. Sánchez-Maldonado AF, Schieber A, Ganzle MG. Structure-function relationships of the antibacterial activity of phenolic acids and their metabolism by lactic acid bacteria, J Appl Microbiol, 2011; 111: 1176-1184.
18. Ramalho VC, Jorge N. Antioxidantes utilizados em óleos, gorduras e alimentos gordurosos. Quím Nova, 2006: 29 (40): 755- 760.
19. Boroski M, Giroux H, Sabik H, Petit HV, Visentainer JV, Pintro PTM, Britten NM. Use of oregano extract and oregano essential oil as antioxidants in functional dairy beverage formulations. Food Sci Technol-LEB, 2012; 47: 167-174.
20. Robles-Ramírez MC, Monterrubio-López R, Mora-Escobedo R, Beltrán-Orozco MC. Evaluation of extracts from potato and tomato wastes as natural antioxidant additives. Arch Latinoam Nutr, 2016; 66 (1): 66-73.
21. Jaeger J. Produção de Maionese. 2012. 160 f. Trabalho de Conclusão de Curso (Engenharia Química) - Curso de Ciências Tecnológicas, Universidade Regional de Blumenau, Blumenau, 2012.
22. Amin MHH, Elbeltagy AE, Mustafa M, Khalil AH. Development of low fat mayonnaise containing different types and levels of hydrocolloid gum. J Agroaliment Proc Technol, 2014; 20 (1): 54-63.
23. Brasil. MINISTÉRIO DA SAÚDE. AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA. Resolução nº 276, de 22 de setembro de 2005. Aprova o Regulamento Técnico para Especiarias, Temperos e Molhos. Diário Oficial [da República Federativa do Brasil], Brasília, DF, 22 de setembro de 2005.
24. Food and Drug Administration. CFR - Code of Federal Regulations Title 21, PART 169 -FOOD DRESSINGS AND FLAVORING. Subpart B-Requirements for Specific Standardized Food Dressings and Flavorings. Sec. 169.140 Mayonnaise, 1993.
25. Silva JPL, Souza EF, Modesta RCD, Gomes IA, Silva OF, Franco BDGM. Antibacterial activity of nisin, oregano essential oil, EDTA, and their combination against *Salmonella Enteritidis* for application in mayonnaise. Vigil Sanit Debate, 2016; 4 (1): 83-91.
26. Rodrigues ML. Azeite de pequi: efeito do aquecimento em temperatura de fritura e utilização como ingrediente na formulação de maionese. 2011. 94 p. Dissertação (Mestrado) -

Escola de Agronomia e Engenharia de Alimentos da Universidade Federal de Goiás, Goiás, 2011.

27. Téo CRPA, Oliveira TCRM. *Salmonella* spp.: O ovo como veículo de transmissão e as implicações da resistência antimicrobiana para a saúde pública. Cienc Agrar, 2005; 26 (2): 195-210.
28. Gole VC, Roberts JR, Sexton M, May D, Kiermeier A, Chousalkar KK. Effect of egg washing and correlation between cuticle and egg penetration by various *Salmonella* strains. Int J Food Microbiol, 2014; 18: 182–183.
29. Jay JM. Modern Food Microbiology, 2000. 6 ed. Local de publicação: Aspen Publishers, 625 p.
30. Araújo JMA. Química de Alimentos: Teoria e Prática, 1995. Viçosa-MG: Imprensa Universitária, 355p.
31. Martin G. Comportamento de *Salmonella* em ovo em pó em função da Atividade de água (Aa) e do binômio Tempo x Temperatura de armazenamento. 2005. 81 p. Dissertação (Mestrado). Departamento de Alimentos e Nutrição Experimental, Faculdade de Ciências Farmacêuticas da Universidade de São Paulo, São Paulo, 2005.
32. Mattos DA, Araújo ES, Aragão SF, Fook SML, Vieira KVM, Meira CMBS, Santiago AM. Qualidade dos grãos de milho utilizados em uma indústria alimentícia de Campina Grande - PB, no período de 2004-2005. Rev Bras Toxicol, 2009; 22 (1-2): 34-41.
33. Ditchfield C. Estudo dos métodos para medida da atividade de água. 2000. 195 p. Dissertação (Mestrado). Escola Politécnica, Universidade de São Paulo, São Paulo, 2000.
34. Depree JA, Savage GP. Physical and flavour stability of mayonnaise. Trends Food Sci Tech, 2001; 12 (5): 157-163
35. acobsen C, Timm M, Meyer AS. Oxidation in fish oil enriched mayonnaise: Ascorbic acid and low pH increase oxidative deterioration. J Agric Food Chem, 2001; 49 (8): 3947-3956.
36. Embuscado ME. Spices and herbs: Natural sources of antioxidants – a mini review. J Funct Foods, 2005; 18: 1-10.
37. Kulisic T, Radonic A, Milos M. Inhibition of lard oxidation by fractions of different essential oils. Grasas Aceites, 2005; 56: 284-291.
38. Cansian RL, Mossi AJ, Oliveira D, Toniazzo G, Treichel H, Paroul N, Astolf V, Serafini LA. Atividade antimicrobiana e antioxidante do óleo essencial de ho-sho (*Cinnamomum camphora* Ness e Eberm Var. *Linaloolifera fujita*). Rev Ciênc Tecnol, 2010; 30 (2): 378-384.
39. Lagouri V, Boskou D. Nutrient antioxidants in oregano. Int J Food Sci Nutr, 1996; 47: 493-497.
40. Roesler R, Malta LG, Carrasco LC, Holanda RH, Sousa CAS, Pastore GM. Atividade antioxidante de frutas do cerrado. Ciênc Tecnol Aliment, 2007; 27 (1): 53-60.
41. Mimica-Dukic N, Bozin B, Sokovic M.; Simin M. Antimicrobial and antioxidant of *Melissa officinalis* L. (Laminaceae) essential oil. J Agric Food Chem, 2004; 52 (9): 2485-2489.
42. Vicentino ARR, Menezes FS. Atividade antioxidante de tinturas vegetais, vendidas em farmácias com manipulação e indicadas para diversos tipos de doenças pela metodologia de DPPH. Rev Bras Farmacogn, 2007; 17 (3): 384-387.
43. Bozin B, Mimica-Dukic N, Simin N, Anackov G. Characterization of the volatile composition of essential oils of some Lamiaceae spices and the animicrobial and antioxidant activities of the entire oils. J Agric Food Chem, 2006; 54 (5): 1822-1828.
44. Calo JR, Crandall PG, O'Bryan CA, Ricke SC. Essential oils as antimicrobials in food systems – A review. Food Control, 2015; 54: 111-119.
45. Hajji M, Masmoudi O, Souissi N, Triki Y, Kammoun S, Nasri M. Chemical composition, angiotensin I-converting enzyme (ACE) inhibitory, antioxidant and antimicrobial activities of the essential oil from *Periploca laevigata* root barks. Food Chem, 2010; 121 (3): 724-731.
46. Lima RK, Cardoso MG, Moraes JC, Carvalho SM, Melo BA, Vieira SS. Composição química e toxicidade de óleos essenciais para o pulgão-verde *Schizaphis graminum* (Rondani, 1852). Arq Inst Biol, 2014; 81 (1): 22-29.
47. Dorman HJD, Deans SG. Antimicrobial agents from plants, antibacterial activity of plant volatile

oils. J Appl Microbiol, 2000; 88: 308-316.

48. Burt S. Essential oils: their antibacterial properties and potential applications in foods-a review. Int J Food Microbiol, 2004; 94: 223– 253.
49. Daferera DJ, Ziogas BN, Polissiou MG. The effectiveness of plant essential oils in the growth of *Botrytis cinerea*, *Fusarium* sp. and *Clavibacter michiganensis subsp. michiganensis*. Crop Prot, 2003; 22 (1): 39-44.
50. Lens-Lisbonne C, Cremieux A, Maillard C, Balansard G. Methodes d'evaluation de l'activite´ antibacterienne des huiles essentielles: application aux essences de thym et de cannelle. J Pharm Belg, 1987; 42 (5): 297-302.
51. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils and other plant extracts. J Appl Microbiol, 1999; 86: 985-990.
52. Delaquis PJ, Stanich K, Girad B, Mazza G. Antimicrobial activity of individual and mixed fractions of dill, cilantro, coriander and eucalyptus essential oils. Int J Food Microbiol, 2002; 74: 101-109.
53. Bauer K, Garbe D, Surburg H. Common Fragrance and Flavor Materials: Preparation, Properties and Uses. Wiley-VCH, 923, 2001.
54. Marino M, Bersani C, Comi G. Impedance measurements to study the antimicrobial activity of essential oils from *Lamiacea* and *Compositae.* Int J Food Microbiol, 2001; 67: 187-195.
55. Juliano C, Mattana A, Usai M. Composition and *in vitro* antimicrobial activity of the essential oil of *Thymus* herba-barona Loisel growing wild in Sardinia. J Essent Oil Res, 2000; 12: 516–522.

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Cintura e índice de masa corporal: los mejores predictores antropométricos en la reducción y progresión de la agregación de factores de riesgo cardiometabólicos

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RESUMEN: El objetivo de este estudio fue determinar el impacto de la variación de distintas mediciones antropométricas en la evolución del síndrome metabólico (SM). El estudio fue prospectivo en 178 sujetos que asistieron a un programa de salud cardiovascular entre el año 2013 y 2016. Se recolectaron datos demográficos, historia médica, factores de riesgo cardiovascular, y se midió perfil lipídico, glicemia de ayuno, presión arterial y medidas antropométricas (IMC, perímetro de cintura y cadera y % de grasa corporal). Se consideró la agregación de 2 o más componentes de síndrome metabólico (SM), excluyendo cintura y se determinó la probabilidad de reversión del SM, considerándose como la reducción desde 2 o más componentes a 1 o ninguno. El tiempo de seguimiento promedio fue de 2 años. La edad promedio fue de 40 años y 37% eran mujeres. Según los modelos de odds proporcionales, ajustados por edad, sexo y tiempo de seguimiento, aquellos sujetos con 2 o más componentes de SM triplicaron su probabilidad de revertir el SM por cada reducción de 1 Kg/m^2 de IMC por año (OR IMC = 3,03; 1,74-5,28; p<0,001). En el caso de cintura, esta probabilidad aumentó en 52% por la reducción de 1 cm por año (ORcintura =1,52; 1,28-1,81; p<0,001). Finalmente una reducción de 0,01 en el índice cintura/cadera aumentó en 26% la probabilidad de revertir el SM (ORcintura/cadera =1,26; 1,06-1,491; p<0,01); sin embargo, el % de grasa corporal no tuvo un efecto significativo Los cambios en IMC y circunferencia de cintura serían los parámetros antropométricos más confiables para monitorear la evolución del SM.

Palabras clave: Antropometría, síndrome metabólico, cintura, relación cintura-cadera.

SUMMARY: Waist and body mass index: The best anthropometric predictors in the reduction and progression of the aggregation of cardiometabolic risk factors The objective of this study was to determine the impact of variation of different anthropometric parameters at follow-up in the evolution of the metabolic syndrome (MetS). Prospective study in 178 subjects who attended a cardiovascular health program between 2013 and 2016. Demographical data, medical history and cardiovascular (CV) risk factors (RFs) were collected. In addition, fasting lipid profile, blood glucose, blood pressure and anthropometrical parameters (BMI, WC, hip, and fat percentage) were measured. To determine the evolution of MetS, the clustering of 2 or more of the MetS components were considered, excluding WC. Odds proportional models adjusted by age, sex and time of follow-up were built to determine the probability of reverting the MetS. MetS reversion was considered as the reduction to 1 or 0 components in subjects with 2 or more. Mean follow-up time was 2 years. Mean age was 40 years old and 37% were women. According to the odds proportional models, subjects tripled their chance of reverting MetS for each 1 kg/m^2 of BMI reduction (ORBMI=3.03; 1.74-5.28; p<0.001). For WC, the chance of reverting MetS increased 52% for each reduction of 1 cm of waist (ORwaist =1.52; 1.28-1.81; p<0.001). A reduction of 0.01 in the waist to hip ratio increased in 26% the chance of reverting MetS (ORwaist/hip=1.26; 1.06-1.491; p<0.01); however, fat percentage did not have a significant effect on the evolution of the MetS. BMI and WC are the most reliable anthropometrical parameters for monitoring the evolution of MetS aggregation in the out-patient clinical setting.

Key words: Anthropometry, metabolic syndrome, waist, waist to hip ratio.

INTRODUCCIÓN

El síndrome metabólico (SM) es definido como la agregación de factores de riesgo (FR) cardiometabólicos que aumentan el riesgo de

enfermedad cardiovascular (CV) y diabetes. Según el criterio ATP III armonizado, el diagnóstico se realiza con la presencia de 3 o más de los siguientes componentes: obesidad abdominal, hipertrigliceridemia, HDL bajo, hiperglicemia de ayuno o diabetes y, presión arterial ≥130/85 o hipertensión en tratamiento (1). Así mismo, los sujetos con SM presentan niveles elevados de marcadores inflamatorios, lo cual acelera el proceso aterosclerótico (2, 3). Como resultado, estos pacientes presentan 2 veces más riesgo de eventos CV y un riesgo de mortalidad 50% mayor comparado con sujetos sanos (4). En Chile, las cifras son alarmantes. Según la última encuesta nacional de salud (ENS) 2009, la prevalencia de SM fue de 35% y la prevalencia de diabetes aumentó en un 50% (desde 6% a 9%) en 6 años en la población adulta (5,6).

La fisiopatología del síndrome metabólico es complejo con resistencia a la insulina y regulación anormal del metabolismo de lípidos, los cuales juegan un papel central en la patogénesis (7,8). La predisposición genética es un factor en el síndrome metabólico, y la prevalencia difiere entre los grupos étnicos (9,10). Sin embargo, la obesidad juega un papel central en la fisiopatología ya que el tejido adiposo visceral favorece la liberación de adipoquinas, la mayoría pro-inflamatorias, tales como interleucina-6, factor de necrosis tumoral alfa (TNF-a), angiotensinógeno y ácidos grasos no esterificados, entre otros (11). Estos factores son etiológicos en el desarrollo de hipertensión, dislipidemia aterogénica, resistencia a la insulina y posterior intolerancia a la glucosa en los pacientes obesos.

Por ello, tanto la obesidad junto a un estilo de vida sedentario son los principales responsables del SM en la población general, siendo la modificación de la dieta y el ejercicio, los pilares fundamentales del tratamiento. Sin embargo, en los últimos años ha existido un aumento alarmante en el consumo de bebidas azucaradas: Chile es el país con mayor consumo per cápita a nivel mundial (12). A esto se suman los resultados del último Sistema de Medición de la Calidad de la Educación (SIMCE) de actividad física en alumnos de 8vo básico, en el cual destacan el aumento de obesidad y el empeoramiento de la capacidad aeróbica en nuestros adolescentes (13), es decir, no hay indicios que la prevalencia de SM vaya a revertirse en el futuro.

Según la ENS 2009, 64% de la población adulta en Chile presenta malnutrición por exceso, en concordancia con la elevada prevalencia de SM y diabetes reportadas. Trabajos previos han demostrado que diversos indicadores de obesidad, como índice de masa corporal (IMC), cintura y porcentaje de grasa, se asocian en forma directa y significativa con triglicéridos, presión arterial y glicemia y, en forma inversa, con colesterol HDL (14-16). Sin embargo, la cintura o el índice cintura/talla han demostrado ser los indicadores más sensibles en el diagnóstico de SM, debido a su directa relación con adiposidad visceral (15). El último consenso presentado por el Ministerio de Salud de Chile sugiere la utilización de los puntos de corte propuestos por el ATP III armonizado para población asiática y Latinoamericana: 90 cm para el hombre y 80 cm para la mujer. Estudios previos realizados en nuestro país han reportado que valores por "sobre" estas cifras, ya muestran un aumento significativo de los componentes cardiometabólicos, respaldando la sugerencia del ATP III armonizado (15, 16).

Existe escasa evidencia sobre el efecto de la variación de estos parámetros antropométricos, específicamente cintura, relación cintura-cadera y porcentaje de grasa, en la regresión o progresión del SM. Esto tiene especial relevancia en el planteamiento de qué metas se propondrán en el tratamiento. Por ello, el principal objetivo de este estudio fue determinar los cambios en los diferentes parámetros antropométricos, después de al menos 1 año en un programa de salud CV, y medir su impacto en la reducción o progresión de la agregación de los componentes del SM.

MATERIALES Y MÉTODOS

Estudio longitudinal. 178 sujetos jóvenes, sin antecedentes de enfermedad aterosclerótica, asistieron en forma voluntaria a un programa de prevención primaria cardiovascular, entre los años 2013 y 2016. Todos firmaron un consentimiento informado que autorizaba a utilizar sus datos en forma anónima para fines académicos.

Protocolo general:

Todos los sujetos se entrevistaron con la enfermera del programa. Esta recolectó los datos demográficos, antecedentes médicos, medicamentos y antecedentes de factores de riesgo cardiovascular (FRCV) tradicionales: dislipidemia-DLP (colesterol total > 200 mg/dL y/o colesterol HDL < 40/50 mg/dL y/o triglicéridos > 150 mg/dL y/o colesterol LDL > 130 mg/dL y/o uso de hipolipemiantes), hipertensión-HTA (PAS y/o PAD > 140/90 mmHg y/o tratamiento antihipertensivo), diabetes (glicemia ≥ 126 mg/dl y/o tratamiento hipoglicemiante), tabaquismo activo, sedentarismo y obesidad.

En todos los sujetos, se tomó perfil lipídico, glicemia de ayuno, creatininemia y TSH. La presión arterial sistólica (PAS) y diastólica (PAD) se midieron en tres ocasiones distintas y se calculó el promedió según las guías de "Seventh Report of the Joint National Committee"(17). También se midió cintura e índice de masa corporal (IMC). La cintura se midió en el punto medio entre la cresta ilíaca y la última costilla y el IMC se clasificó según los estándares de la Organización Mundial de la Salud (OMS). Se midió cadera para calcular relación cintura/cadera (ICC) y 4 pliegues cutáneos (tríceps, bíceps, cresta iliaca y subescapular) para determinar el porcentaje de grasa (%Grasa) según ha sido descrito por Durnin & Womersley (18). El protocolo de medición para estas variables antropométricas se basó en los estándares propuestos por Sociedad Internacional para la Cine-antropometría (ISAK) (19). Todas las mediciones antropométricas fueron realizadas por la misma nutricionista certificada por ISAK.

Muestras de Sangre:

El perfil lipídico y la glicemia de ayuno se determinaron en laboratorio con las siguientes técnicas:

a) Colesterol total, colesterol HDL, y triglicéridos se determinaron con métodos enzimáticos estándar (analizador Hitachi).

b) El LDL se calculó con la fórmula de Friedewald

c) Glicemia se determinó con el método de glucosa oxidasa.

Las muestras de sangre periférica se extrajeron entre las 08:00 y las 10:30 de la mañana: bioquímica: 5 ml de sangre en tubo BD Vacutainer® SST II advance. Se empleó el analizador automático de química clínica Roche/ Hitachi, y los reactivos correspondientes. Todas las determinaciones se realizaron en el laboratorio clínico central de la universidad ejecutora, acreditado por la CDC, Center for Diseases Control, de Estados Unidos.

Agregación de factores de riesgo cardiometabólicos:

Se consideró regresión del SM, cuando un sujeto con 2 o más componentes, reducía la agregación de ellos a 0 o 1 componente del SM, es decir se reducía al menos 1 FR cardiometabólico. Para ello, se consideraron los siguientes componentes del SM, excluyendo cintura ya que ésta se consideró como variable independiente y predictor de la evolución del SM:

1. Hipertrigliceridemia: Se consideraron aquellos sujetos con triglicéridos ≥150 mg/dL y/o en tratamiento hipolipemiante.
2. Colesterol HDL bajo: <40 mg/dL en hombres y <50 mg/dL en mujeres
3. Presión arterial elevada: Se consideraron

aquellos sujetos con diagnóstico previo de HTA con tratamiento medicamentoso o que durante el estudio presentaran PAS≥ 130 mmHg y/o PAD≥85 mmHg.

4. Alteración del metabolismo de la glucosa: Se consideraron aquellos sujetos con un diagnóstico previo de diabetes con o sin tratamiento medicamentoso y aquellos sujetos con una glicemia de ayuno ≥100 mg/dL.

Análisis estadístico:

El análisis estadístico se realizó en R v. 3.4.1. Los resultados se presentan en términos de promedio, desviación estándar o frecuencia, porcentaje. Se consideró significancia estadística con $p<0.05$. Las comparaciones pareadas para un mismo sujeto se realizaron mediante pruebas t pareadas para variables continuas y prueba de Mcnemar para prevalencias. Para la agregación de factores de riesgo cardiometabólicos se consideró como respuesta el número de componentes del síndrome metabólico en el segundo control, categorizado como 2+, 1 o 0, lo que significa que la distribución de probabilidad de esta respuesta para el total de sujetos sigue una distribución multinomial. La asociación entre la respuesta y las variables predictoras se modeló mediante un modelo de odds proporcionales. Esto significa que, en la escala logística (logit(p)=logp1−plogit(p)=logp1−p), es decir, las odds de tener o no un determinado número de componentes del síndrome metabólico en escala logarítmica, la asociación con los distintos niveles de cada factor de riesgo se supone en términos proporcionales, es decir, rectas paralelas. El odds ratio representa, entonces, el aumento o disminución relativa en términos de odds de la probabilidad de disminuir en una categoría la agregación de factores de riesgo cardiometabólico. Para cada modelo de odds proporcionales se ajustó por el número de factores de riesgo en el primer control, sexo y edad (20, 21).

RESULTADOS

En el control inicial, la edad promedio del grupo fue de 40 años; 37% eran mujeres, y 80% tenía >12 años de educación. La prevalencia de SM fue de 21% según criterio ATP III armonizado, siendo mayor en hombres que en mujeres (29 vs 8%, $p<0.01$). El tiempo de seguimiento promedio fue de 2 años. La Tabla 1 describe las variables demográficas, antropométricas y bioquímicas del grupo total y según sexo en el primer control. La tabla 2 compara las variables antropométricas y bioquímicas del grupo total en el primer y segundo control según sexo.

Los resultados de los modelos de odds proporcionales, ajustados por edad, sexo y tiempo de seguimiento (2 a) en los participantes con 2 o más componentes de SM se presentan en la tabla 3. Estos demuestran la probabilidad de reducir a 0 o a 1 componentes del SM, según los cambios en las variables antropométricas. Los cambios en el IMC, cintura o ICC demostraron ser predictores significativos de la evolución del SM. Aquellos sujetos con 2 o más componentes del SM aumentaron 3 veces su probabilidad de reducir a 0 ó 1 FR del SM por cada reducción de 1 kg/m^2 de IMC por año (OR IMC = 3.03; 1.74-5.28; $p<0.0001$; Figura 1). En el caso de cintura, esta probabilidad aumentó en 52% por la reducción de 1 cm por año en la cintura (ORcintura =1.52; 1.28-1.81; $p<0.0001$; Figura 2). En el caso de ICC, se observó una probabilidad de reversión del 26% por cada reducción de 0.01 cm/cm por año de ICC (ORICC =1.26; 1.06-1.491; $p<0.01$)

El % de grasa no tuvo un efecto significativo en la probabilidad de reducción de componentes cardiometabólicos.

TABLA 1. Promedio de variables de demografía general, variables antropométricas, y factores de riesgo cardiovascular en el primer control según sexo.

	Grupo Total (n=178)	Mujeres (n=66)	Hombres (n=112)	P
Edad (años)	40 ± 11	38 ± 9	42 ± 13	<0.01
Tiempo de seguimiento (años)	-	2.1 ± 0.4	2.1 ± 0.4	NS
Variables Antropométricas				
Cintura (cm)	89 ± 11	82 ± 12	93 ± 9	<0.0001
IMC (Kg/m^2)	26.4 ± 3	25.6 ± 4	27 ± 3	<0.01
Porcentaje de grasa (%)	29 ± 7	35 ± 5	26 ± 5	<0.0001
Índice cintura/cadera	0.88 ± 0.08	0.83 ± 0.08	0.92 ± 0.08	<0.0001
Variables Bioquímicas				
Colesterol LDL (mg/dL)	109 ± 30	103 ± 27	112 ± 30	0.03
Colesterol HDL (mg/dL)	54 ± 15	62 ± 14	48 ± 12	<0.0001
Triglicéridos (mg/dL)	121 ± 60	104 ± 52	132 ± 67	<0.01
Glicemia (mg/dL)	89 ± 11	86 ± 14	92 ± 20	0.06
Presión Arterial				
Presión arterial sistólica (mmHg)	113 ± 15	108 ± 13	117 ± 17	<0.001
Presión arterial diastólica (mmHg)	71 ± 9	68 ± 7	73 ± 9	<0.01
Factores de Riesgo Cardiovascular				
Obesidad abdominal (%)	58	52	62	NS
Sobrepeso/Obesidad (%)	63	47	73	<0.01
Hipertensión (%)	15	2	22	<0.01
Dislipidemia (%)	58	56	60	<0.0001
Diabetes (%)	2	2	4	NS
Tabaquismo (%)	21.5	24	20	0.03
Síndrome Metabólico (%)	21	8	29	<0.01

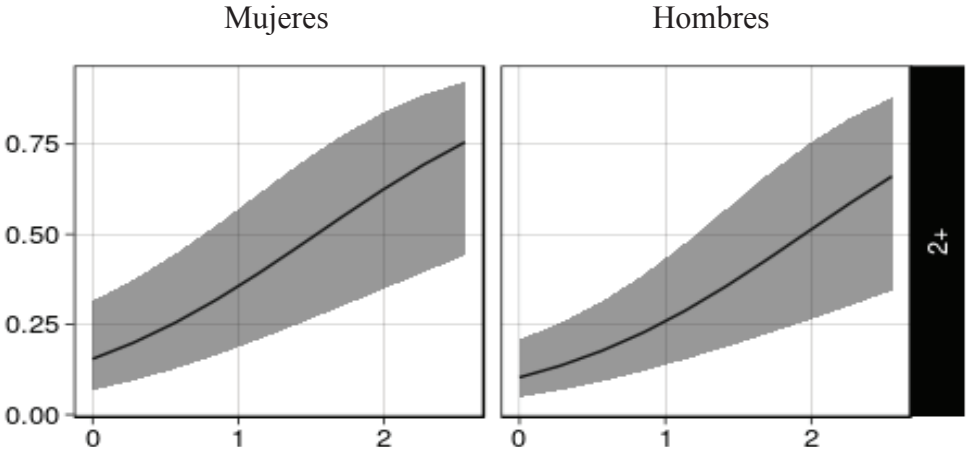
TABLA 2. Promedio de variables de demografía general, variables antropométricas, y factores de riesgo cardiovascular en el primer control y al seguimiento para grupo total.

	Mujeres Inicial	Hombres Final	P	Inicial	Final	P
Edad (años)	38 ± 9	40 ± 9		42 ± 13	44 ± 13	
Variables Antropométricas						
Cintura (cm)	82 ± 12	83 ± 11	NS	93 ± 9	94 ± 10	NS
IMC (Kg/m^2)	25.6 ± 4	25.7 ± 4	NS	27 ± 3	27.1 ± 3.2	NS
Porcentaje de grasa (%)	35 ± 5	36 ±4	<0.01	26 ± 5	28 ± 5	<0.0001
Índice cintura/cadera	0.83 ± 0.08	0.83 ± 0.07	NS	0.92 ± 0.08	0.92 ± 0.06	NS
Variables Bioquímicas						
Colesterol LDL (mg/dL)	103 ± 27	107 ± 32	0.01	112 ± 30	115 ± 32	NS
Colesterol HDL (mg/dL)	62 ± 14	62 ± 13	NS	48 ± 12	48 ± 12	NS
Triglicéridos (mg/dL)	104 ± 52	102 ± 50	NS	132 ± 67	138 ± 79	NS
Glicemia (mg/dL)	86 ± 14	86 ± 14	NS	92 ± 20	93 ± 18	<0.01
Presión Arterial (mmHg)						
Presión arterial sistólica	108 ± 13	109 ± 11	NS	117 ± 17	118 ± 12	NS
Presión arterial diastólica	68 ± 7	69 ± 8	NS	73 ± 9	75 ± 9	<0.001
Factores de Riesgo Cardiovascular						
Obesidad abdominal (%)	52	56	NS	62	63	NS
Sobrepeso/Obesidad (%)	47	53	0.08	73	72	NS
Hipertensión (%)	2	2	NS	22	23	NS
Dislipidemia (%)	60	55	<0.01	56	72	NS
Diabetes (%)	2	4	NS	4	2	NS
Tabaquismo (%)	24	24	NS	20	18	NS
Síndrome Metabólico (%)	8	12	NS	29	38	<0.01

TABLA 3. Probabilidad de reducir a 0-1 componente del síndrome metabólico según la reducción de una unidad en cada parámetro antropométrico, por año de seguimiento, en sujetos con 2 o más componentes de síndrome metabólico (ajustado por edad, sexo y tiempo de seguimiento).

Parámetro antropométrico		Odds Ratio (I.C. 95%)	P
IMC	([1 kg/m^2] / año)	3.03 (1.74 - 5.28)	<0.0001
Cintura	(1 cm / año)	1.52 (1.28 - 1.81)	<0.0001
Índice Cintura/Cadera	(0.01 / año)	1.26 (1.06 - 1.49)	<0.01
% Grasa	(1 % / año)	1.09 (0.88 - 1.34)	NS

Ejemplo: La reducción de 1 punto de IMC / año representa un O.R. de 3.03, es decir, se triplica la probabilidad de reducir el número de componentes de SM a 1 o ninguno.



Reducción IMC ((Kg/m^2) / (T.Seg. (años)))
Or=3.03 (1.74 - 5.28); P<0.0001

En el gráfico se muestra específicamente la probabilidad de reducir el número de componentes de SM de 2 o más a 1 o ningún componente, separado por sexo. Por ejemplo, una mujer que inicialmente tenía 2 o más componentes de SM y baja 1.5 puntos de IMC / año, tiene una probabilidad estimada de 50% de revertir el SM, es decir, reducir a 1 ó ningún componente del SM. Para conseguir lo mismo, un hombre tiene que reducir el IMC en 2 puntos / año.

FIGURA 1. Modelo de Odds Proporcionales que muestran la probabilidad de revertir el síndrome metabólico en hombres y mujeres según reducción de IMC (ajustado por edad y tiempo de seguimiento).

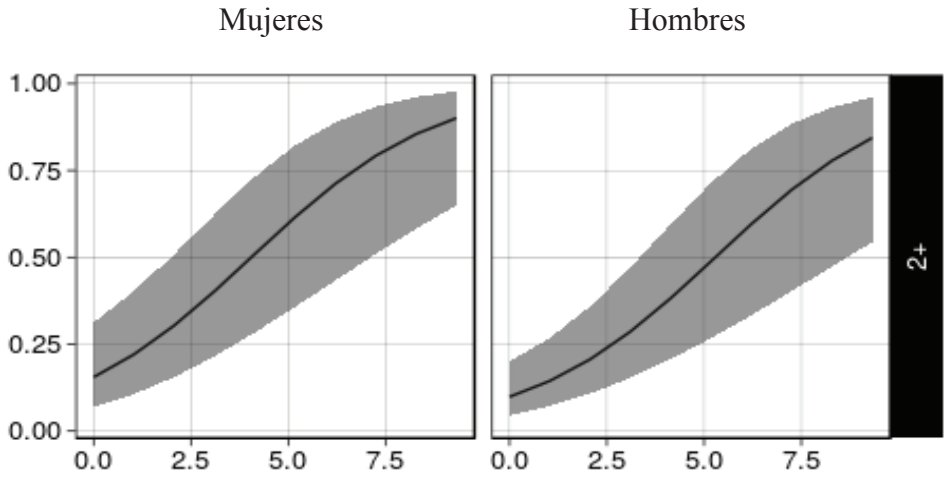


FIGURA 2. Modelo de Odds Proporcionales que muestran la probabilidad de revertir el síndrome metabólico en hombres y mujeres según reducción de cintura (ajustado por edad y tiempo de seguimiento).

DISCUSIÓN

El principal resultado del estudio demuestra que los cambios en la circunferencia de cintura e IMC fueron los mejores predictores de la evolución en el tiempo del SM, es decir, en la regresión o progresión de los componentes cardio-metabólicos del SM. La modificación del % de grasa no demostró un efecto significativo en la evolución de los FR, y el ICC, no fue superior a la cintura.

Los resultados obtenidos en este estudio confirmarían 2 hipótesis: la primera es que la variación de la adiposidad central determina con mayor precisión la evolución de los componentes del SM; la segunda es que el exceso de grasa subcutánea no predice la evolución del SM. Lo último, estaría fundamentado en que el % de grasa fue estimado a través de la medición de pliegues cutáneos, es decir, grasa subcutánea, y en la superioridad del parámetro cintura por sobre el ICC, este último que corrige el valor de cintura por grasa periférica, que también es subcutánea (cadera). Además, es importante destacar que el IMC, al menos en esta población no deportista, tendría relación directa con la masa adiposa total, lo cual incluiría la adiposidad visceral.

Estos resultados tienen mucha importancia en clínica y en el sistema de salud, ya que según ellos, no se justificaría en términos de costo-efectividad, la utilización de otras mediciones antropométricas más sofisticadas y caras, o de composición corporal (ej: grasa visceral por tomografía computada) para monitorizar la evolución del SM. Medidas tan simples como el IMC y la cintura, son muy buenos predictores. Esto también había sido confirmado por el estudio INTERHEART, que reportó que la obesidad central, determinada por la cintura, era uno de los FR que se asociaba con mayor fuerza a eventos coronarios. Este mismo grupo reportó que la cintura sería el parámetro más sensible para predecir la presencia de FR CV(16).

En la literatura no existe evidencia en cuanto al impacto de la variación de la cintura en el tiempo sobre la agregación de FR cardio-metabólicos: esto es lo que se trató de determinar en nuestro estudio.

Tal como ha sido publicado en las últimas guías del manejo de obesidad del Colegio y Asociación Americanas de Endocrinólogos, es sabido que una reducción de al menos un 5% del peso corporal tiene un impacto significativo en la reducción de lípidos y presión arterial, y por ello es una recomendación con un grado de evidencia IA (22). Lo mismo ha sido avalado por las guías de manejo de la obesidad de la Asociación Americana del Corazón (23). Incluso estos últimos refieren que pérdidas más modestas, pero sostenidas, del 3% al 5% del peso, ya tendrían un impacto en los niveles de lípidos y glicemia, pero no en la presión arterial. Sin embargo, para la prevención de diabetes en sujetos con SM, se recomienda una reducción de peso de al menos un 10% (Grado de evidencia II B)(22). Según nuestros resultados, un sujeto con presencia de 2 o más FR cardiometabólicos, que reduce en un 10% el peso (~3 kg/m2 en su IMC) tendría una probabilidad de 75% de reducir a 0 o 1 componente si es mujer, y 65% si es hombre. Esto equivaldría a reducir el IMC de este grupo de sujetos de 28 a 25, pasando del sobrepeso a la normalidad. El peso promedio de las mujeres con 2 o más FR en este estudio fue de 72 kg. En estas mujeres, el 10% del peso serían ~7 kg, o sea, debieran bajar a ≤ 65 kg. En el caso de los hombres, el peso promedio fue 81 kg y debieran bajar a 72 kg. El llegar a estos pesos los llevaría a dejar el grupo de pacientes con más riesgo cardio-metabólico.

Un meta-análisis reciente reportó que la rehabilitación cardiaca resultó en una reducción significativa en el promedio de circunferencia de cintura. Además, esta reducción de la circunferencia de cintura se asoció significativamente con la disminución en el colesterol LDL, PAS y PAD, glucosa en ayuna, y triglicéridos y un aumento significativo en el colesterol-HDL, en conjunto con una tendencia no significativa para la asociación con colesterol total (24). Es sabido que la medición más sensible para hacer el diagnóstico de SM es la cintura. Sin embargo, tanto para los pacientes como para los clínicos, no están claras las metas de reducción de cintura para lograr revertir el SM. Esto es importante, ya que al igual que para el peso, es necesario tener metas de reducción en distintas proporciones según el valor inicial, para así favorecer la auto-eficacia y adherencia de los pacientes (25). Esto, porque el alcance de los valores óptimos son muy difíciles de lograr en el corto plazo. Así, según nuestros datos, una reducción de ~7 cm de cintura en mujeres y ~8 cm en hombres tendría efectos similares a la reducción del 10% del peso descrita previamente. Con el gráfico de odds proporcionales (Figura 2) presentado en este estudio, el clínico podría establecer metas menos exigentes, mostrándole al paciente, según cintura e IMC, cuál sería el impacto en la agregación de factores de SM.

Así, los resultados de este estudio podrían ayudar a motivar a los pacientes que se encuentran en tratamiento, y podría ayudarlos a adherirse a la terapia, incluso, pidiéndoles a ellos mismo que monitoreen su progreso.

Este estudio presenta limitaciones. La principal limitación es el tiempo de seguimiento. Sabemos que los cambios antropométricos son muy difíciles de lograr, por lo cual, hubiéramos visto más impacto si hubiéramos tenido más tiempo de seguimiento, o a través de una intervención intensiva en sujetos con SM. Estos sujetos, sin embargo, continúan en nuestro programa CV. Por otro lado, la estimación del % de grasa se realizó a través de las ecuaciones de Durnin & Womersely (17), las cuales consideran la edad como parte del cálculo, por lo tanto, puede influir en el % de grasa. Sin embargo, al incluir la sumatoria de 4 pliegues en el análisis, no se observó un efecto significativo en la evolución de los componentes de SM (OR=1.00; 0.98-1.03), lo cual valida nuestros resultados.

CONCLUSIONES

Los cambios en IMC y circunferencia de cintura serían los parámetros antropométricos más

confiables para monitorear la evolución del SM. Los cambios en indicadores antropométricos que incluyen adiposidad subcutánea, como el % de grasa o la sumatoria de pliegues, no se relacionaron con la evolución del SM, mientras que los cambios en el ICC presentaron una relación más débil que la cintura en forma aislada.

REFERENCIAS

1. Assmann G, Guerra R, Fox G, Cullen P, Schulte H, Willett D, et al. Harmonizing the definition of the metabolic syndrome: comparison of the criteria of the Adult Treatment Panel III and the International Diabetes Federation in United States American and European populations. Am J Cardiol. 2007; 99(4):541-8.
2. Acevedo M, Varleta P, Kramer V, Valentino G, Quiroga T, Prieto C, et al. Comparison of Lipoprotein-Associated Phospholipase A2 and High Sensitive C-Reactive Protein as Determinants of Metabolic Syndrome in Subjects without Coronary Heart Disease: In Search of the Best Predictor. Int J Endocrinol. 2015; 2015:934681.
3. Acevedo M, Arnaíz P, Corbalán R, Godoy I, Morales D, Chalhub M, et al. Modificación del grosor intima-media carotídeo según factores de riesgo clásicos y síndrome metabólico con o sin inflamación. Rev Chil Cardiol. 2009; 28:337-48.
4. Mottillo S, Filion KB, Genest J, Joseph L, Pilote L, Poirier P, et al. The metabolic syndrome and cardiovascular risk a systematic review and meta-analysis. J Am Coll Cardiol. 2010; 56(14):1113-32.
5. MINSAL. Primera Encuesta Nacional de Salud. Chile: Ministerio de Salud; 2003 [cited 2014 30-12-2014]; Available from: http://epi.minsal.cl/epi/html/invest/ENS/InformeFinalENS.pdf.
6. MINSAL. Segunda Encuesta Nacional de Salud. Chile: Ministerio de Salud; 2009 [cited 2014 29-12-2014]; Available from: http://web.minsal.cl/portal/url/item/bcb03d7bc28b64dfe040010165012d23.pdf.
7. Reaven GM. Role of insulin resistance in human disease. Diabetes. 1988;37(12):1595–1607.
8. DeFronzo RA, Ferrannini E. Insulin resistance: a multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease. Diabetes Care. 1991;14(3):173–194.
9. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA. 2002;287(3):356–359.
10. Ranasinghe P, Mathangasinghe Y, Jayawardena R, Hills AP, Misra A. Prevalence and trends of metabolic syndrome among adults in the asia-pacific region: a systematic review. BMC Public Health. 2017;17(1):101.
11. Yanai H, Tomono Y, Ito K, Furutani N, Yoshida H, Tada N. The underlying mechanisms for development of hypertension in the metabolic síndrome. Nutrition Journal 2008, 7:10
12. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. Lancet Diabetes Endocrinol. 2016; 4(2):174-86.
13. Informe de resultados: Estudio Nacional Educación Física 8° Básico. 2015. http://archivos.agenciaeducacion.cl/Informe_Nacional_EducacionFisica2015.pdf
14. Valentino G, Bustamante MJ, Orellana L, Kramer V, Duran S, Adasme M, et al. Body fat and its relationship with clustering of cardiovascular risk factors. Nutr Hosp. 2015;31(5):2253-60.
15. Lanas F, Seron P, Munoz S, Margozzini P, Puig T. Central obesity measurements better identified risk factors for coronary heart disease risk in the Chilean National Health Survey (2009-2010). J Clin Epidemiol. 2016. [Epub ahead of print]
16. Fasce EF, Zarate H, Campos I, Flores M, Ibañez P. Relación entre perímetro abdominal, nivel socioeconómico y presión arterial. Rev Chil Cardiol. 2010;29:11-8.
17. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jr., et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension. 2003;42(6):1206-52.
18. Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men

and women aged from 16 to 72 years. Br J Nutr. 1974;32(1):77-97.

19. Stewart A, Marfell-Jones M, Olds T, de Ridder H. International Standards for Anthropometric Assessment. Lower Hutt, New Zealand: ISAK; 2011. http://www.ceap.br/material/MAT17032011184632.pdf. Accessed April 05, 2013.
20. Yee, T. W. (2015) Vector Generalized Linear and Additive Models: With an Implementation in R. New York, USA: Springer.
21. Yee, T. W. and Wild, C. J. (1996) Vector generalized additive models. Journal of the Royal Statistical Society, Series B, Methodological, 58, 481–493.
22. Garvey WT, Mechanick JI, Brett EM, Garber AJ, Hurley DL, Jastreboff AM, et al. American Association of Clinical Endocrinologists and American College of Endocrinology Comprehensive Clinical Practice Guidelines for Medical Care of Patients with Obesity. Endocr Pract. 2016;22 Suppl 3:1-203.
23. Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. J Am Coll Cardiol. 2014;63(25 Pt B):2985-3023.
24. Sadeghi M, Salehi-Abargouei A, Kasaei Z, Sajjadieh-Khajooie H, Heidari R, Roohafza H. Effect of cardiac rehabilitation on metabolic syndrome and its components: A systematic review and meta-analysis. J Res Med Sci. 2016;21:18. eCollection 2016.
25. Warziski MT, Sereika SM, Styn MA, Music E, Burke LE. Changes in self-efficacy and dietary adherence: the impact on weight loss in the PREFER study. J Behav Med. 2008;31(1):81-92.

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Influence of extraction solvent on phenolic content and antioxidant capacity level of a commercial food supplement from *Moringa oleifera* leaves

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SUMMARY: The objective of this research was to evaluate the effect of extraction solvent on phenolic compounds content (total phenols, total flavonoids) and antioxidant capacity levels (DPPH, ABTS and FRAP) of a commercial food supplement from *Moringa oleifera* leaves. The content of total phenols, total flavonoids and total non-flavonoids ranged from 55.98 to 226.20 mg ChlAE/g, from 17.63 to 23.46 mg CatE/g and from 38.34 to 202.73 mg CatE/g mg/g, respectively, while condensed tannins were not detected in none of the extracts. Non-flavonoids compounds were the most abundant group of phenolics in all the extracts ranging from 68 to 90% of the total phenols content. Levels of antioxidant capacity ranged from 22.43 to 124.93, 101.03 to 245.25 and 77.06 to 214.17 µmolTE/g in ABTS, DPPH and FRAP, respectively. In addition, EtOH 50% and EtOH 100% extracts showed the highest and lowest content in phenolics content and antioxidant capacity level. Finally, data obtained in the content of phenolics and antioxidant capacity levels of the present study are higher than most of data of scientific literature reported previously by other authors.

Key words: Antioxidant capacity, food supplement, *Moringa oleifera*, phenolics.

RESUMEN: Influencia del solvente de extracción en el contenido fenólico y nivel de capacidad antioxidante de un suplemento alimenticio comercial de hojas de *Moringa oleifera*. El objetivo de esta investigación fue evaluar el efecto del solvente de extracción en el contenido de compuestos fenólicos (fenoles totales, flavonoides totales) y los niveles de capacidad antioxidante (DPPH, ABTS y FRAP) de un suplemento comercial de hojas de *Moringa oleifera*. El contenido de fenoles totales, flavonoides totales, no-flavonoides totales oscilaron de 55.98 a 226.20 mg ChlAE/g, de 17.63 a 23.46 mg CatE/g y de 38.34 a 202.73 mg/g, respectivamente, mientras que no fue detectada la presencia de taninos condensados en ninguno de los extractos. Los compuestos fenólicos no-flavonoides fueron el grupo más abundante de compuestos fenólicos en todos los extractos y oscilaron de 68 a 90% del total de los fenoles totales. Los niveles de capacidad oscilaron de 22.43 a 124.93, de 101.03 a 245.25 y de 77.06 a 214.17 µmolTE/g en ABTS, DPPH y FRAP, respectivamente. Además, los extractos con EtOH 50% y EtOH 100% mostraron el contenido más alto y más bajo de fenólicos y niveles de capacidad antioxidante, respectivamente. Finalmente, los datos obtenidos en el contenido de compuestos fenólicos y los niveles de capacidad antioxidante del presente estudio son más altos que la mayoría de los datos reportados previamente en literatura por otros autores.

Palabras clave: Capacidad antioxidante, fenólicos, *Moringa oleifera*, suplemento alimenticio.

INTRODUCTION

Moringa oleifera is a plant native from the sub-Himalayan regions and is now distributed in many regions of the world and is used as food and medicinal purposes. Medicinal properties are attributed almost all parts of the plant including root, bark, leaf, pod, flower and seed (1). *Moringa oleifera* is widely

cultivated in different zones of Mexico, it is found in more than ten states of the country and it has gained attention of Mexican market because of its pharmaceutical properties (2). The antioxidant properties of *Moringa oleifera* leaves have been attributed to their content of phenolic compounds, which are able to decrease damage in tissues by free radical scavenging mechanism and thus several health benefits is related with its consume (3). The yield of phenolic compounds extraction is determined mainly by the extraction solvent, extraction time and temperature. The solubility of phenolics is governed by the chemical nature of the plant sample, as well as the polarity of the extraction solvent used. Solvents such as methanol and ethanol with different proportions of water have been used for the extraction of phenolics from plant materials because of they are found to be the most efficient solvents (4). The aim of this work was to evaluate the effect of extraction solvent on the phenolics content and antioxidant capacity levels of a commercial food supplement from *Moringa oleifera* leaves.

MATERIALS AND METHODS

Food supplement

Commercial food supplement capsules product from *Moringa oleifera* leaves were kindly provided by PhD Emilio Olivares-Saenz, who produce and market the product in the Protected Agriculture Center of the Autonomous University of Nuevo León. Samples were taken out from capsules and sieved trough 500 µm sieve (mesh 35).

Proximate composition

The methods of Association of Official Analytical Chemists (AOAC) (5) were used to determine moisture (method 925.09), protein (N x 6.25) (method 960.52), ash (method 923.03), fat (method 923.03) and crude fiber (920.86). Results were expressed in terms of percentage (g/100g). The total carbohydrates content was obtained by difference as follows: total carbohydrates = 100 − (g of water + g of protein + g of ash + g of fat + g of crude fiber).

Extraction of phenolics

Three hundred milligrams of samples were mixed with 30 mL of solvent for 2 h at 200 rpm at room temperature. After that, samples were centrifuged at 2600 g, supernatants collected, protected from light and stored at -20°C until they were used for phenolics and antioxidant capacity analysis. Extraction solvents were methanol (MeOH) and ethanol (EtOH) at 100%, 80% aqueous and 50% aqueous.

Phenolics and antioxidant capacity

Phenolics and antioxidant capacity assays were carried out according to López-Contreras et al. (6). The total phenols, total flavonoids and condensed tannins contents were evaluated by Folin-Ciocalteu, aluminum chloride and vanillin-HCl methods. Results were expressed as milligrams of chlorogenic acid per gram of sample for total phenols (mg ChlAE/g) and milligrams of catechin equivalents per gram of sample (mg CatE/g) for total flavonoids and condensed tannins. In addition, percentage of flavonoids (Fla) and non-flavonoids (Non-Fla) compounds were calculated as follows: %Fla=((total flavonoids*100)/total phenols), %Non-Fla=(100-%Fla).

Antioxidant capacity by DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2′-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt) radicals was measured based on the reduction of their absorbance, while FRAP (Ferric Reducing Antioxidant Power) was determined based on the reaction of ferrous tripyridyltriazine complex. Results of ABTS, DPPH and FRAP were expressed as micromoles of Trolox equivalents per gram of sample (µmolTE/g)

Statistical analysis

All of the results were expressed as mean values of three samples ± standard deviation. Statistical significance among samples was evaluated by analysis of variance (ANOVA) followed by Tukey's test using Minitab 14.0 (7). A level of probability of $p<0.05$(5%) was set as statistical significance. Results were expressed as mean values of three samples ± standard deviation.

RESULTS

The proximate composition of the commercial food supplement from *Moringa oleifera* leaves is shown in Table 1. Carbohydrates were the main component followed by protein, ash, fat, moisture and crude fiber.

There were significant differences in the phenolics analysis ($p<0.05$), EtOH50% and EtOH 100% obtained the highest and lowest content in total phenols, total flavonoids and total non-flavonoids respectively. EtOH 50% was 4.0 and 1.3 and 5.2 fold-higher than EtOH 100% in total phenols, total flavonoids and total non-flavonoids, respectively. The levels obtained for total phenols, total flavonoids and total non-flavonoids ranged from 55.98 to 226.20 mg ChlAE/g, 17.63 to 23.46 mgCatE/g and from 38.34 to 202.73 mg/g, respectively, while condensed tannins were not detected in none of the samples (Figure 1).

TABLE 1. Proximate composition of a commercial food supplement from *Moringa oleifera* leaves.

Component (g/100g)					
Moisture	Protein	Ash	Fat	Crude fiber	Total Carbohydrates
5.23±0.31	22.45±0.40	7.37±0.06	5.95±0.17	0.1±0.04	58.90±0.24

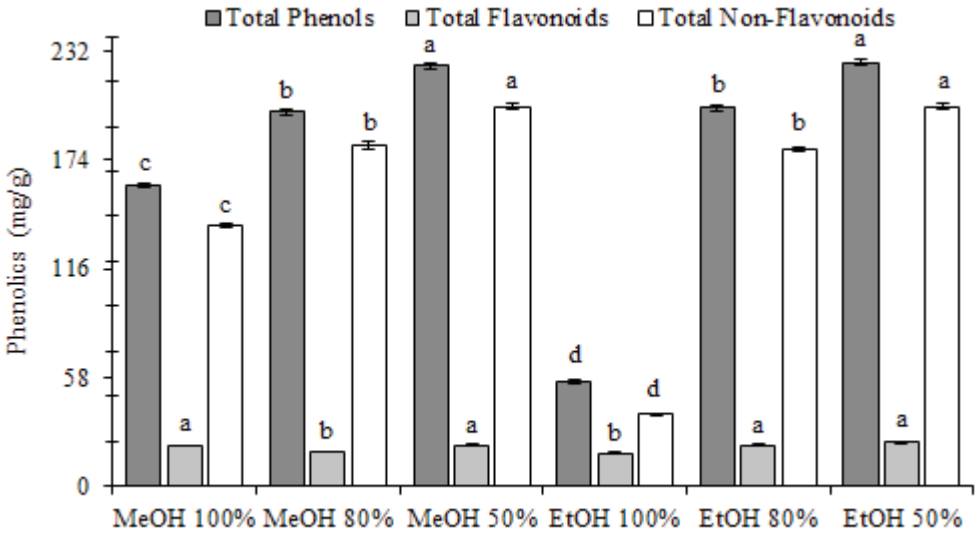

FIGURE 1. Influence of extraction solvent on phenolic content of a commercial food supplement from *Moringa oleifera* leaves. Different letters within the same evaluation are significantly different ($p<0.05$).

Non-flavonoids compounds were the most abundant group of phenolics in all the extracts showing MeOH 80%, MeOH 50%, EtOH 80% and EtOH 50% values around 90% of non-flavonoids in their phenolic composition, followed by MeOH 100% with 86% and the lowest value was shown by EtOH 100% with 68% on non-flavonoids compounds (Figure 2).

Also, significant differences ($p<0.05$) between samples were observed in DPPH, ABTS and FRAP antioxidant capacity assays. Same pattern observed in phenolics was obtained in antioxidant capacity, being EtOH 50% and EtOH 100% the extracts that showed highest and lowest levels of antioxidant capacity. Results of antioxidant capacity were from 22.43 to 124.93, from 101.03 to 245.25 and from 77.06 to 214.17 µmolTE/g in ABTS, DPPH and FRAP, respectively. EtOH 50% was 5.5, 2.4, and 2.7 fold-higher than EtOH 100% in ABTS, DPPH and FRAP, respectively (Figure 3).

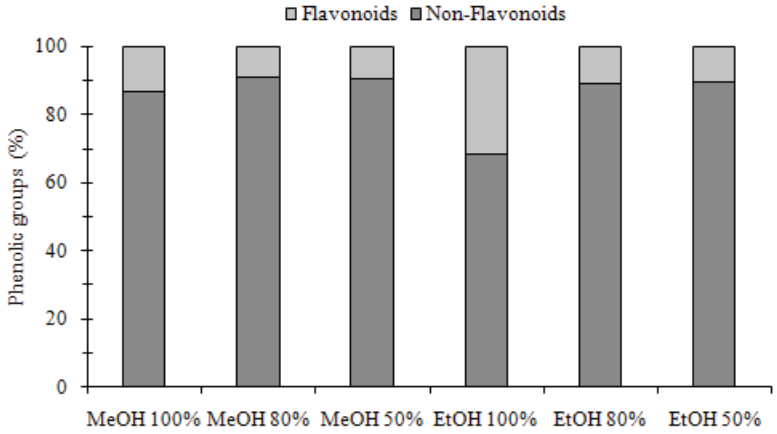

FIGURE 2. Influence of extraction solvent on phenolic composition of a commercial food supplement from *Moringa oleifera* leaves.

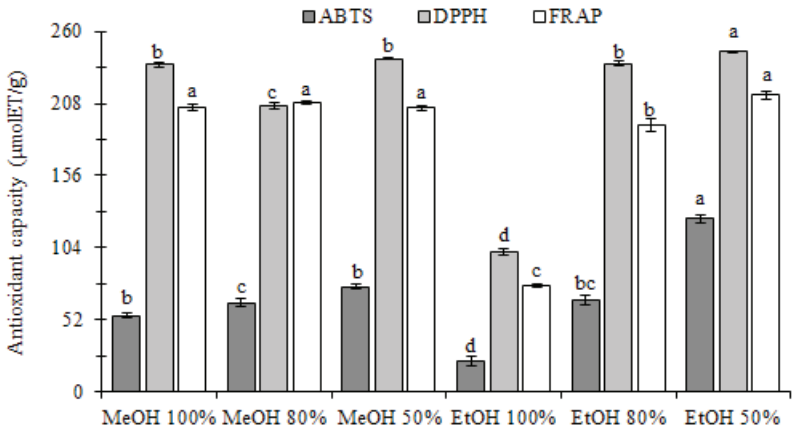

FIGURE 3. Influence of extraction solvent on antioxidant capacity of a commercial food supplement from *Moringa oleifera* leaves. Different letters within the same evaluation are significantly different ($p<0.05$).

DISCUSSION

Moringa oleifera leaves are considered a high source of protein with high content of essential amino acids such as methionine, cystine, tryptophan and lysine, but also a good source of minerals (1). The protein content of the commercial food supplement from *Moringa oleifera* leaves of our study is higher than the content reported previously by Valdez-Solana et al. (2), who found 10.74% and 11.48% in *Moringa oleifera* leaf powder from two Mexican cultivars, but is in the range of the data reported by Makkar and Becker (8) and Aye and Adegun (9) who found 25.1% and 22.2% of protein content, respectively. On the other hand, our results are very close to the findings reported by Moyo et al. (10) in fat and ash with 6.50% and 7.64%, respectively. Contrary to protein, the content of crude fiber of our study is lower than all the data obtained by authors mentioned before since they reported data ranging from 7 to 30%.

The results in the content of phenolics and antioxidant capacity of commercial food supplement from *Moringa oleifera* leaves, showed that an increasing in the polarity of the solvent leads to an increasing in the content of phenolics compounds and thus in the antioxidant capacity level. This behavior was previously described by Turkmen et al. (11) who extracted bioactive compounds from black tea (*Camellia sinensis* L.) and black mate tea (*Ilex paraguariensis*) using the same ethanol and methanol solvent mixtures and reporting EtOH 50% and EtOH 100% as the solvents with the highest and lowest content of phenolics content and antioxidant capacity level, which is similar to our observations.

Several studies have evaluated the phenolic content of leaves from *Moringa oleifera*. For instance, Vongsak et al. (12) obtained bioactive compounds using maceration at 1:20 (w/v) ratio sample respecting solvent by using 70% aqueous ethanol finding 377.8 and 82.9 mg/g in total phenols and total flavonoids, respectively, which is higher than our results. Singh et al. (13), obtained an aqueous phenolic extract by stirring sample for 2 h at 80°C and they found 105 and 31.28 mg/g of total phenols and total flavonoids, respectively, being their results in phenolics lower than most of our data, but higher in flavonoids.

In addition, although they did not calculate the percentage of non-flavonoids and flavonoids compounds, we applied our formulas to their data, obtaining 55-79% and 70% of non-flavonoids for Vongsak et al. (12) and Singh et al. (13), respectively, which is in the range of our observations. In addition, our observation in condensed tannins are in agreement with Bennet et al. (14) since they did not detect the presence of condensed tannins in *Moringa oleifera* leaves, but are contrary to data reported by Sriwichai et al. (15) who obtained 0.77 mg/g of this phenolic group in this plant material.

The Antioxidant capacity has been also evaluated in phenolic extracts from *Moringa oleifera* leaves. In this regard, Surveswaran et al. (16), extracted phenolics by 80% methanol overnight at room temperature with occasional shaking and they obtained antioxidant capacity levels of 7.4, 4.7 and 0.17 µmolTE/g in ABTS, DPPH and FRAP assays, respectively, being these results lower than our data.

Kunyanga et al. (17), extracted phenolics by sequential ultrasonic extractions with acidifiedmethanol, and aqueous methanol, purified extracts with polyvinylpolypyrrolidone, freeze-dried and finally extract was dissolved in water-ethanol-formic acid solution and they reported 186 micromoles of Iron Equivalents per gram of sample (µmolFeE/g) in FRAP assay. Jaiswal et al. (18), obtained an aqueous extract at

40-60°C for 48 h and they reported 85 μmolFeE/g in FRAP assay. The results obtained by these two authors are also lower than our data. On the other hand, Pari et al. (19) obtained extracts by soaking sample in methanol overnight and obtained 636 μmolTE/g in ABTS, which is higher than our results.

CONCLUSIONS

Based on results obtained in the present study, we concluded that: EtOH 50% is the best solvent to obtained phenolics with the higher antioxidant capacity in the commercial food supplement from *Moringa oleifera* leaves. Independently of the solvent, non-flavonoids is the main group of phenolics present in the methanolic and ethanolic extracts of a commercially food supplement from *Moringa oleifera*. In addition, data obtained in phenolics and antioxidant capacity of the present study are in most of the cases higher than data of scientific literature reported previously by other authors and thus the commercial food supplement used in the present work could be considered a nutraceutical product, although studies on the phenolics bioavailability are recommended.

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REFERENCES

1. Anwar F, Latif S, Ashraf M, Hassam GA. *Moringa oleifera*: a food plant with multiple medicinal uses. Phytother. Res. 2007; 21(1), 17-25.
2. Valdez-Solana MA, Mejía-García VY, Téllez-Valencia A, García-Arenas G, Salas-Pacheco J, Alba-Romero JJ, Sierra-Campos E. Nutritional content and elemental and phytochemical analyses of *Moringa oleifera* grown in Mexico. J. Chem. 2015; Vol. 2015, Article ID 860381, 9 pages.
3. Razis AFA, Ibrahim MD, Kntayya SB. Health benefits of *Moringa oleifera*. Asian Pac. J. Cancer Prev. 2014; 15(20), 8571-8576.
4. Dai J, Mumper RJ. Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. Molecules. 2010; 15(10), 7313-7352.
5. Official Methods of Analysis. Association of Official Analytical Chemist International (AOAC). 1998; 16th Edition, 4th Revision. AOAC International Maryland, USA.
6. López-Contreras JJ, Zavala-García F, Urías-Orona V, Martínez-Ávila GCG, Rojas R, Niño-Medina G. Chromatic, phenolic and antioxidant properties of *Sorghum bicolor* genotypes. Not. Bot. Horti Agrobo. Cluj-Na. 2015; 43(2), 366-370.
7. Minitab 14 statistical software. Computer software. State College, PA: Minitab Inc. 2004; www.minitab.com.
8. Makkar HPS, Becker K. Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Anim. Feed Sci. Technol. 1996; 63(1-4), 211-228.
9. Aye PA, Adegun MK. Chemical Composition and some functional properties of *Moringa, Leucaena* and *Gliricidia* leaf meals. Agric. Biol. J. N. Am. 2013; 4(1), 71-77.
10. Moyo B, Masika PJ, Hugo A, Muchenje V. Nutritional characterization of moringa (*Moringa oleifera* Lam.) leaves. Afr. J. Biotechnol. 2011; 10(60), 12925-12933.
11. Turkmen N, Sari F, Velioglu YS. Effects of extraction solvents on concentration and antioxidant activity of black and black mate tea polyphenols determined by ferrous tartrate and Folin–Ciocalteu methods. Food Chem. 2006; 99(4), 835-841.
12. Vongsak B, Sithisarn P, Mangmool S, Thongpraditchote S, Wongkrajang Y, Gritsanapan

W. Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. Ind. Crops Prod. 2013; 44, 566-571.

13. Singh BN,Singh BR, Singh RL, Prakash D, Dhakarey R, Upadhyay G, Singh HB. Oxidative DNA damage protective activity, antioxidant activity and anti-quorum sensing potential of *Moringa oleifera*. Food Chem. Toxicol. 2009; 47(6), 1109-1116.
14. Bennet RN, Mellon FA, Foidl N, Pratt JH, Dupont MS, Perkins L, Kroon PA. Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees *Moringa oleifera* L. (horseradish tree) and *Moringa stenopetala* L. J. Agric. Food Chem. 2003; 51(12), 3546-3553.
15. Sriwichai W, Berger J, Picq C, Avallone S. Determining factors of lipophilic micronutrient bioaccessibility in several leafy vegetables. J. Agric. Food Chem. 2016; 64(8), 1695-1701.
16. Surveswaran S, Cai YZ, Corke H, Sun, M. Systematic evaluation of natural phenolic antioxidants from 133 Indian medicinal plants. Food Chem. 2007; 102(3), 938-953.
17. Kunyanga CN, Imungi JK, Okoth MW, Biesalski HK, Vadivel V. Total phenolic content, antioxidant and antidiabetic properties of methanolic extract of raw and traditionally processed Kenyan indigenous food ingredients. LWT-Food Sci. Technol. 2012; 45(2), 269-276.
18. Jaiswal D, Rai PK, Mehta S, Chatterj S, Shukla S, Rai DK, Sharma G, Sharma B, Khair S, Watal G. Role of *Moringa oleifera* in regulation of diabetes-induced oxidative stress. Asian Pac. J. Trop. Med. 2013; 6(6), 426-432.
19. Pari L, Karamać M, Kosińska A, Rybarczyk A, Amarowicz R. Antioxidant activity of the crude extracts of drumstick tree (*Moringa oleifera* Lam.) and sweet broomweed (*Scopariadulcis* L.) leaves. Pol. J. Food Nutr. Sci. 2007; 57(2), 203-208.

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The effect of foliar fertilization with organic products on some nutritional value during post-harvest storage of tomatoes (*Lycopersicon esculentum* Mill)

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SUMMARY: The aim of this study was to observe the effect of foliar fertilization with organic products on the nutritional quality of fruits stored. The time between harvest and consumption of fruits and vegetables, may be up to several weeks. In this regard, the storage capacity of tomato fruits at three hybrids has been studied: Antalya, Chocolat and Tiger. The culture was founded in a greenhouse in the south-west of Romania. The fruits were stored at a temperature of 15°C ± 0.5°C and a relative atmospheric humidity of 82% for a period of 42 days. In order to assess the nutritional fruit value during storage, biochemical analyzes were carried out at 7, 21, 35 and 42 days. Experimental results have shown that the best variants of organic manure and storage time, which positive influenced the content of carotene and vitamin C were variants with humic acids + *Vitis vinifera* seeds extract and humic acids + extract from the seeds of *Vitis vinifera* + Boro.

Key words: Tomatoes, vitamin C, total carotenes, titratable acidity.

RESUMEN: El efecto de la fertilización foliar con productos orgánicos sobre el valor nutricional durante el almacenamiento post-cosecha de los tomates (*Lycopersicon esculentum* Mill). El objetivo de este estudio fue observar el efecto de la fertilización foliar con productos orgánicos sobre la calidad nutricional en los frutos almacenados. En este sentido, la capacidad de almacenamiento de los frutos de tomates ha sido sometida a tres híbridos: Antalya, Chocolat y Tiger. Los tomates han sido cultivados en un invernadero, en la parte sur-oeste de Rumanía. Los frutos se han guardado a una temperatura de 15°C ± 0.5°C y a una humedad atmosférica relativa de 82%, durante un período de 42 días. Para la evaluación nutricional de los frutos durante el periodo de almacenamiento, se realizaron análisis bioquímicos a los 7, 21, 35 y 42 días. Los resultados de los experimentos mostraron que las mejores fórmulas empleadas en la fertilización orgánica, así como el tiempo de almacenamiento, que han influido positívamente en el contenido de carotenos y vitamina C, han sido: la fórmula con ácidos húmicos + extracto de semillas de *Vitis vinifera* y la fórmula con ácidos húmicos + extracto de semillas de *Vitis vinifera* + Boro.

Palabras clave: Tomates, vitamina C, carotenos totales, acidez titulable.

INTRODUCTION

The tomatoes (*Lycopersicon esculentum* Mill.) are one of the vegetable most consumed worldwide because they are the main supplier of several phytonutrients that provide important nutritional value for the human diet (1). An average consume of tomatoes provides 40% of the recommended daily allowance of vitamin C (ascorbic acid), 20% of the RDA of vitamin A, substantial amounts of potassium, dietary fibbers, calcium, and smaller amounts of iron, magnesium, thiamine, riboflavin, niacin, and it contains only about 35 calories.

The regular consumption of fruits and vegetables was associated with the maintenance of health and prevention of diseases. The tomatoes are an important species due to the major contribution of carotenoids, phenols, vitamin C, vitamin E that come in daily ration of nutrition of the world population .

The results of different studies showed that tomatoes and products obtained from tomatoes

may have a protective effect against various diseases such as prostate, cancer and cardiovascular diseases (2). Several studies have shown that during ripening important changes occur in the synthesis of pigments (e.g. of lycopene). Some authors like (3), reported an increase in the content of ascorbic acid during ripening, and argue that the main antioxidants in tomatoes are the carotenoids, ascorbic acid and phenolic compounds.

The entire antioxidant activity of tomatoes varies considerably depending on the variety, on genetic information, maturing stage and growing conditions (4). There is a wide variation in the content of vitamin C among tomatoes varieties. The carotene content is greatly influenced by the type of culture (5) and by the fertilization that is made during vegetation.

Humic acids in combination with other products represent an important source of natural organic matter in agricultural fertilization. The action of polyphenols in plants is distinguished by their role in the formation of pigments, in growth, for their the resistance to pathogens and for UV protection (6).

Studies in scientific literature show a varied effect of applications of humic acids simple or in combination with other stimulators. Fertilizer applications based on humic acids on tomatoes grown in greenhouses positively influence the qualitative and quantitative characteristics of the fruit (7). Other studies show that humic acids applied both on the root and foliar on a crop of peppers, determine a higher yield and better quality fruit that can significantly increase the content of capsaicin (8).

An important role in the development of plants plays also the boron influencing the synthesis of aromatic compounds, the permeability of protoplasmic membrans, translocation of carbohydrates, division of cells, fruit maturation, accumulation of free auxin and biosynthesis of nucleic acids (9, 2).

A deficit of boron in plants and soil leads to a decline in plant vascularization, root elongation, slowdown in the metabolism of carbohydrates, reduction of the synthesis of nucleic acids etc. (2). In its absence leaves become vulnerable, begin to twist inward, flowers fall and fruits start to smudge (starts tissue damage).

The tomatoes metabolism continues even after the removal of fruits from the plant when fruits are red, then reaching a point where they become devoid of nutritional value . To extend the life of fruits and vegetables, on the shelf, and to slow down the respiratory metabolism during storage, these are stored at low temperatures in an atmosphere of carbon dioxide (10).

The production quality after harvesting is done during the growing season and could be maintained, but not enhanced by post-harvest technologies. This can be achieved through a selection of genotypes with a better quality at storage, at harvest and at optimum maturity (11) indicated that the genetic material available on the market allows the discrimination of external and internal attributes of quality that must meet the consumer demands. The aim of this study was to observe the dynamics on days of storage, the nutritional value of the three hybrids of tomatoes fertilized in vegetation with organic products.

MATERIAL AND METHOD

Vegetal material

The experiment of the tomato crop was created in the didactic field of Horticulture Faculty of Craiova, Romania (44°19’ North latitude and 23°48’ East longitude), in an un-

heated greenhouse, and the biochemical determinations were performed in laboratory.

Antalya, Chocolat and Tiger tomato hybrids were studied. The experiment was bifactorial located in randomized blocks, with five variants of 3 repetitions/each variant. The first factor (A) was the fertilizing product assortment with five graduations: a1 – control without fertilizing; a2 - *Vitis vinifera* seed extract (Vv.Se); a3 - humic acids (HA.); a4 - humic acids + *Vitis vinifera* seeds extract (HA+VvSe); a5 - humic acids + extract from the seeds of *Vitis vinifera* + Boron (HA + VvSe + B) and the second factor (B) was the storage life with also five graduations: b1-without storage (at harvest), b2-storage for 7 days, b3-storage for 21 days, b4- storage for 35 days and b5- storage for 42 days.

The bio-fertilizer was applied to foliage at a concentration of 1% humic acids and 1.5% for the variants with polyphenolic and boron extract. The first foliar treatment was applied at 2 weeks after planting, and the following treatments at an interval of 14 days.

The fruits from three tomato hybrids that were different between them by colour were used in the study. Antalya hybrid has red fruits, Chocolat hybrid has chocolate brown fruits and Tiger hybrid has red-green fruits. The fruits for laboratory samples were collected manually at physiological maturity. They were brought from the field in the laboratory where they were washed with tap water to remove the field heat, soil and to reduce the microbial populations on their surface and then they were stored in ambient conditions. Each hybrid had a sample of 90 fruits per repetition, which were assessed throughout the storage period. They were kept at a constant temperature of 15 ± 0.5°C for 42 days. In this interval there were determined the content of vitamin C, total carotene and titratable acidity to see the evolution of these elements during storage.

The determination of vitamin C content

A sample of 5-10 g of tomatoes, previously ground with quartz sand has been put into a 100 ml- balloon by using a solution of 2% hydrochloric acid. It has been stirred and after sedimenting it has been filtered into a dry glass. A 10-ml aliquot has been passed into a Berzelius glass, to which 30 ml of distilled water; 5 ml of 1% potassium iodate and 1 ml solution of starch have been added. It has been then titrated with potassium iodate N/250 stirred until becoming bluish (2).

The calculation of ascorbic acid concentration is made by using the equation:

Vitamin C mg % = 352. n.f / G, Where:

n - ml used for titration; f – the factor of the potassium iodate N/250;

G – the sample weight in grams.

The determination of total carotenoids

The weighed samples, having been put separately in 95% in acetone (50 ml for each gram), were homogenized with Braun MR 404 Plus for one minute. The homogenate was filtered and was centrifuged using the Hettich Universal 320/320R centrifuge at 2500 rpm for ten minutes. The supernatant was separated and the absorbencies were read at 400-700nm on Cary 50 spectrophotometer. It was recorded that Chlorophyll a showed the maximum absorbance at 662 nm, chlorophyll b at 646 nm and total caroten at 470 nm and the amount of these pigments was calculated according to the formulas.

Ca = 11.75 A662 - 2.350 A645; Cb = 18.61 A645 - 3.960 A662

Cx+c = 1000 A470 - 2.270 Ca - 81.4 Cb/227

Ca = Chlorophyll a, Cb = Chlorophyll b; Cx + c = Total carotene

The determination of titratable acidity.

From a sample of 5-10 g of tomatoes homogenated with a vertical blender Braun MR 404 Plus for 1 minute, 1-2 ml were taken which were diluted in 10 ml of distilled water and titrated with 0.1 N sodium hydroxide in the presence of phenolphthalein.

The acidity calculation is made using the formula:

Where:

V - volume of NaOH solution used for titration, (ml);

m - sample weight, (grame);

N - normality of NaOH solution

Statistical Calculation

The data recorded were statistically processed by using the analysis of the variant (ANOVA) and the calculation of the limit differences, $P \leq 0.05$.

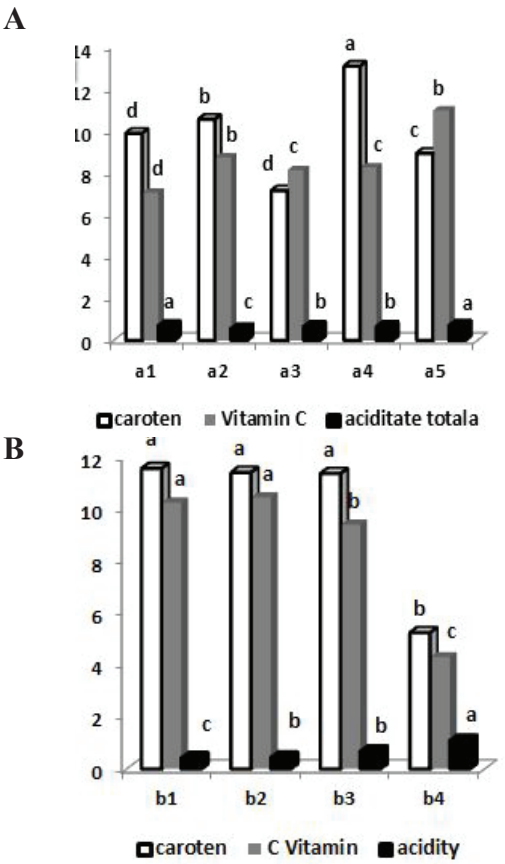

FIGURE 1.The influence of organic fertilization (A) and storage time (B) on the chemical composition of fruits at Antalya hybrid

RESULTS

In the storage room, the relative air humidity was 82%, in accordance to what was reported previously by (12). Therefore, the environmental conditions for storage had the temperature and relative humidity that did not affect the tomatoes during storage.

In the present study, the harvest, fertility treatments with organic products have significantly influenced the chemical composition in terms of content in carotene, vitamin C and acidity for Antalya hybrid. Thus, the best accumulation in carotene was at the version a4-humic acids + extract from the seeds of *Vitis vinifera* (HA + VvSe), in vitamin C at version a5 humic acids + extract from the seeds of *Vitis vinifera* + Boron (HA + VvSe + B) and for acidity in a1 and a5 (Figure 1A). During storage over a longer period of time, in tomato fruits metabolic reactions take place forming new acids that contribute to changing the acidity.

During storage, in the study, the storage time significantly affects the chemical composition of the fruit at Antalya cultivar. The highest level of content in carotene, vitamin C and acidity was recorded by the variants b1-without storage, b2-storage for seven days, b3-storage for 21 days. For the b4 version, the values decreased for carotene and vitamin C while acidity increased. In the b5 version, storage for 42 days, the fruits degraded (Figure 1B) and did not have the nutritional value.

In the interaction of factors, the fertilizing product assortment and the period of storage, at Antalya cultivar, it appears that the best variants were a4b1, a4b2, a4b3 for carotene con-

tent and a5b1, a5b2 and a5b3 for vitamin C content (Table 1).

TABLE 1. The effect of organic fertilization and storage time interactions on the chemical composition of the fruits at Antalya hybrid

Treatment	Total Carotene (mg/100 g)$^{-1}$	Vitamin C (mg/100 g)$^{-1}$	Titratable acidity (mg/100 g)
a_1b_1	11.3^{def}	9.0^{cd}	0.42^{i}
a_1b_2	11.5^{cdef}	9.1^{cd}	0.44^{i}
a_1b_3	11.6^{cdef}	7.5^{e}	0.6^{g}
a_1b_4	5.0^{k}	2.5i	1.4^{a}
a_2b_1	12.4^{bcd}	10.1^{b}	0.43^{i}
a_2b_2	12.7^{bc}	10.2^{b}	0.44^{i}
a_2b_3	13.0^{b}	9.5^{bc}	0.51^{h}
a_2b_4	5.9^{jk}	5.0^{fg}	0.9^{d}
a_3b_1	8.3^{i}	9.7^{bc}	0.43^{i}
a_3b_2	8.4^{i}	9.7^{bc}	0.45^{i}
a_3b_3	8.3^{i}	8.5^{d}	0.65^{g}
a_3b_4	3.5^{l}	4.5^{gh}	1.15^{b}
a_4b_1	15.2^{a}	9.9^{b}	0.44^{i}
a_4b_2	15.3^{a}	10.0^{b}	0.46^{hi}
a_4b_3	14.8^{a}	9.0^{cd}	0.8^{f}
a_4b_4	6.9^{j}	4.0^{h}	1.0^{c}
a_5b_1	10.6^{fg}	12.5^{a}	0.44^{i}
a_5b_2	11.0^{ef}	13.2^{a}	0.47^{hi}
a_5b_3	9.1^{hi}	12.5^{a}	0.9^{d}
a_5b_4	9.4^{ghi}	5.5^{f}	1.1^{b}
$P \leq 0.05$	1.396	0.767	0.057

[a-k] Different letters indicate differences according to the probability value (P)

For the Chocolat hybrid the highest values of vitamin C content were at a2 and a4 variants, and for carotene a4. Acidity recorded oscillations depending on variants (Figure 2A). After harvesting and storage for 7-21 days, these indicators values increased and then they started to decrease. Compared to Antalya, the vitamin C is also found in 42 days from harvest, but in small amounts (Figure 2B).

Regarding the interaction between foliar fertilizer products and the storage period of fruits, the

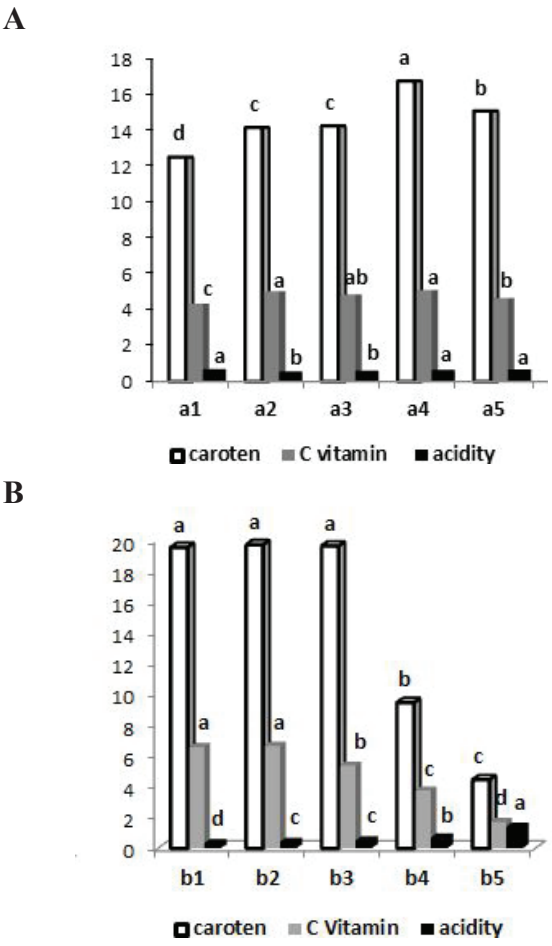

FIGURE 2. The influence of organic fertilization (A) and storage time (B) on the chemical composition of fruits at Chocolat hybrid

best carotene accumulation was recorded at a4b1; a4b2 and a4b3 variants and vitamin C was recorded at a4b2 variants, and for titratable acidity a1b5 (Table 2).

For the Tiger hybrid the application of organic fertilizers significantly affected the accumulation of carotene and vitamin C, compared to the unfertilized plant. The best accumulation was in variants a5, a4 for the content in carotene, a2 and a4 for the content in vitamin C and for titratable acidity a1 (Figure 3A). On storage period, there was a slight in-

TABLE 2. The effect of organic fertilization and storage time interactions on the chemical composition of fruits at the Chocolat hybrid

Treatment	Total Carotene (mg/100 g)$^{-1}$	Vitamin C (mg/100 g)$^{-1}$	Titratable acidity (mg/100 g)
a_1b_1	16.8^{d}	6.1^{cdf}	0.33^{i}
a_1b_2	17.0^{d}	6.1^{cdf}	0.4^{ghi}
a_1b_3	17.1^{d}	5.0^{h}	0.55^{efgh}
a_1b_4	8.4^{g}	3.0^{kl}	0.8^{d}
a_2b_1	3.3^{k}	1.1^{o}	1.5^{a}
a_2b_2	18.5^{c}	6.5^{abc}	0.31^{i}
a_2b_3	18.8^{c}	6.7^{abc}	0.35^{hi}
a_2b_4	19.0^{c}	5.5^{fgh}	0.4^{ghi}
a_3b_1	9.6^{f}	4.0^{ij}	0.6^{defg}
a_3b_2	5.0^{i}	2.5^{l}	1.15^{c}
a_3b_3	19.0^{c}	6.4^{bc}	0.34^{hi}
a_3b_4	19.1^{c}	6.5^{abc}	0.4^{ghi}
a_4b_1	19.0^{c}	5.2^{gh}	0.45^{fghi}
a_4b_2	9.4^{f}	4.2^{i}	0.65^{def}
a_4b_3	4.8^{j}	2.0l^{m}	1.2^{bc}
a_4b_4	22.5^{a}	7.0^{ab}	0.35^{hi}
a_5b_1	22.7^{a}	7,1^{a}	0.45^{fghi}
a_5b_2	22.8^{a}	5,7^{dfg}	0.5^{efghi}
a_5b_3	10.7^{e}	4.0^{ij}	0.7^{de}
a_5b_4	5.1^{h}	1.7^{mn}	1.3^{abc}
$P \leq 0.05$	0.725	0.696	0.218

a-o Different letters indicate differences according to the probability value (P)

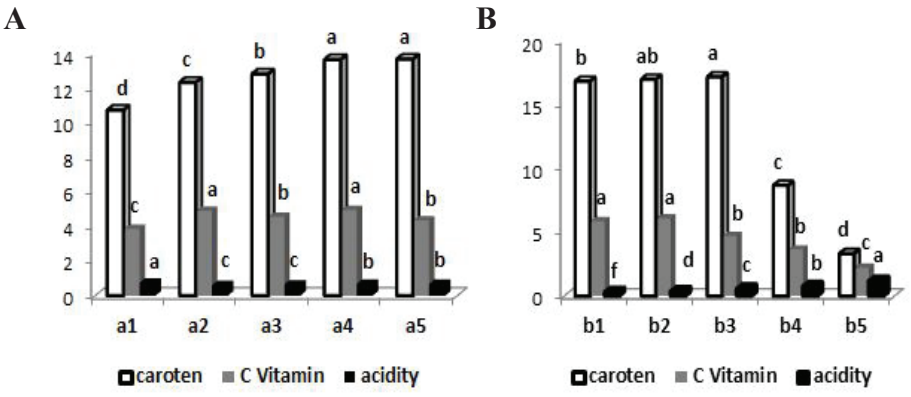

FIGURE 3. The influence of organic fertilization (A) and storage time (B) on the chemical composition of the fruits of the Tiger hybrid

crease in vitamin C and carotene in 7-21 days of fruits storing and then slightly decreased (Figure 3B). The results are also confirmed by (13) who in their study recorded the same values for a period of 10 days of tomatoes storage. In interaction the best variants were a3b2 and a4b2 for vitamin C and for carotene the a4b3 version (Table 3).

TABLE 3. The effect of organic fertilization and storage time interactions on the chemical composition of the fruits of Tiger hybrid

Treatment	Total Carotene (mg/100 g)$^{-1}$	Vitamin C (mg/100 g)$^{-1}$	Titratable acidity (mg/100 g)
a_1b_1	14.6^{h}	5.5^{bc}	0.39^{jkl}
a_1b_2	14.6^{h}	5.6^{bc}	0.41^{ijkl}
a_1b_3	14.8^{h}	4.0^{ef}	0.7^{ef}
a_1b_4	7.4^{l}	3.0^{gh}	0.9^{c}
a_2b_1	2.0^{p}	1.1^{j}	1.3^{a}
a_2b_2	16.5^{g}	5.8^{ab}	0.3^{l}
a_2b_3	16.7^{fg}	6.1^{ab}	0.35^{jkl}
a_2b_4	16.8^{efg}	5.0^{cd}	0.55^{ghi}
a_3b_1	8.3^{k}	4.5^{de}	0.7^{ef}
a_3b_2	3.1^{o}	3.0^{gh}	1.1^{b}
a_3b_3	17.2^{defg}	5.9^{ab}	0.3^{l}
a_3b_4	17.3^{cdef}	6.3^{a}	0.4^{jkl}
a_4b_1	17.5^{bcde}	4.5^{de}	0.55^{ghi}
a_4b_2	8.5^{jk}	3.5^{fg}	0.75^{de}
a_4b_3	3.3^{no}	2.5^{hi}	1.2^{ab}
a_4b_4	18.0^{abc}	6.1^{ab}	0.33^{kl}
a_5b_1	18.2^{ab}	6.4^{a}	0.45^{hij}
a_5b_2	18.5^{a}	5.5^{bc}	0.6^{fg}
a_5b_3	9.2^{ij}	4.5^{de}	0.8^{cd}
a_5b_4	4.0^{mn}	2.5^{hi}	1.25^{a}
$P \leq 0.05$	0,703	0,675	0,106

$^{a-o}$ Different letters indicate differences according to the probability value (P)

DISCUSSION

After Castro et al (14) it is generally accepted that the mature tomatoes can be stored for relatively long periods at a temperature of 10-15°C and an atmospheric humidity of 85-95%. Therefore, the temperature in the storage room it is also similar to thst in our study, except for the humidity that lower.

Generally at relatively low temperatures it is maintained the quality of fruit and vegetables due to the effects breathing intensity reduction, transpiration, ethylene production, maturation, aging and slime growth.

It should be noted that towards the end of the storage period of tomato fruits, the vitamin C content decreases because the fruits reach the over maturation. This trend was consistent with the results obtained by Toor and Savage (13). There are cases where there were reported increases in vitamin C content during the final stages of the fruit maturation. For example Brecht et al (15) found a high content of vitamin C along with increasing maturity of fruits. The literature shows that the tomatoes fertilized during vegetation with organic products have a higher content of vitamin C than the non-fertilized ones (16). The difference between the hybrids in terms of the content of vitamin C, for the tomatoes for fresh consumption varied in our study similarly to the data reported by Toor and Savage (13).

The tomatoes grown in greenhouse recorded lower levels of ascorbic acid than those grown outdoors due to the intensity of light which is smaller in greenhouses than in the culture on the open field (17). This could explain the relatively lower content of ascorbic acid at the studied hybrids.

The lycopene represents 60-74% of the tomato carotenoids and of the tomato products. The lycopene content is affected by many factors such as maturity, variety (2), treatments applied during vegetation,

the influence of environmental factors and especially of the heat. Depending on the stages of development, at the tomatoes at the immature green fruit stage until the physiological maturity stage, when the fruit is yellow-orange or deep red, the carotenoid content increases and it is related to the increased lycopene content in plastids.

Our results showed that the carotene biosynthesis continues during storage, this being consistent with the results of (18). It increased from the harvest of 21 days of storage and then began to decrease at all the three studied cultivars.

After Gyanendra et al (19) the content of carotenoids in tomatoes increases during storage due to progressing towards full maturity when chlorophyll degradation happens and there is increased synthesis of carotenoids. Increased levels of lycopene in tomato during storage might be due to ripening advancements of tomato fruits and conversion of chloroplasts to chromoplasts. This effect was also reported by Ajlouni et al (20) which registered increases in the content of lycopene in tomato fruits during storage at 22 °C for a period of 14 days.

The titratable acidity in the present study ranged from 0.39 mg/100g at Tiger cultivar to 0.42 mg/100g at Antalya cultivar for the unfertilized variants. The latter cultivar forms larger fruits than the Tiger and Chocolate hybrids. This variation could be due to the difference in size of the fruits. After Tigist et al (12) showed that large tomato fruits had higher acidity, which is consistent with the results of our study. The titratable acidity continued to grow throughout the storage period and the results are similar to those obtained by (10, 21). According to Tigist et al (12) in a study on some tomatoes cultivars, stored for 32 days, the acidity increased only in the first 4 days of storage, and then decreased.

Application of humic acids influenced significantly the quality of tomato fruit (7). Also, cumulative application of humic acids with potassium to a cucumbers crop in greenhouse has resulted in a significant improvement of the fruits (22). The same results were observed when humic acid was applied to an apricot crop which led to an increase in the content of T.S.S and decreasing fruit acidity (23).

CONCLUSION

The best fertilizers on carotene content and vitamin C in the hybrids studied were a4 - humic acids + *Vitis vinifera* seeds extract and a5 - humic acids + extract from the seeds of *Vitis vinifera* + Boron.

Applying fertilizers with humic acids combined with extract from the seeds of *Vitis vinifera* (a4) and extract from the seeds of *Vitis vinifera* + Boron (a5) determines a good accumulation in nutrient substances over the retention period up to 21 days of tomato fruits.

In the interaction of factors organic fertilization during the vegetation period and storing time there were highlighted the variations a4b1, a4b2 and a4b3 in Antalya and Chocolat and a4b3 at Tiger, regarding the carotene accumulation, For vitamin C there were emphasized variants a5b1, a5b2 Antalya, a4b2 at Tiger and Chocolat.

REFERENCES

1. Willcox JK, Catignani GL, Lazarus S. Tomatoes and cardiovascular health. Crit Rev Food Sci Nutr 2003;(43):1-18.
2. Dinu M, Dumitru MG, Soare R. The effect of some biofertilizers on the biochemical components of the tomato plants and fruits. Bulg J Agric Sci 2015;21(5):998-1004.
3. Giovanelli G, Lavelli V, Peri C, Nobili S. Variation in antioxidant components of tomato during vine and post-harvest ripening. J Sci Food Agric 1999;(79):583–1588.
4. Leonardi C, Ambrosino P, Esposito F, Fogliano V. Antioxidant activity and carotenoid and to-

matine contents in different typologies of fresh consumption tomatoes. J. Agric Food Chem 2002;(48):723–4727.

5. Zoran IS, Nikolaos K, Ljubomir S. Tomato Fruit Quality from Organic and Conventional Production. pp. 147-169 In: Organic Agriculture Towards Sustainability. Vytautas Pilipavicius (ed). In Tech Publisher, Rijeka, Croatia 2014.
6. Lattanzio V, Veronica M, Lattanzio T, Cardinali A. Role of phenolics in the resistance mechanisms of plants against fungal pathogens and insects. Phytochemistry: Advances in Research. Editor: Filippo Imperato 2006;23-67.
7. Yildirim E. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agr Scand B 2007;57(2):182-186.
8. Karakurt Y, Unlu H, Ulnu H, Padem H. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agr Scand B 2009;579(2):233-237.
9. Waqar A, Munir HZ, Sukhdev SM, Abid N, Saifullah. Boron Deficiency in Soils and Crops: A Review. Crop plant, Publisher In Tech 2012;77-114
10. Kalt W, Forney CF, Martin A, Prior RL. Antioxidant capacity, Vitamin C, Phenolics, and anthocyanins after fresh storage of small fruits. J. Agr Food Chem 1999;(47):638–644.
11. Ramakrishnan K, Narayanan P, Vasudevan V, Muthukumaran G, Antony U. Nutrient composition of cultivated stevia leaves and the influence of polyphenols and plant pigments on sensory and antioxidant properties of leaf extracts. J Food Sci Technol 2010;47(1):27–33.
12. Tigist, M, Tilahun SW, Woldetsadik K. Effects of variety on the quality of tomato stored under ambient conditions. J. Food Sci. Technol 2013;50(3):477–486.
13. Toor RK., Savage GP. Changes in major antioxidant components of tomatoes during postharvest storage. Food Chem 2006;(99):24–727.
14. Castro LR, Vigneault C, Charles MT, Cortez LA. Effect of cooling delay and cold-chain breakage on 'Santa Clara' tomato. J. Food Agric. Environ 2005;(3):49-54.
15. Brecht JK, Bisogni L, Mungek HM. Effect of fruit position, stage of ripeness and growth habit on chemical composition of fresh tomatoes. J. Am Soc Hort Sci 1976;(41):945–948.
16. Hoza Ghe. Research regarding the effect of foliar fertilization on tomato growth and fructification. J. Hortic Forest Biotech 2010;(1):257-260.
17. Dumas Y, Dadomo M, Di Lucca G, Grolier P. Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. J. Sci Food Agric 2003;83(5):369-382.
18. Brashlyanova BP, Ganeva PD. Colour parameters during cold storage and ripening of tomatoes. Acta hortic 2009;(830):345-348.
19. Gyanendar KR, Rajesh K, Singh AK, Rai PK, Rai M, Chaturvedi AK, Rai AB. Changes in antioxidant and phytochemical properties of tomato (*Lycopersicon esculentum* Mill.) under ambient condition. Pak. J. Bot 2012;44(2):667-670.
20. Ajlouni S, Kremer S, Masih S. Lycopene content in hydroponic and non-hydroponic tomatoes during postharveststorage. Food Australia 2001;53(5):195-196.
21. Moneruzzaman KM, Hossain AB, Sani W, Saifuddin M. Effect of harvesting and storage conditions on the post harvest quality of tomato (*Lycopersicon esculentum* Mill) cv. Roma VF. Aus J Food Crops 2009;(3):113-121.
22. Mohsen K. Effect of Foliar Application of Humic Acid and Potassium Nitrate on Cucumber Growth. Bull. Env. Pharmacol. Life Sci 2003;2(11):03-06.
23. Fathy MA, Gabr MA, El Shall SA. Effect of humic acid treatments on 'Canino' apricot growth, yield and fruit quality. New York Sci. J 2010;(3):109-115.

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Análisis proximal, de textura y aceptación de las galletas de trigo, sorgo y frijol

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RESUMEN: Las galletas son actualmente productos de gran demanda, constituyendo un sector sustancial de la industria alimentaria. Considerando la importancia de la buena alimentación y la oportunidad de incorporar leguminosas a productos de panificación como alternativa saludable logrando un mejor balance proteico, se planteó la propuesta de elaborar galletas a base de harina de trigo, sorgo y frijol. El objetivo del presente trabajo fue elaborar y evaluar galletas de harina de trigo sustituidas al 10%, 30% y 100% de harina de sorgo y frijol. Se diseñaron tres formulaciones para la elaboración de galletas al 10%, 30%, 100% de harina de sorgo y harina de frijol y la muestra control 100% trigo. Se realizó la evaluación proximal y perfil instrumental de textura a cada uno de las formulaciones; así mismo, el análisis sensorial para evaluar los atributos de color, olor, sabor y textura por medio de una escala hedónica de siete puntos. El reemplazo parcial de trigo por sorgo 10% - 30% y frijol al 10% fueron las formulaciones más acertadas con un porcentaje promedio de proteínas de 19 a 23%, además de presentar una alta puntuación en la evaluación sensorial. Estas combinaciones de harinas podrían ser utilizadas por la industria alimentaria para producir galletas de buena calidad nutricional, con características físicas y sensoriales aceptables para la población en general.
Palabras clave: Galletas, harina compuesta, trigo, sorgo, frijol.

SUMMARY: Nutritional, texture and sensory profile of cookies from wheat, sorghum and bean. Nowadays, cookies are in a real high demand, constituting a substantial sector of the food industry. Considering the importance of a good nutrition and the opportunity to incorporate legumes into baking products as a healthy alternative achieving a better protein balance, it was made a proposal to make cookies based on wheat flour, sorghum and beans. The objective of the current work was to elaborate and evaluate wheat flour cookies substituted to 10%, 30% and a 100% of sorghum and bean flour. Three formulations were prepared for the making of the cookies at 10%, 30% and a 100% of sorghum and bean flour and the control sample at a 100% of wheat. The proximal evaluation was made to each of the treatments, as well as the sensorial analysis for the evaluation of color attributes, odor, taste and texture through a hedonic scale of 7 points. The partial replacement of wheat by sorghum 10% - 30% and 10% of bean were the most successful formulations with a protein percentage average of 19 to 23% besides presenting a high score in sensory evaluation. These flour combinations could be used in the food industry for the making of cookies with a well nutritional quality, with physical and sensory qualities acceptable for the general population.
Key words: Cookies, composite flour, wheat, sorghum, bean.

INTRODUCCION

La alimentación de la sociedad actual, debido en gran parte al acelerado ritmo de vida, involucra un elevado consumo de alimentos de bajo valor nutritivo con altos porcentajes de grasas saturadas, azúcares refinados, aditivos, conservadores y elevado valor calórico (1) observándose una creciente tendencia en el consumo de alimentos y bebidas fuera de casa, de autoservicio, congelados, precocinados y para llevar, los cuales son de fácil acceso (2). En el caso de productos de panadería, como las galletas, se ha registrado un consumo importante desde edades tempranas (3), convirtiéndose en unas de las opciones preferidas entre todos los grupos de edad (1). Por concepto,

las galletas se definen como bocadillos obtenidos de pasta única o compuesta sometidas a un proceso de cocción en horno (4) y se preparan generalmente de harina de trigo, sin embargo, se ha observado que su contenido nutricional aumenta de acuerdo a la materia prima utilizada, como harinas de trigo combinadas con soya, germen de maíz y leguminosa, entre otros (5).

Las ventajas de utilizar cereales, como el sorgo, arroz, y maíz, es su fuente de proteína, antioxidantes, fibra y además están libres de gluten. Tomando en cuenta que México es el cuarto productor mundial de sorgo, con una participación de 10% de la producción mundial, con valor nutricional promedio de 10-15% de proteínas, 7-10% de fibra, fuente de calcio y zinc. Sin embargo, su uso se ha destinado básicamente para la elaboración de alimentos para aves de corral y ganado (6). Otra alternativa es el uso de leguminosas, como el frijol, el cual es una de las principales fuentes de proteína en Latinoamérica y África; su contenido nutricional es destacable, y de acuerdo a la variedad los porcentajes de proteína oscilan de 14 a 33%, 14 a 19% de fibra y 2.9 a 4.5% de minerales (7,8). Además, la ingesta de frijol en la dieta tiene un efecto significativo sobre la salud, ayudando a la prevención de enfermedades como el cáncer de mama y colón, la regulación del colesterol y glucosa en sangre (9). No obstante, las proteínas de las legumbres son deficientes en metionina, mientras que las de cereales en lisina o cisteína; pero la mezcla de estos alimentos proporciona proteínas de alto valor biológico ya que se completa el perfil de aminiácidos esenciales (10,11). La formulación de productos alimenticios aludables y la generación de nuevas materias primas, es una tarea prioritaria para la seguridad alimentaria, siendo de gran interés el grupo de los cereales, granos y semillas, como fuente de alimentos (12). Es por eso que el objetivo del presente estudio fue elaborar y evaluar galletas a base de trigo, sorgo y frijol, así como determinar su aceptación por los consumidores; como un alimento saludable y nutritivo.

MATERIALES Y MÉTODOS

Materia prima

Se utilizó grano de sorgo blanco variedad RB-Paloma, el cual fue proporcionado por el Centro de Investigación Regional del Noreste (INIFAP)-Campo Experimental Río Bravo. La harina de trigo, el frijol pinto nacional (grano), manteca vegetal, azúcar, canela y esencia de vainilla, fueron adquiridos en centros comerciales de Reynosa, Tamaulipas, México. Se utilizó una variedad de sorgo blanco, la cual no contiene taninos a diferencia de las variedades de grano rojo (6); en cuanto al frijol se llevó a cabo una molienda sin remojo ya que la cocción elimina los inhibidores de tripsina y otros compuestos tóxicos que pudieran estar presentes (12).

Preparación de las galletas

Las harinas de sorgo y frijol fueron obtenidas utilizando un molino de martillos (Azteca N. 6 tipi GP100) con una criba de 0.1 mm; posteriormente fueron tamizadas con mallas del número 40 para obtener una harina similar a la de trigo. Se diseñaron seis formulaciones mezclando harina de trigo-frijol y harina de sorgo-trigo, sustituyendo para ambas mezclas en un 10 y 30% la harina de trigo (Tabla 1). Siguiendo el mismo procedimiento se obtuvieron galletas de 100% harina de trigo como control. Las formulaciones fueron nombradas como H100 (control), S100 (100% sorgo), S10 (con sustitución de 10% sorgo), S30 (sustitución 30% sorgo), F100 (100% frijol), F10 (sustitución 10% frijol) y F30 (sustitución 30% frijol). Para la obtención de las galletas se siguieron las etapas de amasado, reposo, laminado, cortado, enfriado y empaquetado de acuerdo a Gil, 2010 (13). Una vez que se tuvo la masa cortada se llevó a cocción en un horno

TABLA 1. Porcentajes de cada tipo de harina en los diferentes tratamientos

Formulación	Harina de trigo (HT)	Harina de sorgo (HS)	Harina de frijol (HF)
T100	100	0	0
S100	0	100	0
F100	0	0	100
S10	90	10	0
S30	70	30	0
F10	90	0	10
F30	70	0	30

convencional por 30 min a 200°C; se dejaron enfriar, se espolvorearon con azúcar y canela.

Análisis de composición proximal

Una vez obtenidos las galletas se procedió a la realización del análisis de composición proximal utilizando métodos oficiales de la AACC (1995), se determinó el contenido de proteína total por el método de Kjeldhal (método oficial 950.36), fibra (método oficial 950.37), cenizas (método oficial 930.22), grasa (método oficial 935.38) y humedad (método oficial 935.36). Los carbohidratos fueron calculados por diferencia.

Determinación de perfil de textura (TPA)

El análisis de textura se realizó empleando el método de compresión por punción (Lloyd Instruments, modelo TA plus). Para la prueba de dureza se utilizó una sonda cilíndrica de punta esférica con una velocidad de descenso de 2 mm/s y una distancia de penetración de 5 mm, con una fuerza de contacto de 0.5 Newton. Para cada una de las pruebas se realizaron 10 repeticiones de cada tratamiento, en las pruebas se emplearon dos sondas. Para la fracturabilidad se empleó una sonda de cuchilla sin filo, con una velocidad de descenso de 2 mm/s y una distancia de penetración de 6 mm, con una fuerza de contacto de 0.5 Newton.

Evaluación sensorial

Para evaluar el grado de satisfacción del producto se realizó la prueba afectiva de nivel de agrado de acuerdo con el método citado por Aguilar et al., (14) con algunas modificaciones. En la prueba participaron 55 jueces no entrenados seleccionados, de edades entre 19 y 85 años. Se les proporcionaron muestras codificadas con números aleatorios de tres cifras con 10 g de muestra, correspondiente a dos piezas de galletas de cada formulación junto con un vaso de agua purificada para enjuague bucal entre muestras. Para medir el nivel de agrado se utilizó una escala hedónica de 7 puntos (1: me disgusta extremadamente, 4: ni me gusta, ni me disgusta y 7: me gusta extremadamente), para evaluar los atributos de color, olor, granulosidad, dureza, pegajosidad, sabor dulce o amargo y aceptación total.

Análisis de datos

Para evaluar las diferencias de los distintos parámetros proximales y de textura en las formulaciones, se realizó un análisis de varianza ANOVA de una vía con el paquete estadístico Statisticav 7.0. Los resultados se presentaron como media ± la desviación estándar de los valores obtenidos. Para determinar si existían diferencias significativas entre las muestras se realizó una comparación de medias por el de diferencia mínima significativa de Fisher, con un valor de significancia de $p<0.05$. Para el análisis de la evaluación sensorial se utilizó prueba de Kruskal-Wallis con ayuda del paquete Minitad 15.

RESULTADOS

Análisis de composición proximal

En la Tabla 2 se muestra la composición proximal de los tratamientos, la galleta de harina de trigo (HT100%) como muestra control y para el comparativo se realizaron galletas de harina sorgo (HS100%) y galletas de harina de frijol (HF100%) con sus respectivas combinaciones. El

TABLA 2. Resultados del análisis proximal en base seca (g/100 g).

Formulación	Humedad	Ceniza	Grasa	Fibra	Proteína	CHO
T100	0.92 ± 0.02^{c}	0.44 ± 0.06^{d}	19.10 ± 0.65^{b}	$2.88^{c} \pm 0.01$	19.55 ± 0.35^{c}	57.11
S100	1.58 ± 0.03^{a}	1.02 ± 0.03^{b}	19.22 ± 1.30^{b}	$3.03^{c} \pm 0.27$	12.04 ± 0.89^{d}	63.11
F100	1.11 ± 0.05^{b}	2.41 ± 0.06^{a}	21.04 ± 1.30^{ab}	$3.38^{b} \pm 0.01$	29.81 ± 0.36^{a}	42.25
S10	1.04 ± 0.01^{b}	0.41 ± 0.01^{d}	21.98 ± 1.70^{a}	$3.4^{b} \pm 0.01$	19.17 ± 0.07^{c}	54.00
S30	1.05 ± 0.10^{b}	0.43 ± 0.03^{d}	22.08 ± 1.01^{a}	$3.36^{b} \pm 0.04$	19.01 ± 0.89^{c}	54.07
F10	1.36 ± 0.19^{a}	0.62 ± 0.04^{c}	22.29 ± 0.88^{a}	$3.38^{b} \pm 0.04$	21.23 ± 0.88^{b}	51.12
F30	1.19 ± 0.06^{b}	0.23 ± 0.02^{e}	22.68 ± 1.63^{a}	$3.5^{a} \pm 0.03$	23.29 ± 0.11^{b}	49.11

HT: Harina de trigo; HS: Harina de sorgo; HF: Harina de frijol. ^{a,b,c,d}Letras diferentes en la misma columna indican diferencias significativas entre los tratamientos ($p < 0.05$). *Valores promedio de 3 repeticiones y desviación estándar.

contenido de grasa se presentó entre 18 y 23 %, el porcentaje de fibra de los diferentes tratamientos fue de 0.01 a 0.25%; siendo más alto en el control, y más bajo en el tratamiento con 30% de frijol. En lo referente al contenido proteico, estos fueron mayores en los tratamientos con harina de frijol, mientras que en el control se encontró 19%. El porcentaje de carbohidratos fue mayor en el control (66%) y menor en la galleta100% frijol (45%).

TABLA 3. Valores de dureza y fracturabilidad en los distintos tratamientos.

Formulación	Dureza (Kgf)	Fracturabilidad (Kgf)
T100	0.565 ± 0.186b	0.488 ± 0.134a
S100	0.981 ± 0.191a	0.304 ± 0.075ab
F100	0.465 ± 0.101b	0.305 ± 0.115ab
S10	0.509 ± 0.130b	0.382 ± 0.103ab
S30	0.476 ± 0.110b	0.257 ± 0.083b
F10	0.656 ± 0.120b	0.459 ± 0.054a
F30	0.638 ± 0.191a	0.316 ± 0.054ab

HT: Harina de trigo; HS: Harina de sorgo; HF: Harina de frijol. a,bLetras diferentes en la misma columna indican diferencias significativas entre los tratamientos ($p < 0.05$). *Valores promedio de 3 repeticiones y desviación estándar.

La Tabla 3 muestra los resultados del análisis de textura, se observa que la dureza fue mayor en la galleta de sorgo, comparada con el control; mientras la fracturabilidad fue mayor en el control. Los resultados obtenidos del análisis de nivel de agrado de las diferentes formulaciones mostraron diferencias significativas ($p \leq 0.05$) solamente en los atributos de sabor y aceptación total. Por cada tratamiento se obtuvo un promedio de aceptación de cada atributo evaluado y la desviación estándar (Tabla 4), las galletas con harina de trigo-sorgo mostraron los más altos niveles de agrado; sin embargo ningún tratamiento tuvo diferencias significativas ($p \leq 0.05$) con respecto al control, en el parámetro de aceptación general.

TABLA 4. Resultados de evaluación sensorial de las galletas de harinas compuestas.

	Color	Olor	Granulosidad	Dureza	Pegajosidad	Dulce	Amargo	Aceptación total
T100	5.40^{a}±1.20	5.00^{a}±0.99	5.37^{a}±1.21	5.53^{a}1.02	5.22^{a}±1.14	5.41^{a}1.06	5.24^{a}±1.27	5.00^{a} ±1.04
S100	4.79^{a}±1.46	4.51^{a}±1.28	4.90^{a}±1.37	5.34^{a}±1.05	5.15^{a}±1.33	4.86^{ab}±1.36	4.81^{ab}±1.35	4.82^{ab} ±1.42
F100	4.34^{a} ±1.63	3.08^{a}±1.53	3.96^{a}±1.68	4.43^{a}±1.50	3.91^{a}±1.55	2.68^{b}1.55	2.27^{b}±1.32	2.44^{b} ±1.42
S10	5.43^{a} ±0.97	5.15^{a}±1.30	5.67^{a}±0.96	5.65^{a}±1.00	5.29^{a}±1.21	5.67^{a}±1.03	5.34^{a}±1.17	5.56^{a}±1.12
S30	5.53^{a}±1.06	5.18^{a}±1.06	5.47^{a}±1.07	5.58^{a}±0.93	5.13^{a}±1.17	5.46^{a}±1.07	5.13^{a}±1.33	5.65^{a}±0.96

^{a,b}Letras diferentes en la misma columna indican diferencias significativas entre los tratamientos ($p \leq 0.05$).
*Valores promedio de 3 repeticiones y desviación estándar

DISCUSIÓN

El contenido de humedad se encontró entre los porcentajes de 0.92 % a 1.58 %; Okpala et al., (15) obtuvieron valores de 6.6 a 8% en galletas hechas de guisantes, sorgo y ocumo blanco (*Xanthosoma sagittifolium*); Adebowale et al., (16) reportaron una humedad de 10.67% en galletas de trigo enriquecidas con 10% de sorgo; mientras que Ubbor & Akobundu (17) encontraron en promedio 10 % en galletas de trigo enriquecidas con 10 y 15% de harina de semillas de sandía. Estos valores son superiores a los encontrados en el presente trabajo; sin embargo, las galletas generalmente son alimentos con poca humedad, lo que las hace menos deteriorables, facilitando su transporte, conservación y almacenamiento. En lo que respecta al contenido de cenizas se encontró que las formulaciones de 100% harina de sorgo y frijol tuvieron los valores más altos, mientras que el resto de las formulaciones tuvieron valores similares al control. De Camargo et al., (18) reportaron valores de 1.78 a 2.89 en galletas de trigo fortificadas con cáscara de cacahuate, encontrándose también los valores más altos en las formulaciones con mayor porcentaje de cáscara de cacahuate, en comparación con el control.

En lo referente al contenido de grasa, se encontró que las galletas elaboradas a base de harinas compuestas tienen mayor contenido con respecto a la galleta control, sin embargo, los valores se ubican dentro del rango del contenido de lípidos de acuerdo al valor nutricional de la galleta que abarca del 12 al 25 % de grasas de origen vegetal (19). Okpala et al., (15) encontraron un 6.84% de grasa en galletas a base de harina 100% sorgo y 5.64 % en las realizadas con harina de trigo, estos valores se encuentran por debajo de lo encontrado en el presente estudio, que puede ser por la variedad de grano utilizado, y los ingredientes añadidos que aportaron nutrientes tales como el huevo y la leche. Por otro lado, el contenido de fibra oscilo entre 2.88 a 3.5, siendo los valores más bajos para la formulación control y la galleta de 100% sorgo; la galleta con sustitución de frijol al 30% (F30) tuvo el porcentaje más alto, mostrando diferencias significativas ($p \leq 0.05$) con el resto de las formulaciones. en el mismo estudio de Okpala et al., (15) se reportó un promedio de 2% en galletas de sorgo, trigo, garbanzo y ocumo blanco (cocoyam). En un estudio realizado por Ndife et al., (4) encontraron un alto contenido de fibra, 4.67 y 6.74% para galletas de trigo y soya, respectivamente.

En cuanto al porcentaje de proteína, se encontró un aumento de 10% en las galletas de frijol, comparado con el control, esto debido al alto contenido proteico de esta leguminosa, que al combinarla con trigo el contenido de proteínas de la

galleta aumenta comparativamente con la de sorgo o trigo solo. Ndife et al., (4) reportan un 37% de proteína en galletas a base de harina de soya, un contenido similar al encontrado en las galletas de frijol. Patil et al., (19) realizaron la sustitución de harina de trigo por harinas de chícharo, lenteja o garbanzo, en porcentajes de 5, 10 y 15% en snacks extruidos; encontraron un aumento en el contenido proteico mayor mientras más alto fue el porcentaje de sustitución. En lo que respecta al contenido de carbohidratos, en el presente estudio se encontró entre 45 y 66%. De Camargo et al., (18) reportaron un 60-66% en galletas de trigo enriquecidas con cáscara de cacahuate, siendo mayor en el control que en las formulaciones. Resultados similares se reportaron en galletas de guisantes, sorgo y ocumo blanco donde se encontraron porcentajes de 57 a 72%, siendo mayores en el control (100% trigo). Las variedades de sorgo blanco son preferidas para consumo humano que las de grano rojo, ya que estas no poseen taninos (2); por otro lado los inhibidores enzimáticos del frijol son eliminados a 80°C por 9 min; estas galletas fueron cocidas a 200°C por 30 min, por lo que este tratamiento es eficiente para eliminar dichos compuestos tóxicos y las galletas sean seguras para su consumo (12).

Perfil de textura

La dureza y la fracturabilidad son características importantes de la textura en este tipo de alimentos (20); por ello se realizó la determinación de dureza y fracturabilidad de las galletas obtenidas. Se encontró que la formulación S100 y en la que se sustituyó en un 30% de trigo con frijol (F30) obtuvieron la mayor dureza; en lo que respecta a las demás formulaciones, no se encontraron diferencias significativas ($p \geq 0.05$) entre los demás tratamientos. En lo que se refiere a la fracturabilidad, las galletas de la formulación con 90% de harina de trigo y 10% de harina de frijol (F10) presentaron mayor fracturabilidad. Chung et al., (21) reportaron una disminución de la dureza en galletas en las que se sustituyó parcialmente la harina de trigo por arroz y arroz germinado; resultados similares fueron encontrados por Chauhan et al., (22) que encontraron una disminución de 9.40 a 4.28 kilogramos-fuerza (Kgf), en galletas de trigo enriquecidas con amaranto crudo y germinado, en comparación con el control de harina de trigo. Un estudio reporta una disminución de 48% en la dureza al comparar galletas germinado de cenizo (*Chenopodium álbum*) con galletas de trigo. Estos efectos de disminución de textura, principalmente de granos germinados, se atribuyen a la degradación estructural de las proteínas y almidón, lo que lleva a una matriz más débil dando por resultado la textura más suave (20). Resultados similares se observaron en este estudio, encontrando valores menores con respecto a la dureza en todas las formulaciones, resultando galletas más suaves debido al contenido de nutrientes.

Prueba de evaluación sensorial

La galleta de harina de frijol fue la de menor aceptación, mientras que las formulaciones con mejor aceptación fueron los que tuvieron sustitución de 10% y 30 % de sorgo (HT90-HS10%y HT70-HS30%) y la de 10% frijol y 90% trigo (HT90-HF10%). Rai et al., (23) determinaron la aceptación de galletas de diferentes mezclas de cereales, encontrando mejor aceptación en las mezclas de sorgo-arroz, sorgo-maíz y sorgo-mijo; el nivel de aceptación entre los panelistas fue mayor en comparación con las galletas control hechas de trigo. Por otro lado, Cutullé et al., (1), evaluaron galletas de trigo sustituidas al 30% de harina de lenteja y 20% de harina de arroz; ambas presentaron buenos valores de aceptabilidad en cuanto a los atributos de color, crujencia y sabor.

CONCLUSIONES

Las galletas obtenidas con las diferentes combinaciones mostraron un alto contenido proteico; el reemplazo parcial de trigo por sorgo o frijol

además de ser una buena fuente de proteínas presentaron un buen nivel de aceptación en la evaluación sensorial con respecto al color, sabor, aroma, textura y aceptabilidad general por los panelistas. Estas combinaciones de harinas podrían ser utilizadas por la industria alimentaria para producir galletas de buena calidad nutricional, con características físicas y sensoriales aceptables para la población en general.

REFERENCIAS

1. Cutullé, B., Berruti, V., Campagna, F., Colombaroni, M. B., Robidarte, M. S., Wiedemann, A., & Vázquez, M. (2012). Desarrollo y evaluación sensorial de galletitas de jengibre con sustitución parcial de harina de trigo por harina de arroz y lenteja (Gallentinas). Diaeta, 30(138), 25-31.
2. Ramos, E. G., Castro-Sánchez, A. E., Zambrano, A., & Núñez, G. M. (2012). Aporte calórico y macronutrimental de los menús infantiles de la comida rápida y convencional. Rev Chil Nutr, 39(3), 27-33.
3. Quizán Plata T., Galaviz Moreno S., Espinosa López A., Orozco García M.E. 2011. Patrones alimentarios y su relación con el estado nutricio en escolares de primer grado de dos escuelas públicas de Hermosillo, Sonora. Epistemus, 10:15-20
4. Ndife, J., Kida, F., &Fagbemi, S. (2014). Production and quality assessment of enriched cookies from whole wheat and full fat soya. Eur J Food Sci Technol, 2(1), 19-28.
5. Serrem, C. A., de Kock, H. L., & Taylor, J. (2011). Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. International J Food Sci Technol, 46(1), 74-83.
6. Montes-García, N., Williams-Alanís, H., Moreno-Gallegos, T., Cisneros-López, M. E., Pecina-Quintero, V. (2012)- Rb-paloma variedad de sorgo blanco para producción de grano y forraje. Rev Fitotec Mex, 35(2):185-187.
7. Raya-Pérez, J. C., Gutiérrez-Benicio, G. M., Pimentel, J. G. R., Prieto, J. C., & Aguirre-Mancilla, C. L. (2014). Caracterización de proteínas y contenido mineral de dos variedades nativas de frijol de México. Agronomía Mesoamericana, 25(1), 1-11.
8. Maldonado, S. H. G., Gallegos, J. A. A., de los Ángeles Álvarez-Muñoz, M., García-Delgado, S., & Piña, G. L. (2015). Calidad alimentaria y potencial nutracéutico del frijol (*Phaseolus vulgaris L.*). Remexca, 28(2), 159-173.
9. Lanza, E.T.J. Hartman, P.S.A, R. Schields, M. Slattery, B. Caan, E. Paskett, F. Iber, J.W. Kikendall, P. Lance, C. Daston and Schatzkin. A. 2006. High dry bean intake and reduced risk of advanced colorectal adenoma recurrence among participants in the polyp prevention. J Nutr, 136 (7): 1896-903.
10. Delgado-Andrade, C., Olías, R., Jiménez-López, J. C., & Clemente, A. (2016). Aspectos de las legumbres nutricionales y beneficiosos para la salud humana. Arbor, 192(779), a313.
11. Muñoz Jáuregui, A. M. (2013). Año Internacional de la Quinua. Revista de la Sociedad Química del Perú, 79(1), 1-2.
12. Bilbao Reboredo, T., Hampe Amador, S., Smith, R. A., Puerta García, F., & Ledesma Rivero, L. 2000. Ocurrencia de tóxicos naturales en frijol colorado (*Phaseolus vulgaris*) y arveja (*Pisum sativum*). efecto del tiempo de almacenamiento y los tratamientos caseros. Rev Fac Nac Agro Medellín. 53(1): 901-912.
13. Gil A. 2010. Tratado de Nutrición. Composición y Calidad Nutritiva de los Alimentos. Capítulo 5. Cereales y Productos Derivados. 2° Edición. Ed. Médica Panamericana. México, D.F. P.p: 119-122.
14. Aguilar V.J., Esparza R.J.R., Meza V.J.A., Candelas C.M.G., Aguilera O.M., Ramírez B.P. 2011. Efecto de la harina de lenteja (*Lens culinaris*) sobre las propiedades reológicas y de panificación de la harina de trigo. Ciencia@UAQ. 4(2):4-9
15. Okpala, L., Okoli, E., &Udensi, E. (2013). Physico-chemical and sensory properties of cookies made from blends of germinated pigeon pea, fermented sorghum, and cocoyam flours. Food Sci Nutr, 1(1), 8-14.
16. Adebowale, A. A., Adegoke, M. T., Sanni, S. A., Adegunwa, M. O., &Fetuga, G. O. (2012).

Functional properties and biscuit making potentials of sorghum-wheat flour composite. Amer J Food Technol, 7(6), 372-379.

17. Akobundu, S. U. E. (2009). Quality characteristics of cookies from composite flours of watermelon seed, cassava and wheat. Pakistan J Nutr, 8(7), 1097-1102.
18. De Camargo, A. C., Vidal, C. M. M., Canniatti-Brazaca, S. G., &Shahidi, F. (2014). Fortification of cookies with peanut skins: Effects on the composition, polyphenols, antioxidant properties, and sensory quality. J Agricul Food Chem, 62(46), 11228-11235.
19. Patil, S. S., Brennan, M. A., Mason, S. L., & Brennan, C. S. (2016). The Effects of Fortification of Legumes and Extrusion on the Protein Digestibility of Wheat Based Snack, Foods, 5(2), 26.
20. Jan, R., Saxena, D. C., & Singh, S. (2016). Physico-chemical, textural, sensory and antioxidant characteristics of gluten–Free cookies made from raw and germinated Chenopodium (*Chenopodium album*) flour. LWT-Food Sci Technol, 71, 281-287.
21. Chung, H. J., Cho, A., & Lim, S. T. (2014). Utilization of germinated and heat-moisture treated brown rices in sugar-snap cookies. LWT-Food SciTechnol, 57(1), 260-266.
22. Chauhan, A., Saxena, D. C., & Singh, S. (2015). Total dietary fiber and antioxidant activity of gluten free cookies made from raw and germinated amaranth (*Amaranthus* spp.) flour. LWT-Food Sci Technol, 63(2), 939-945.
23. Rai, S., Kaur, A., & Singh, B. (2014). Quality characteristics of gluten free cookies prepared from different flour combinations. J Food Sci Technol, 51(4), 785-789.

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FE DE ERRATAS

- En el Volumen 66, No 4, Diciembre 2016, en ARTÍCULOS GENERALES, pag. 261, en la adscripción de los autores, donde lee "Laboratorio de Ciencia de los Alimentos, Facultad de Ciencias, Universidad Nacional UNAL, Medellín, Colombia", debe leer "Laboratorio de Ciencia de los Alimentos, Facultad de Ciencias, Universidad Nacional de Colombia, Sede Medellín, Colombia.

- En el manuscrito **"Indicadores de síndrome metabólico en escolares mexicanos con talla baja, sobrepeso u obesidad"**, de la sección Bioquímica Nutricional, del área TRABAJOS DE INVESTIGACION, publicado en el Número 4, Volumen 66, Diciembre 2016, en la página 311 de la versión impresa, aparte **Anemia**, debe leer:

  "… los valores fueron ajustados por la altitud de la localidad donde habitaban los niños con la siguiente fórmula: [93,3197 ($10^{(0.0000251)\ (altitud)}$] (14). Para diagnosticar… "

- En el manuscrito **"Evaluación del contenido de amilosa en arroz mediante espectroscopía de infrarrojo cercano-NIRS"** de la sección Ciencia de Alimentos, del área TRABAJOS DE INVESTIGACION, publicado en el Número 1, Volumen 67, Marzo 2017, en la página 59 de la versión impresa, la FIGURA 1 y la FIGURA 2 deben leer:

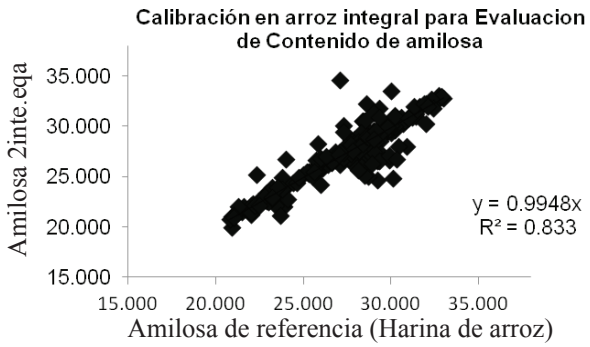

FIGURA 1. Correlación de la validación interna.

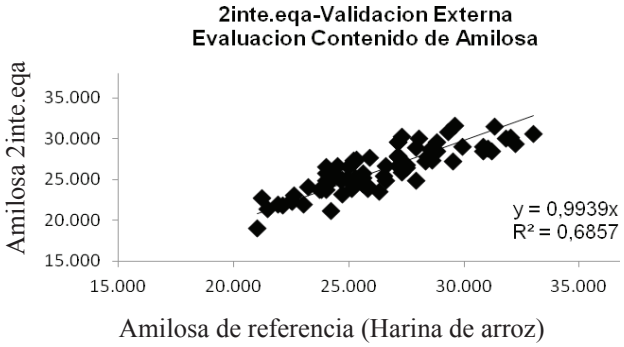

FIGURA 2. Correlación validación externa.

- En atención a solicitud del Fondo Nacional de Investigación Científica y Tecnología de Chile, se hace constar que los siguientes estudios publicados en Archivos Latinoamericanos de Nutrición, fueron financiados por este Fondo, con los Números de Proyectos que allí se indican:

  "Consumo de frutas, verduras y presión arterial. Un estudio poblacional" de los autores Pienovi L., Lara M., Bustos P. y Amigo H. Volumen 65, Número 1, Marzo 2015, pags. 21 – 26. Proyectos No 1100414 y 1140453.

  "Indice, carga glicémica y fibra dietética de los alimentos y su asociación con resistencia a la insulina en adultos chilenos" de los autores Evans J., Amigo H. y Bustos P. Volumen 66, Número 4, Diciembre 2016, pags. 294 – 299. Proyectos No 1100414 y 1140453.

INFORMACION PARA LOS AUTORES

En 1950 el Instituto Nacional de Nutrición de Venezuela edita su revista Archivos Venezolanos de Nutrición la cual en 1966 es donada a la recién creada Sociedad Latinoamericana de Nutrición, SLAN, para convertirse en su órgano oficial de divulgación Archivos Latinoamericanos de Nutrición, ALAN.

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Enuncie la finalidad o el objetivo de investigación específico del estudio u observaciones, o bien la hipótesis que se ha puesto a prueba. Cite las referencias estrictamente pertinentes.

MATERIALES Y MÉTODOS

Identifique los métodos, los aparatos y equipos (nombre y dirección del fabricante) y los procedimientos realizados. Identifique los reactivos y productos químicos utilizados.

Describa los métodos estadísticos con detalles e indique el método y modelo estadístico.

RESULTADOS

Limite las Tablas y las Figuras al número necesario para explicar el argumento y resultados de la investigación y evaluar los datos en que se apoya. Se sugiere un máximo de 5 Tablas y 3 Figuras.

DISCUSIÓN

Breve y concisa, contrastada con observaciones realizadas en otros estudios. Proponga nuevas hipótesis cuando haya justificación para ello, pero identificándolas claramente como tales.

CONCLUSIONES

Refiérase a las más relevantes y oriente sobre posibles vías para continuar la investigación o el estudio emprendido.
No cite referencias bibliográficas en esta sección.

AGRADECIMIENTOS

Mencione la procedencia del apoyo recibido en forma de subvenciones (equipos, reactivos, medicamentos) y a las instituciones financiadoras del estudio, dependencia e instituciones que apoyaron su ejecución, así como a personas y colaboradores.

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Numérelas consecutivamente en arábigos siguiendo el orden en que se citan por primera vez en el texto. Cerciórese de que cada Tabla y Figura aparezca citada en el manuscrito.

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Archivos Latinoamericanos de Nutrición

Volumen 67. N° 3, Septiembre 2017

Contenido

Páginas

ARTICULOS GENERALES

WHO body mass index for age charts overestimate thinness and overweight compared to international and US charts applied to indigenous and non-indigenous Mexican children.

Erik Ramírez, Juan E. Ramos Salas, Martha Barrera Bustillos, Luis Ricardo González Franco, Elena Flores Guillen, Alfredo Pérez Jacome, Mauro E. Valencia..... 159

Suplementos nutricionales como modificadores de morbimortalidad en pacientes con cáncer

Annette Faria, Jeanette Coriat, María Camila Rueda-Rodriguez, Camilo Castañeda-Cardona, Diego Rosselli..... 169

PERSPECTIVA

Comparison of nonnutritive artificial sweetener consumption among university students in Latin American: Multicentric Study

Samuel Durán Agüero; María del Pilar Rodríguez Noel; Karla Cordón Arrivillaga; Julieta Salazar de Ariza; Jiniva Record Cornwall; María del Pilar Cereceda Bujaico; Sonia Antezana Alzamora; Sissy Espinoza Bernardo; Claudia Encina Vega. 178

Ingredients of mayonnaise: Future perspectives focusing on essential oils to reduce oxidation and microbial counts

Izabela Alves Gomes; Flávia dos Santos Gomes; Otniel Freitas-Silva; Janine Passos Lima da Silva..... 187

TRABAJOS DE INVESTIGACION

Riesgo Cardiometabólico

Cintura e índice de masa corporal: los mejores predictores antropométricos en la reducción y progresión de la agregación de factores de riesgo cardiometabólicos

Giovanna Valentino; María José Bustamante, Samuel Durán Agüero, Lorena Orellana, Marcela Adasme, Fernando Baraona, Gastón Chamorro, Jorge Jalil, Carlos Navarrete y Mónica Acevedo 200

Ciencia de Alimentos

Influence of extraction solvent on phenolic content and antioxidant capacity level of a commercial food supplement from *Moringa oleifera* leaves

Vania Urías-Orona, Guadalupe Gutiérrez-Soto, Jahir Ruiz-Bautista, Raúl Flores-Alonso, Isac Montiel-Ramos, Guillermo C. G. Martínez-Ávila, Juana Aranda-Ruiz, Guillermo Niño-Medina..... 211

The effect of foliar fertilization with organic products on some nutritional value during post-harvest storage of tomatoes (*Lycopersicon esculentum* Mill)

Dinu Maria, Soare Rodica, Dumitru Mihaela Gabriela 218

Tecnología de Alimentos

Análisis proximal, de textura y aceptación de las galletas de trigo, sorgo y frijol

Norma Soler Martínez, Octelina Castillo Ruíz, Guadalupe Rodríguez Castillejos, Adriana Perales-Torres, Ana Luisa González Pérez.. 227

FE DE ERRATAS..... 235

INFORMACION PARA LOS AUTORES..... 236