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Link Between Green Coffee, Emotions and Skin Fatigue

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1. Introduction

Cosmetics play an important role in people's life. Numerous publications provide evidence of the importance of cosmetics in daily life: human wellbeing, facial attractiveness, professionalism, pain management, quality of life, self-esteem (1) (2) (3) (4).

Skin homeostasis is intrinsically linked to emotional well-being and conversely. Indeed, psychological (e.g., stress) or hormonal (e.g., menstrual cycle) factors can trigger psoriasis, atopic dermatitis and sensitive skin (5) (6). Conversely, extrinsic factors resulting in itchy and sensitive skin are closely linked to a decrease in quality of life and even depression (7) (8). Boosting positive emotions is therefore becoming essential for a global wellbeing approach to skincare (9) (10).

Over the past few years, the concept of "traditional" cosmetics has been surpassed, with a focus instead on skincare products that can influence skin-brain connections.

The first definition of neurocosmetic is attributed to Prof. Misery, referring to them as products exhibiting activity on the cutaneous nervous system or general effects on the skin neurotransmitters (6) (11).

Green Coffee is a well-known plant commonly consumed in the morning to wake up and combat energy crashes.

In the first part, the role of beta endorphin in skin will be detailed, and then the effect of Robusta Green Coffee Beans Extract (GCE) will be evaluated both *in vitro* and *in vivo* on emotions, as well as on skin fatigue, in order to see if there is a correlation between the well-known energising systemic impact and local skin benefits.

2. Materials and Methods

2.1 Carbon Footprint / Extraction study

A digestion at 80°C is compared to an Ultrasound assisted extraction at 60°C. Chlorogenic acid is quantified in order to compare the extraction yield of each process.

The manufacturing energy consumption in MWh is calculated for each extraction method by taking into consideration only the industrial extraction process. The raw material (green coffee) is the same, and the process for treating the extract, including digestion and Ultrasound, involves the same filtration and conditioning steps.

The specific heating source, heat capacity of the solvent, delta heating temperature, heating time, chiller power, pumps, agitation, ultrasound generating power as well as the heating power of the apparatus are used for the computation of each technic (digestion and Ultrasound).

The conversion from kilowatt of electricity or gas consumption to their equivalent CO_2 emission is calculated according to the IEA (International Energy Agency) (12) and to ADEME's guideline and formula (13) (14) (15):

2.2 EEG/GSR

Electrodermography (EDG) or Galvanic skin Response (GSR) is one of the most sensitive methods for detecting emotional arousal. When a positive or a negative stimulus is emotionally arousing, it activates the autonomic nervous system, which triggers an increase in sweating produced in the eccrine sweat glands, especially in the palms of the hands and in the fingers, as well as the soles of the feet (16).

In our case, it is sensed by two non-invasive electrodes placed on 2 fingers measuring the conductivity of the skin in the form of GSR peaks (17) (16).

To analyse EEG waves data, frontal alpha asymmetry (FAA) is used. FAA refers to the differential activity of alpha brain waves (8-12 Hz) in the left and right frontal lobes (18) (19) (20) (21). An increase in left frontal activity generally associates with positive emotions, approach behaviour, and active engagement. Higher left frontal alpha activity often correlates with feelings of happiness and enthusiasm. On the other hand, an increase in right frontal activity is associated with negative emotions, withdrawal behaviour, and passive engagement. Increased right frontal alpha activity is often linked to feelings of sadness, anxiety, or fear.

12 Healthy volunteers, whose average age is 48 years, are asked to calm down and then to rub 0,05g of the sample on a 2-inch circular test site on their forearm until it is absorbed, while their emotions are recorded by EEG / GSR (128-Hz Emotiv EPOC+ / Shimmer3 GSR+). The active cream with 3% GCE extract is compared against a placebo in a single blinded manner.

2.3 β Endorphin

GCE extract is incubated for 72 hours with normal human epidermal Keratinocytes at 37°C. Extracellular β Endorphin is quantified by Elisa.

2.4 Elasticity and Fatigue

28 tired and stressed volunteers (49 years old on average) applied the cream twice daily for 1 month. Fatigue (F2) and elasticity (F3/F4) are measured by a Cutometer (MPA 590 Courage & Khazaka GmbH). The active cream is compared against placebo in a single blinded manner.

To increase accuracy, the cycle is repeated 20 times and parameters selected for evaluation are based on areas rather than individual measurement points (figure 1).

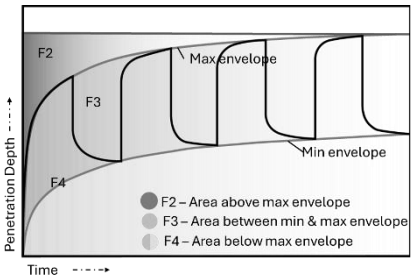


Figure 1: Cutometer Parameters

Skin elasticity is assessed by the ratio F3/F4. The larger F3 is in comparison to F4, the larger the restoring forces are and the smaller the remaining residual deformation is. The closer the resulting value is to 1, the more elastic the skin is.

Skin fatigue resistance is assessed by the parameter F2 which is the area between the final extension and the approximated envelope function of the maximum extensions. A decrease in F2 corresponds to an increase in fatigue resistance.

3. Results

3.1. Carbon Footprint / Extraction study

The Ultrasound technology used is a method for performing ultrasound-assisted extractions. An ultrasound is a mechanical wave with a frequency between 20 kHz and 1 GHz. In a liquid environment, the movement of ultrasounds generates cycles of high and low pressures, leading to a phenomenon known as acoustic cavitation. This cavitation phenomenon involves the alternating compression and expansion of the liquid. As these cycles progress, solvent cavitation bubbles form and grow until they reach their critical size and implode near the plant walls. These implosions produce micro-jets of liquid carrying gas and heat, forming a concentrated energy. This energy exerts forces capable of perforating cell walls and membranes to release metabolites into the extraction solvent. This technique is approved by COSMOS.

	MWh	Eq kg CO_2 / 1 kg of GCE	Ratio Chlorogenic Acid / CO_2 (%/kg CO_2/kg of GCE)
Green Coffee Digestion 80°C	0.208	0.09	**59**
Green Coffee Ultrasound 60°C	0.123	0.04	**137**

Table 1: Ratio of the Extraction of Active Molecule vs the CO2 emitted during the Extraction Process

The ultrasound-assisted extraction method is both more eco-friendly and efficient compared to traditional digestion (Table 1). This technical innovation allows for the extraction of the same quantity of active compounds while using 41% less energy and emitting 55% less CO_2 into the atmosphere. Additionally, the Ultrasound process is conducted at 60°C, which is 20°C lower than the digestion temperature of 80°C. As a result, the ratio of active molecules to CO_2 emissions improves strongly, increasing from 59 to 137 which is a 2.3-fold increase for Ultrasound extraction compared to digestion at 80°C. This highlights the method's superior durability and effectiveness in harnessing valuable compounds.

3.2 EEG/GSR

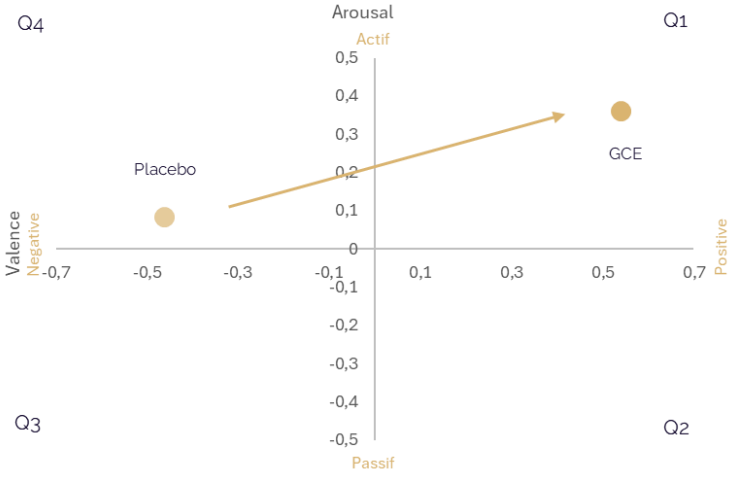
Emotion results from the communication between neurons within our brain and skin. This communication induces brainwaves by producing synchronised electrical pulses, which can be detected using EEG (Electroencephalography) and GSR (Galvanic Skin Response).

The 2 chassis (placebos vs active cream) are compared to check if formulations can be discriminated by a sensory evaluation (figure 2). No significant difference is perceived among formulations (placebo vs active cream) in the experimental condition of this assay.

Figure 2: After Feel Spider Web Plot of the 2 Chassis Formulations.

The four class model by Russell is widely adopted by various researchers. It represents the emotions around a circle of which only two axes would be necessary: the dimensions of valence (pleasure/unpleasure) and arousal (weak/strong), which represent the affect. The model consist of four quadrants. The first quadrant shows high arousal with positive valence which is associated with happy emotion, the second quadrant shows low arousal with positive valence that associates with calm emotion, the third quadrant show low arousal with negative valence that represents a sad emotion and the fourth quadrant with high arousal with negative valence usually associated with angry emotions (22). At present, this approach is probably the most common for measuring subjective emotional experience.

Table 2: EEG/GSR Record after Application of a GCE Cream vs Placebo. Wilcoxon test is proceeded for non parametric values. ***:p≤0.06



Even if the texture of creams can't be discriminated in the experimental condition of this assay, the Valence of the active cream containing 3% GCE shifts statistically significantly towards more positive emotions (table 2). Emotions are shifting from the Q4 or Q3 of the placebo to Q1. The Arousal also increases. This means that the emotion is moving from a sleepy, sad, anxious state of mind towards a more wake up / excited /pleasure / delighted state.

3.3 β Endorphin

The skin is a system for the surveillance of environmental changes (heat, humidity, etc.) and the perception of the environment (body limits, recognition of the non-self and objects, touch, etc.) (23),

The skin contains a wide range of receptors that encode vibration, pressure, temperature, pain and, as recently uncovered, pleasure. Those receptors exert a slow stimulation of afferent C-

fibers that generally respond to non-painful stimulation, such as, for example, light touch (24) (figure 4).

In order to communicate those environmental changes, the skin produces mediators, that are transmitted to the nervous system (23) (25).

Among those mediators are neurotransmitters. These are chemical messengers, naturally synthesised by nervous fiber endings, skin cells (keratinocytes, melanocytes, fibroblasts, etc.) and the immune system. The release of neuromediators can be induced by physical, chemical, or even emotional stimuli (26).

Endorphin is derived from ἔνδον in Greek meaning “within” and morphine, from Morpheus (Ancient Greek: Μορφεύς), the god of dreams in the Greek mythology. Thus, Endorphin is a contraction of 'endo(genous) and (mo)rphin (27).

Endogenous opioids including β-Endorphins (figure 3) share the same N-terminal amino acid sequence Tyr–Gly–Gly–Phe–X (X = Met or Leu), necessary to bind to the opioid receptor.

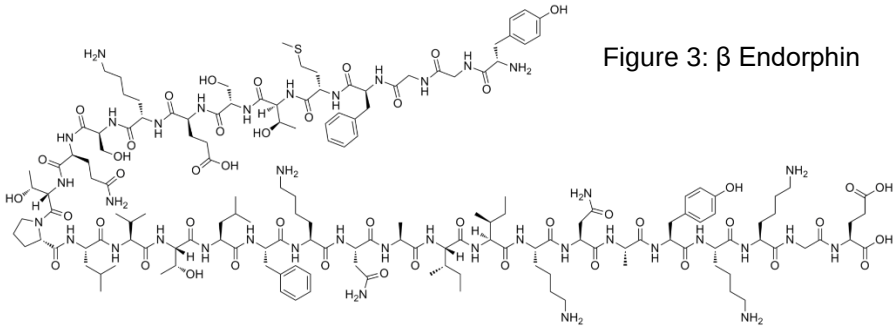


Figure 3: β Endorphin

Opioid peptides in the brain were first discovered in 1973 by J Hughes and H Kosterlitz. EA Schleicher and his team demonstrated the presence of β Endorphin in keratinocytes in skin in the 80‘s. W Feldberg and DG Smyth in 1976 found that β Endorphin was 100 times more potent than morphine (28).

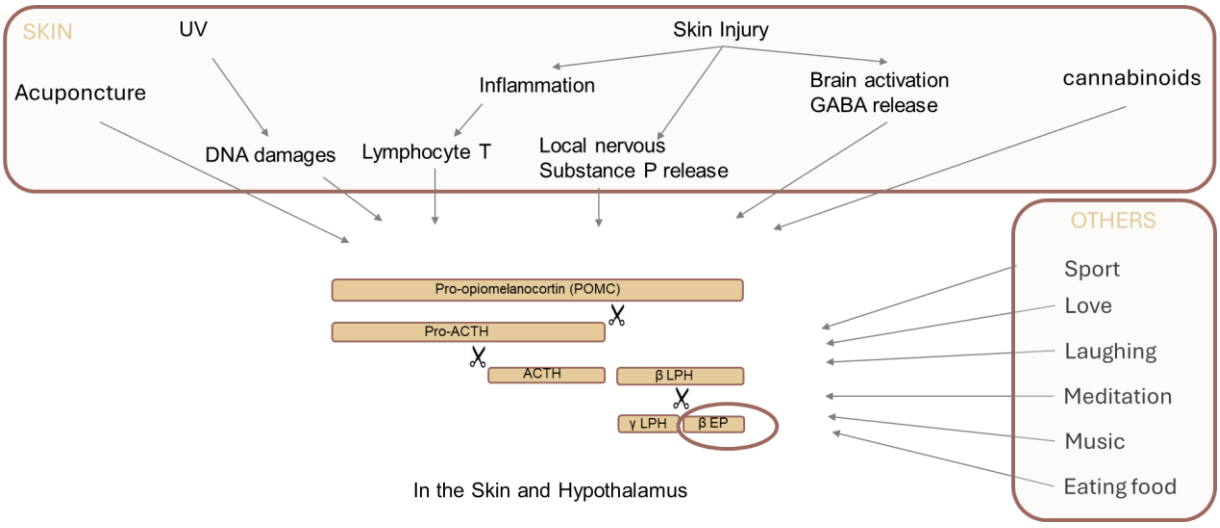


Figure 4: Factors that can Trigger β Endorphin’s Synthesis in the Skin and in the Hypothalamus (16) (29) (30). EP: Endorphin.

β Endorphin is a peptide that produces analgesia (absence of pain) by acting on both, central and peripheral opioid receptors which inhibits the transmission of the signal along nervous

cells from the source of the pain (nociceptor) to the spinal cord and generate wellbeing generate euphoric feelings (16). Guillemin and Schally in 1977 won the Nobel price for their research and findings on Endorphins.

Locally, β Endorphin plays a key role in the final reepithelialisation and tissue regeneration in wound healing (31) (32) as well as in local pain management (33) (figure 5).

β Endorphin released by keratinocytes may also explain the feeling of wellbeing that often accompanies sunbathing, contributing to the addiction of sunworshippers (34). Indeed, Levins and Belon indicate that total body UV irradiation of human subjects increases β Endorphin serum levels by approximately 30% (35) (36).

β Endorphin production follows a circadian rhythm if not activated by external stimuli, with peak expression observed in the morning, typically between 6am and 8am. The lowest levels are observed in the evening or around midnight (37) (38).

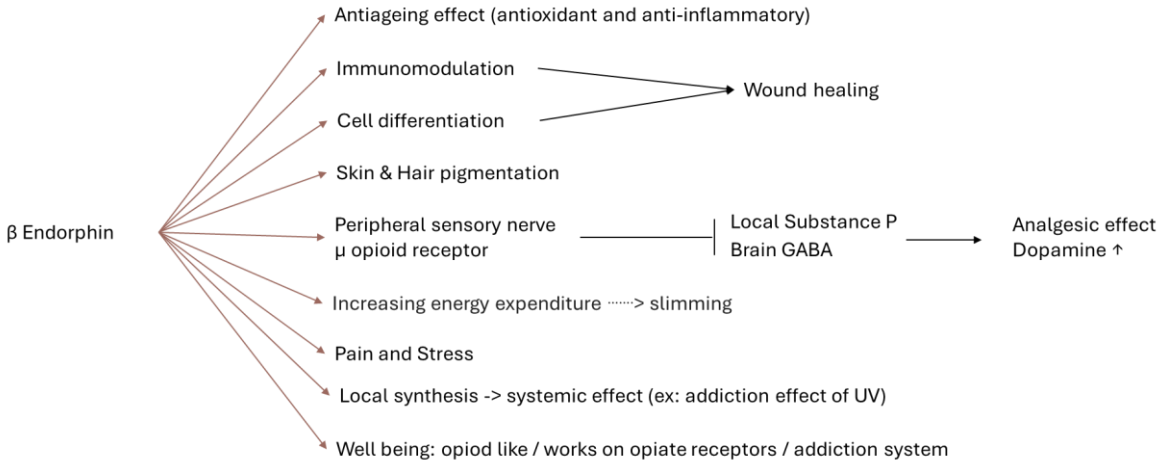


Figure 5: Local Skin Effect of β Endorphin (16) (29) (30) (31) (32) (33) (39).

GCE, in the experimental condition of this assay, is able to stimulate statistically significantly in a dose-dependant manner the synthesis and the excretion of β Endorphin by up to +84%** (figure 6).

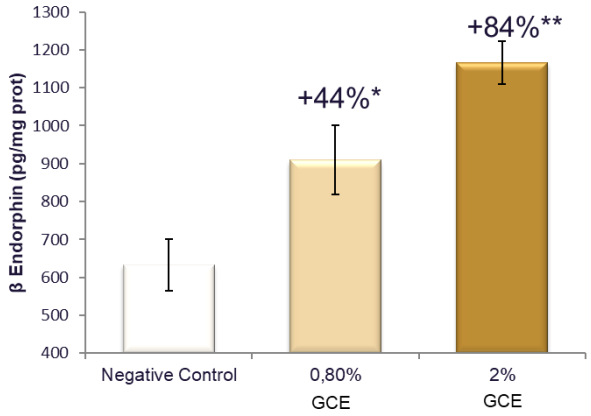


Figure 6: β Endorphin Quantification with GCE in Keratinocytes. Two-tailed student unpaired t-test for parametric values with homogeneous variance vs control. *: p< 0.05,**: p<0.01.

3.4 Elasticity and Fatigue

	Cutometre F3/F4		
	D0	**D15**	**D28**
Mean	0,68	0,72	0,73
Median	0,67	0,69	0,72
SEM	0,02	0,02	0,03
Variation vs D0 (%)		**+6,5%***	**+7,9%***
% of subjects having improvement	100	**68%**	**71%**
% Max		**47%**	**62%**

Table 3: Cutometer F3/F4 Values of Skin Elasticity. Results are obtained using the air generated by the profile of 20 repetitions (n=20). A bilateral Student t test is proceeded for parametric paired values with homogenous variances. *:p≤0.05.

The application of a 3% GCE cream leads to a statistically significant increase in skin elasticity after 15 and 28 days of +6.5%* and +7.9%* respectively. This increase reaches 47% and 62% respectively. Up to 71% of the volunteers using the active cream showed an improvement of skin elasticity (table 3).

The placebo results were found to be not statistically different from the initial condition at D0.

Fatigue	**Active Cream**	
	Cutometre F2	
	D0	**D28**
Mean	1,51	1,37
Median	1,47	1,29
SEM	0,08	0,08
Variation vs D0 (%)		**-9,2%***
% of subjects having improvement	100	**71%**
% Max	x	**-38%**

Table 4: Cutometer F2 Values of Skin Fatigue. Results are obtained using the air generated by the profile of 20 repetitions (n=20). A bilateral Student t test is proceeded for parametric paired values with homogenous variances. *:p≤0.05.

Application of a 3% GCE cream leads to a statistically significant decrease in skin fatigue after 28 days of -9.2%*. This increase reaches to 38% and 71% of volunteers applying the active cream showed improvement of skin fatigue (table 4).

The placebo results were found to be not statistically different from the initial condition at D0.

4. Discussion

For the same active molecule content extracted, the Ultrasound extract of *Coffea canephora var. robusta* allows for saving 41% of energy and emitting 55% less CO_2 compared to traditional digestion.

Coffea seeds are globally renowned for their systemic antifatigue and energising activity. We found that topically applied green coffee extract fights against skin ageing and signs of fatigue as well as creates positive invigorating emotions when applying it (**:p<0.01; *:p<0.05; ***:p<0.06).

To our knowledge, this is the first time that a topical preparation of green coffee has been shown to have positive effects on mood. This action may be due to its effect on skin neuro-mediators β Endorphin.

5. Conclusion

The industry of wellness is a 6.3 trillion market globally and its's growing from 5 to 10% each year. Today, cosmetics no longer have to be limited to delivering skin benefits. The arrival of holistic products opens the way to beauty products that also provide emotional well-being, showing the skin-brain connection. This is particularly important when considering that stress, fatigue and negative emotions increase for more than a decade worldwide (40).

Physical fatigue often manifests visibly on the skin, creating a cycle that can amplify negative emotions. When the body is tired, the skin appears less attractive and healthy with decreased elasticity, desquamation or increased in TEWL and sensitivity, reflecting the internal state of exhaustion. These visible signs can evoke feelings of stress, anxiety, and lowered self-esteem, further exacerbating emotional strain. The interplay between physical fatigue and emotional well-being highlights the importance of holistic self-care, addressing both the body's need for rest and the mind's need for emotional support to break this cycle and promote overall wellness.

6. References

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