EVALUATION OF THE EFFECTIVENESS OF NIACINAMIDE-BASED COSMETIC PREPARATIONS IN REDUCING FACIAL SKIN SEBUM LEVELS

ORIGINAL SCIENTIFIC ARTICLE

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DOI: 10.51558/2232-7568.2024.17.2.59

RECEIVED 2025-02-03 **ACCEPTED** 2025-04-07

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ABSTRACT:
Sebum is an oily liquid produced by the sebaceous glands. It serves as a protective barrier for the skin, keeping it hydrated and enhancing its elasticity. Sebum contains triglycerides, fatty acids, wax esters, antioxidant squalene, and cholesterol. While the highest concentration of sebum is produced on the face, it is also present on other parts of the skin, including the scalp. Excessive sebum secretion leads to oily skin, but even dry and normal skin types produce a certain amount of sebum. Cleansing foams and tonics for oily skin have an advantage over other pharmaceutical products, such as creams, soaps, and liquid powders, as they can be applied to all areas of the skin. Niacinamide ($C_6H_6N_2O$) is a pyridinecarboxyamide and organic molecule belonging to the vitamin B group. In recent years, niacinamide has become widely used in cosmetology for the formulation of various pharmaceutical products, primarily for dermal application. However, it is also incorporated into shampoos and hair tonics. Niacinamide is effective in reducing sebum levels on the skin, providing hydration, strengthening the skin's protective barrier, and minimizing visible wrinkles. This study explores the effectiveness of niacinamide as an active component in tonics and foams, along with the stability of these formulations, their microbiological purity, and *in vivo* testing on volunteers. The MPA 6 device, used in skin bioengineering, was employed to measure the amount of sebum on volunteers' facial skin before and after using a cleansing foam for oily skin.

KEYWORDS: oily skin, niacinamide ,sebum, cleansing foams, cleansing tonics

INTRODUCTION

Niacinamide, the amide form of vitamin B3 (niacin), is a hydrophilic endogenous substance and a derivative of nicotinic acid, also known as nicotinamide. It is an organic compound with the molecular formula $C_6H_6N_2O$ and a molar mass of 123.11 g/mol. White crystalline powder, odorless and slightly acidic. Figure 1 shows the structure of the niacinamide molecule.

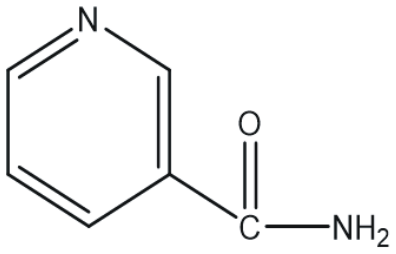

Figure 1. Chemical structure of niacinamide

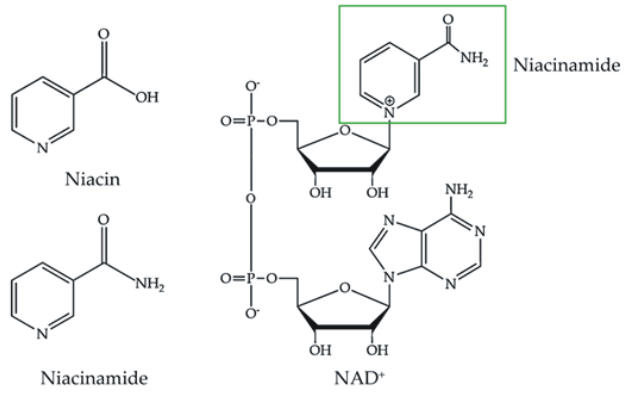

Figure 2. Molecular structures of niacin and niacinamide in the B3 vitamin complex and their molecular constitutive role in NAD+ synthesis

It belongs to the group of B-complex vitamins, specifically one of the eight essential B vitamins [1]. Within the complex metabolic system, niacinamide regulates NFκB-mediated transcription of signaling molecules by inhibiting nuclear poly (ADP-ribose) polymerase-1 (PARP-1).

Vitamin B3 plays a crucial role as a component of the coenzyme NAD (nicotinamide adenine dinucleotide). In living organisms, niacinamide is a vital part of two important coenzymes: NAD+ (nicotinamide adenine dinucleotide) and NADP+ (nicotinamide adenine dinucleotide phosphate). Their reduced forms, NADH and NADPH, act as electron carriers in oxidation and reduction reactions. NAD+ functions as a direct oxidant in glycolysis, fatty acid oxidation, and the citric acid cycle, where it is reduced to NADH. During these reactions, carbon atoms are released as carbon dioxide (CO_2), and NADH transfers electrons to the final oxidant—oxygen. In the phosphogluconate pathway (an alternative glucose metabolism pathway), NADP+ is reduced to NADPH, which then participates in biosynthetic reduction reactions [2].

Vitamin B3, particularly niacinamide, is naturally present in many foods. It is commonly used as a dietary supplement and as an active ingredient in pharmaceutical formulations [3]. Many organisms cannot synthesize niacinamide, making dietary intake or supplementation essential. Pharmaceutical and food-grade niacinamide is used to treat vitamin B3 deficiency and nicotinic acid deficiency-related conditions. It is also effective in managing inflammatory skin diseases, such as acne and pellagra.

In dermatology, extensive research has been conducted on niacinamide and its analogs for the prevention and treatment of cancer, blistering disorders, acne vulgaris, psoriasis, wound healing, and pigmentation disorders. Niacinamide has also been widely used in cosmetics for decades to prevent skin aging and improve skin tone.

Sebum is secreted by the sebaceous glands, which are most numerous on the face, with a density of 400–800 glands/cm^2. Sebum is secreted by the sebaceous glands, which are most numerous on the face, with a density of 400–800 glands/cm^2 [4].

Various dermocosmetic formulations are used in the care of oily skin, with foams standing out as a newer pharmaceutical form. Medicinal foams offer an advantage over other cosmetic products as they can be applied to all areas of the skin, including those covered with hair. Cleansing foams for oily skin are designed to reduce excess sebum on the skin's surface, leaving it looking firmer and less shiny [5].

The aim of this study was to explore the effectiveness of niacinamide as an active component in tonics and foams, along with the stability of these formulations, their microbiological purity, and *in vivo* testing on volunteers.

MATERIALS AND METHODS

All raw materials used in the research were donated by the company (Volimo prirodno d.o.o., Mostar, Bosnia and Herzegovina). The effectiveness of the cosmetic preparations was tested using the MPA 6 skin bioengineering device (Courage+Khazaka) with a sebumeter SM 815.

FORMULATION OF FACIAL CLEANSING FOAM

The production of the facial cleansing foam began by heating an appropriate amount of lavender hydrolate while maintaining a controlled temperature of approximately 40–50°C. This process ensured the proper dissolution of niacinamide, which was then added to the heated hydrolate. Once the niacinamide had completely dissolved, the mixture was blended with the remaining ingredients to achieve a uniform formulation.The specific quantities of raw materials used in the formulation of the niacinamide-based cosmetic foam are detailed in Table 1.

Table 1. Quantities of raw materials used in the formulation of facial cleansing foam with niacinamide

Components	Amount (g)
Niacinamide	4.0
Coconut glucoside	40.0
Lavender hydrolate	45.0
Geogard 221	1.0
Aqua destillata	ad 100.0

FORMULATION OF FACIAL CLEANSING TONIC

Niacinamide was first dissolved in lavender macerate at an elevated temperature (approximately 40–50°C). The lavender macerate was then mixed with the preservative Geogard 221, aloe vera gel and panthenol to create the toner. The quantities of raw materials used for the preparation of the cosmetic toner are shown in Table 2.

Table 2. Quantities of raw materials used in the formulation of the niacinamide-based tonic.

Components	Amount (g)
Niacinamide	4.0
Lavender macerate	85.0
Panthenol	3.0
Aloe vera	7.0
Geogard 221	1.0

TESTING THE pH VALUE OF NIACINAMIDE-BASED FOAM AND TONIC

Seventy-two (72) hours after the preparation of the formulations, the pH values of the tested foam and tonic samples were determined potentiometrically at room temperature (22±2°C). The measurement was repeated after two months to assess the chemical stability of the formulations. The foam and tonic samples were stored at room temperature. The recommended pH range for cosmetic skin cleansing products is between 3.5 and 9 [6].

TESTING THE EFFECTIVENESS OF NIACINAMIDE-BASED FOAM AND TONIC ON SEBUM LEVELS

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethical Committee for Scientific Research University of Tuzla (03/7-6990-1-2/24). It was conducted at the Faculty of Pharmacy, University of Tuzla.

PARTICIPANTS AND PROCEDURE

The study involved 13 participants, women aged between 17 and 36 years, with normal to oily skin and skin prone to hyperpigmentation. Participants were volunteers who had previously signed an informed consent prior to the study, in which the objectives, methods, and procedures of the research were detailed [7]. Each participant received verbal instructions on how to use the formulations, as well as the scheduled times for skin parameter measurements.

The verbal instructions included the regular application of the cosmetic formulations twice daily until the next measurement appointment. First, participants were instructed to clean their faces using a specific facial foam and tonic at least 3 hours before arriving at the testing facility. After cleaning, no additional skincare or cosmetic products were to be applied.

Measurements were taken after a 15-minute acclimatization period in the testing room (with a constant temperature of 20°C ± 2°C and humidity of 50% ± 5%) to ensure that sweating had subsided, which is critical for accurate sebum measurements.

SEBUM MEASUREMENT PROCEDURE

The Sebumeter® SM 815 was used to measure sebum levels on the skin surface. This probe utilizes a transparent film that absorbs sebum from the skin. The light transmission through the film is measured before and after contact with the skin using a photometer, providing an accurate quantification of sebum in μg/cm2 [8].

A probe containing a plastic strip is pressed against the measurement point, and the device is left for 15 seconds. Afterward, the probe is returned to the device, and the amount of lipids is determined by measuring the transparency of the plastic film using a photodetector.

After the objective assessment of sebum level, participants were asked about their personal experiences with the foam and tonic, including their subjective perceptions and any potential side effects such as itching, irritation, etc. The study lasted for a total of four weeks, during which three measurements were conducted. The study was conducted under the supervision of a dermatology specialists.

DETERMINING THE MICROBIOLOGICAL PURITY OF FOAM AND TONIC

The microbiological purity of the foam and tonic formulations was evaluated by testing for the presence of microorganisms. The smear method was used, in which a sample suspension was prepared and then applied to the surface of a solid nutrient medium. The samples were incubated for 24 hours at 37°C [9].

RESULTS AND DISCUSSION

DETERMINATION OF pH VALUE

pH of the facial cleansing foam after 72 hours of production was 5.14, which corresponds to the pH values of formulations that are close to the

physiological pH of the skin [12]. After two months from production, the pH of the foam was 4.96, with no significant deviation observed, indicating that the formulations maintained stability in terms of pH value *(Table 3).*

pH of the facial cleansing tonic after 72 hours of production was 4.76, and after two months from production, the pH was 4.65, with no significant deviation observed, indicating that these formulations also maintained stability in terms of pH value *(Table 4).*

Table 3. Changes in pH value for the niacinamide-based facial cleansing foam sample

Time	pH value
After 72 hours	5.14
After 2 months	4.96

Table 4. Changes in pH value for the niacinamide-based facial cleansing tonic sample

Time	pH value
After 72 hours	4.76
After 2 months	4.65

RESULTS OF THE MICROBIOLOGICAL PURITY OF FOAM AND TONIC

After 24 hours of incubation, no visible colonies were observed on the plates. This indicates that there was no microbial growth, and the products (foam and tonic) can be considered microbiologically stable. Niacinamide itself has potentially antimicrobial effects [10] and prevents the development of microorganisms.

Figure 3. Plates with niacinamide foam and tonic after 24 hours of incubation

MEASUREMENT OF SEBUM LEVELS ON THE SKIN

Table 5 presents the characteristics of the participants, including age and skin type. Table 6 shows percentage results obtained after measuring sebum levels. Table 7 presents the degree of sebum level reduction after one month, and the presence of side effects following the application of the foam and toner.

Table 5. Characteristics of study participants

Characteristic		%
Age	17-30	90
	>30	10
Skin type	Oily	80
	Mixed	10
	Normal	10

Following the application of the foam and tonic, sebum levels decreased in all participants. However, after one month of use, sebum levels remained lower than the initial measurement but higher than the second measurement. The sebum level before applying the foam and toner ranged from 78 to 223 g/cm², and after application, it ranged from 11 to 56 g/cm². One month after the application of the products, the sebum level ranged from 42 to 112 g/cm². These fluctuations may be attributed to factors such as stress, diet, hormonal imbalance, or irregular use of the foam and tonic.

Table 6. Percentage Results Obtained After Measuring Sebum Levels

Participant	Sebum level before applying foam and tonic	Sebum level after using foam and tonic	Sebum level after one month	Percentage of sebum reduction after application of foam and tonic	Percentage of sebum reduction after one month
1.	197	11	75	94%	62%
2.	82	39	51	52%	63%
3.	112	40	42	64%	36%
4.	88	19	56	78%	61%
5.	220	33	87	85%	73%
6.	223	56	60	75%	32%
7.	127	33	87	74%	49%
8.	134	56	68	58%	33%
9.	78	24	52	69%	48%
10.	89	27	46	70%	40%
11.	187	45	112	76%	51%
12.	195	23	95	88%	60%
13.	221	45	88	80%	50%

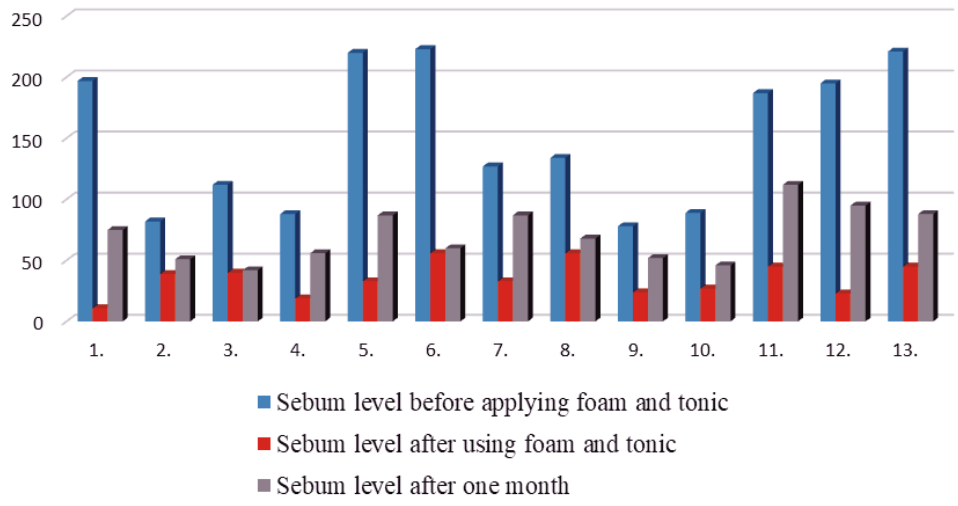

Figure 4. Sebum level on facial skin

Beyond sebum level measurements, participants also provided feedback through a survey. Notably, 80% of them reported that the formulated products improved their overall skin condition. After applying the foam and tonic, the volunteers' skin became softer and smoother, while sebum levels on the facial skin decreased in most participants.

Table 7. Skin condition after applying the foam and toner (subjective feeling)

Characteristic		%
Reduced appearance of oily skin	Yes	80
	No	20
Side effects	Itching	15
	Irritation	15
	No side effects	70

Previous studies have demonstrated that niacinamide reduces sebum production on the skin, which aligns with the findings of our research [11, 12, 13]. The study conducted by Draelos [14] shows that a 2% niacinamide gel reduces sebum levels on the facial skin. The study was conducted in Japan. Volunteers began noticing the effects of niacinamide after two and four weeks of using the cream, with a significant reduction in sebum levels.

CONCLUSIONS

Niacinamide (heterocyclic aromatic amide) as the active ingredient in the foam and tonic, played a crucial role in significantly reducing sebum levels on the facial skin. This reduction in sebum was accompanied by a noticeable improvement in skin texture, making the skin softer, smoother, and more refined to the touch. These findings suggest that the foam and tonic, with their niacinamide content, offer an effective solution for managing oily skin and improving overall skin quality. This study highlights the potential of niacinamide as a key ingredient in skincare products designed to control sebum production while promoting healthier, more nourished skin.

ACKNOWLEDGEMENTS

This research was supported by the Federal Ministry of Education and Science (FMON BiH). The authors would like to thank „Zen prirodna kozmetika“ for their participation in the research. The authors are also grateful for the donation of raw materials to the company Volim prirodno d.o.o, Mostar.

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