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## ***"The perfect balance of texture and sustainability: Optimization of sunscreen with enhanced sensory performance and eco conscious filters to encourage daily photoprotection usage"***

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### **1. Introduction**

During the past few years, There is a rise of fluid textures in the suncare market, being the fastest growing trend in 2022 in Latin America. Sunscreen textures have evolved significantly over the years, driven by consumer demand for improved sensory experiences, enhanced performance, and added skincare benefits. (1).

Different studies (2) show the importance of sensory and texture for the category, highlighting it as the main purchase driver. Thus, the vehicle used in the formulation impacts the product's sensory attributes, inducing the consumer to use it. It's characterized for lightweight, non-greasy formulas that are easy to apply and comfortable to wear. This texture is highly desirable by consumers as it offers a comfortable and often "invisible" finish, making it ideal for daily use, even under makeup.

In this field we have combined several formulation approaches to maximize the user experience, though with a high UV protection (SPF > 60 and UVA PF > 20), focusing also in the sustainability for this new lighter cosmetic sunscreen compositions with high stability, green ingredients, good sensory properties and high SPF.

This research was focused to provide this ideal sensory journey with a good spreadability, the dry touch/oil control and hydration + resistance, all of this benefits with the lightweight and fresh skin feel that the consumers are looking for.

### **2. Materials and Methods**

#### **Sun Protection Factor (SPF) & UVA-PF factor (UVA-PF) determination**

To determine the Sun Protection Factor (SPF) of formula controlled clinical study in accordance with international standards (ISO 24444:2019, AS/NZS 2604:2021, ISO 16217:2020, ISO 18861:2020) was conducted with eleven female subjects. Following ISO 24442:2022, a single-center, open-label, randomized study measured the UVA-PF of formula on ten subjects.

### **Consumer Quantitative blind use test**

120 women (Brazil) aged of 18-55 y.o., dermo users of gel cream and fluid sunscreens (minimum SPF50, minimum of 4-5 days per week), all skin types, all skin tones, daily use for 7 days, were recruited to evaluate the performances and measure the formula's competitiveness vs a relevant market benchmark (leading market product).

In this blind use test in monadic, the product was applied daily on the face in place of their usual daily photoprotection product for 1 week. The volunteers were asked to fill in one questionnaire after the use. The scale used was 5 points-scale (agree / somewhat agree, neither agree, nor disagree, somewhat disagree & disagree) and statistical Student test was used with significance considered at 95 %.

### **Consumer use-test protocol**

This test had two cells to evaluate the product performance:

- 100 women and men aged of 18-60 y.o., mix of skin types (50% oily/50% mixed to dry), **users of sunscreen** (6 or 7x times a week) no tinted sunscreens, SPF 50, 60 or 60+. Mix of skin tones, daily use for 28 days, São Paulo (Brazil) were recruited to confirm the efficacy & acceptability of the product .
- 100 women and men aged of 18-60 y.o., mix of skin types (50% oily/50% mixed to dry), **non users of sunscreen** where texture is the primary reason for avoiding it, mix of skin tones, daily use for 28 days, São Paulo (Brazil) were recruited to confirm the efficacy & acceptability of the product .
- 102 women and men aged of 18-60 y.o., mix of skin types (50% oily/50% mixed to dry), **users of a market-leading sunscreen**, mix of skin tones, daily use for 28 days, São Paulo (Brazil) were recruited to confirm the efficacy & acceptability of the product .

The product was applied once a day in the morning on the face in place of their usual daily photoprotection product for 28 days. The volunteers were asked to fill one questionnaire just after the first application (10 questions) and another one after 28 days of use (49 questions). The scale used was 5 points-scale (agree / somewhat agree, neither agree, nor disagree, somewhat disagree & disagree).

## Hydration test

The objectives is to evaluate an important performance parameter, which is hydration.

Methods : Corneometer® CM 825 (Courage Khazaka electronic GmbH) is the gold standard methodology for the assessment of skin hydration.

Panel: 30 volunteers (26 female / 4 male) from 19-65 years old with Dry skin (Corneometer index of  $40 \pm 10$  a.u.)

The methodology is based on hydration measurements in the forearm at different time points: (T6h), 12 (T12h) and 24 hours (T24h).

## Oil Control test

The objective is to evaluate the oiliness and shine control of a sunscreen for 12 hours

Panel characteristics with 23 women from 18 to 48 y.o, All phototypes and Sebum excretion rate  $> 70 \mu\text{g}/\text{cm}^2$  after delipidation with alcohol 70%.

The protocol is:

Face washing with soap -> Acclimatization (20°C to 23°C | 50%  $\pm 10$  R.H) for 30 minutes -> Shine and oiliness evaluation (T0) -> Product application on randomized half-face -> Acclimatization (20°C to 23°C | 50%  $\pm 10$  R.H) for 15 minutes -> Shine and oiliness evaluation (Timm) -> Shine and oiliness evaluation after 4 (T4h), 8 (T8h) and 12 hours (T12h)

## Film resistance test

The objective of this study was to verify the resistance, quality and percentage of loss of the film formed by the sunscreen under extreme conditions, temperature/humidity variations and after physical activity (Figure 1). Panel characteristics :

- 20 women, aged between 19 and 59 years old, oily skin, phototypes II-III.
- Time-points: T0: before product application -> Timm: after product application -> THam-mam:  $40^\circ\text{C} \pm 2^\circ\text{C}$  and  $75\% \pm 5$  Room humidity -> TCold\_Room:  $21^\circ\text{C} \pm 1^\circ\text{C}$  and  $45\% \pm 5$  room humidity -> TPhysical\_Activity: external activity like walking

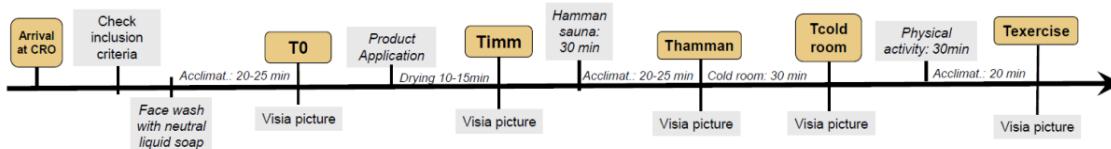


Figure 1 : test scheme – film resistance in extreme conditios

## 3. Results and Discussion

### UV filters selection and Plant-derived wax + polymer network

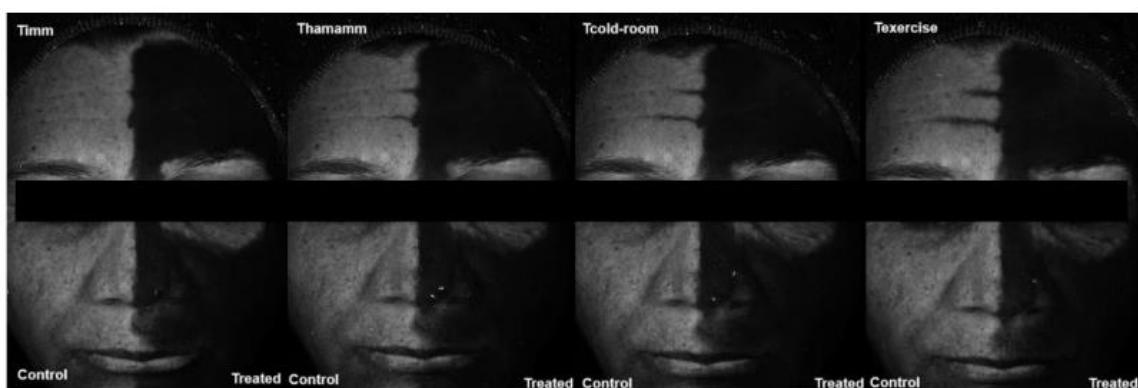
The formula addresses SPF 50+ and a UVA protection factor exceeding the 1/3 ratio required by regulatory agencies by using only organic UV filters (total concentration = 13,5%),

designed to prevent the formation of a white film on skin ensuring relevant protection for the category (respectively ISO 24444: 2019 & ISO 24442: 2011 methods). (3)

In addition to the essential UV protection, after numerous trials based on stability and sensory global assessment, the formula uses a combination of polymers:

- Xanthan gum: This polysaccharide is an excellent suspending agent, even with electrolytes (4). It's eco-friendly and it spreads easily due to its shear-thinning properties
- ACRYLATES/C10-30 ALKYL ACRYLATE CROSSPOLYMER: a popular ingredient in cosmetics and personal care products because of its excellent film-forming.

This polymer network with the addition of Carnauba wax used to thicken the oil phase and bring more stability to the formulation, forming a resilient film that withstands heat, humidity, and even physical exercise (Figure 2).



*Figure 2 : UV image of a volunteer with the product applied under different conditions  
(after hamman, after cold room and after exercise)*

### **Fillers selection**

A pre-selection of fillers, widely used in skincare products for their absorbing, mattifying and/or gentle properties, have been tested to identify the best candidates for our prototype.

- **Silica Silylate** : it is a silica-derived aerogel that contains 99% of air in the “pores” of its low-density structure. These empty spaces create a quasi-unlimited surface to capture and absorb sebum.
- **Silica** : Due to its micron-sized spherical structure, it absorbs sebum (oil control) and disguises imperfections. This charge can create matte-finish sunscreens.
- **Perlite** : Bigger than both silicas, perlite has porous and irregular nature that leads to a macroscopic scattering (blur) effect.

These raw materials are the main responsible for sebum absorption (delivering dry touch plus oil control during the day) and optical properties (hiding imperfections with blur effect). In order to have oil control, without having sensorial losses (drag, low spreadability), several tests were carried out to find the ideal balance of these ingredients between dry touch and spreadability. Providing good results in the perception of consumers and also with instrumental results: 12h of oil control (Figure 3).

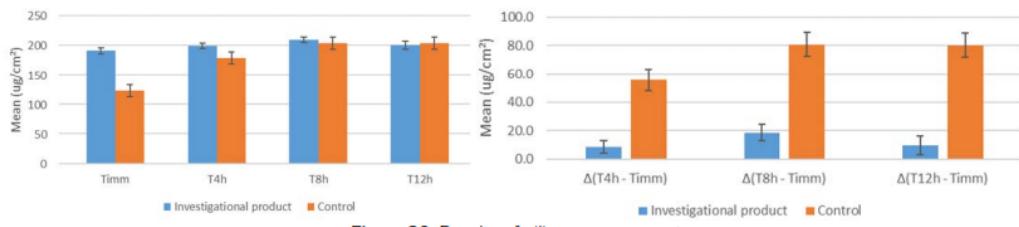


Figure 38: Results of oiliness assessment

	Time-point	Shine control	Oiliness control
Control Area versus Treated Area	T4h	25.1%	40.9%
	T8h	23.0%	56.4%
	T12h	25.9%	60.6%

Figure 3 : oil and shine control results at different time points

### Aqueous phase

This technology is enriched with more than 50% of watery ingredients, which are naturally hydrating. Water can either evaporate or be absorbed into skin, “disappearing” and avoiding heavy and occlusive sensations. Adding glycerin, another ecofriendly humectant ingredient, boosts this hydration.

This way, the formula has a lightweight texture that hydrates skin and leaves a comfortable sensation all day long. The addition of ethanol at a 7% reinforced the perceived feeling of freshness by a well-known effect of quick evaporation while spreading.

With this composition of the aqueous phase, in the results of the consumer test, the consumers have the perception of hydrated skin in addition to seeing up to 24 hours of hydration in the instrumental tests with volunteers (Figure 4).

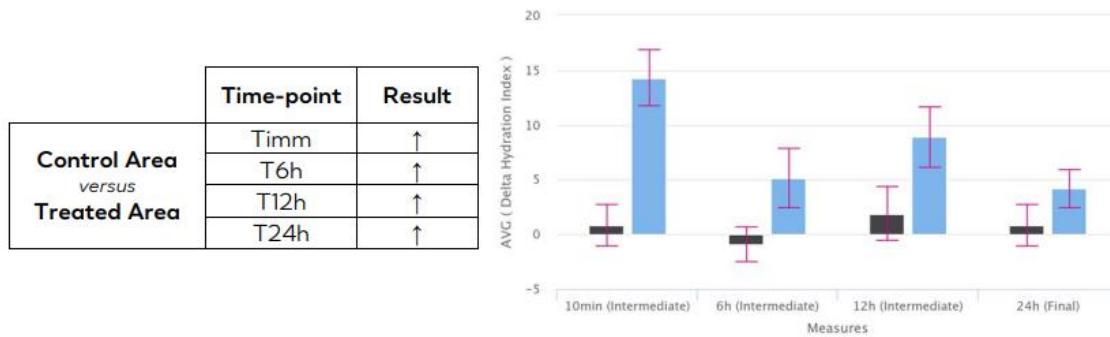


Figure 32: Results of hydration assessment

Figure 4 : hydration results with product applied vs control area at different time points

### Biobased Emollients selection

Beyond contributing to the product's sensory feel, emollients play a role in solubilizing the UV filters, preventing stability issues as crystallization (5). The second selection criteria was its sensory properties. Each molecule has its own characteristics that can impact easiness of spreadability and absorption as well as thickness of film on skin. In addition, using bio-based emollients demonstrates a commitment to sustainability.

- Dicaprylyl Carbonate:** This emollient provides a light, dry, and non-greasy feel. It spreads easily and absorbs quickly, making it ideal for the application sensation.
- Isopropyl Myristate:** This emollient spreads quickly but is less volatile than Di-caprylyl Carbonate. It contributes to both initial and mid-term sensations
- Diisopropyl Sebacate:** this emollient spreads well but is less volatile. It offers good spreadability and a slightly richer feel.
- Propylene Glycol Dicaprylate/Dicaprante:** This emollient spreads easily and absorbs relatively quickly. It can contribute to a smooth, silky skin feel.

This combination of emollient with a focus on more sustainable alternatives, provided an excellent evaluation of spreadability by consumers in the tests.

### Consumer Quantitative blind use test

After 7 days of use on regular of face daily photoprotection SPF 50 / 50+, the formula achieves a superior performance with the benchmark with a few superiorities (Figure 5):

- dry touch and oil control, with fresh sensation/nourished,
- lightweight and spreadability, with resistance to water and resistance to sweat.

	Formula	vs.	Bench
	Base	120	120
LIKING (% T3B)(% T2B/% T1B) /6	99 / <b>94 / 60</b>		98 / 85 / 40
SATISFACTION (% T3B)(% T2B/% T1B) /6	98 / <b>96 / 65</b>		94 / 89 / 43
APPLICATION (%T2B) (%TB) /5			
APPLICATION			
[KPA] Pleasant to apply	100	<b>97</b>	98
[KPA] Good spreadability	100	<b>98</b>	98
[MH] Glides on the skin, evenness of product application skin	99	<b>96</b>	98
TEXTURE			
[MH] Liking texture	98 / 93 / <b>69</b>		95 / 86 / 56
[MH] JR texture thickness (%Thinner/JAR/%Thicker)	<b>5 / 92 / 3</b>		15 / 82 / 3
[KCD] JR stickiness (%Less/JAR/%More)	3 / 97 / -		6 / 92 / 2
ABSORPTION			
[KPA] Quick absorption	98	<b>96</b>	98
[KPA] Scent liking	99 / <b>91 / 63</b>		97 / 78 / 38
SCENT			
Pleasant Scent	98	89	95
[MH] JR intensity (%Less/JAR/%More)	1 / 99 / -		- / 94 / 6
CLEAN & FRESH SENSATION			
CLEAN & FRESH SENSATION	[KPA] Fresh sensation at application	98 / <b>89</b>	94 / 75
IMMEDIATE RESULTS (%T2B) (%TB) /5			
SHINE & OIL CONTROL			
[KCD] Shininess immediate	96	<b>84</b>	79
COMFORT			
[MH] Comfort feel after application	99	88	95
MAKEUP & SKINCARE			
[MH] Easy make up after application	98	<b>88</b>	93
COMPATIBILITY			
[KCD] Skin feels moisturized after application	99	89	96
FEELING CARE/HYDRATION			
[KCD] No white marks on skin after application	98	91	95
NO WHITE MARKS			
THROUGHOUT THE DAY (%T2B) (%TB) /5			
DRY TOUCH			
[KCD] Dry touch	92	<b>85</b>	84
SHINE & OIL CONTROL			
[KCD] Oiliness	96	<b>87</b>	88
[KCD] Shininess all day long	93	<b>84</b>	74
COMFORT & FRESH SENSATION			
[KPA] Lightweight on skin	98	<b>92</b>	95
[KCD] Does not clog pores	96	<b>86</b>	90
[KCD] Lets the skin breath	98	89	96
[MH] No discomfort	98	92	96
[KCD] Skin quality: healthy looking skin	98	<b>91</b>	96
SKINCARE BENEFITS			
[KCD] Clean sensation	98	<b>91</b>	95
[KCD] Matte effect	95	<b>84</b>	82
[KCD] Skin quality: overall skin quality	98	89	96
[KCD] Skin quality: smooth skin	99	88	97
TOUCH ON SKIN			
[KCD] Skin feels moisturized throughout the day	98	<b>91</b>	95
[KCD] Nourished	98	<b>91</b>	95
[KCD] No dryness sensation	98	<b>88</b>	87
MAKEUP AND SKINCARE COMPATIBILITY			
[MH] Makeup Long lasting	98	<b>88</b>	92
[MH] Routine compatible (make up)	98	86	92
NO MELTING/NO WHITE MARKS			
[KCD] No white marks on skin after perspiration	98	87	92
[KCD] No melting with water contact	96	<b>82</b>	85
NO NOODLES			
[KCD] No melting with sweat contact	98	<b>89</b>	88
[MH] No noodles - crumble	99	91	97
[MH] No noodles - crack	99	89	97
UV PROTECTION/RESISTANCE			
[KCD] Prevents skin of getting dark	98	<b>89</b>	84
[KCD] Feeling of protection until the end of the day	98	<b>88</b>	88
[KCD] Resistance to water	97	<b>87</b>	90
[KCD] Resistance to sweat	98	<b>88</b>	88
[KCD] Prevents skin from sun burns	98	88	94
			83

Figure 5: Results of the evaluation of the cosmeticity of the formula by consumers (n=120)

(% of answers "Totally" and "agree"). **Bold & underlined** indicated significantly better vs market benchmark

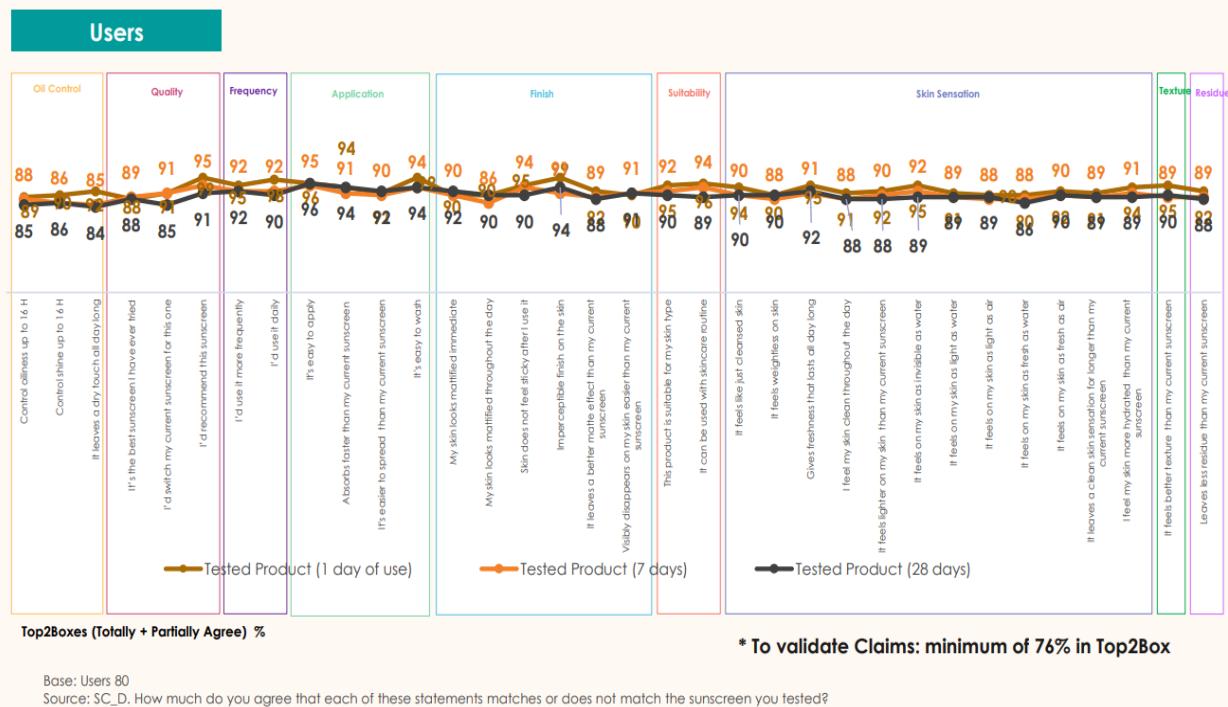
## Consumer use-test

For this consumer test, two consumer cells evaluated the product:

- One with 80 daily users of photoprotection (Women and men, 18-60 y.o., AB SEL. Daily users (6 or 7x times a week) no tinted sunscreens, SPF 50, 60 or 60+)
- Another with 80 non-users of photoprotection (Women and men, 18-60 y.o., AB SEL)

To see the perception in both consumers and understand the recruitment potential due to the sensory aspect of the formula. In the table below (Figure 6), the results of consumer evaluations for different attributes appear, at the time point of 1 day, 7 days and 28 days. of use, where performance was constant.

**Demonstrating top-tier performance, the product has received approval for all stated claims among current users of sunscreen**



*Figure 6: Results of the evaluation of the cosmeticity of the formula by consumers (n=80)*

(% of answers "Totally" and "Partially agree")

- The formula is perceived as easy to apply (96%), It feels weightless on skin (90%) and Gives freshness that lasts all day long (92%), the formula is perceived as the best sunscreen I have ever tried (88%), leaves a dry touch all day long (84%).

**For Non-Users of Sunscreen, the product showcases superior effectiveness, meeting all approved claims with high standards**

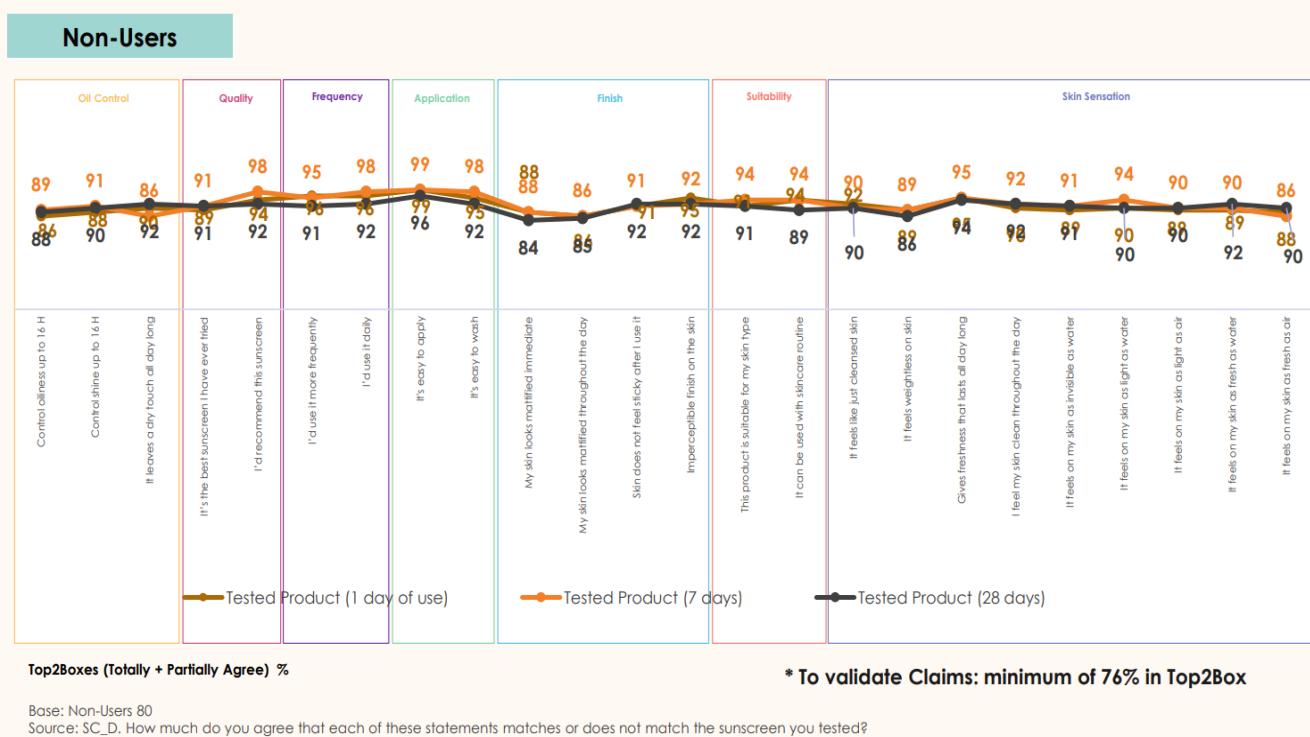


Figure 7: Results of the evaluation of the cosmeticity of the formula by consumers (n=80)

(% of answers "Totally" and "Partially agree")

- The formula is perceived as easy to apply (92.%), It feels weightless on skin (86%) and Gives freshness that lasts all day long (94 %); the formula is perceived as the best sunscreen I have ever tried (91%), leaves a dry touch all day long (92%)
- It shows that the product is approved across all target groups, demonstrating high levels of Liking and Satisfaction, indicating potential to attract competitor users and non-users.
- And most impressively, were the high scores that non-users of photoprotection had for the following questions:

- 93% answered: I would use it daily
- 93% answered: I would recommend this sunscreen

Also, in another cell (number of volunteers 102), this evaluation was made with users of a market-leading sunscreen, where the following responses show great recruitment potential for daily use, showing that this new technology with a pleasant texture can further encourage the daily use of photoprotection.

- 95%: I would switch my current sunscreen for this one
- 95%: It is the best sunscreen that I have ever tried

#### 4. Conclusion

This new sunscreen formulation successfully addresses consumer demands for high SPF and a comfortable wear. With an evaluation plan using different types of consumers and placing sustainability at the center. Combining biodegradable emollients, carnauba wax, and combinations of fillers and humectants, the formula achieves a lightweight texture, with stability, and a fresh skin feel. Delivering SPF 50+ and broad-spectrum UVA protection using organic UV filters, the formula also provides oil control and lasting hydration. Extensive consumer testing validates its efficacy and sensory appeal across diverse populations, demonstrating that this eco-friendly and silicon-free sunscreen offers a desirable solution for daily photoprotection and with the potential to recruit new consumers.

#### CONFLICT OF INTEREST STATEMENT

All authors are full employees of L'Oréal.

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