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Consumer Preferences for Labeled Plant-Based Products Associated with Traditional Knowledge: A Study in Protected Natural Areas of Northwest Mexico

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Abstract: The use of plants associated with traditional knowledge by pharmaceutical, cosmetic, agro-food, and biotechnology industries represents a potential source of benefits for indigenous groups and local communities within the access and benefit-sharing mechanisms established in the Nagoya Protocol. We used a consumer-choice experiment to evaluate consumer preferences concerning a cosmetic product with attributes related to the traditional knowledge of local plants (efficacy, price, and information). The results indicate that consumers experience higher wellness levels by consuming a cosmetic product with an information label associated with a plant of traditional use. A rise in consumer income increases the likelihood of consuming products with traditional-knowledge attributes. Higher prices are associated with a lower probability of purchase. The random coefficient reveals mixed preferences related to product efficacy level. This work shows the potential demand, by high-income consumers, of cosmetic products labeled with formulation information based on traditional knowledge associated with local plants growing in Protected Natural Areas of northwest Mexico.

Keywords: traditional knowledge; medicinal plants; Protected Natural Areas; choice experiment; consumer preferences; cosmetics

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1. Introduction

From the 1992 Convention on Biological Diversity (CBD), a concern arose regarding the inclusion of the protection of traditional knowledge, innovations, and practices associated with biodiversity conservation. However, the inclusion of the protection of genetic resources associated with traditional knowledge was deemed insufficient to ensure fair access to and equitable sharing of the benefits derived from their use [1]. Ten years later, during the 2002 World Summit on Sustainable Development in Johannesburg, some members of the CBD acknowledged the need to implement additional actions to meet the third objective of the CBD. Accordingly, it was proposed to negotiate an international agreement that would set the basis of a system to ensure the fair and equitable sharing of the benefits derived from the use of genetic resources. From the Johannesburg 2002 summit, the CBD parties that met in Kuala Lumpur (2004), Curitiba (2006), and Bonn (2008) worked on the development of an international Access and Benefit-Sharing (ABS) regime. The Bonn Guidelines were issued in 2008, aiming to help governments to adopt measures to implement ABS mechanisms in their countries. However, its main limitations were the non-binding nature and limited attention to the interests of genetic-resource providers related to conservation and sustainable use. Finally, the Nagoya Protocol was finalized at the Nagoya 2010 conference of the parties; from that year, interested parties signed and ratified the Protocol, which came into force on 12 October 2014 [2].

Article 12 of the Protocol sets out the minimum requirements for mutually agreed terms to ensure fair and equitable sharing of the benefits arising from the use of traditional knowledge associated with genetic resources, as well as the contractual clauses regarding monetary (first payment and royalties) or non-monetary (in-kind, infrastructure, services, training, and technology transfer) benefit sharing. Since the entry into force of the Nagoya Protocol to November 2020, Mexico has registered eight Internationally Recognized Certificates of Compliance (IRCC) related to ABS; seven for non-commercial purposes and one for non-commercial/commercial purposes. This ABS contract was concluded between a civil organization called Mujeres y Ambiente (Women and Environment), located in the El Charape and La Joya communities, state of Queretaro, and an international cosmetic company. The mutually agreed terms specify the authorization to carry out the scientific collection of a plant associated with traditional knowledge for commercial purposes [3].

Protected Natural Areas, and specifically those classified as biosphere reserves, include local human communities in buffer zones that can conduct activities related to natural resource management and use with minimal environmental impact. The use of plants by indigenous groups and local communities inhabiting Protected Natural Areas in northwest Mexico has resulted in the collection of traditional knowledge. Since protection programs restrict extractive land-use activities, these communities have specialized in activities that promote economic development. Extractive and non-extractive uses of these plants represent an alternative that is consistent with sustainable development.

Recent studies have identified and described the domestic uses and local small-scale trade of plants associated with natural resources in Natural Protected Areas in northwest Mexico [4–6]. The extractive and non-extractive domestic use and local small-scale marketing of local plants for medicinal or recreational uses evidence the value of using the traditional knowledge of indigenous communities living in Protected Natural Areas in northwest Mexico. Recently, the cosmetics industry has shown interest in studying the traditional knowledge related to the use of genetic material through ABS approaches, aiming to identify and isolate compounds with wound-healing, regenerative, and skin-care properties.

The potential benefits for the cosmetics industry from the study of genetic resources associated with traditional knowledge through ABS contracts reside in the lower costs of data search or research. According to [7], the probability of identifying and isolating a novel natural compound through random plant selection is approximately 1/10,000. On the other hand, the probability of finding a new compound with pharmaceutical or cosmetic properties through the use of traditional knowledge increases to 1/100.

Another potential benefit is the identification of market segments with preferences for products made from genetic resources associated with traditional knowledge, under the fair and equitable sharing of economic benefits for indigenous groups or communities that hold these resources and knowledge. The objective of this work was to analyze the preferences of potential consumers for cosmetic products with labels claiming that the product is formulated from plants associated with traditional knowledge in Natural Protected Areas of northwest Mexico. Specifically, we explored consumer preferences for cosmetic products with label information claiming the use of traditional knowledge on the Golondrina plant *Euphorbia polycarpa* Benth [basionym: *Chamaesyce polycarpa* (Benth.) Millsp.] in its formulation.

In addition to the above, this work focuses on protected natural areas due to the following reasons: (1) Due to their isolation, insular, and peninsular location, they have endemic plants associated with traditional knowledge of local communities, (2) their local communities have legal personality to establish mechanisms of access and benefit sharing within the Nagoya Protocol through the Natural Commission of Natural Protected Areas (CONANP).

This work consists of two parts. The first describes the materials and methods used to identify the uses of plants of Baja California Sur associated with traditional knowledge through literature search and surveys/interviews to communities living within Protected

Natural Areas. The second part identified and selected the local plant *Euphorbia polycarpa* Benth [*Chamaesyce polycarpa* (Benth.) Millsp.], commonly known as smallseed sandmat or Golondrina, for delivering the documented perceived benefits of reducing and eliminating skin irritation [6]; these benefits were explored through interviews. A choice experiment was conducted on consumer preferences for a cosmetic formulated based on traditional knowledge associated with this plant. The estimation method was a Mixed Logit model. This study addressed the following research questions: Is there a potential demand for cosmetic products formulated from local plants growing in Protected Natural Areas of northwest Mexico, associated with traditional knowledge? Do consumers perceive an increased wellness level by consuming cosmetic products formulated based on traditional knowledge associated with local plants in Protected Natural Areas of northwest Mexico?

2. Literature Review

Ethno-medicinal studies have documented the use of medicinal plants by the population and the cosmetic industry. Narayanaswamy and Ismael [8] were motivated by the loss of traditional knowledge on plants of medicinal and cosmetic use resulting from deforestation and urbanization. Uses of cosmetic plants from southeast Asian countries (Malaysia, Cambodia, Laos, Myanmar, Thailand, Vietnam, Brunei, East Timor, Indonesia, Philippines, and Singapore) have been gathered through literature searches in databases such as PubMed, Google Scholar, Science Direct, and Springer for publications and patents. Plant species with documented cosmetic use include *Allium sativum*, *Aloe vera*, *Centella asiatica*, *Curcuma longa*, *Hibiscus rosa-sinensis*, *Lawsonia inermis*, and *Tamarindus indica* L.; these are claimed to have potential cosmetic or anti-aging, anti-acne, melanogenic, and anti-tyrosinase properties. These reports acknowledge the need to conduct clinical studies to validate the efficacy, stability, shelf life, and safety of cosmetic formulations including ingredients from these plants. In another study, Elansary et al. [9] analyzed the diversity of medicinal plants used for cosmetic purposes in Alexandria, Egypt, and found that 27 ethnomedicinal plants are used by the local cosmetic industry. The study found that sociodemographic factors of consumers, such as marital status, age, education, and occupation are important to explain the use of cosmetic products based on medicinal plants. They contend that the socioeconomic value of these plants comes from their use by women for the treatment of hair and skin (body and face). These studies also suggest that although these species are neither threatened nor endangered, adequate monitoring is necessary to avoid unsustainable harvesting. Leso et al. [10], in a study carried out in South Africa, found that the medicinal plant species registered are not randomly distributed across families, which indicates a possible taxonomic signal in ethnobotanical uses driven by the distribution and abundance of species from certain families. That is, human communities with traditional knowledge about medicinal plants use those that are most abundant in their local environment.

Other studies have addressed the drivers of ecologically based purchase and the strategies of commercial marking through eco-labels. Liobikeenė and Bernatonienė [11], in a meta-analysis on green-purchase drivers, found that higher prices associated with the additional costs of better raw materials may deter consumers to buy them. However, some brands seek to influence the purchase decision through eco-labels to catch the environmental awareness of consumers. Johri and Sahasakmontri [12] analyzed the key attributes for Thai consumers when buying cosmetics and toiletries. Through focus group including groups of managers, both sales staff and customers commented that consumers set their preferences according to basic attributes such as fragrance, color, safety, performance, good value for money, packaging, outlet ambience, opportunity to pre-test, brand image, and label claims on ecological attributes such as Ingredients and Not Tested on Animals. They also mention that consumers can choose green cosmetics when this does not compromise critical aspects such as price and safety.

Recent studies have used random utility models to analyze consumer preferences for cosmetics with environmentally friendly attributes. Joung et al. [13] used the Contingent

Valuation Method to estimate consumer willingness to pay (WTP) for organic cosmetics targeting women aged between 20 and 49 years old in Seoul and the Kyeonggi area, South Korea. Their findings include a 21% higher WTP for low-priced organic cosmetics compared to non-conventional low-price cosmetics, and a 15.3% higher WTP for high-priced organic cosmetics, compared to non-organic cosmetics of the same price. They report that sociodemographic variables such as age, education, marital status, occupation, and income were not statistically significant. Marangon et al. [14] estimated, through a choice experiment (CE), consumer preferences for organic cosmetics in the Friuli Venezia Giulia region, northeast Italy. In addition to the organic attribute, they included origin of the cosmetic ingredient, use of animal-testing methods, and recyclable package. Their results indicate that consumers perceive a higher level of well-being when using cosmetics of regional origin (WTP = €1.52); cosmetics produced with no animal testing (€4.52); or organic cosmetics (€3.60). An interesting finding regarding preferences in consumers over 55 years old was that they experience a high disutility compared to the recyclable package option, with a negative WTP (€−2.14), indicating that they are willing to spend on average €2.14 more in a product with a non-recyclable packaging.

Other studies have analyzed the willingness of consumers to participate in experimental clinical treatments aiming to identify treatment preferences for specific conditions through a couple of approaches: (1) Investigate the availability of patients or consumers that would use treatments to prevent or reduce the incidence of skin diseases such as psoriasis and actinic keratosis, considering attributes and efficacy levels (percentage of improvement in skin appearance and reduction of skin cancer risk), intensity, duration, and severity of secondary reactions Kopasker et al. [15]; (2) analyze the commercial availability of cosmetic treatments with different attributes, including the function (restore wrinkled skin, reduce pore size, treat acne dots and spots, skin moisturizer), presentation (ointment, cream, lotion), packaging (pump-style, tube, jar, ampoule), and price [16].

3. Materials and Methods

The selection criterion for the product to be used to estimate consumer preferences was the identification of medicinal plants used by rural communities living in buffer zones of the following Natural Protected Areas: Sierra de la Laguna Biosphere Reserve, Cabo Pulmo National Park, Bahía de Los Ángeles Biosphere Reserve, and Bahía de Loreto National Park. To this end, a literature search was conducted and validated through field surveys and interviews. The profile required of interviewees included the following: (1) Being an authority or chronicler in the community; (2) practice traditional medicine with local plants and be recognized or recommended by other community members as a guardian of traditional knowledge. Two interviews were conducted in a fishing community in the Bahia de Los Angeles Biosphere Reserve, one in the Ligui community in the Bahía de Loreto National Park, and two in the Cabo Pulmo community in the Cabo Pulmo National Park. Besides, we interviewed a field guide of researchers and wildlife monitoring authorities and recognized as a guardian of traditional knowledge by the San Dionisio community in the Sierra La Laguna Biosphere Reserve. The interviews were conducted during the period from September to November 2019. The results of the identification of plant use from the literature search and fieldwork are shown in Figure 1.

We found 88 plant species associated with the traditional knowledge of medicinal use: 47 species used as wild fodder of cattle and goats; 21 species used as timber; 37 edible plants; 5 for industrial use in the textile and tannery sectors; and 52 with no use identified. From these, 53 plant species are endemic to the study area and 10 are for medicinal uses [6]. These 10 endemic species with medicinal use are shown in Table 1.

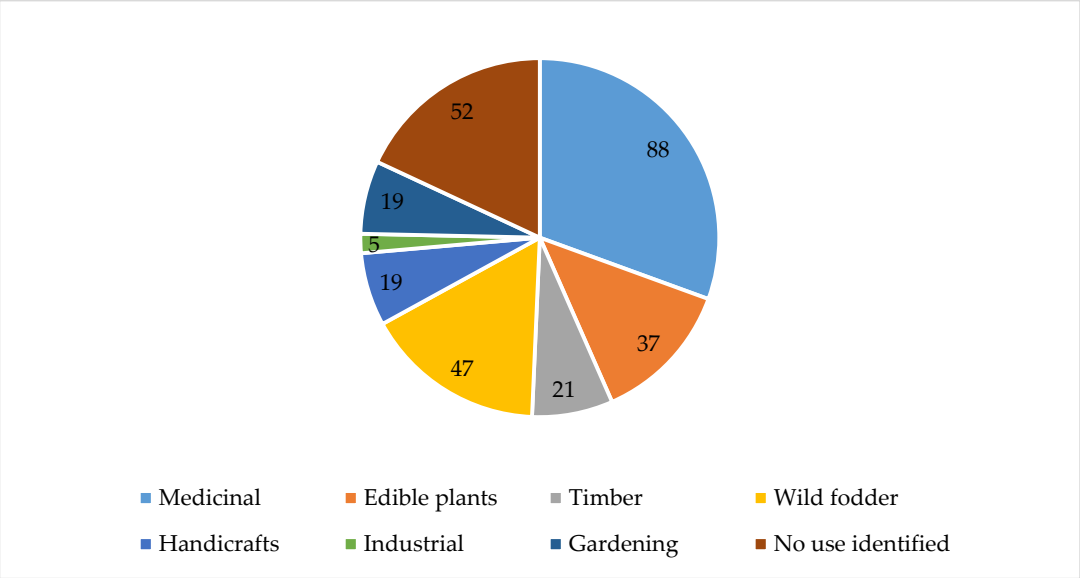

Figure 1. Number of plant species identified by type of use in Natural Protected Areas: Sierra de la Laguna, Cabo Pulmo, Bahía de Los Ángeles, and Bahía de Loreto.

Table 1. Endemic plant species of ecosystems located in Sierra La Laguna, Cabo Pulmo, Bahía de Los Ángeles, and Bahía de Loreto protected natural areas, Baja California Sur, associated with traditional knowledge.

Scientific Name	Family	Local Common Name	Uses
Anemopsis californica Hook et Arn.	*Saururaceae*	Hierba del Manso, Yerba Mansa	Skin wounds, bumps, cuts, aches, indigestion, asthma
Arbutus peninsularis Rose et Goldman	*Ericaceae*	Madroño	Strengthen the circulatory system
Aristolochia monticola Brandegee; *A. porphyrophylla* Pfeifer	*Aristolochiaceae*	Hierba del Indio	Eliminate intestinal parasites, stomach pain, diarrhea and vomiting, malaria, gallbladder ailments, diabetes, common cold, cough, wound healing
Arracia brandegeei Coulter et Rose	*Apiaceae (Umbelliferae)*	Chuchupate	Diabetes, kidney discomfort, rheumatism, blood pressure, stomach and kidney pain, blood pressure control
Euphorbia polycarpa Benth; *Chamaesyce polycarpa* (Benth.) Millsp.; *Ch. tomentulosa* (S. Wats.) Millsp.; *Ch. leucophylla* (Benth.) Millso.	*Euphorbiaceae*	Golondrina	Eye discomfort (although this application is hazardous), skin irritation, rash, itching
Cyrtoparpa edulis (Brandegee) Stand.; C. edulis *(Brandegee)* Stand. var glabra León de la Luz and Pérez-Navarro	*Anacardiaceae*	Wild plum, cimarron plum, Chunique	Toothache, urinary tract pain, kidney discomfort, prostate discomfort, wound healing, treatment of skin conditions
Ibervillea sonorae (S. Wats) Greene	*Cucurbitaceae*	Melón de Coyote, Guerequi	Stomach ulcers, stomachache, diabetes
Jatropha vernicosa Brandegee (M. Brown)	*Euphorbiaceae*	Lomboy rojo, Lomboy colorado	Toothaches, wound healing
Schaefferia pilosa Standl	*Celastraceae*	Hierba del Cuervo	Rheumatism, dandruff, treatment of rabies
Yucca valida Brandegee (A. Garcia M.); *Yucca capensis* L.W. Lenz	*Agavaceae*	Datil, Datilillo	Treatment of snake bites

Note: own elaboration based on surveys, field interviews, and references [4–6].

According to [4], the most common uses of the local flora in rural communities in Baja California Sur are recreational infusions or teas. The main species used are: anís de la sierra *Tagetes filifolia* Lag, palo de brasil *Haematoxylon brasiletto* H. Karst, cerezo *Prunus serotina* Ehrt. Subsp. Virens, Wooton et Standley, Mac Vaugh, confiturilla *Lantana velutina* Martens et Galeotti, damiana negra *Turnera diffusa* Willd. var. *aphrodisiaca* (Ward) Urb, helecho peyote *Pellaea ternifolia* (Cav.) Link subsp. *brandegeei* (C.C. Hall) mickel, and hierba del venado *Platymiscium gracile* Benth. These species are used for domestic consumption and local small-scale trade.

3.1. Product Selection

Of the three Natural Protected Areas studied, the Sierra La Laguna Biosphere Reserve (RBSL) was selected to choose the species associated with traditional knowledge to run the choice experiment. Figure 2 shows the location of the study site.

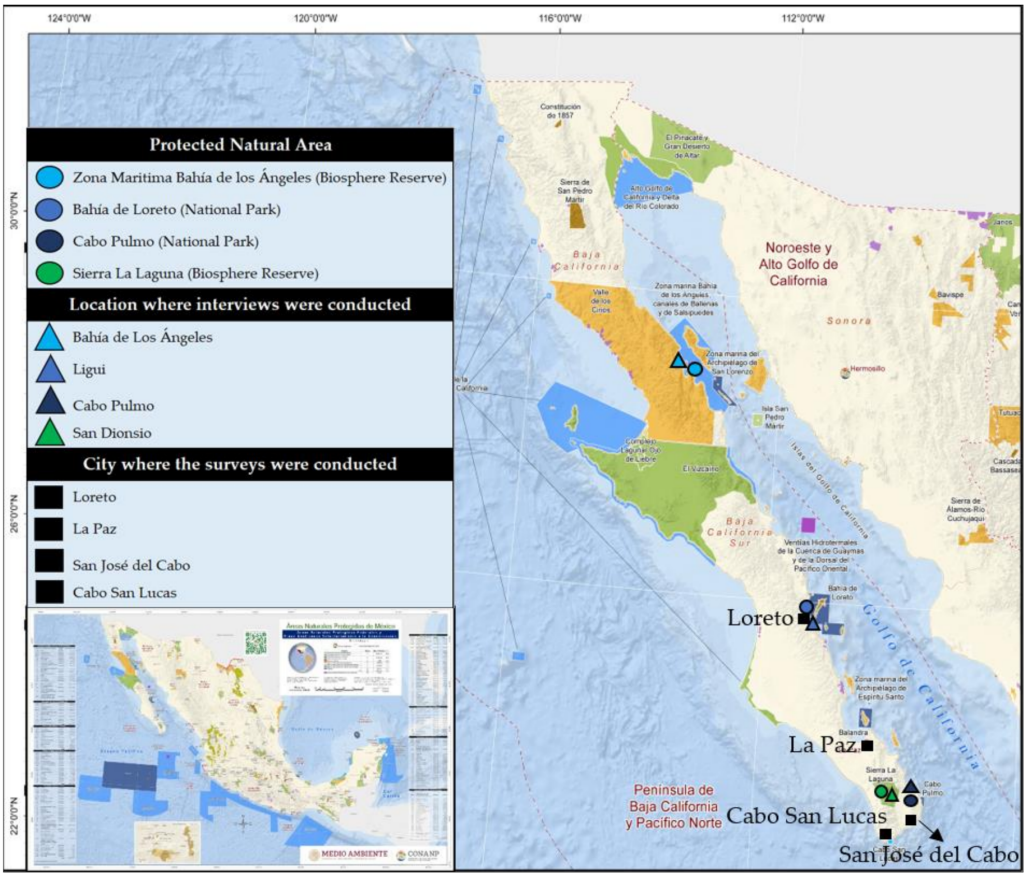

Figure 2. Protected natural areas, towns, and cities where the interviews and surveys were conducted. Source: [17].

Fieldwork was carried out in the rural town of San Dionisio, specifically at the El Refugio ecological ranch located at Longitude −109.865000 and latitude 23.558333, at 474 m above sea level. In this ranch, the local community provides various ecotourism services, including low-impact camping, hiking, rappelling, environmental education courses, preparation and tasting of regional food, leather-product trade, beekeeping, and trade of teas and infusions made with local plants. An innovative community activity related to the non-extractive use of plants with associated traditional knowledge is the "Living Pharmacy" thematic hiking, consisting of a guided walking tour in which medicinal plants are identified by common and scientific names and described in terms of the part of the plant used, mode of use, and specific use for the treatment of particular discomforts or health disorders. Some of the plants associated with traditional knowledge are described in Table 2.

Table 2. Species associated with traditional knowledge in San Dionisio, BCS, Mexico.

Scientific Name	Family	Local Common Name	Use	Part Used
Aralia scopulorum Brandegee	*Araliaceae*	Sauco, Zauco	Treatment of stings of poisonous animals	Leaves, flower, and fruit
Euphorbia polycarpa Benth [*Chamaesyce polycarpa* (Benth.) Millsp.]; *Ch. tomentulosa* (S. Wats.) Millsp.; *Ch. leucophylla* (Benth.) Millsp.	*Euphorbiaceae*	Golondrina	Skin irritation, herpes, and chickenpox	Leaves and branches
Cylindropuntia cholla Weber	*Cactaceae*	Choya pelona	Lower the fever	Root
Cyrtoparpa edulis (Brandegee) Stand. C. *edulis* (Brandegee) Stand. var glabra León de la Luz and Pérez-Navarro	*Anacardiaceae*	Ciruelo Silvestre, Ciruelo Cimarrón, Chunique	Skin regeneration Diuretic, to clean kidneys	Bark
Ficus palmeri S. Watson; *F. brandegeei* Standley	*Moraceae*	Zalate, Higuera Cimarrona, Higuera Silvestre	Anti-inflammatory agent and treatment of rattlesnake bites. Fever control	Sap, leaves, and fruit
Jatropha cinerea (C.G. Ortega) Muell.-Arg. In DC.	*Euphorbiaceae*	Lomboy Blanco	Skin regeneration, wound healing	Leaves and branches
Jatropha vernicosa Brandegee	*Euphorbiaceae*	Lomboy rojo, Lomboy Colorado	Relief of intestinal ulcers and gastritis	Sap
Lophocereus schottii (Engem.) Britton et Rose	*Cactaceae*	Garambullo	Skin regeneration	Sap
Matelea cordifolia (A. Gray) Woodson; *M. fruticosa* (Brandegee) Woodson; *M. pringlei* (A. Gray) Woodson; M. *umbellata* (Brandegee) Woodson	*Asclepiadaceae*	Talayote	Stomach anti-inflammatory agent	Flower
Pellaea ternifolia (Cav.) *Link Pellaea ternifolia* (Cav.) Link subsp. *brandegeei* (C.C. Hall) Mickel	*Pteridaceae*	Helecho peyote	Joint aches and cramps	Root
Prunus serotina Ehrt. Subsp. virens (Wooton et Standley) Mac Vaugh	*Rosacease*	Cerezo	Cold and sore throat	Resin
Tecoma stans (L.) Juss	*Bignoniaceae*	Palo de Arco	Control sugar levels	Leaves and flower
Turnera diffusa Willd. Ex Schult.; *Turnera diffusa* Willd. var. *aphrodisiaca* (Ward) Urb.	*Turneraceae*	Damiana; Damiana negra	Relaxing and aphrodisiac agent	Leaves and flower

Note: own elaboration based on interviews with Lic. Rogelio Rosas, an inhabitant of the San Dionisio community; [4–6].

From the species documented and later confirmed through interviews in the San Dionisio community, the plant *Euphorbia polycarpa* Benth [*Chamaesyce polycarpa* (Benth.) Millsp.], locally nown as Golondrina, was selected for the choice experiment of a cosmetic product formulated based on traditional knowledge with claimed benefits to treat skin irritation, regenerate injured skin, and heal chickenpox and herpes lesions, all of which are desirable properties in cosmetic products. In this sense, this experiment aimed to demonstrate that the cosmetics industry may consider consumer preferences to reach profit-sharing agreements with local communities inhabiting protected natural areas for purposes of product research and marketing of products manufactured with ingredients from plants associated with traditional knowledge.

According to [18], within the genus *Euphorbia* L. (2000 species), the clade Chamaesyce comprises 350 species of which the majority (210) have their origin on the American continent. The specie *Euphorbia polycarpa* Benth. is distributed in warm and arid areas of North America.

The *golondrina*, *Euphorbia polycarpa* Benth. [*Chamaesyce polycarpa* (Benth.) Millsp.], belongs to the family Euphorbiaceae and thrives in sandy soils, disturbed land, and alongside roads and highways, ranging throughout the Baja California peninsula and nearby islands [5]. Figure 3 illustrates a specimen of *Golondrina*, *Euphorbia polycarpa* Benth [*Chamaesyce polycarpa* (Benth.) Millsp.].

Figure 3. Golondrina *Euphorbia polycarpa* Benth [*Chamaesyce polycarpa* (Benth.) Millsp.]. Source: [5].

3.2. Study Area

Given the importance of the use of Golondrina associated with traditional knowledge in rural communities of Natural Protected Areas of Baja California Sur, a search was conducted for patents granted associated with species of the family *Euphorbiaceae* and the genus *Euphorbia*, including several species within the genus that share common properties as sources of useful compounds for the pharmaceutical and cosmetic industries. The search was performed in the Google Patents application as of 2 December 2020. This search engine retrieves information from databases of the following patent offices: World Intellectual Property Organization (WIPO), United States and Trademark Office (USPTO), European Patent Office (EPO), Chinese National Intellectual Property Administration (CNIPA), Canadian Intellectual Property Office (CIPO), Japan Patent Office (JPO), Korean Intellectual Property Office (KIPO), Deutsches Patent-und Markenamt/DPMA), and patent offices in the United Kingdom, Russia, France, Spain, Belgium, Denmark, Finland, Luxembourg, the Netherlands, Austria, Brazil, Switzerland, and Taiwan. By performing a search of patents in this site using the keywords "*Chamaesyce polycarpa*", two patents were identified as an invention for the treatment of human papillomavirus (HPV)-induced lesions and treatment of photo-aged skin with submission dates prior to the entry into force of the Nagoya Protocol (12 October 2014). The results are shown in Table 3.

Table 3. Patents identified and associated with the use of *Euphorbia polycarpa* Benth.

I.D. Patent.	Title	Asignee	Especies	Isolated Compound
ES-2564173-T3	Treatment of virus induced lesions	Leo Laboratories Limited	Various species in the genus *Euphorbia*, including *Euphorbia polycarpa* Benth.	3-ingenol angelate (PEP005, ingenol mebutate)
EP-2395993-B1	Skin treatment	Leo Laboratories Limited	Various species in the genus *Euphorbia*, including *Euphorbia polycarpa* Benth.	Ingenol (Angelatos de ingenol)

Source: [19].

There are two patents granted to Leo Laboratories Limited, one for the treatment of virus-induced injuries (ES-2564173-T3) associated with the use of species of the genus Euphorbia, including the species *Euphorbia polycarpa* Benth. The other patent as an invention for skin treatment (EP-2395993-B1) considers the genus Euphorbia, including Euphorbia polycarpa, as a particularly suitable element of its invention [12]. These patent requests were submitted on 30 April 2008 and 12 February 2010, respectively. To note, the use of Golondrina, *Euphorbia polycarpa* Benth. [*Chamaesyce polycarpa* (Benth.) Millsp.] to treat skin rash is documented by [6] and was verified through interviews conducted on 18 September 2019 in the San Dionisio community of the Sierra de La Laguna Biosphere Reserve.

3.3. Choice Experiment

To explore consumer preferences for skin-care cosmetic products labeled with traditional knowledge associated with the Golondrina plant, *Euphorbia polycarpa* Benth [*Chamaesyce polycarpa* (Benth.) Millsp.], we used the Discrete Choice Experiment method based on the Lancaster consumer theory [20] and the Random Utility theory [21]. The attributes and levels used in option sets are shown in the Table 4.

Table 4. Attributes and levels used in choice sets.

Attribute	Levels
Information level	1. Cosmetics labeled with information on traditional knowledge associated with the Golondrina plant 2. Cosmetics no label on the use of the Golondrina plant and traditional knowledge
Efficacy	1. High 2. Moderate 3. Low
Price (USD) per package 50 mL. 1.69 fl.oz.	1. 1.10 2. 2.39 3. 3.93

Source: Own elaboration.

The information attribute is split into two levels. The first involves no label information on the Golondrina plant associated with traditional knowledge; the other indicates that the cosmetic product was manufactured from the Golondrina plant based on the traditional knowledge from communities inhabiting the Sierra La Laguna Natural Protected Area.

3.3.1. Design

We identified 18 potential cosmetic options with three attributes, two with three levels and one with two ($3^2 \times 2 = 18$). The orthogonal-design method was applied using the software SPSS Conjoint considering the main effects. We obtained 16 product options, which were randomly arranged in pairs to obtain eight sets of cards randomly paired with two profiles (options A and B) for the cosmetic products and including option C (opt-out), so that the respondent is offered 24 options, including the opt-out or not-to-buy option. Status-quo (an option not including traditional knowledge) and exclusion options

were included, both necessary to obtain wellness measures consistent with economic theory [22–24]. The following information was given to respondents "Researchers from the Northwest Biological Research Center are conducting a study on the economic valuation of natural resources associated with traditional knowledge in Protected Areas of Northwest Mexico. The purpose of this study is to identify and document the use of natural resources associated with traditional knowledge and measure the willingness of the communities of these protected areas to sign Access and Benefit-Sharing agreements, as a pharmaceutical, cosmetics, or biotechnology company might be interested in using natural resources associated with traditional knowledge for commercial purposes. Specifically, we would like to have your collaboration to answer this questionnaire, which aims to identify preferences for cosmetics with various attributes, including a label with information on the use of traditional knowledge of the Golondrina plant from the community of San Dionisio, Baja California Sur, Mexico". Objectively answer the following questions:

Figure 4 shows an example of a choice set included in the choice experiment.

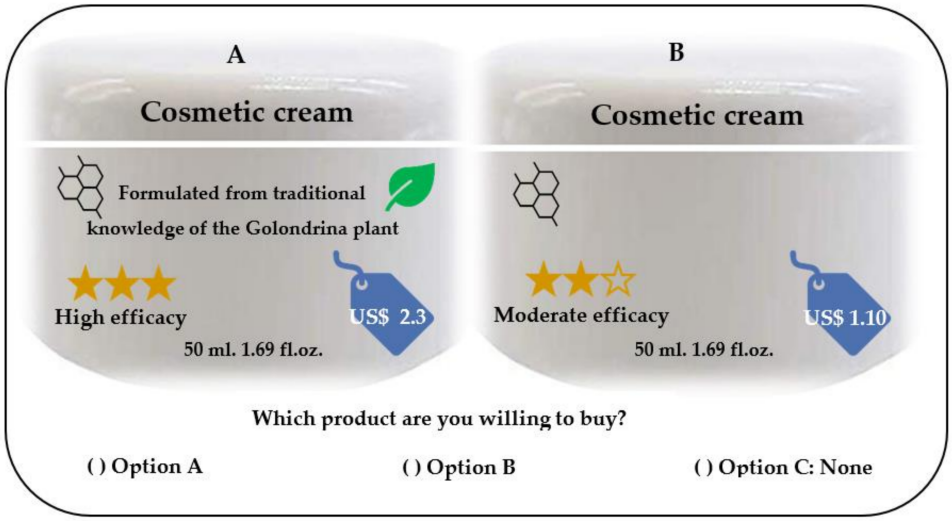

Figure 4. Example of a choice set included in the choice experiment. Source: Own elaboration.

3.3.2. Sample

The minimum sample size was determined using the formula developed by [25], in which the required sample size depends on the number of attributes, levels, and alternatives to choose from:

$$N > \frac{500c}{txa} = \frac{500 \times 3}{8 \times 3} = 63, \quad (1)$$

where $c = 3$ is the number of attribute levels (US $1.10, $2.39, US $3.93); $t = 8$ is the number of choice cards used in the experiment; and $a = 3$ is the number of options in each card (A, B, or C).

The final sample included 64 respondents, resulting in 512 options (64 × 8) and 1536 observations (512 × 3 options). According to the literature, choice models should include at least 500 options to obtain valid estimators using Mixed Logit models [26–28]. Surveys were applied face-to-face to permanent residents aged 18 years or older, at shopping malls in the cities of Cabo San Lucas, San José del Cabo, La Paz, and Loreto, between September 2019 and March 2020. The response rate was 85%, which is higher than the rates commonly reported for choice experiments, probably because of the interest in the subject and the availability to respond during leisure or shopping time. Table 5 summarizes the socio-demographic characteristics of respondents.

Table 5. Descriptive statistics of sociodemographic sample attributes (n = 64).

Variable	Description	Mean	Standard Deviation	Minimum	Maximum
Age	Quantitative variable (years)	38	9.84	18	60
Sex	Dichotomous variable, 1 for men and 0 for women.	0.5	-	0	1
Income	Categorial variable (monthly income, USD). (1) 0—183.88; (2) 183.89—367.81; (3) 367.82—551.69; (4) 551.70—735.64; (5) 731.65—919.55; (6) greater than 919.55.	3.32 ($460.00)	276	91.98	920

Source: Own elaboration.

The sample composition by sex was 50% men and 50% women, closely matching the sex proportions (50.8% men and 49.2% women) in the overall population of Baja California Sur, as per [29].

3.3.3. Data Analysis

For the choice experiment, a Mixed Logit model was fitted, given its flexibility and ability to approximate any random utility model [30]. Consumer preferences can be estimated on the assumption of either homogeneity or heterogeneity. Under the assumption of homogeneity, the parameters are the same for all consumers and should be estimated using fixed-effect models. If preferences are heterogeneous, the parameters should be estimated using random effects models. To estimate consumer preferences given the alternatives of the cosmetic product, we used a discrete choice model with random coefficients as this allows flexibility in the assumption of independence of irrelevant alternatives (IIA). According to [31], the utility of an alternative i, as perceived by individual n, in a choice set t, includes two parts: A systematic component, V_{jn}, that can be specified as a function of the attributes of the alternatives, $V(X_{in}, \beta)$, and a random component, ε_{ni}, that represents unmeasured variation in preferences, which may be due to heteroegenity in tastes or specification or measurement errors. Thus, the utility of alternative i is calculated as:

$$U_{ni} = V(X_{ni}, \beta) + \varepsilon_{ni} \quad (2)$$

A consumer will choose option i if it maximizes its utility among all the options (j) included in the choice set t. That is,

$$(V_{ni} + \varepsilon_{ni}) > (V_{nj} + \varepsilon_{nj}) \cdot \forall\, j \neq i \ \in t \quad (3)$$

Rearranging the observable and unobservable components yields:

$$(V_{ni} - V_{nj}) > (\varepsilon_{nj} - \ \varepsilon_{ni}) \quad (4)$$

Since component $(\varepsilon_{nj} - \varepsilon_{ni})$ is unobservable, it is impossible to determine exactly whether it is smaller than the observable component, as stated in Equation (4). Therefore, the consumer choice can only be inferred from the probability of occurrence, based on the latent utility of alternative i among a choice set t:

$$y_{ni} = f(U_{ni}) = \begin{cases} 1\ if\ U_{ni} = max(U_{ij}) \\ 0\ otherwise \end{cases} \ \forall j \neq i \in t \quad (5)$$

where y_{ni} equals 1 if individual n chooses alternative i of the choice set t that maximizes its utility, and 0 otherwise. Thus, the probability that individual n chooses alternative i described by attributes x can be expressed as:

$$P_{ni} = Pr(y_{ni} = 1|X_{ni}, \beta) = Pr\left(U_{ni} > U_{nj}\right) \forall\, j \neq i \in t = Pr\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\right) \forall\, j \neq i \in t$$
$$= Pr\left(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}\right) \forall\, j \neq i \in t \quad (6)$$

According to [21,31], the probability that individual n chooses alternative i equals the probability that the difference between the random components of the utility of alternative i and any other alternative j, $\left(\varepsilon_{nj} - \varepsilon_{ni}\right)$, is smaller than the difference between the observable components of the utility of alternatives i and j, $\left(V_{ni} - V_{nj}\right)$. Since the random component is unknown, a distribution associated with the probability of choice is assumed. According to [32–34] a consumer will choose option i if, and only if, $U_{ni} > U_{nj} \forall\, j \neq i$. Thus, the unconditional probability P_{ni} in a mixed-logit model can be expressed as:

$$P_{ni} = \int \frac{e^{\alpha_i + \beta_n' x_{nit}}}{\sum_j e^{\alpha_i + \beta_n' x_{njt}}} f(\beta_n|\theta) d\beta_n \quad (7)$$

where x_{njt} represents the attribute levels; α_i is an Alternative-Specific Constant (ASC); β_n is a vector of random parameters associated with the attribute levels, $f(\beta_n|\theta)d\beta_n$ denotes the marginal joint density of the random coefficients β_n given the distributional parameter θ.

We fitted a mixed logit model to estimate heterogeneous consumer preferences, with the cosmetic efficiency attribute included in the random parameters. The model fitted was an alternative-specific mixed logit regression:

$$v_{ni} = \alpha\, Information\ level + \beta\, Efficacy_{ni} + \gamma\, Price_{ni} + \delta X_{ni} + \varepsilon_{ni} \quad (8)$$

where v_{ni} is the utility that the surveyed individual n obtains from choosing alternative i among the choice set t. α is the ASC for cosmetics labeled with information on traditional knowledge associated with the Golondrina plant (TK), or with no label on the use of the Golondrina plant and traditional knowledge, compared to the opt-out option $(j-1)$.

The ASC captures the average effect on utility of factors that are not included in the model [31–33]. X is a vector of sociodemographic variables such as sex, age, and income, which are specific to cosmetics with information on traditional knowledge associated with the Golondrina plant (TK), or with no label on the use of the Golondrina plant and traditional knowledge, compared to the opt-out option $(j-1)$ β is the random coefficient associated with efficiency level, δ is the fixed coefficient associated with price, and ε_{njt} is a term error.

3.3.4. Welfare Analysis

The Willingness to Pay (WTP) attribute measures the change in welfare resulting from a change in an attribute of a given good or service. To answer the question, do respondents perceive an increase in their welfare level by choosing a product labeled with information on traditional knowledge associated with the Golondrina plant, compared to products with no label claims associated with traditional knowledge, to estimate mean aggregate WTP for policy changes, the logarithmic expression of the classic sum of welfare (log-sum) is commonly used [35,36]:

$$WTP = -\frac{1}{\gamma} \cdot ln\left[\frac{e^{\nu 0}}{e^{\nu 0} + e^{\nu 1}}\right] \quad (9)$$

where $\nu 0$ is the utility of the opt-out alternative and $\nu 1$ represents the indirect observable utility before and after the proposed change, and γ is the coefficient estimated for price. According to [31,35,36] the marginal WTP (MWTP) can be expressed as:

$$MWTP = -\left[\frac{1}{\gamma} \cdot \left[\nu 1^M - \nu 0^M\right]\right] \quad (10)$$

where $\nu 0^M$ and $\nu 1^M$ represent the indirect observable utility of the baseline profile and utility level achieved by incrementing one of the one attribute only. The marginal WTP

(MWTP) for cosmetic products with claims related to traditional knowledge from the Alternative-specific mixed logit model in Equation (8) is calculated as:

$$MWTP = -\left[\frac{\alpha_{TK} - \alpha_{No\_TK}}{\gamma}\right] \quad (11)$$

where α_{TK} and α_{No_TK} correspond to ASC for cosmetics labeled with information on traditional knowledge associated with the Golondrina plant and cosmetic products with no claims label on related to traditional knowledge.

4. Results

The model was estimated in the software Stata version 15.1 (StataCorp, College Station, Texas, USA). An Alternative-specific mixed logit model was estimated using the command asmixlogit. The results are shown in Table 6.

Table 6. Results of the discrete choice model with random parameters.

Category	Variable		Coefficient	Standard Error	$P>\|z\|$
Options	Efficacy	μ	1.3165	0.0413	0.00
		σ	0.8200	0.0556	0.00
	Price		−0.0347	0.0134	0.01
No traditional knowledge	Sex		−0.0759	0.0409	0.06
	Age		0.0124	0.0026	0.00
	Income		−0.1836	0.0152	0.00
	Constant (ASC)		−0.0939	0.0832	0.26
Based on traditional knowledge	Sex		−0.0812	0.0528	0.12
	Age		−0.0325	0.0038	0.00
	Income		0.2577	0.0207	0.00
	Constant (ASC)		0.4052	0.1080	0.00
None (opt-out)	Baseline option				

Source: Own elaboration. LR test versus fixed parameters: chibar2(01) = 22.70 Prob $\geq$ chibar2 = 0.0000.

The ASC of cosmetic products with claims related to traditional knowledge was positive and statistically significant at 1% (p = 0.01), suggesting that this alternative is chosen more often than the other alternatives. The coefficients of the socioeconomic variables age and income specific to the traditional knowledge attribute were statistically significant, the positive sign of the income coefficient reveals that the preference for this attribute increases with increasing income of consumers, indicating that the consumers surveyed of a higher income level claim to obtain a greater wellness level by choosing a product based on traditional knowledge, while the negative sign of the age coefficient indicates that the preference for this attribute decreases with increasing age of consumers. With regards to. sex, no statistically significant differences were found in preferences between men and women for this attribute.

On the other hand, the ASC for cosmetic products with no claims on the Golondrina plant associated with traditional knowledge had a negative sign but was non-significant. This indicates that, if the specific sociodemographic variables of the specific alternative cosmetic product with no label claims on traditional knowledge of the Golondrina plant are not considered, this is not statistically preferred to the alternative none (opt-out). However, the age coefficient, by being statistically significant and with a positive sign, indicates the existence of an important segment of consumers that prefer cosmetic products with no claims on the Golondrina plant associated with traditional knowledge in their formulation. The negative sign of the income variable in the alternative with no traditional knowledge reveals that consumers perceive less wellness in products with this attribute as income increases. Regarding sex, no statistically significant differences were found in preferences between men and women for this attribute.

The price coefficient was negative and statistically significant $(P = 0.01)$, indicating that the respondents perceive a lower wellness level when product price increases, in line with the economic theory, since it is a function of demand. The model includes a random coefficient that captures the effect of the efficacy attribute. The distribution of the coefficients of the efficacy variable has a mean of 1.32, which is statistically significant, and a standard deviation of 0.82, also statistically significant, at conventional significance levels in both cases. The likelihood ratio test indicates that it is possible to reject the null hypothesis that the coefficients on efficacy are fixed and that the coefficients of the estimated model with the inclusion of random effects are statistically equal to zero. Under the model assumptions, the set of coefficients of each consumer surveyed approaches a normal distribution, thus confirming the heterogeneity in respondent preferences. Thus, with 95% confidence, the distribution of coefficients ranges from -0.29 to 2.92 $[1.3165 - 1.96(0.82) = -0.29$ and $1.3165 + 1.96(0.82) = 2.92]$ indicates that most consumers increase their wellness level by consuming cosmetics with higher efficiency. The dataset file (.dta) is available for replication purposes in Supplements.

4.1. Effect of Attributes on Utility

To measure the probability of acceptance of a cosmetic product with label claims on traditional knowledge of the Golondrina plant, the indirect utility of cosmetic products with and without label claims on traditional knowledge was estimated considering that the respondent is a woman and assuming the mean value of the random parameter efficacy, the averages of price and effectiveness, and the specific variables age and income.

$$\nu\_tk = \alpha Tk + \beta Efficacy + \gamma Price + \delta_1 Sex + \delta_2 Age + \delta_3 Income = 2.29 \quad (12)$$

$$\nu_{no\_tk} = \alpha No\_tk + \beta Efficacy + \gamma Price + \delta_1 Sex + \delta_2 Age + \delta_3 Income = 2.27 \quad (13)$$

$$\nu_{none} = 0 \quad (14)$$

where ν_tk, ν_{no_tk}, and ν_{none} are the indirect utilities associated with choosing cosmetic options with and without label claims on traditional knowledge of the Golondrina plant, as well as the opt-out option of not buying, respectively. The utility for a 32-year-old female respondent with a monthly income of $460.00 (USD), when choosing a cosmetic product with a label claim on traditional knowledge of the Golondrina plant, average efficacy, and price, experienced a utility slightly greater than the one when choosing a cosmetic product of the same efficiency and price attribute levels but lacking label claims on traditional knowledge.

4.2. Probability of Acceptance

The probability of acceptance of the previous profile is as follows:

$$Pr(tk) = \frac{e^{\nu_{tk}}}{e^{\nu_{no\_tk}} + e^{\nu V_{tk}} + e^{\nu_{none}}} = 0.48 \quad (15)$$

$$Pr(no\_tk) = \frac{e^{\nu_{no\_tk}}}{e^{\nu_{tk}} + e^{\nu V_{no\_tk}} + e^{\nu_{none}}} = 0.47 \quad (16)$$

$$Pr(none) = \frac{e^{\nu_{none}}}{e^{\nu V_{no\_tk}} + e^{\nu_{none}} + e^{\nu_{tk}}} = 0.05 \quad (17)$$

According to the estimated utilities, it is possible to predict that a 32-year-old woman with a monthly income of $460.00 (USD) per month has a 48% probability of choosing a cosmetic product with a label claim on traditional knowledge of the Golondrina plant, average efficacy, and price, versus 47% of choosing a cosmetic product with no label claims associated with traditional knowledge, and 5% of choosing none.

The indirect utility and probability of acceptance were estimated considering minimum, mean, and maximum values of efficacy random coefficients obtained assuming a normal distribution with 95% confidence. These results are shown in the Table 7.

Table 7. Distribution of heterogeneity of preferences for cosmetic attributes under normally distributed random coefficients.

Utility				
Level	**Random Coefficient**	**Claim on Traditional Knowledge**	**No Claim on Raditional Knowledge**	**None**
Minimum	−0.29	−0.93	−0.95	0
Medium	1.32	2.29	2.27	0
Maximum	2.92	5.49	5.47	0
Probability				
Level	**Random Coefficient**	**Claim on Traditional Knowledge**	**No Claim on Traditional Knowledge**	**None**
Minimum	−0.29	0.22	0.22	0.36
Medium	1.32	0.48	0.47	0.05
Maximum	2.92	0.50	0.49	0.01

Source: Own elaboration.

When evaluating the changes in the utility and probability of choice for minimum, mean, and maximum values of the efficacy random parameter, it was found that on average, consumers surveyed with a greater preference for high efficacy experience greater utility and, therefore, greater probability of acceptance, when choosing cosmetic products with label claims on traditional information from the Golondrina plant, relative to the utility they would get by choosing a cosmetic product including no label claims associated with traditional knowledge.

4.3. Marginal Willingness to Pay

The marginal WTP by Cosmetic with the Golondrina plant traditional knowledge information label was calculated with the following equation:

$$MWTP = -\left[\frac{\alpha_{TK} - \alpha_{No_{TK}}}{\gamma}\right] = \$2.30\ (USD) \quad (18)$$

where α_{TK} and $\alpha_{No_{TK}}$ are the ASC for a cosmetic product with and without label claims associated with traditional knowledge. γ is the price coefficient. On average, respondents are willing to pay $2.30 (USD) more for a cosmetic products with label claims on traditional knowledge about the Golondrina plant, rather than a conventional product with no label claims associated with traditional knowledge.

5. Discussion

The issue of consumer preferences for cosmetic products has been studied through different approaches in the scarce existing literature. Four approaches were identified: (1) Ethnomedicinal studies that document the use of medicinal plants by the population and the cosmetics industry [8]; (2) studies on the drivers of intent of purchase of ecological cosmetic products through the use of eco-labels by commercial brands [11]; (3) studies on consumer preferences for cosmetic products with environmentally friendly attributes such as organic/inorganic, local/regional/national/imported origin, produced with no animal experimentation and recyclable packaging [13,14]; and (4) studies that address the willingness of consumers to participate in experimental clinical treatments to identify treatment preferences for specific conditions [15,16].

Many of these studies have addressed the preferences for cosmetic products considering different attributes and methods: Attributes such as specific function, design, organic origin, and eco-labels were analyzed using methods such as the purchase behavior model and contingent valuation method in South Korea [11,13]; attributes such as fragrance, color, safety, performance, good value for money, packaging, outlet atmosphere, opportunity to pre-test, and brand image were analyzed using attitude towards brands models in Thailand [12]. Other attributes such as geographic origin, use of animal-testing methods,

organic origin of raw materials, and recyclable packaging were analyzed using a choice experiment with a random parameter logit model in Italy [14]. The efficacy of some cosmetic treatments was analyzed using multinomial and mixed logit models in the United Kingdom [15].

Another group of studies have provided valuable information on cosmetic products formulated with ingredients from plants associated with traditional knowledge of indigenous groups and local communities. However, it is necessary to conduct studies addressing the fair and equitable sharing of benefits to indigenous groups and communities for the use of plants associated with traditional knowledge by of the cosmetics industry, including attributes of label information on the use of plants associated with traditional knowledge in studies on consumer preferences.

In this regard, the present study seeks to reduce the gap in the literature on the value that consumers assigned to cosmetic products formulated with ingredients from plants associated with traditional knowledge of local communities in Protected Natural Areas. Consumers were found to experience increases in welfare by choosing cosmetic products with label claims on TK information associated with the Golondrina plant, with a marginal willingness to pay of $2.30 (USD). Indicating that consumers experience greater utility in choosing cosmetic products labeled with information on the use of traditional knowledge of the Golondrina plant due to its documented properties to eliminate skin irritation, regenerate injured skin, and heal chickenpox and herpes lesions [5,6]. Regarding the effect of sociodemographic characteristics on the probability of choosing cosmetic products with label information on traditional knowledge of the Golondrina plant, it was found that older consumers show a lower preference for cosmetic products with label claims on traditional knowledge. This suggests the existence of market segments by age groups, according to the specific functions of the cosmetic product, such as eliminating acne and blemishes in consumers under 30 years of age and hydrating the skin in consumers over 30 years of age, as reported [16]. An important finding was that an increase in the income level of consumers is associated with a lower probability of choosing cosmetic products with no claims on the Golondrina plant associated with traditional knowledge in their formulation and a greater probability of choosing cosmetic products with claims related to traditional knowledge. This is consistent with the literature on income as a determinant of green purchasing [11].

The price coefficient was negative and statistically significant, a finding consistent with the theory of random utility [21] that establishes that the choice of consumers according to the utility offered by the product options available depends on the combination of attributes that maximizes product utility, as well as with the results reported in the literature on choice experiments to estimate consumer preference for cosmetics [14].

The random efficacy coefficient was statistically significant and positive for the entire interval assuming a normal distribution, indicating the existence of heterogeneous preferences for the levels of this attribute. This is consistent with the finding of [16], who found that some consumers are willing to accept a reduction in the effectiveness of cosmetic treatments if this reduces the risk of adverse skin reactions.

The results of this study show that plants associated with traditional knowledge have use value with marketing potential through ABS mechanisms. The scope of this study is limited to the analysis of preferences for the consumption of products labeled as associated with traditional knowledge in the manufacture of cosmetic products, based on a choice experiment; it does not address clinical or chemical-pharmaceutical research aspects. However, the study of these properties opens up new research lines on basic science, technology transfer, and ABS mechanisms under the Nagoya Protocol.

6. Conclusions

There are at least 88 plants with associated traditional knowledge in the Natural Protected Areas of Natural Protected Sierra de la Laguna, Cabo Pulmo, Bahía de Los Ángeles, and Bahía de Loreto, documented in the literature and verified in field work. Much of this knowledge is safeguarded by local communities within their buffer zones. Due to the value of these plants for medicinal and cosmetic use, they represent an alternative for sustainable development as an intangible asset within the access and benefit-sharing mechanisms of the Nagoya Protocol. This work represents a contribution on the utility for consumers in the major cities of Baja California Sur, Mexico, choosing cosmetic products with information on traditional knowledge of the Golondrina plant. Our results reveal that consumers increase their welfare level and are willing to pay $2.30 (USD) more for cosmetic products with this attribute. Higher income level positively affects the choice of cosmetic products with this attribute. The values of the distribution of random coefficients show that consumers have heterogeneous preferences on this attribute, consistent with the literature.

These results indicate that cosmetic companies may be interested in setting access and benefit-sharing agreements, within the Nagoya Protocol, with local communities living in buffer zones of protected natural areas and build greater brand recognition by an important segment of consumers of cosmetic products who value the use of plants with traditional knowledge. Finally, the commercial use of traditional knowledge of the Golondrina plant in cosmetics represents an alternative for economic development through the establishment of access and benefit-sharing agreements for communities with restrictions on the extractive use of land.

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