

## Upcycling of plant residuals to cosmetic ingredients

Andrea Wanninger\*, Vanessa Deckenhoff<sup>1</sup>, Carolin Goj<sup>2</sup>, Larissa Jackszis<sup>1</sup>, Julia Pastewski<sup>1</sup>, Shokufa Rajabi<sup>1</sup>, Lea Viktoria Rubbert<sup>1</sup>; Hochschule Niederrhein<sup>1</sup>

\*Faculty of Chemistry, Adlerstrasse 32, 47798 Krefeld, Germany

<sup>1</sup>Students of M.Sc. Applied Chemistry, focus on Applied Organic Chemistry

<sup>2</sup>Student of B.Sc. Chemistry and Biotechnology

### ABSTRACT

Upcycling of by-products and waste from the agricultural, beverage, food and fragrance industry is a promising solution to produce valuable ingredients for cosmetics and to have full circularity with a zero-waste approach.

**Keyword:** Upcycling – plant residuals – sustainability – cosmetic ingredients – food waste – beverage waste – crops – fragrance raw materials

### Introduction

Large quantities of fruit and vegetable waste are obtained through the food and beverage industry. Citrus fruits, which include oranges, grapefruits, lemons, limes and tangerines, are the largest quantity of harvested fruit in the world. Over 115 million tons of citrus fruit are produced annually, and over 30 million tons are industrially processed into juice. What remains is nearly 50% of the fruit in the form of citrus peel. Other types of fruit also generate large amounts of waste. The annual production of bananas is 107.1 million tons and that of apples is 75.5 million tons, with 25-40% disposed of as waste after industrial processing [1].

The production of edible olive oil is about 3.26 million tons. This generates a large quantity of by-products [2]. Annually, 4.5 million tons of olive leaves are produced by the cultivation of olives for mainly edible oil. Until recently, these were burned directly in the fields or fed to livestock.

To reduce the waste load and meet the increasing public demand for bio-based and natural cosmetic products, there is a growing interest to utilize agricultural waste as cosmetic raw materials and to practice the so-called upcycling [3].

In upcycling, the final product has a higher value than the starting material. The source of the upcycled products is waste, which relates to an image of bad quality and diminished value. This causes great scepticism. It is important to emphasize the benefits of the upcycled products and to create a positive image. A different wording is required. One could refer to products out of waste as products out of unused resources or as untapped talents. Furthermore, words like by-products or co-products work because they are not stigmatized.

### Ingredients from agricultural residuals



*Olives and leaves*

### Olive leaves, squalane and pits

Researchers are working on a project that aims at the complete upcycling of olive leaves. A smart value chain will be created based on the cascade utilization of olive leaf biomass. Different extraction and isolation techniques will be applied to achieve the zero-waste approach [4]. One important ingredient is hydroxytyrosol, which stimulates the formation of melanin in the skin. Melanin protects the skin against harmful environmental influences and premature aging [5]. Olive leaf extract (INCI: Olea Europaea Leaf Extract) is used in skin care creams [6].

Squalane (INCI: Squalane (Olive)) is a low viscosity oil contained in the unsaponifiable fraction of the oil of certain plants, especially olive oil. This high-quality emollient can moisturize [7] and stimulate the self-regeneration of the skin [8]. It is made from by-products of edible olive oil production.

Finely-milled leftover olive pits (INCI: Olea Europaea (Olive) Seed Powder) form a purifying, oil-absorbing powder that can serve as a base for skin care, hair care, make-up applications, scrubs and skin cleansers. From 1.500 olive pits, 1 kg of the fine powder or scrub can be obtained [9].



*Artichokes*

### Artichoke stem extract

The world production of artichokes is about 1.7 million tons. Artichokes are characterized by a high content of bioactive compounds such as phenols, inulin, fibers and minerals. About 60-85% of artichoke biomass is not suitable for consumption. The aqueous extract (INCI: Artichoke Stem Extract) obtained from artichoke stems contains chlorogenic acid, which inhibits the formation of advanced glycation end products (AGEs). This extract, which is further investigated, could act as a potential antiglycative to promote elasticity and firmness in skin [10].



*Tomatoes*

### Lycopene from Tomatoes

Around 180 million tons of tomatoes are produced annually, of which 3-7% are inedible and can be used as cosmetic raw material. The peel, the pulps and the seeds, also called “tomato pomace” contain the ingredient lycopene (INCI: Lycopene), which is responsible for the red color. It is a powerful antioxidant and radical scavenger [11,12], which can be used in facial creams and serums. It is said to refine the complexion and to protect the skin against UV-A and UV-B rays. Thus, pigment spots and wrinkles are prevented [13].



*Chicorees*

### Chicorees and Cucumber

Regarding upcycled vegetable oils and agricultural by-products, the range of ingredients includes actives, naturally colored oils, vegetable oils and vegetable active waters. Specific enzymatic mixtures are used for an extraction without organic solvents, which increases the environmental friendliness of the products. Chicory seed vegetable oil (INCI: Cichorium Intybus Seed Oil) can be used in skin care for anti-aging products. An aqueous cucumber extract (INCI: Cucumis Sativus Fruit Extract and Propanediol) can be used as a moisturizing agent. It is extracted from agricultural co-products and cucumbers which do not have the right size for sale. [14]



*Orange peels*

### Orange and lemon peels and seeds

Citrus peels (INCI: Citrus (Lemon) Peel) are a rich source of antioxidants as well as vitamins C and E, which can be used in body lotions and body sprays, but also in soaps. Orange peels can be used for skin whitening creams for the treatment of dark skin spots. Citrus seed oil (INCI: Citrus Seed Oil) has antimicrobial, antifungal, antiparasitic and antioxidant properties and can therefore be used in soaps [15]. The widely used fragrance component limonene (INCI:

Limonene) is the major component of citrus fruit peel oil and a by-product of the juice industry.

Pectin from lemon peel fibers is combined with sclerotium gum resulting in a biodegradable thickener and stabilizer for skin care products. (INCI: Citrus Limon (Lemon) Peel Powder and Sclerotium Gum) is used in 0.5-2 % [16].



*Bananas*

### Banana residuals

Each year an estimated 20% of the world's banana production is discarded due to damage and defects. Thus, 24 million tons of bananas are directly thrown away. A company in Martinique produces certified organic beauty products with active banana ingredients. They are extracted from banana (INCI: Musa Paradisia (Banana) Fruit Extract) peels and pulp. Yellow, green and pink banana fruit extracts are used in the products. The extracts have firming, healing, anti-aging and brightening effects. The banana ingredients can be used in face creams and masks as well as in hair and body care products [17,18].



*Madagascan pink berries*

### Fragrance raw materials

After the supercritical CO<sub>2</sub> extraction of the spicy olfactory compounds of Madagascan pink berries, biflavonoids are extracted from the residuals. The extract (INCI: Maltodextrin (and) Schinus Terebinthifolia Seed Extract) is said to have antioxidant and anti-inflammatory properties in dosages from 0.1 -1.0 %. It inhibits the itching cascade involving TRPV4 to help scalp recover a healthy look in only seven days [19]. The product is especially suitable for people wearing helmets or hijab to reduce redness, scales and flakes on the scalp caused by the physical irritation.

### From crops to care products

Crops provide a versatile source for various sustainable and upcycled products.



*Rice*

### Rice

Misshapen white rice is milled to crystalline powder (INCI: Oryza Sativa Germ Powder), which is excellent to use in scrubs for face or body, depending on the particle size. The larger particles are used for body scrubs, whereas the smaller ones are ideal for facial skincare like polish [20].

The fermentation of rice produces sake lees, while molasse is a by-product of the purification of Sanuki Wasanbou sugar. Both products together (INCI: Molasses (and) Oryza Sativa (Rice) Lees Extract) improve skin moisture level and skin texture density [21].



*Corn*

### Corn and wheat

Succinic acid (INCI: Succinic Acid), can be obtained from corn starch. It is an efficient substitute for salicylic acid in facial care products and thus well suited for anti-acne formulations. A by-product from wheat starch extraction (INCI: Triticum Vulgare (Wheat) Seed Extract) is a complex composition of Glycosylceramides and Digalactosyl Diglyceride [22]. It ensures an effective barrier function between skin cells.

### Actives from beverage waste



*Coffee*

### Coffee

The by-products of the coffee industry, pulp, husks but also unripe coffee beans can be processed into cosmetic

products.[11] Around 103 million tons of coffee are produced worldwide every year [23]. The coffee grounds themselves also contain valuable ingredients and can serve as a raw material. For example, Germany generates around 20 million tons of waste from coffee grounds every year [24]. Coffee is used as mild scrub for body care. Caffeine has a skin-refining effect and strengthens the top layer of skin increasing the moisturizing capacity and leading to a better complexion. As caffeine has a blood circulation-enhancing effect on the scalp, it is used in shampoos which are supposed to stimulate hair growth [11,25].



Blueberries and Raspberries

### Blueberries and Raspberries

Blueberries are a source of pro-retinol and anthocyanins. Therefore, the by-products of blueberries can be used against blue light and as antioxidant and free radical scavengers. (INCI: Vaccinium Myrtillus (Blueberry) Seed Oil) is made from upcycled blueberry seeds. Compared to standard blueberry seed oil the level of carotenoids of this product is significantly higher. Raspberry seed oil (INCI: Rubus Idaeus (Raspberry) Seed Oil) contains vitamin E and fatty acids. Therefore, it can be used as antioxidant in skin care formulations. [26] [27] [28] Leftovers of the seed oil processing are milled and used as exfoliants.

Exfoliating fruit powders in two grades suitable either for face scrubs or body scrubs are made from raspberry and blueberry juicing waste. The small grade is also a good texture enhancer for soaps or other solid formulations. Use levels of (INCI: Rubus Idaeus (Raspberry) Seed Powder) and (INCI: Vaccinium Myrtillus (Blueberry) Seedcake Powder) are 1 – 15 % [29].



Apple

### Apple leftovers

In processing apples to beverages, biomass containing apple pulp, skin and seeds remains as waste. Apple pulp

(INCI: Pyrus Malus (Apple) Fiber) contains natural alpha hydroxy acids. It has a peeling effect, regenerates the skin and helps cell formation. Cold-pressed apple seed oil (INCI: Pyrus Malus (Apple) Seed Oil) has an anti-aging effect and contains antioxidants. The skin of the apple seeds (INCI: Pyrus Malus (Apple) Seed Oil (and) Coco-Caprylate (and) Caprylic/Capric Triglyceride) is used in dry and powdered form, has an antiaging effect and strengthens the skin. [30].



Grapes

### Actives from alcoholic beverages

Waste from gin, beer and wine production is used for the manufacture of cosmetic ingredients. Proteins contained in barley are converted into peptides, polypeptides and amino acids by enzymes. (INCI: Hordeum Vulgare Extract and Propanediol) is manufactured from these proteins, which can reduce the redness of skin. (INCI: Saccharomyces/Barley Seed Ferment Filtrate and Glycerin) contains a combination of glycerin and grain fermentation products for long-lasting hydration of the skin. Grapeseed is a by-product of wine production. The antioxidative and antibacterial effect of grapeseed oil (INCI: Vitis Vinifera Seed Oil) is beneficial for sensitive skin and keeps it in a good condition. [31] [32] [33]

### Conclusion

Upcycling of agricultural and industrial plant leftovers to cosmetic actives and basic ingredients for face, body and hair care is an excellent approach towards more sustainability and circular beauty.

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