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Exploring Nordic Cica: Unlocking the Potential of Finnish Bio-Based Raw Materials in Skincare Applications

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1. Background Info

In recent years, there has been a notable increase in the popularity of skincare products containing *Centella asiatica*, commonly referred to as Gotu Kola or Cica. Originating from traditional Chinese and Ayurvedic medicinal practices, Cica has gained recognition in the cosmetic chemistry sector for its purported skin-soothing, wound-healing, and anti-inflammatory properties [1]. This surge in consumer interest can be attributed to several factors, including the growing awareness of skin health, the rise of the natural beauty movement, and a preference for products that promise gentle yet effective results [2,3].

As consumers increasingly seek formulations with natural ingredients [4], Cica stands out due to its efficacy and versatility. Many brands have incorporated *C. asiatica* into various products, including serums, creams, masks, and cleansers. The compound is especially popular among individuals with sensitive skin or skin conditions such as acne, eczema, and psoriasis, as it aids in calming irritation while promoting overall skin health [5,6].

However, the growing demand for Cica raises important environmental considerations. The sourcing of *C. asiatica* can impact biodiversity and ecosystem balance, particularly if cultivation practices are unsustainable or if wild harvesting techniques are employed without regard for conservation. The rapid commercial cultivation of Cica could lead to monoculture practices, which may affect soil quality and local flora and fauna [7, 8].

Therefore, while the demand for Cica products highlights a progressive shift towards natural ingredients in skincare, the cosmetic industry must adopt responsible sourcing practices. This includes ensuring sustainable agricultural practices, supporting local farming communities, and implementing ethical harvesting methods to mitigate any negative environmental impacts. Addressing these issues is vital for aligning the benefits of using *C. asiatica* in cosmetic products with a commitment to environmental sustainability and the preservation of biodiversity.

As the demand for *C. asiatica* continues to rise, there is an increasing need to explore alternatives that can fulfil consumer preferences while being sourced sustainably. This necessitates the identification of ingredients that can either serve as direct substitutes for Cica or complement its benefits, specifically from side streams or waste by-products generated in other industries.

The cosmetic chemistry sector can reduce reliance on conventional cultivation while minimising environmental impact by utilizing agricultural residues, by-products from food processing, or other waste materials. For instance, plants often overlooked for aesthetic or commercial reasons may possess comparable skin-soothing properties. Ingredients derived from hemp [9] for example, have beneficial properties for skin health and can also be cultivated with a lower environmental footprint than traditional crops.

Moreover, engaging in partnerships with the food industry can promote the use of unutilized crops or components that would otherwise go to waste. Collaborations focused on finding new purposes for these materials can lead to the development of high-performance skincare products that appeal to environmentally conscious consumers. This not only ensures ingredient availability but fosters a more integrated approach to sustainability.

The potential raw materials looked at in this study are all grown in Finland, and most of them are from side-stream sources. Due to the closeness of the Artic Circle, the phenolic content of the plant material will greatly differ due to plants that have grown at more southern latitudes [10, 11]. Due to the relative low temperatures and high amounts of UV exposure, these plants will have vastly different phenolic content, and this could possibly make then more suitable for cosmetic purposes, even rivalling *C. asiatica*.

In conclusion, while the rise in popularity of *Centella Asiatica* and its derivatives reflects consumers' desires for effective natural products, there is a pressing need to innovate and explore sustainable sourcing alternatives. By prioritizing the use of side streams or waste materials and embracing biotechnological solutions, the cosmetic chemistry industry can mitigate environmental impacts associated with Cica cultivation and promote a more sustainable future for skincare formulations. This dual focus on efficacy and environmental responsibility will not only satisfy consumer demand but also contribute positively to ecosystem preservation and biodiversity.

2. Aims

This study aims to investigate potential alternative raw materials that possess high skin conditioning properties and are more readily available in the Nordic region and other Northern latitudes.

This study will also incorporate these extracts into an emulsion base and investigate their performance in a finished cosmetic product.

3. Materials and Methods

3.1. Bio-based raw materials

The selection of bio-based raw materials for this study was guided by their abundance in Finland and, in the case of side streams, the innovative goal of developing upcycled ingredients that will add value to otherwise compostable mass. This project was part of a larger investigation into different side-stream ingredients in Finland [12].

The raw materials investigated were a winery's side stream of apple, *Pyrus malus*, and Japanese quince, *Chaenomeles japonica*. Barley spent grain (BSG), rye, *Secale cereale*, and

Fireweed, *Epilobium angustifolium*, were also included in the study and outlined in detail in Table 1.

Table 1. Table showing the source of each bio-based ingredient used in this study

Raw Material	Obtained from	Sourcing
Apple (*Pyrus malus*) [13,14]	Lepaa winery, Hämeenlinna, Finland	By-product of wine production
Japanese quince [15] (*Chaenomeles japonica)*	Lepaa winery, Hämeenlinna, Finland	By-product of wine production
Fireweed (*Epilobium angustifolium*) [16]	Yrttipaja, Säkylä, Finland	Wild-harvested
Barley spent grain (BSG) (*Hordeum vulgare*) [17,18]	Lepaa winery, Hämeenlinna, Finland	By-product of beer production
Rye (*Secale cereale*) [19,20]	Sorsso farming, Finland	Cultivated

3.2. Materials used

EtOH (Ethanol) (Altia, Finland)
MilliQ water (Millipore, Direct Q3, SAS Molscheim, France)
Ultrasound bath (VWR)
Folin phenol reagent (VWR Chemicals)
Sodium carbonate, anhydrous for analysis (Supelco)
Gallic acid, anhydrous for synthesis (Merck)

3.3 Methods for sample preparation

The plant materials (brewer's spent grain, apple, and Japansese quince) were dried at 80 °C in an oven (Termaks TS 8056, Memmert ULM 500 and UF 1060). The results of the analysis were expressed as mg/100 g dry material.
The plant material of fireweed was supplied in dried form and was ground down to smaller particles.

3.4 Ultrasound-assisted extraction (UAE)

Ultrasound-assisted extraction (UAE) was chosen as the method of extraction due to its high yield-values for phenolic compounds and suitability for naturally certified cosmetics [21,22].
UAE was performed on the biomass of the different plants and side streams using different concentrations of water and ethanol mixtures as solvents.
The phenolic compounds were extracted in triplicate. 2.5g of material was put in a storage bottle (100 ml) and 50 ml of 50 % EtOH (for Japanese quince, apple, and fireweed) or 60 % EtOH (for BGS and rye) was added. After that the samples were put in an ultrasonic bath (USC TH) The temperature was 60°C. The extraction time varied between 20-60 min. After extraction, the samples were centrifuged for 5 min, 3000 rpm (Sorvall Instruments RC5C) and filtered. The extracts were stored in the freezer, -20°C.

3.5. Total phenolic content determination

The phenolic content of the extracts was determined using Folin-Ciocalteu assay according to Satue et al (1995). 0.2 ml of phenolic extract was put in a test tube and then 1 ml of Folin reagent (1:10) was added. After 5 min, 0.8 ml 7.5 % Na_2CO_3 (Sodium Carbonate) solution was added and the samples were stirred. The samples were then put in the dark and after 30 min, the total phenolic content was measured by spectrophotometer (Shimadzu UV-1800) at 765 nm using gallic acid (100 mg/100 ml) as external standard (0, 5, 10, 20, 30, 40, and 100 mg/ml). The zero solution was used which contained MilliQ water instead of phenolic standard or phenolic extract.

3.6. Emulsion preparation for testing extracts in a finished product

To test the extracts produced in section 3.4, in a finished cosmetic product, a simple emulsion was formulated to act as a chassis for the extracts (Table 2).

Table 2. Formulation for chassis emulsion

Phase	Raw Material	INCI	w/w%
A	RO water	Aqua	Up to 100%
A	Glycerin	Glycerin	3.00%
A	Solagum AX (Seppic)	Xanthan Gum, Acasia Senegal Gum	0.60%
B	Caprylic/Capric Triglyceride	Caprylic/Capric Triglyceride	8.00%
B	Polyaquol 2W (Innovacos)	Polyglyceryl-2 Stearate, Glyceryl Stearate, Stearyl Alcohol	3.00%
C	Euxyl K712 (Schülke & Mayr)	Potassium Sorbate, Sodium Benzoate	1.00%
C	UAE Extract	See table 1	1.00%
C	Citric Acid	Citric Acid	q.s.

Method of manufacture: Heat A and B phase to 75°C (IKA RCT digital magnetic stirrer, IKA-Werke GmbH & Co. KG, Staufen, Germany), then pour B into A. Homogenise under 15 000 rpm for 1 min using a homogeniser (IKA T18 digital Ultra-Turrax homogeniser, IKA-Werke GmbH & Co. KG, Staufen, Germany), then stir at 2000 rpm until RT using an overhead stirrer (Eurostar 20, IKA-Werke GmbH & Co. KG, Staufen, Germany). Add in phase C, and adjust the pH (Orion Star A211, Thermo Fisher Scientific Inc., Waltham, MA, USA) to 5 with 70% Citric Acid solution.

4. Results and discussion

4.1. Phenolic content

Each UAE's total phenolic content was quantified.
The results were expressed as means of triplicate analyses and CV% (coefficient of variance %).

Table 3. Phenolic content

Plant	20min	40min	60min
Apple (*Pyrus malus*)	271.1 +/- 10.9 mg/100 g	321.2 +/- 4.1 mg/100 g	312.7 +/- 8.0 mg/100 g
Japansese quince (*Chaenomeles japonica)*	3187.7 +/- 7.0 mg/100 g		3069.3 +/- 1.2 mg/100 g
Fireweed flower (*Epolibium angustifolium*)		1516.8 +/- 12.5 mg/100 g	
BSG (*Hordeum vuglare*)	197.4 +/- 13.8 mg/100 g		233.0 +/- 32.4 mg/100 g
Rye (*Secale cereale*)	133.0 +/- 0 mg/100 g		157.1 +/- 5.2 mg/100 g

4.1.1. Apple

Wang et al. [13] tested ultrasound-assisted extraction of apple pomace using different conditions and the maximum phenolic content was 850 mg/100 g. According to a study of Pollini et all. [14], the concentration of the main phenolic compounds in fresh apple pomace ranged from 385.84 to 650.56 ug/g. The phenolic contents are highly dependent on the variety, the by-product, and the extraction method.
The results obtained for apple in this study are not comparable, as some of the phenols had already been extracted in the wine-making process.

4.1.2. Japanese quince

The results of Japanese quince are in accordance with Urbanavičiūtė et al. [15], who found the phenolic content 3906 to 4550 mg GAE/100 g, also using the ultrasound-assisted extraction method. This suggests that the phenolic content of Japanese quince grown in Northern latitudes does not yield significant differences in the phenolic content of the extracts. Despite the lack of variation between growth latitude, the added value of developing quince side-streams into cosmetic ingredients should not be ignored.

Japanese quince also showed the highest phenolic content of all of the samples studied. This indicates a high level of active compounds, suggesting great potential in skincare applications where antioxidant activity is required.

4.1.3. Fireweed

A study by Monschein et al. [16] showed a correlation between the phenolic content and the altitude of growth in fireweed. Higher altitudes seemed to produce plants with a higher phenolic content. The same conclusion can be drawn from the results of this study – Northern latitudes may possibly produce a higher phenolic content in fireweed plants. This would require further experiments to prove.

Fireweed exhibited the second-highest phenolic content, and, like Japanese quince, could serve as an ideal starting point for the development of new cosmetic raw materials.

4.1.4. BSG

The phenolic content of BGS varied considerably from 0.7-2.0 g GAE/100 g reported by Zuorro et al. 2019 [17], to phenolics 97.83-114.23mg GAE/100 g as studied by Socaci et al. [18]. The content of phenolics in brewer's spent grain is highly dependent on barley variety, brewing conditions and extraction method, which would explain the variations.

The results obtained in this work were higher than those in the two studies mentioned above, which suggests that the extraction method, variety, brewing, and growing conditions contribute to a higher phenolic content extract. This could provide an added benefit to the end cosmetic product.

4.1.5. Rye

The amount of phenolic content is highly dependent on the variety, part of the rye grain, and the extraction method [19,20]. In rye, most of the phenolics are bound in the grain and the extraction may not release these phenolics. This could explain the rather low results obtained from the rye extract.

Iftikhar et al. [23] tested the ultrasound-assisted extraction of rye bran phenolics and found that the best extraction conditions provided the total phenolic content 245,74 mg/100 g dw. Kulichova et al. [24] determined the total phenolic content of different genotypes of rye grains after solvent extraction with 80 % methanol and found that the contents varied from 98,4 to 336,9 mg/100g.

4.2. Extracts in emulsions

Some of the UAEs were more suitable for skincare applications than others due to their physical characteristics, such as smell and colour. These results are reported in Table 4.

Table 4. Table showing the results of using each extract in an emulsion

Raw Material	Effect in an emulsion	Suitability for further study
Apple (Pyrus malus)	No effect on viscosity or skinfeel. Slight change in odour that was not unpleasant and easily masked.	Suitable for further study.

Japanese quince (*Chaenomeles japonica)*	No effect on viscosity or skinfeel. Slight change in colour.	Extremely suitable for further study. Highest phenolic content.
Fireweed (*Epilobium angustifolium*)	No effect on viscosity, smell or skinfeel. Very slight change in colour that was not unpleasant.	Extremely suitable for further study.
BSG (*Hordeum vuglare*)	No effect on viscosity or skinfeel. Mild odour and colour change in product.	Colour and odour change have to be mitigated for suitability in cosmetic formulations.
Rye (*Secale cereale*)	No effect on viscosity or skinfeel. Mild odour and colour change in product.	Suitable for further study.

While all extracts are suitable for cosmetic purposes, the least colourful and least scented are usually preferred. Extracts with Cica tend to be colourless and odourless, rendering it ideal for several cosmetic applications.

While the extracts of Japanese quince and fireweed were not completely odourless, their high phenolic content suggests them to be ideal candidates for further study and possibly fractionation. Specific phenolic compounds can be fractionated and purified, thereby creating a raw material that functions similarly to Madecassoside.

These results provide a promising insight into the potential for further refinement of extracts obtained from Japanese quince and fireweed. The industry's demand for bio-based raw materials is growing, and these extracts are a great place to start [25]. In particular, the Japanese quince extract has great potential, as it is also a byproduct, and would therefore fit with the current trends of upcycling and sustainability.

Plants such as fireweed [26] also have variations in phenolic content depending on the time of harvesting. This would also need to be taken into consideration when developing a cosmetic ingredient, as the phenolic content should ideally remain consistent from batch to batch to ensure stable product quality.

5. Conclusion

This study demonstrates that several bio-based raw materials available in Northern latitudes—particularly Japanese quince (*Chaenomeles japonica*) and fireweed (*Epilobium angustifolium*)—exhibit high phenolic content and favourable characteristics for use in cosmetic emulsions. These findings offer a compelling foundation for developing sustainable skincare ingredients that can serve as potential alternatives or complements to *Centella asiatica*, particularly in formulations seeking similar antioxidant and skin-soothing properties. Possible future directions also include the purification and derivatisation of UAE extracts to produce single active compounds, such as Chlorogenic Acid from quince [27], to rival the effects of *C. asiatica*-derived ingredients such as Madecassoside.

The use of side streams and regionally sourced botanical materials aligns with the growing demand for sustainable and upcycled cosmetic ingredients, while also reducing reliance on traditionally used resources like Cica. Although sensory attributes such as odour and colour must be addressed through further refinement or fractionation, the promising bioactivity and environmental advantages of these ingredients position them as valuable candidates for future formulation development. Continued research into extraction optimisation, standardisation of phenolic content, and stability in finished products will be essential to realise their potential in commercial skincare applications fully.

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