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GLOBAL

PERSONAL CARE

INGREDIENTS • FORMULATION • MANUFACTURE

- Endorphin peptide-based wrinkle treatment
- Fermented, multi-plant ingredients in cosmetics
- A collagen alternative from acacia trees

A collagen alternative from acacia trees

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ABSTRACT

PhytoCollagen is a unique plant-derived collagen alternative sourced from the acacia tree, which combines the cosmetic benefits of collagen with a green, sustainable source and matches consumer preferences. *In vivo* studies confirm that it entirely mimics the cosmetic benefits of animal collagen. This makes it an ideal replacement – a truly plant-derived, sustainable, green, vegan alternative to animal collagen.

Collagen is the most abundant structural polymer throughout the animal kingdom. It provides strength, elasticity and resilience to animal and human tissues. Collagen is found in connective tissues, in cartilage, bones, tendons, ligaments and skin. For example, it makes up 80% of the skin by dry weight and gives the dermis its mechanical and structural integrity[1].

Collagen is also one of the most popular cosmetic ingredients[2]. According to a worldwide Mintel database search, about 2,500 new products with collagen as a raw material have been launched within the past three years: 1,472 in skin care, 582 in hair care, 310 in colour cosmetics, 87 in soap and bath products, and 12 in shaving and depilatories. Thanks to its versatile cosmetic properties, collagen finds applications as an anti-ageing active, a moisturising agent, a film-former or a texture-improving ingredient, among others.

Despite its popularity, collagen has a disadvantage in being mainly derived from animal sources. It is manufactured on an industrial scale from hair, skin, nails, bones, ligaments or skin, which originate from cattle, pigs, poultry or fish[1].

Consumer awareness of animal welfare has made animal-derived cosmetic raw materials unpopular. In fact, cosmetic shoppers increasingly trust in natural, plant-derived, sustainable and cruelty-free beauty products. This drives innovation towards ethical cosmetics and pushes brands to think of alternatives, including alternatives for animal-derived collagen.

Moreover, animal proteins, including collagen, carry health risks. Animal proteins are associated with causing allergic reactions, with the transmission of prion disease (bovine spongiform encephalopathy) or with microbial contamination[3]. In some communities there are religious constraints over using bovine- and porcine-derived materials.

To replace animal collagen, synthetic collagens have been developed. *In vitro* cultures of GMOs, such as bacteria, yeast or wild plants, produce biomimetic collagen fragments or recombinant collagen peptides, which after further processing mimic the structure and function of conventional collagen[4].

Like animal collagen, artificial collagens also suffer from disadvantages: for example, collagen-producing *in vitro* cultures are expensive, they suffer from low yields and the collagen produced often lacks functionality[2]. Furthermore, the use of GMOs is a concern to many consumers. For all these reasons, animal collagen remains the standard today. Figure 1 shows the pros and cons of the different kinds of collagen.

Acacia tree alternative

Is there collagen from plants? Yes and no. Unlike animals, plants do not produce true collagen. Instead, the functional requirement for strength, elasticity, resilience, wound healing, water retention and more, in plants, is filled by long, branched, vegetable biopolymers, which are complex structures of interlinked protein and carbohydrate chains.

One example is arabinogalactan from the acacia tree[5,6]. The acacia is a thorny tree growing up to six metres in height. It is the predominant species of the African savannah in two species: *Acacia senegal* and *Acacia seyal*.

The acacia produces a unique set of biopolymers that have been harvested in a traditional way since antiquity. Native farmers introduce small incisions into the trunks or branches of acacia trees. After injury, an amber-coloured, gum-like substance exudes, which is scraped off, collected in leather bags and dried in the sun. It is also known as gum Arabic or acacia gum. Due to its functional homologies to collagen, however, we will call it acacia collagen (Figure 2).

Acacia collagen consists of multi-functional hydrocolloids with a neutral to slightly acidic, arabinogalactan-protein complex, a branched-chain polysaccharide with arabic aid as the main component. It is characterised by a high proportion of carbohydrates (D-galactose and L-arabinose) (~97%) and a low proportion of proteins (<3%), complexed to calcium, magnesium and potassium[6].

Rather like animal collagen, acacia collagen is a high molecular weight biopolymer with hydroxyproline as the characteristic and most abundant amino acid. Hydroxyproline anchors the polysaccharides to the peptide chains and provides flexibility to the polymer. Like animal collagen, its biosynthesis also depends on the co-factor vitamin C.

When looking at its biological function, acacia collagen shares similarities with animal collagen. It gives structure and stability to plant cells, it binds moisture and it is directly involved in wound healing of plants, where it closes, protects and disinfects injuries on branches and trunks.

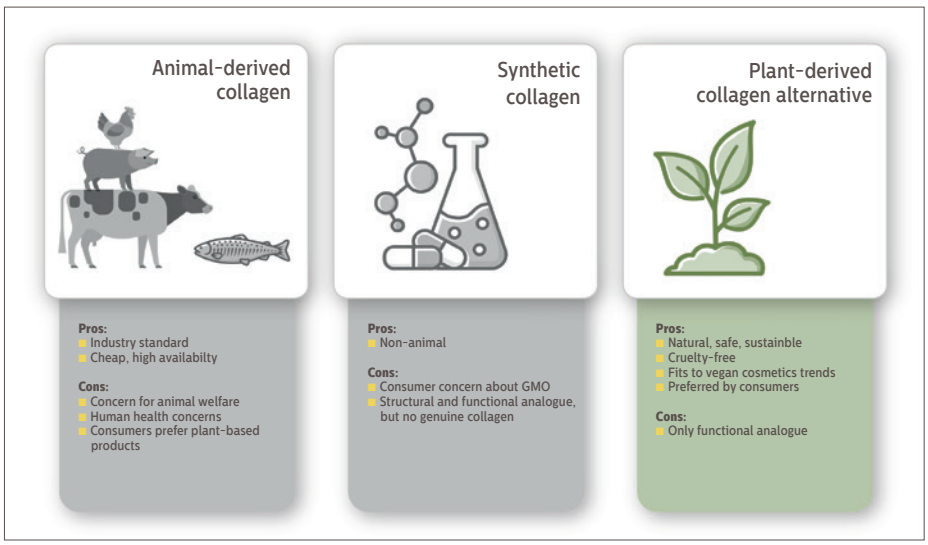

Figure 1: Sources of collagen

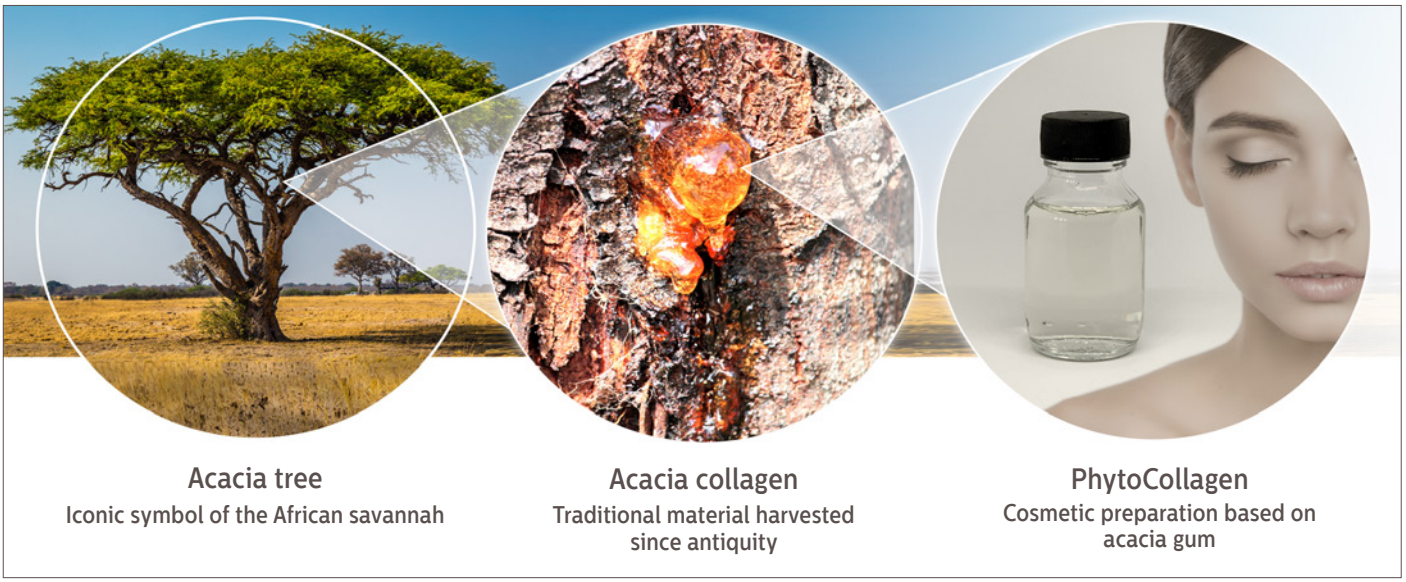

Figure 2: Collagen-mimicking biopolymers from the acacia tree

As demonstrated below, the cosmetic preparation based on this complex polymer composition also shares many of the cosmetic benefits of genuine collagen, such as its anti-ageing and moisturising efficacy, its ability to improve skin barrier function and its excellent film-forming properties. This makes acacia collagen a plant-derived cosmetic alternative to animal collagen.

Consumer survey

We carried out a survey of overall consumer expectations about collagen in general, its use and its benefits in cosmetics. Then, we asked consumers to directly compare plant-derived collagen with synthetic and animal collagen, to find the most attractive form for cosmetics.

In the first part, 42 women were asked to rate six statements related to collagen in general on a scale from 0 to 10. In the second part, the same subjects were asked their opinion about which source of collagen they would prefer in respect to product safety, product efficacy or general preference for use in cosmetics.

The results are very clear. First, consumers associate collagen with cosmetic benefits: they expect it to be a powerful active ingredient with anti-ageing (firming, wrinkle reduction, plumping), moisturising and protective properties (Figure 3). Second, consumers have a clear preference for plant-derived collagen (Figure 4). When given the choice between plant-derived, animal-derived and synthetic collagen, they attribute higher efficacy and more safety to the former.

Therefore, strong cosmetic concepts can be built on collagen as consumers already associate it with cosmetic benefits and positive attributes. This advantage is elaborated even further by choosing the right source of collagen: a plant-derived alternative.

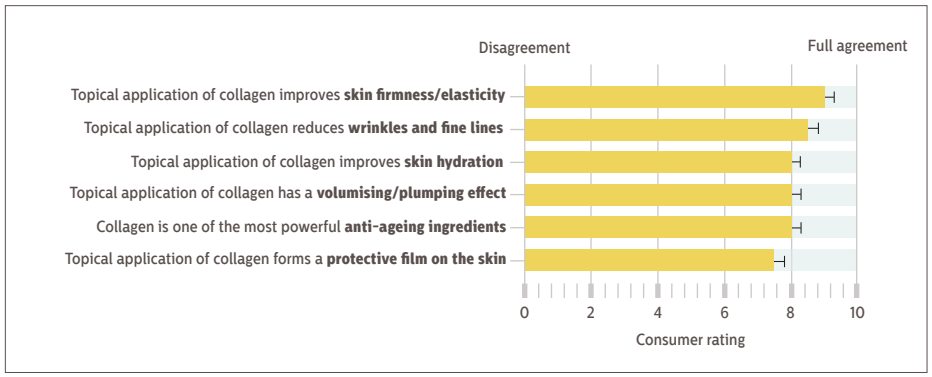

Figure 3: Consumer opinion about the cosmetic benefits of collagen
Note: N = 42, Median + SEM.

In vivo activity

In a double-blinded, placebo-controlled, randomised, *in vivo* study, two groups of 20 women with mixed to dry skin and with signs of ageing – such as wrinkles and lack of skin firmness – applied a face cream twice daily

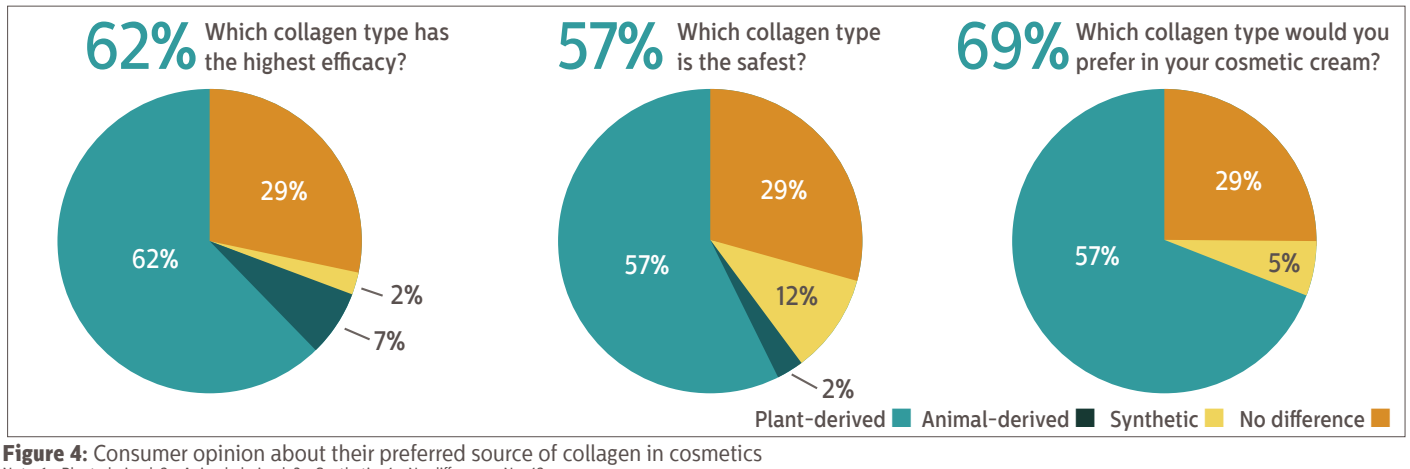

Figure 4: Consumer opinion about their preferred source of collagen in cosmetics
Note: 1 – Plant-derived, 2 – Animal-derived, 3 – Synthetic, 4 – No difference. N = 42.

for 56 days, either with 2% active ingredient or placebo. Instrumental measurements of various properties were made at days 0 and 56.

The biomechanical skin properties of firmness and elasticity were both measured with a cutometer. Their value represents the force necessary to elevate the skin and the ability of the skin to return to its original position respectively (Figure 5). Representative images obtained by the Primos system were taken to show that the active ingredient reduces skin roughness and wrinkles (Figure 6).

Similarly, images obtained by instrumental measurements of the collagen quality, with a confocal microscope showed that the active improves collagen perimeter and directionality (Figure 7). This reflects a structural rearrangement of the collagen fibre network by newly formed collagen fibres and an increase in collagen network quality.

Trans-epidermal water loss (TEWL) was measured using a tewameter. The results showed that the active ingredient reduces TEWL (Figure 8)

In a second *in vivo* test, we directly compared the skin hydration efficacy of the acacia-derived collagen alternative with animal-derived collagen. 20 women with dry skin applied a test cream with 1% active ingredient to one forearm and a second test cream containing 1% animal collagen to the other forearm. Skin hydration was measured with a corneometer. After seven and 14 days, the treatment with both products equally increased skin hydration. (Figure 9).

The studies confirmed that the plant-derived collagen alternative is a functional equivalent to animal-derived collagen in cosmetics with a broad spectrum of cosmetic activities. It enhances the biomechanical properties of skin, improves skin topography, remodels and improves collagen network quality, and enhances skin barrier function and moisturisation.

Conclusion

PhytoCollagen represents a functional equivalent to animal-derived collagen in cosmetics with a broad spectrum of cosmetic activities. It also picks up current trends of more sustainable, vegan, cruelty-free cosmetics and perfectly matches consumer expectations. Therefore, it is the ideal replacement for animal-derived collagen in collagen-based cosmetic concepts. **PC**

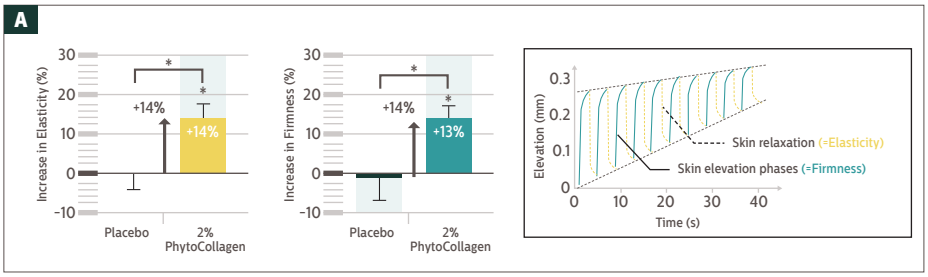

Figure 5: Analysis of biomechanical skin properties
N = 20, Mean + SEM. Student's t-test vs. baseline and between treatments; * = p < 0.05.

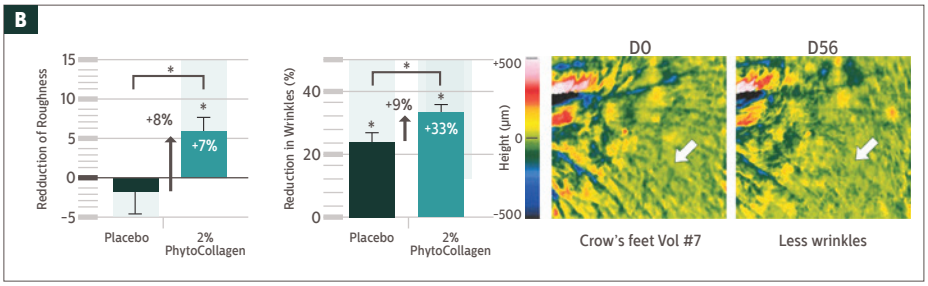

Figure 6: Analysis of skin topography
N = 20, Mean + SEM. Student's t-test vs. baseline and between treatments; * = p < 0.05.

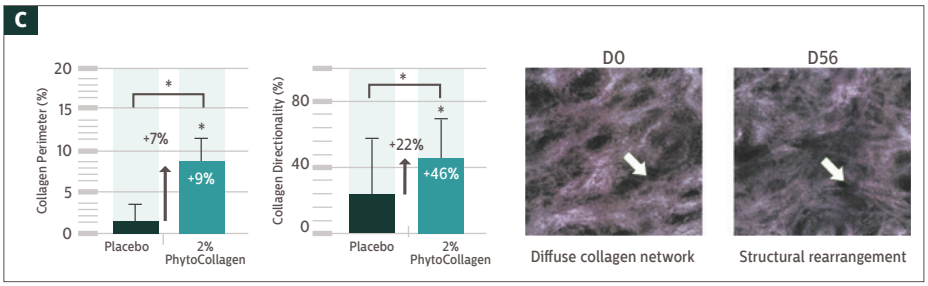

Figure 7: Analysis of collagen quality
N = 20; Mean + SEM. Student's t-test vs. baseline and between treatments; * = p < 0.05.

References

1. Matthew *et al.* Collagen structure & stability. *Annu. Rev. Biochem.* 2009. 178, 929–58
2. Rodriguez *et al.* Collagen: A review on its sources & potential cosmetic applications. *J. Cosmet. Dermatol.* 2017. 17, 20–26
3. Alves *et al.* Cosmetic potential of marine fish skin collagen. *Cosmetics.* 2017. 4, 39
4. Peng *et al.* Non–animal collagens as new options for cosmetic formulation. *Int. J. Cos. Sci.* 2015. 37, 636–641
5. Li *et al.* Comparative study of the physiological properties of collagen, gelatin and collagen hydrolysate as cosmetic materials. *Int. J. Cos. Sci.* 2015. 27, 101–106
6. Patel *et al.* Applications of natural polymer gum Arabic: A review. *Int. J. Food Prop.* 2015. 18, 986–998

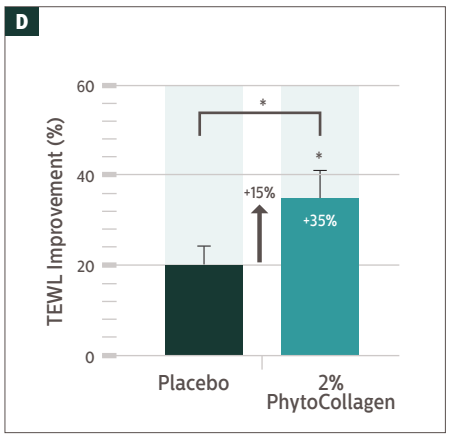

Figure 8: Analysis of skin barrier function
N = 20; Mean + SEM. Student's t-test vs. baseline and between treatments; * = p < 0.05.

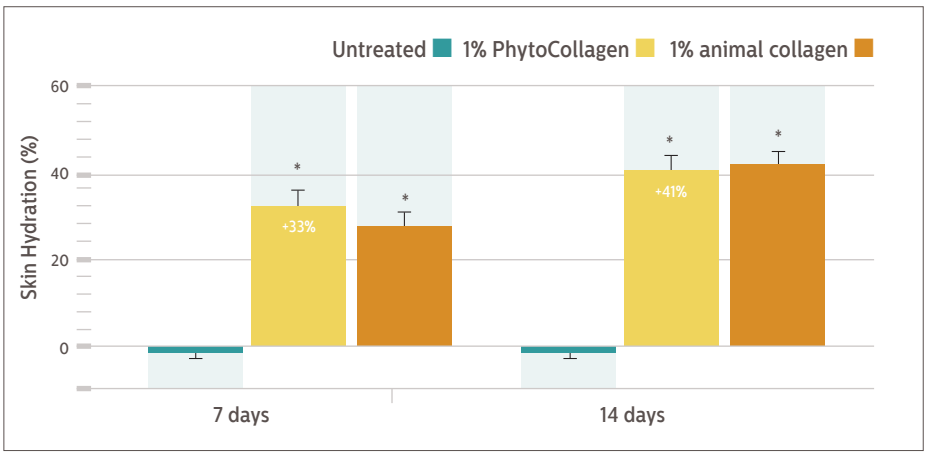

Figure 9: Comparison of skin hydration using animal-derived & acacia-derived collagen
Note: N = 20; Mean + SEM. Student's t-test vs. untreated; * = p < 0.05