SCIENTIFIC NOTE

Value chain approach for research on *Moringa oleifera* as a nutritional supplement in the human diet

Enfoque de cadena de valor de la investigación de *Moringa oleifera* como suplemento nutricional en la dieta humana

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ABSTRACT

Research in Cuba suggests a value chain approach for the production of *Moringa oleifera* that might identify the strengths and weaknesses that influence food production and the advantage of applying a value chain model to integrate the productive links. As part of these strengths, we established an evaluation of *Moringa oleifera* quality using analytical methods to diagnose the value chain of the industrial process as a nutritional supplement for human use, increase production and product quality, and improve manufacturing and production. Potentialities were found that diversified the products in different areas, demonstrated by the high content of metabolites that positively influence human health using products supplemented with moringa. An approach that applied the value chain defined the steps in moringa industrial processing that guaranteed and expanded the moringa product portfolio that impacted effectiveness, safety, and quality for the consume.

Key words: urban agriculture, sustainable development, nutraceuticals.

RESUMEN

La investigación en Cuba sugiere un enfoque de cadena de valor para la producción de *Moringa oleifera* que podría identificar fortalezas y debilidades que influyen en la producción de alimentos y la ventaja de aplicar un modelo de cadena de valor para integrar los eslabones productivos. Como parte de estas fortalezas se estableció la valorización de la calidad de *Moringa oleifera* a través de métodos analíticos para el diagnóstico de la cadena de valor del proceso industrial como suplemento nutricional para uso humano e incrementar la producción, la calidad de los productos y mejorar su manufactura y procesos productivos. Se encontraron potencialidades que diversificaron los productos en diferentes ámbitos, evidenciadas por el alto contenido de metabolitos que influyen de forma positiva en la salud humana con productos suplementados con moringa. La aplicación de cadena de valor expuso los pasos del procesamiento industrial de la moringa que garantizan y amplían la cartera de productos de moringa con impacto en el consumidor en términos de efectividad, seguridad y calidad.

Palabras clave: agricultura urbana, desarrollo sostenible, nutracéuticos.

Introduction

Moringa oleifera is a plant native to India that is rich in nutrients. The plant can be grown for its green biomass for human or animal consumption (Foidl *et al*., 2001). The only difference between its use in a human or animal diet lies in measures applied for the microbiological control of the cultural practices, industrial processing, and the recurrent process of obtaining the seeds. *Moringa oleifera* crops differ in their genetic features (Gutiérrez *et al*., 2015), edaphoclimatic conditions, cultural practices, spacing, and harvest periods. This analysis focused on using Moringa to produce green biomass for human use and applying a value chain approach to produce dry leaves as nutraceuticals for human consumption (Almora-Hernández *et al*., 2021).

The value chain provides a general application model that allows the representation of activities of any organization based on the concepts of cost, value, and profit. It consists of productive processes that provide a scheme for diagnosing the enterprise's position concerning its competitors and possible actions leading to a sustainable competitive advantage (Tumbaco-Laje *et al*., 2022).

Nowadays, Cuba promotes a value chain approach that increases yields in food production, food quality, and nontoxic nature, including all the chain links that meet consumer requirements (Murgueitio Escobar, 2005). This efficiently contributes to the sustainability of the national economy and establishes food security as a national priority, as declared in 2007 (Castro, 2007).

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Various studies in Cuba demonstrate the potential use of different parts of the *Moringa* tree for food applications. Leaves can be used as a dietary supplement to prepare soups (Liu, 2018) as well as infusions for medicinal purposes (Bancessi *et al*., 2019) and crackers (Almora-Hernández *et al*., 2021).

The development of functional foods and their associated science mark guidelines in industrial research. Scientific research on *Moringa* is important to discover specific foods that principally clarify benefits leading to a reduction of degenerative chronic diseases, such as diabetes, hypertension, and obesity, as well as the need to find functional foods that improve the living quality of the population (Aguirre, 2019).

Applying a model for the value chain is beneficial since it considers actors, critical points, access to supporting services, and the search to increase competitiveness and equity. It identifies factors leading to success and value creation (Murgueitio Escobar, 2005).

This research defined the value of *Moringa oleifera* tree parts through strategic actions based on the diagnosis of the value chain of industrial processing of this plant as a nutritional supplement for human use. This increased the product´s production, quality, and non-toxicity and improved the manufacturing process, productive areas, and goods.

Materials and methods

Plant material

The plant material used was the leaves of the Criolla, Supergenius, Plain, and Nicaragua ecotypes of *Moringa oleifera* Lam. 1783, Moringaceae (Bocarando-Guzmán *et al*., 2020). The ecotypes Supergenius, Plain, and Nicaragua were planted from seeds. Supergenius and Plain were donated by India, and the Nicaragua ecotype was donated by Nicaragua. The Criolla seeds came from the national germplasm collection. All ecotypes are preserved by the National Germplasm Collection from the Basic Productive Unit (BPU) "El Pitirre," Los Palacios, Pinar del Rio provinces, belonging to the Research Center on Protein Plants and Bionatural Products (CIPB, Cuba). The leaves of the four ecotypes were harvested in areas of the BPU "Futuro Lechero" in Havana, also part of the CIPB, which is devoted to crops for nutraceutical purposes. The area established for these crops is located at 23°04'20" N, 82°29'20" E. The climate in this area is classified as tropical, with an average temperature of 33°C and a rainy season from May to June.

Cultural practices used with these crops are similar, and leaf drying used the following procedure. After 45 d of growth, the leaves from the upper 1/3 part of the plant from the ground were collected (without the apical tips). The *M. oleifera* plants used were obtained from a study that quantified secondary metabolites (Lago Abascal *et al*., 2020). The age of the plant was noted for this study since previous studies show that metabolites vary according to the age of the leaves. This demonstrates that the state of development of the plants affects the biosynthesis and accumulation of chemical compounds, and the young mature leaves synthesize the most significant amount. The phenols and flavonoids have higher contents in the leaves of the medial parts of the plants (Cabrera-Carrión *et al*., 2017). The harvest of the ecotypes Criolla, Supergenius, and Plain took place in June 2019, and that of the ecotype Nicaragua took place in October 2020.

Leaf collection occurred manually using latex gloves (according to Good Agricultural Practices - GAP). The leaves were placed vertically on aseptic plastic boxes supported on canvas in the field (Sánchez *et al*., 2014). These were transported in a closed vehicle to the processing site, where they were manually peeled wearing latex gloves (Good Manufacturing Practices - GMP). The plant fragments were immediately subjected to continuous washing and mechanical centrifuging. Drying occurred on stainless steel trays, using solar ovens CONA at a controlled temperature of 45ºC.

The GAP and GMP correlated with the set of agricultural strategies of *Moringa* growers and the guarantee of having microbiological control over the vegetal fragments and repetition of the procedures.

Strengths, opportunities, weaknesses, and threats to the industrial processing of *Moringa* were identified following a value chain approach, as shown in Figure 1. This value chain approach consisted of several stages, from agriculture to final product marketing. The first stage of crop establishment began with seed propagation and sowing that was carried out on selected soils, free of chemical contaminants, under conditions of temperature varying from 25ºC to 35ºC, with a pH of 5.9, and well-drained. After first pruning at 30-50 cm from the ground after 6 months, the crop began the second productive stage: every 45-60 d, the new leaves were collected and pruned again.

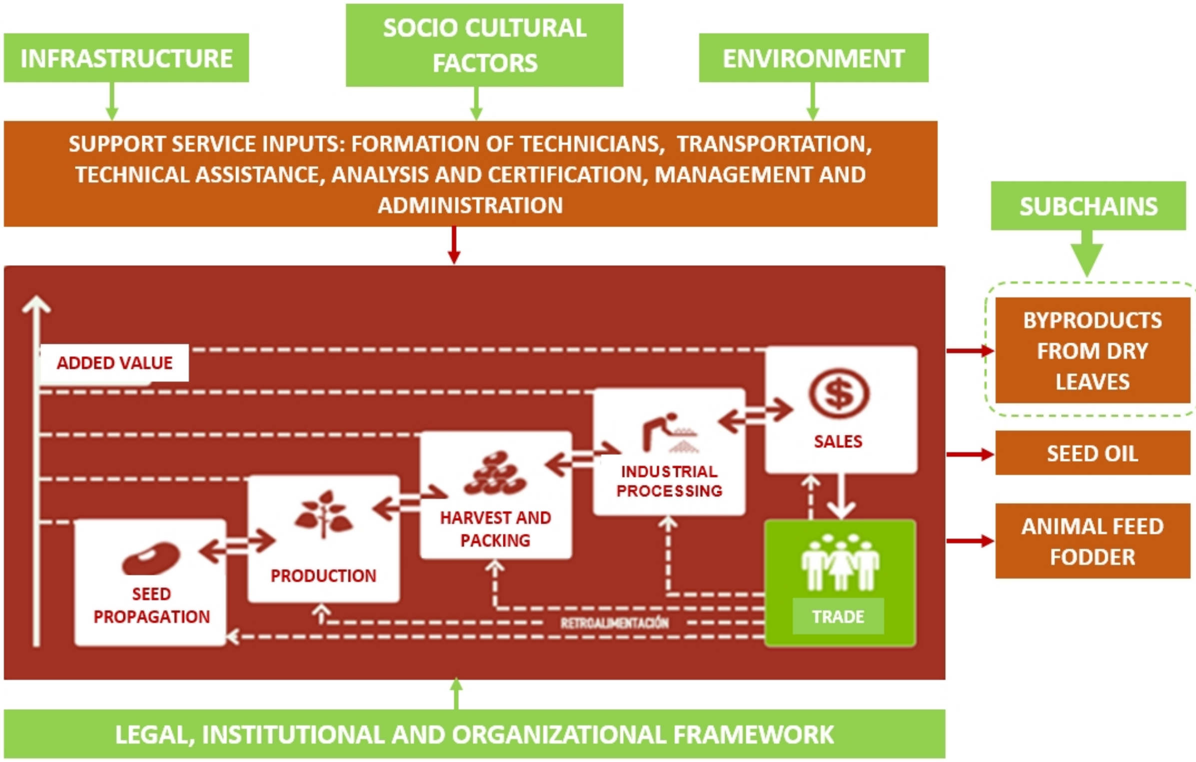

FIGURE 1. Value chain of *Moringa oleifera* industrial processing.

The third stage of the industrial process began with the reception and weighing of the raw material (harvested leaves). The selected material (leaves and rachis) was washed and dried. The final products derived from the raw material were dried leaves, dried leaf powder, dried rachis, and dried rachis powder. For subsequent marketing, these products acquired a sanitary registry from the Institute of Hygiene, Epidemiology and Microbiology (Inhem) of Cuba.

Throughout the stages, the strengths, opportunities, weaknesses, and threats of the *Moringa* industrial process were identified with a value chain approach based on an analysis of Figure 1. This study did not discuss the sub-chains for producing seed oil and animal feed fodder (Fig. 1) since each depends on differences during the first stage.

Quantification of metabolites in the ecotypes of *Moringa oleifera*

The quantification of metabolites in leaves was carried out according to Lago Abascal *et al.* (2020). The content of total polyphenols was determined by forming tungsten and molybdenum salts using pyrogallol (Merck) as a standard. The reaction was carried out at room temperature for 30 min in darkness, and absorbance was measured at 760 nm with a spectrophotometer (Shimadsu UV160-A). Results were expressed as milligram-equivalents of pyrogallol per gram of dry extract. Quercetin was used as a standard to determine flavonoids, and the samples were treated with ethanol, aluminum chloride, and potassium acetate. The reaction was carried out at 30°C for 30 min, and absorbance was measured at 415 nm with a spectrophotometer (Shimadsu UV160-A). The result was expressed as milligram-equivalents of quercetin per gram of dry extract. All assays were performed in triplicate.

Statistical analysis

All tests were triplicated. For the statistical analysis, means and standard deviations were used as descriptive measures of the central trend and data dispersal. Before processing, data normality and variance homogeneity were evaluated through Kolmogorov-Smirnov and the Bartlett test. A comparison among groups was made through an analysis of variance of simple classification (ANOVA). Means were compared using ANOVA. Statistical analyses were accomplished using the statistical package SPSS 10.0.1.

Results and discussion

The DAFO matrix analysis of the process (–D– weaknesses, –A– threats, –F– strengths, and –O– opportunities) is shown in Table 1.

TABLE 1. Evaluation of the industrial process of *Moringa oleifera* using a value chain approach.

Aspects	Strengths	Weaknesses
Internal	• The plant is present in Cuba • Over 10 years of experience with the crop • Propagation is either by seeds or cuttings • Drought resistant • Adaptability of the crop to a wide range of soils • There is experience for the crop, harvest, and processing of the plant • There is governmental support to expand the crop • High nutritional value • Preventive and curative properties • All the parts of the plant can be used • Plant parts have different uses • The national sanitary registration is available for the products derived from the plant • There is a national association of *Moringa* growers • The domestic market has prices for the products • Imports and exports throughout the year can be controlled	• There are few growers in the country • Access to funding to consolidate production is difficult • Plant production is not stable throughout the year • Little incentives by growers to adopt this new crop • It is an "extractive" plant that demands fertilization of soil
Aspects	**Opportunities**	**Threats**
External	• It generates natural products that are accepted by the population • It generates scientific research • It creates permanent employment • There are interests in the food and cosmetic industries • Diversification of the crop is possible • There is quantitative data on Moringa's annual exports and imports There are established prices for the final products • Low-level technology is required for agricultural and industrial processing	• Climate change affects plots, either by flooding or extreme drought. The former one is the most severe problem affecting the crop(manageable) • Hurricanes can destroy crop plots

Products generated from the green biomass

As a result of research on various *Moringa* parts and the diverse use of the plant, it is possible to diversify products in other branches. In the Cuban pharmaceutical industry, *Moringa* is part of the basic basket of natural medicines available in powder from dry vegetal fragments for direct consumption as a protein source, vitamins and minerals, and its formulation in 500 mg gel capsules (Lago Abascal, Thu Huong *et al.,* 2021) and dry plant fragments for tea (Lago Abascal, Almora Hernández, González Garcia, Hernández Rivera *et al.,* 2021). Integral rice crackers are also manufactured and supplemented with fresh apical buds (Almora Hernández *et al*., 2020). All natural products made from plant leaves are sanitarily registered by the Institute of Hygiene, Epidemiology, and Microbiology (Inhem), the National Regulatory Organ of the Ministry of Public Health (Minsap) for foods for human consumption.

In the food industry, dry vegetal fragments powder, rachis powder, and other products derived from seeds are used to fortify meat sausages, snacks, and preserves; in cosmetics, the *Moringa* oil is used for shampoos and soaps.

Identification of the biological effects of the different parts of the plant, specifically of the leaves that are present in the dry plant fragments after processing and that have been underlined in animal models after consumption (Lago Abascal, Thu Huong *et al*., 2021), confirms the value chain approach of research carried out to develop uses for this plant. Antimicrobial effects (Monteagudo Borges *et al*., 2022) and antioxidant effects are known (Lago Abascal, Almora Hernández, González García, Hernández Rivera *et al*., 2021) as well as hypolipemiant (Lago Abascal, Thu Huong *et al*., 2021) and anti-inflammatory (Lago Abascal, Menéndez Soto del Valle *et al*., 2021) effects. These effects are attributed to flavonoids and polyphenols present in the dry plant fragments after the manufacturing process, based on results where the different evaluated ecotypes showed a similar composition (Tab. 2) without expressing significant differences among levels. These results are the basis for performing clinical tests made in humans (Lago Abascal *et al*., 2020).

Studies of *Moringa* plant fragments demonstrate many beneficial compounds for human health that favor the enrichment of foods with this plant (Lago Abascal *et al*., 2020). Powder from dry *Moringa* plant fragments is used by the food industry. It can be stored for some months at room temperature without losing nutritional value (Srinivasamurthy *et al*., 2017). *Moringa* sprouts, after harvesting, can be used for human nutrition as integral rice crackers; these are increasingly accepted (Almora-Hernández *et al*., 2021) and as fresh vegetables.

The value chain approach of the research on the nutraceutical uses of *Moringa* consists of generating products that are beneficial for health from the properties present in the plant. The objective is to obtain new products from the circular economy (Cosme, 2022). The production of dry plant fragments involves using only two-thirds of the plant leaves. The apical third of the plant can also extract metabolites with biological effects. The stems can be used to organically fertilize the crop. There are ongoing projects with Project MOR-*e* and the University of Zaragoza, Spain, and Cubaenergia (Cuba) to design a technology for the production of fuel pellets that can be used to heat water on a boiler that, in turn, will supply heat to warm the air used in plant fragments drying. This is an added value for this product that integrates into the circular economy. Rachis from the leaf peeling process are also processed through drying and are used as expanders and strengtheners for other products like coffee or tea with positive acceptance (Lago Abascal *et al*., 2020; Almora-Hernández *et al*., 2021; Lago Abascal, Thu Huong, *et al*., 2021).

Quantification of metabolites of the ecotypes of *Moringa oleifera* grown in Cuba

All the ecotypes generally showed an elevated secondary metabolite content in their leaves (Tab. 2). The highest flavonoid content corresponded to the Supergenius ecotype, and polyphenols corresponded to the Nicaragua ecotype. However, among all these levels, no significant differences were found, confirming the possibility of using any of the four ecotypes in the production procedure of dried plant fragments to be used as nutraceuticals for human consumption.

The contents of polyphenols and flavonoids in this study were superior to that of Cabrera-Carrión *et al*. (2017) where the polyphenol contents were 13.00 mg-eq g^{-1} and flavonoid contents were 22.88 mg-eq g^{-1}. They are also superior to those Campo-Fernández *et al*. (2020) describe, who recorded polyphenol values of 21.27 mg-eq gallic acid g^{-1} DW and flavonoids of 37.60 mg-eq quercetin g^{-1} DW.

The similarities found in the metabolite contents between these ecotypes coincided with the phytochemical evaluations previously made for three of these ecotypes. Such evaluations confirmed that Moringa effectively accumulates phenolic compounds (Lago Abascal, Almora Hernández, González García, Campa Huergo *et al*., 2021). These ecotypes showed antimicrobial properties against pathogens of biological interest (Lago Abascal *et al*., 2020).

The high metabolite content in Moring leaves of this study might be due to factors relating to the plant´s age and harvest practices (Yusof, 2015). Our research showed that the four ecotypes had similar results under field conditions for the composition of compounds used for human consumption.

Food products fortified with polyphenols have high impacts for human health; they prevent neurodegenerative diseases (Farzaei *et al*., 2018) and help to control high blood pressure (Oudot *et al*., 2019). They also influence the oxidized form of the low-density cholesterol responsible for increased lipid levels in arteries (Frankel & Meyer, 2000).

This plant can regulate the content of secondary metabolites in its photosynthetic organs, given possible climate changes that might occur with increased temperatures and ultraviolet radiation (Ballaré *et al*., 2011). All the above confirms the value of *Moringa oleifera* as a food enrichment and/or its direct consumption as a nutritional supplement.

Conclusions

Applying the value chain approach breaks down the steps of both agricultural and industrial processing of *Moringa oleifera*. It guarantees a portfolio of products for this plant that impacts the consumer for effectiveness, security, and quality.

Recommendations

Undoubtedly, the use of the value chain is one of those organizational approaches that help identify and develop all the links in manufacturing products originating from *Moringa oleifera*.

TABLE 2. Quantification of secondary metabolites in leaves of ecotypes of *Moringa oleifera*.

Ecotype	Flavonoid content (mg-eq quercetin g^{-1} DW)	Polyphenol content (mg-eq pirogallol g^{-1} DW)	Harvest date	Reference
Criolla	80.91±1.64	71.23±0.38		
Supergenius	97.67±0.97	94.54±1.67	June 2019	Lago Abascal *et al*. (2020)
Plain	110.12±0.75	93.77±0.65		
Nicaragua	82.55±2.43	98.50±4.76	October 2020	Lago-Abascal *et al*. (2024)

$P>0.05$, there is no statistical difference among ecotypes and metabolites at the 95% probability level.

Conflict of interest statement

The authors declare no conflicts of interests regarding the publication of this article.

Author's contributions

VLA and ERJ: conceptualization; VLA and EAH: data curation; VLA and EAH: formal analysis; VLA and EAH: research; VLA and EAH: methodology; VLA and EAH: software; ERJ and CC: supervision: VLA: visualization: VLA: writing – original draft; ERJ: writing – review & editing. All authors reviewed the final version of the manuscript.

Literature cited

Aguirre, P. (2019). Alimentos funcionales entre las nuevas y viejas corporalidades. *AIBR Revista Antropología Iberoamericana, 14*(1), 95–120. https://dialnet.unirioja.es/servlet/articulo?codigo=6832409

Almora-Hernández, E., Barrios, L., Monteagudo-Borges, R., Lago-Abascal, V., León, G., & Rodríguez, E. (2021). Evaluación sensorial de galletas de arroz integral suplementadas con stevia y moringa. *Peruvian Agricultural Research*, *3*(2), 80–86. https://doi.org/10.51431/par.v3i2.705

Almora-Hernández, E., Campa-Huergo, C., Monteagudo-Borges, R., Lago-Abascal, V., Echemendia-Arana, O., & Rodríguez. E. (2020). Desarrollo de la galleta de arroz integral suplementada con *Moringa oleifera*. *Revista de Ciencias Farmacéuticas y Alimentarias*, *6*(2), 52–64. https://revistas.uh.cu/rcfa/article/view/3370

Ballaré, C. L., Caldwell, M. M., Flint, S. D., Robinson, S. A., & Bornman, J. F. (2011). Effects of solar ultraviolet radiation on terrestrial ecosystems. Patterns, mechanisms, and interactions with climate change. *Photochemical and Photobiological Sciences, 10*, 226–241. https://doi.org/10.1039/c0pp90035d

Bancessi, A., Bancessi, Q., Baldé, A., & Catarino, L. (2019). Present and potential uses of *Moringa oleifera* as a multipurpose plant in Guinea-Bissau. *South African Journal of Botany, 129*, 206–208. https://doi.org/10.1016/j.sajb.2019.06.013

Bocarando-Guzmán, M. D., Ríos-Corripio, M. A., Hernández-Cázares, A. S., Gómez-Merino, F. C., & Servín-Juárez, R. (2020). Caracterización de la oferta de moringa (*Moringa oleifera* Lam.) en México. *Agro Productividad*, *13*(2), 3-8. https://doi.org/10.32854/agrop.vi0.1483

Cabrera-Carrión, J. L., Jaramillo-Jaramillo, C., Dután-Torres, F., Cun-Carrión, J., García, P. A., & Rojas, de Astudillo, L. (2017). Variación del contenido de alcaloides, fenoles, flavonoides y taninos en *Moringa oleifera* Lam. en función de su edad y altura. *Bioagro, 29*(1), 53–60.

Campo-Fernández, M., Cruz-Alvia, C., Cunalata-Cueva, G., & Matute- Castro, N. (2020) Infusiones de *Moringa oleifera* (moringa) combinada con *Cymbopogon citratus* (hierba luisa) y *Lippia alba* (mastranto). *Ciencia UNEMI, 13*(34), 114–126. https://doi.org/10.29076/issn.2528-7737vol13iss34.2020pp114-126p

Castro, R. (2007). Acto central con motivo del aniversario 54 del asalto a los Cuarteles Moncada y Carlos M. Cespedes en la Plaza de la Revolución "Ignacio Agramonte" Camagüey. IPS. Inter PRESS service en Cuba. https://www.ipscuba.net/archivo/discurso-de-raul-castro-el-26-de-julio-de-2007-en-camaguey

Cosme, C. (2022). La Economía Circular como eje de desarrollo de los países latinoamericanos. *Revista Economía y Política*, *35*, 1–11. https://publicaciones.ucuenca.edu.ec/ojs/index.php/REP/article/view/3939/2889

Farzaei, M. H., Tewari, D., Momtaz, S., Argüelles S., & Nabavi, S. M. (2018). Targeting ERK signaling pathway by polyphenols as novel therapeutic strategy for neurodegeneration. *Food and Chemical Toxicology, 120*, 183–195. https://doi.org/10.1016/j.fct.2018.07.010

Foidl, N., Makkar, H. P. S., & Becker, K. (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. In J. Lowell Funglie (Ed.), *The miracle tree: The multiple attributes of Moringa*. Church World Service.

Frankel, E. N., & Meyer, A. S. (2000). The problems of using one-dimensional methods to evaluate multi-functional food and biological antioxidants. *Journal of the Science of Food and Agriculture, 80*(13), 1925–1941. https://doi.org/10.1002/1097-0010(200010)80:13%3C1925::AID-JSFA714%3E3.0.CO;2-4

Gutiérrez, D., Borjas, R. E., Rodríguez, H. R., Rodríguez, Z., Stuart, R., & Sarduy, L. (2015). Evaluación de la composición química y degradabilidad ruminal *in situ* de ensilaje mixto con *Pennisetum purpureum* cv Cuba CT-169: *Moringa oleifera*. *Avances en Investigación Agropecuaria*, *19*(3), 7–16. https://www.redalyc.org/pdf/837/83743886002.pdf

Lago Abascal, V., Almora Hernández, E., González García, K., Campa Huergo, C., & Rodríguez Jiménez, E. (2021). Caracterización de ecotipos de *Moringa oleifera* cultivada en Cuba e identificación de isoquercitina. *Revista Cubana de Plantas Medicinales, 26*(4), Article e1189. https://revplantasmedicinales.sld.cu/index.php/pla/article/view/1189

Lago Abascal, V., Almora Hernández, E., González García, K., Hernández Rivera, Y., Echemendia Arana, O., & Monteagudo Borges, R. (2021). Metabolitos secundarios y capacidad antioxidante de hojas secas de *Moringa oleifera Lam*. cultivada en Cuba. *Revista Cubana de Plantas Medicinales, 26*(1), Article e1087. https://revplantasmedicinales.sld.cu/index.php/pla/article/view/1087/464

Lago Abascal, V., Echemendia Arana, O., Gonzales García, K. L., Hernández Rivero, Y., Almora Hernández, E., & Monteagudo Borges, R. (2020). Determinación de polifenoles totales, flavonoides y evaluación antimicrobiana en tres ecotipos de *Moringa oleifera* cultivadas en Cuba. *Revista de Ciencias Farmacéuticas y Alimentarias*, *6*(1), 50–61. https://revistas.uh.cu/rcfa/article/view/3461

Lago-Abascal, V., Matos-Oliveros, S., Almora-Hernández, E., Pereira-Cuní, L. B., Monteagudo-Borges, R., & Rodríguez-Jiménez, E. (2024). Evaluación de diferentes densidades de cultivo de *Moringa oleifera* y su manufactura como suplemento nutricional. *Revista Ingeniería Agrícola, 14*(1), 1–8. https://cu-id.com/2284/v14n1e09

Lago Abascal, V., Menéndez Soto del Valle, R., Almora Hernández, E., García Jiménez, T., Monteagudo Borges, R., & Rodríguez Jiménez, E. (2021). Evaluación en modelos animales del efecto antinflamatorio de las cápsulas de hojas secas de *Moringa oleifera*. *Revista Cubana de Plantas Medicinales*, *26*(1), Article e1120. https://revplantasmedicinales.sld.cu/index.php/pla/article/view/1120/467

Lago Abascal, V., Thu Huong, N. T., Hoang Mihn, N., & Rodríguez Jiménez, E. (2021). Efecto de las cápsulas de *Moringa oleifera* sobre la hiperlipidemia en ratones. *Archivos del Hospital Universitario "General Calixto García", 9*(3), 385–395. https://revcalixto.sld.cu/index.php/ahcg/article/view/e758

Liu, Y., Wang, X., Wei, X., Gao, Z., & Han, J. (2018). Values, properties and utility of different parts of *Moringa oleifera*. An overview. *Chinese Herbal Medicines, 10*(4), 371–378. https://doi.org/10.1016/j.chmed.2018.09.002

Monteagudo Borges, R., Fidalgo Perera, O., Almora Hernández, E., Lago Abascal, V., Echemendia Arana, O., & Bolaños Queral, G. (2022). Evaluación de la actividad antimicrobiana de extractos de *Moringa oleifera* Lam. cultivada en Cuba. *Revista de Producción Animal, 34*(1), Article e4153.

Murgueitio Escobar, C. (2005). Identificación de los factores claves de éxito, capacidades y limitaciones para la producción y exportación de café diferenciados en Colombia. [Magister dissertation, Universidad de los Andes]. Seneca Institutional Repository. https://hdl.handle.net/1992/10626

Oudot, C., Gomes, A., Nicolas, V., Le Gall, M., Chaffey, P., Broussard, C., Calamita, G., Mastrodonato, M., Gena, P., Perfettini, J. L., Hamelin, J., Lemoine, A., Fischmeister, R., Vieira, H. L. A., Santos, C. N., & Brenner, C. (2019). CSRP3 mediates polyphenols-induced cardioprotection in hypertension. *The Journal of Nutritional Biochemistry, 66*, 29–42. https://doi.org/10.1016/J.JNUTBIO.2019.01.001

Sánchez García, C. M., Morena, G. S., Acosta Porta, Z. M., & Deus Montes, Y. (2014). *Manual de buenas prácticas agrícolas para frutas frescas*. La Habana: Instituto de Investigaciones de Fruticultura Tropical. https://www.undp.org/es/cuba/publicaciones/manual-de-buenas-practicas-agricolas-para-frutas-frescas

Srinivasamurthy, S., Yadav, U., Sahay, S., & Singh, A. (2017). Development of muffin by incorporation of dried *Moringa oleifera* (Drumstick) leaf powder with enhanced micronutrient content. *International Journal of Food Science and Nutrition, 2*(4), 173–178.

Tumbaco-Laje, G. E., Villafuerte-Muñiz, W. P., & Soledispa-Rodríguez, X. E. (2022). Las cadenas de valor como estrategias de desarrollo microempresarial. *FIPCAEC, 7*(1), 65–87. https://www.fipcaec.com/index.php/fipcaec/article/view/583/1020

Yusof, N. A., Isha, A., Ismail, I. S., Khatib, A., Shaari, K., Abas, F., & Rukayadi, Y. (2015). Infrared-metabolomics approach in detecting changes in *Andrographis paniculata* metabolytes due to different harvesting ages and times. *Journal of the Science of Food and Agriculture*, *95*(12), 2533–2543. https://doi.org/10.1002/jsfa.6987