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# Evaluation of Properties of *Chenopodium pallidicaule* (Cañihua) Oil for Possible Use in Cosmetic Formulations

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**Abstract: In this study, *Chenopodium pallidicaule* (Cañihua) oilseed was investigated to determine the composition, and main physico-chemical properties to establish its potential cosmetic applications. The results were compared with well-known vegetable oils. The extraction yield was 2.14±0.01 g of extracted oil/100 g of dry-weight seeds. Unsaturated fatty acids were the most abundant in Cañihua oil. The major unsaturated fatty acid was linoleic acid (42.1%), followed by oleic acid (24.7%) and linolenic acid (3.0%). The specific gravity was 0.897±0.01 (20°C), the average acid value was 0.48±0.14 mg / KOH, the peroxide value was 5.0±1.34 mEq$O_2$/kg, the iodine value was 175.3±18.63 g $I_2$/100 g, and the saponification number was 190.0±0.01 mg KOH / g oil. Other properties for use in cosmetic formulations like surface tension, viscosity, spreadability, and pour and cloud points were similar to those of other vegetable oils used in these formulations. A stable cosmetic emulsion was formulated using Cañihua oil (5%). All results demonstrated the potential of Cañihua oil as an ingredient for cosmetic emulsions for skin treatment.**

**Key words:** Cañihua oil, physicochemical properties, fatty acids, linoleic acid, emulsion

## 1 Introduction

The Andes highlands of South America are considered a major domestication center for many food crops, particularly for Andean grains such as *Chenopodium pallidicaule* (Cañihua). These crops have played a major role on the nutrition of Andean populations for centuries[1]. Studies have shown the presence of a rich oilseed with essential fatty acids in desirable proportions for an edible oil[1] and for dermo-cosmetics products, given that many vegetable oils are considered relevant ingredients for this kind of products for their multifunctional effects on the skin[2].

Recently, awareness about sustainability has increased around the world, changing the thinking and behavior of consumers and companies, and reshaping the development of raw materials and products[3]. Interest in the development of sustainable products has increased over the years, with a growing trend in the use of natural products in the development of cosmetics. There is a growing market in European countries called the "green consumer"[4], referring to individuals concerned about the use of hazardous synthetic chemicals in cosmetics and looking for organic cosmetics[5].

There are many biologically active substances such as phospholipids, sterols, fatty acids, and tocopherols[6] that can be included when we talk about lipids, and these compounds may play beneficial roles in cosmetic formulations, such as moisturizing agents, emollient, humectant substances, and softening agents. Substances typically used for these aims the phospholipids, fatty acids, fatty alcohols, vegetable waxes, and sterols[7], with some studies showing that unsaturated fatty acids show the best dermo-cosmetic functionality[8−11]. For skincare, the most outstanding oils have high content of linoleic and α-linolenic acid which are incorporated into the cell membranes and regenerate the damaged lipid barrier of the epidermis and restrict water loss. The unsaturated fatty acids show prominent healing effects on skin inflammation and could be used in a variety of cosmetic products[11].

New green methodologies such as Supercritical Fluid Extraction (SFE) make lipids more functional. The most used solvent of SFE procedures is carbon dioxide ($CO_2$), which is a gas at room temperature, however, it acts as a solvent because it can adopt properties midway between a gas and a liquid under supercritical conditions when the

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temperature and pressure are adjusted over 31.3℃ and 72.9 atm, respectively[12]. The advantages of SFE are the diffusion properties of the supercritical form of $CO_2$ that enhance the extraction, reducing the time for extraction; $CO_2$ is a non-polar solvent in combination with other more polar solvents like ethanol can extract molecules with higher polarity[13]. For these reasons, the SFE has many applications, and is used as a suitable technique for natural products and waste and by-product management[14].

Vegetal oils have been used in cosmetics since ancient times[15]. Civilizations like Phoenician, Chinese, Indian and Egyptian have used these oils to treat skin illnesses. Today, some of these oils are used in dermatology to treat various skin diseases like xerosis, atopic dermatitis[16], eczematous conditions, and psoriasis[17]. Also, some oils are used in rejuvenation treatments, and as ingredients for hair and skin cosmetics as primary moisturizing ingredients[18]. The main reasons for their use in the formulation of different types of cosmetics are the presence of essential fatty acids to act as natural emollients and fat-soluble vitamins. Current cosmetic formulations use vegetable oils as carriers of other active substances; however, their biological properties make them valuable ingredients in many cosmetic recipes[15] offering numerous polyunsaturated omega-6 fatty acids (linoleic acid, γ-linolenic acid), sterols and phytosterols for the formation of skin barrier lipids[19]. Furthermore, vegetable oils are used in the production of cosmetics to prevent water loss and maintain skin elasticity and firmness[20].

Andean grains such as *Chenopodium pallidicaule* Aellen are natural sources of oils with quantities of saturated fatty acids (SFAs) and high unsaturated fatty acids content[1] valuable for topical products, so it is necessary to characterize them. Cañihua is an herb between 20 and 60 cm long, its stem and leaves have red and yellow spots, its seeds are dark brown to black in color and are approximately 1 mm in diameter (Fig. 1), and have a rough covering, it is cultivated at an altitude of 3800 m above sea level.

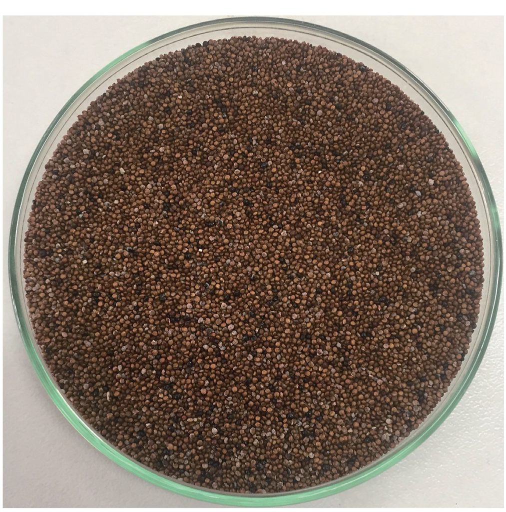

Fig. 1 Dark brown Cañihua seeds.

This study aimed to perform oil extraction of *Chenopodium pallidicaule* seeds using the supercritical fluid method, to analyze the fatty acid content, determine its physicochemical and basic cosmetic characteristics, and develop a stable cosmetic formula to evaluate its potential use in cosmetic products.

## 2 Materials and Methods

### 2.1 Materials

The seeds of *Chenopodium pallidicaule* Aellen, var. Cupi (cañihua) were acquired from Silarani, Cabana sector, San Román – Puno, Perú.

### 2.2 Chemicals

Glacial acetic acid, isooctane, potassium iodide, sodium thiosulfate, starch, Wijs solution, carbon tetrachloride, potassium dichromate, hydrochloric acid, alcoholic potassium hydroxide, phenolphthalein, alcohol-ether mixture, Aqua, Ciclopentano siloxano/dimethiconol, Acrylamide/Sodium Acrylate Copolymer (and) Paraffium Liquidum (and) Trideceth-6, Phenoxyethanol/caprylyl glycol/propylene glycol.

### 2.3 *Chenopodium pallidicaule* oilseeds extraction

The oil extraction was performed using an SFT-100 Supercritical Fluid Extractor (SFE) supplied by Supercritical Fluid Technologies Inc. (Newark, DE, USA). The $CO_2$ with 99.9% of purity was supplied by Praxair, Lima – Perú. The process operation was: The chamber was filed with 480 – 520 g of dehydrated, milled seeds (522 mm size), and the conditions of $CO_2$ in the tank were raised to supercritical conditions. The $CO_2$ at supercritical condition entered the extraction chamber for 30 min (soaking time) for static extraction. For dynamic extraction, the $CO_2$ at supercritical conditions was allowed to flow through the fixed bed formed by the ground seeds, for 180 to 360 min depending on the extraction velocity.

The $CO_2$ with the extracted oil was placed into the separation chamber where the gas was expanded to atmospheric pressure. The extraction process conditions were a flow rate of 4.4 g / min of carbon dioxide, temperature extraction of 45℃, and a pressure extraction of 300 bar.

### 2.4 Determination of fatty acid composition

The fatty acid profile of the *Chenopodium pallidicaule* oil sample was measured by the determination of fatty acids methyl esters (FAMEs). The analysis was performed by a Gas Chromatography/Mass Spectrometry (GC/MS) 6890 N Network GC System (Agilent Technologies, Santa Clara, CA, USA). The FAMEs were separated using a 50 m × 0.35 mm × 1.05 μm film thickness. The Carrier gas used was helium, and the flow rate was 0.8 mL / min. The temperature of the injector and detector was 250℃ and 270℃, respectively. The injection volume of 1.5 μL was made in the Split mode (100:1), the column temperature was 260℃. FAMEs were identified by comparing their mass spectrum and fragmentation patterns in the NIST library and by comparing retention time peaks with appropriate standards. The FA contents were expressed as weight percentages, % w/w (g FA / 100 g of sample).

### 2.5 Physicochemical and basic cosmetic properties of *Chenopodium pallidicaule* oilseed

The physical properties evaluated were appearance and specific gravity[21].

The chemical properties evaluated were acid and peroxide values, iodine, and saponification numbers of cañihua oil were determined according to the official methods of AOAC 1999[22].

Surface tension was measured using the capillary rise method at 25℃[23], viscosity (Brookfield method) was performed using a Brookfield viscometer, model Viscoqc 100-L (Anton Paar, Graz, Austria) with a No. 2, at 25℃. Spreadability was measured by using glass plates coated with gelatin[24], pour point and cloud point of cañihua oil was determined according to Dietz, T. (1999)[25].

### 2.6 Preparation of *Chenopodium pallidicaule* oilseed cosmetic emulsion

An oil-to-water emulsion was prepared using the formulation summarized in Table 1. Emulsification was performed using a digital IKA propeller stirrer EUROSTAR 60 (IKA Works Inc., Staufen, Germany) placed for rotation in the center of a 500 ml borosilicate-glass beaker and at approximately 1 cm above the bottom of the beaker with a rotation speed of 1000 – 1200 rpm. Water was placed into the beaker and Acrylamide/Sodium Acrylate Copolymer (and) Paraffinum Liquidum (and) Tridecenth-6 was added and mixed until a homogeneous gel was formed. Cañihua oil (5%) was added to the previous mixture and finally, cyclopentane siloxane/dimethicol and phenoxyethanol/caprylyl glycol/propylene glycol were added and stirred until complete homogenization. In Table 1, are listed the ingredients of emulsion.

### 2.7 Stability test of cosmetic emulsion

Stability studies were performed based on the ANVISA Cosmetic Products Stability Guide[26]. To evaluate the preliminary stability, the sample was centrifuged at 3000 rpm for 30 minutes (EBA 200 Hettich) to verify if the sample should remain stable. The evaluation of stability, under accelerated conditions, was performed maintaining 30 g (in duplicate) of the sample of emulsion of *Chenopodium pallidicaule* Aellen in three well-sealed jars that were heated in an oven (45 ± 2℃), cooled in a refrigerator (5 ± 2℃) and at to room temperature (20 ± 2℃). The evaluations were run over a period of 90 days. The parameters evaluated were physical-chemical parameters (pH, extensibility, and centrifugation assay). All readings were done at time zero and at 15, 30, 60 and 90 days.

### 2.8 Statistical analysis

The extraction process and all analyses were replicated three times and data were expressed as means ± standard deviation. Descriptive statistical analysis was developed using Excel Microsoft program. Some data were analyzed by analysis of variance (ANOVA) and significance was accepted at a 5% level.

## 3 Results and Discussion

### 3.1 *Chenopodium pallidicaule* oilseeds extraction

The oil extraction yield from *Chenopodium pallidicaule* Var. Cupi was 2.14 ± 0.01 g of extracted oil / 100 g of dry-weight seeds. These yields were lower than previous reports. For example, Repo-Carrasco (2011), using a traditional Soxhlet method (AOAC Method 920.39) obtained an extraction yield of 5.68 ± 0.02 g / 100 g of *Chenopodium pallidicaule* Var. Cupi dry-weight seeds[27], while Villa *et al.* (2014)[28], obtained an extraction yield of 7.0 ± 0.2 g / 100 g of dry weight seeds of *Chenopodium pallidicaule* when using a solvent (dichloromethane) extraction procedure. The different extraction yields could be explained in part by the different methods used for the oil extraction.

Table 1 Ingredients and composition of *Chenopodium pallidicaule* Aellen (Cañihua) oilseeds emulsion.

| Ingredients | Wt % | Function |
|---|---|---|
| Aqua | 90 | Vehicle/solvent |
| Ciclopentano siloxano/dimethiconol | 1 | Emollient |
| Acrylamide/Sodium Acrylate Copolymer (and) Paraffium Liquidum (and) Trideceth-6 | 3 | Emulsifying agent |
| Phenoxyethanol/caprylyl glycol/propylene glycol | 1 | Preservative |
| *Chenopodium pallidicaule* oilseeds | 5 | Active ingredient |

The extraction yields obtained with $CO_2$ Supercritical Fluid Extraction process was found to vary significantly with temperature and pressure changes, highlighting the need for process optimization. In addition, studies show that oil extraction using hexane is complete, while the yields obtained by SFE represents only about 92%[29]. However, it is important to consider, that the extracts obtained using organic solvents have undesirable organoleptic properties[30], and even though this method is easy to perform, it contributes to environmental pollution and requires long extraction times[31].

### 3.2 Determination of fatty acid composition

The fatty acid composition of Cañihua oil is presented in Table 2. Unsaturated fatty acids are the most abundant in cañihua oil. The principal unsaturated fatty acid was linoleic acid (42.1%), followed by oleic acid (24.4%) and linolenic acid (3.0%). The content of saturated fatty acid is lower being palmitic acid (17.5%) the most important, the second one is stearic acid (2.3%). In addition, there is a quantity of 8.6% of squalene. Repo-Carrasco *et al.* (2003)[32] found that Cañihua oil seeds were rich in unsaturated fatty acids highlighting linoleic acid (42.6%), oleic acid (23.5%), and linolenic acid (6.0%), while palmitic acid content was 17.9%. In another study, Villa *et al.* (2014)[28] found a high content of unsaturated fatty acids (71.4%), linoleic acid, oleic acid, and linolenic acid content were 39.2%, 29.8%, and 1.2% as the main respectively. According to these results, our findings are similar because in all cases polyunsaturated fatty acids were the highest, followed by monounsaturated and saturated and the quantity of unsaturated fatty acids is closely related. The unsaturated fat composition highlights omega 3, 6, and 9 acids that bring proper skin hydration and a high degree of spreadability[33].

On the other hand, fatty acids are very important for cell membranes because permit their formation and maintenance, and additionally have emollient, lubricant, and anti-inflammatory properties to help to restore the natural oils of the skin and bring protection from environmental damage[34].

### 3.3 Physicochemical properties

The yellow appearance of cañihua's oil is close to other vegetable oils used in cosmetics formulations like *Avena sativa* (oat) kernel oil and *Argania spinosa* kernel oil. The specific gravity of cañihua oil found was 0.897 ± 0.01 (20℃), a value very close to *Argania spinosa* kernel oil. The acid and peroxide values are properties directly linked with the oil quality, while acid value determines the quantity of free fatty acids, the peroxide value shows the state of oxidation and the susceptibility to rancidity. A peroxide value must be under 20 meq $O_2$ / kg to avoid rancidity

Table 2 Main fatty acid composition of *Chenopodium pallidicaule* Aellen (Cañihua) oilseeds.

| N° | Chemical nomenclature | Fatty acids | % of Component |
|---|---|---|---|
| 1 | $C_{18:2}$ | Linoleic Acid (ω-6) | 42.1 |
| 2 | $C_{18:3}$ | Linolenic Acid (ω-3) | 3.0 |
| | | PUFA | 45.1 |
| 3 | $C_{18:1}$ | Oleic Acid (ω-9) | 24.4 |
| 4 | $C_{20:1}$ | Eicosanoid Acid | 0.4 |
| 5 | $C_{22:1}$ | Erucic Acid (ω-9) | 0.4 |
| | | MUFA | 25.2 |
| 6 | $C_{14:0}$ | Myristic Acid | 0.2 |
| 7 | $C_{16:0}$ | Palmitic Acid | 17.5 |
| 8 | $C_{18:0}$ | Stearic Acid | 2.3 |
| 9 | $C_{20:0}$ | Arachidic Acid | 0.7 |
| 10 | $C_{22:0}$ | Behenic Acid | 0.4 |
| | | SFA | 21.1 |
| 11 | Squalene | Squalene | 8.6 |
| | Fatty acids | Saturated | 21.1 |
| | | Unsaturated | 70.3 |

PUFA, Polyunsaturated fatty acids; MUFA, Monounsaturated fatty acids; SFA, Saturated fatty acids flavor[46]. In the case of the acid value, the literature data indicates that in vegetable oils the range is 1 – 4 mg KOH / g[47]. The average acid value in cañihua seeds oil was 0.48 ± 0.14 mg /KOH which is in the range of acid value of *Olea europaea* (Olive) Fruit Oil (0.24 – 0.78 mg / KOH), and the peroxide value was 5.0 ± 1.34, which is lower than 10 mEq $O_2$ / kg, like the other oils used in cosmetic formulations shown in Table 3. Some previous studies showed that cold-pressed oils had an increased peroxide and acid value because of mineral, protein, and other impurities favoring oxidation processes that take place after extraction[48].

It seems that is necessary to select the better process to obtain vegetable oils according to use and guarantee lower acid and peroxide values which means a product with much better-quality[49].

The iodine value of cañihua oil determined was 175.30 ± 18.63, which indicates the high degree of the unsaturation of the oil in comparison with other cosmetic oils like *Avena sativa* (oat) kernel oil, and *Argania spinosa* kernel oil as shown in Table 3. The saponification number was 190.0 ± 0.01 indicating a high content of polyunsaturated fatty acids as shown in Table 2. The saponification number of oil should be between 180 - 210 mg KOH / g oil, so it can be said that the value reported for the cañihua oil is within the established range. The value of the saponification index provides information on the average length of the fatty acid chains, since its value is higher the lower the molecular weight of the fatty acids, which represents that the cañihua oil is constituted by fatty acids of low molecular weights, due to its high saponification number. Similarly, the value obtained is indicative of the high quality of the oil, therefore, it can be used in the cosmetic industry and in the manufacture of soaps through alkaline hydrolysis of the esters. Similar values are presented in Table 3 for *Olea europaea* (Olive) Fruit Oil, *Argania spinosa* kernel oil, and Macadamia nut oil.

### 3.4 Basic cosmetic properties

The vegetable oils are used as emollients in many cosmetics and dermo-cosmetics formulations, and after water, these are the main components in emulsion systems, and their function is to moisturize and protect the skin. The basic properties of vegetable oils used in cosmetics are surface tension, viscosity, spreadability, and pour and cloud points. The Cañihua oil surface tension was 33.1 mN/m, a value that is close to Macadamia nut oil (33.03 ± 0.33), Avocado oil (34.6 ± 1.7), and Almond oil (36.3 ± 2.60), all used in cosmetic formulations.

Viscosity influences the perception of the oil on the skin that can be greasier or heavier and aids the formulator to select the proper oil combination for emulsions formulation. Cañihua oil viscosity was 71.9 ± 7.58 mPa, which is higher than Jojoba oil (33.0), Macadamia nut oil (40.4 ± 0.77), and Almond oil (54.6 ± 0.40) and is lower than Avocado oil (98.4 ± 0.20).

Spreadability was measured using the diameter of the spreading area, for cañihua oil it was determined to be 7 ± 0.02 mm, which according to Dietz (1999)[25], it is a low spreadability. This value is pretty much like Jojoba oil presented in Table 4. The spreadability parameter helps to match sensory targets with the emollient properties of oils. In summary, the spreadability of oil is associated with the penetration capacity into the *Stratum corneum* and the time course of the greasy feeling[25].

The pour point is the temperature at which an oil solidifies on cooling for Cañihua oil was −11℃, which is close to the Avocado oil value (−15.5 ± 1.50℃). Sometimes the oil becomes cloudy before solidification, this temperature is the cloud point, for Cañihua oil was −1℃. Many previous studies demonstrated a good association between the

Table 3 Physicochemical properties of vegetable oils used in cosmetics formulation compared to *Chenopodium pallidicaule* Aellen (Cañihua) oilseeds.

| Physicochemical properties | *Chenopodium pallidicaule* (Cañihua) oilseed | *Avena sativa* (oat) kernel oil[35, 36] | *Olea europaea* (Olive) fruit oil[37, 38] | *Argania spinosa* kernel oil[39–42] | Macadamia nut oil[43, 44] | *Cocos nucifera* (coconut) oil[45] |
|---|---|---|---|---|---|---|
| Appearance | Yellow | Yellow | Almost colorless to yellow, greenish, or brown in color | Yellow | Pale to golden yellow | White to light yellow - tan |
| Specific gravity | 0.897 ± 0.01 (20℃) | 0.914 − 0.932 (25℃) | 0.914 − 0.918 (20℃) | 0.906 − 0.919 (20℃) | 0.9152 (25℃) | 0.93 |
| Acid value (mg KOH / g) | 0.48 ± 0.14 | 7.16 ± 0.21 | 0.24 − 0.78 | 1 | 0.42 ± 0.01 | 0.77 ± 0.01 |
| Iodine number (g $I_2$ / 100 g) | 175.3 ± 18.63 | 102.8 ± 0.53 | 94 | 97 − 98 | 78.3 ± 0.6 | 11.15 ± 0.02 |
| Peroxide value (mEq$O_2$/kg) | 5.0 ± 1.34 | 0.6 − 1.1 | 20 max | 0.8 − 2.6 | 0.36 ± 0.03 | 6.13 ± 0.01 |
| Saponification number (mg KOH/g) | 190.0 ± 0.01 | 176 − 186 | 185 − 212 | 180 − 197.9 | 193.7 ± 2.4 | 261.33 ± 0.02 |

Table 4 Basic cosmetic properties of vegetable oils used in cosmetic formulations compared to *Chenopodium pallidicaule* Aellen (Cañihua) oilseeds.

| Basic cosmetic properties | *Chenopodium pallidicaule* (Cañihua) seed oil | Macadamia nut oil[23] | Almond oil[50] | Avocado oil[50] | Jojoba oil[51, 52] |
|---|---|---|---|---|---|
| Surface tension mN/m | 33.1 | 33.03 ± 0.33 | 36.3 ± 2.60 | 34.6 ± 1.70 | 49.2 ± 0.04 |
| Viscosity (mPa) | 71.9 ± 7.58 | 40.4 ± 0.77 | 54.6 ± 0.40 (25℃) | 98.4 ± 0.20 | 33.0 |
| Spreadability (mm) | 7 ± 0.02 | 8.2 ± 0.02 | 7.6 ± 0.40 | 7.8 ± 0.30 | 7 ± 0.20 |
| Pour point (℃) | − 11 | − 1.83 ± 0.17 | − 20 ± 1.00 | − 15.5 ± 1.50 | 4 ± 0.40 |
| Cloud point (℃) | − 1 | 0.17 ± 0.17 | − 18.5 ± 1.50 | − 13.5 ± 1.50 | 10 ± 0.50 |

Table 5 Results of stability test of *Chenopodium pallidicaule* Aellen (Cañihua) oilseeds emulsion.

| Parameters / Time | Storage (℃) | 0 day | 15th day | 30th day | 60th day | 90th day |
|---|---|---|---|---|---|---|
| Physical-chemical parameters | | | | | | |
| pH | 5 | 5.3 | 5.2 | 5.2 | 5.2 | 5.1 |
| | 20 | 5.3 | 5.8 | 5.2 | 5.2 | 5.1 |
| | 45 | 5.3 | 5.3 | 5.2 | 5.3 | 5.2 |
| Extensibility (Spreading factor; $mm^2$ / g) | 5 | 6.6 ± 1.30 | 5.7 ± 0.25 | 4.2 ± 0.32 | 4.7 ± 0.31 | 4.6 ± 0.35 |
| | 20 | 6.6 ± 1.30 | 5.7 ± 0.10 | 5.2 ± 0.27 | 5.1 ± 0.31 | 5.1 ± 0.19 |
| | 45 | 6.6 ± 1.30 | 7.2 ± 0.25 | 5.3 ± 0.31 | 5.4 ± 0.27 | 5.9 ± 0.05 |
| Centrifuge | 5 | No phase separation | | | | |
| | 20 | No phase separation | | | | |
| | 45 | No phase separation | | | | |

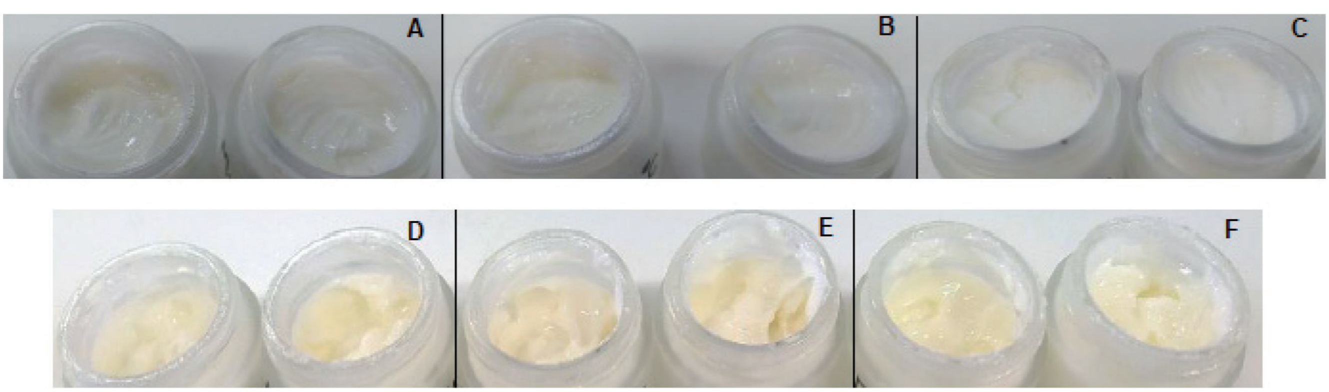


Fig. 2 Photos of formulations subjected to accelerated stability conditions: A (20℃), B (5℃), and C (45℃) on the first day of evaluation. D (20℃), E (5℃), and F (45℃) at 90 days of evaluation.

freezing stability of W/O emulsions and the pour point of the oils used in its formulation. When the pour point of the oils is low, there is better freeze stability of the emulsion, and it could be stored at cooler temperatures with less risk of any segregation or instability process[50].

### 3.5 Stability test of cosmetic emulsion

The results obtained from the stability test are given in Table 5. The pH value of the emulsion stored at 20℃ has a slight increase on the 15th day (5.8), then decreases after the 30th day (5.2), the emulsion stored at 5℃ decreases after the 15th day (5.2), and the emulsion stored at 45℃ stays close to the initial pH value having a very slight increase and decrease throughout the study. The pH values of the emulsion stored at 5℃ and 20℃ tend to decrease throughout the study, although the decrease of the emulsion at 5℃ is greater, the emulsion stored at 5℃ and 20℃ have a greater decrease in pH than the emulsion stored at

45℃ which tends to remain at the initial value, observing a significant difference ($p<0.05$).

The emulsion at 45℃ presented the highest spreading factor, and the lowest was of the emulsion stored at 5℃. No phase separation was observed in the centrifugation test performed on days 0, 15, 30, 60, and 90 as is shown in Fig. 2.

## 4 Conclusion

The present study demonstrated the possible use of *Chenopodium pallidicaule* (cañihua) oilseed for cosmetic applications. The oil contained high levels of polyunsaturated acid (45.1%), with linoleic acid as the most abundant (42.1%). In addition, the physicochemical and basic cosmetic properties are similar to those of other vegetable oils used in cosmetic formulations. The cosmetic emulsion formulated with 5% Cañihua oil proved to be stable under storage conditions of 5℃, 20℃, and 45℃ and for 90 days, showing that Cañihua oil can be useful in the development of this type of formulations and provide some bioactive substances that could contribute to improving the skin condition when applied topically. We believe that the main contribution of the present research work is the stable cosmetic emulsion formulated with Cañihua oil. In conclusion, our results demonstrate that it could be possible to use Cañihua oil to develop cosmetic formulations with potential to prevent or treat common skin illnesses.

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## Conflicts of Interest

The authors report no conflict of interest.

## Autor Contributions

Carla del Carpio-Jiménez, Ruth Sara Molleda-Gutierrez and Profeta Tapia-Delgado had the same participation in designing and performing research and writing the manuscript.

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