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ORIGINAL CONTRIBUTION

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Variability of skin pH after the use of different collagen gels

Agnieszka Ciszek PhD

Department of Physiotherapy and Occupational Therapy, University of Physical Education in Wroclaw, Wroclaw, Poland

Correspondence
Agnieszka Ciszek, Department of Physiotherapy and Occupational Therapy, University of Physical Education in Wroclaw, Wroclaw, Poland.
Email: agnieszka.ciszek@awf.wroc.pl

Summary

Background: Skin pH is an important parameter indicating the condition of the skin because imbalance can contribute to the development of skin problems and earlier aging. Individual skin pH depends on many factors such as hydration, sweating, sebum excretion, genetics, sex, and age. Additionally, it can be affected by exogenous factors such as cosmetics.

Aims: The aim of the study was to compare different collagen gels and determine whether and to what extent they change the pH of the skin.

Patients/Methods: Baseline skin pH was measured in 49 women aged between 19 and 23. It was measured again 20 and 60 minutes following of the application of four collagen gels.

Results: The mean physiological pH values of the forehead and cheek were 5.67 and 5.76, respectively. The analysis of variance and post hoc test revealed that gel no. 1, gel no. 2, and gel no. 3 (but not 4) significantly changed the skin pH.

Conclusion: Collagen gel should be neutral for the skin barrier; however, most collagen skin care preparations significantly changed skin pH. Methods of processing and stabilizing the collagen may account for the difference in effect between gels, but further research is required.

KEYWORDS
barrier function, fish collagen, skin care, skin pH, skin protective barrier

1 | INTRODUCTION

An indispensable part of working with a dermatologic patient is having the excellent ability to diagnose skin problems. Proper diagnosis is based not only on experience and knowledge but also on equipment support. Visits should begin by obtaining patients' accounts of their current skin care regime, general health condition, and diet. Observation with a magnifying lamp helps to identify different type of eruptions, the presence of hyperpigmentation, skin vascularization, and the depth of wrinkles. Detailed examinations involve equipment and include assessment of skin color (Mexameter), hydration (Corneometer, Tewameter), pH (pH meter), sebum level (Sebumeter), and elasticity and flexibility (Cutometer). Those parameters and their variability caused by physical and chemical factors, including drugs, have become an important element of new trends in creating drug, cosmetics, perfumery, and household chemical recipes.

Skin is the body's biggest organ, and it fulfills many crucial functions, including protection, secretion, and sensation. The hydro-lipid film of the corneal layer of the skin is a vital component for maintaining the skin barrier and protecting it from bacteria. Thus, this study also examined the role of the hydro-lipid barrier in maintaining the level of acidity after exposure to physiological and pathological agents.[1,2]

Individual skin pH depends on many factors such as endogenous skin moisture, the composition of apocrine and eccrine sweat, the intensity of sebum excretion, anatomical predisposition, genetics, sex, and age. Additionally, exogenous factors such as detergents, cosmetics, occlusive dressings, and topical antibiotics can affect the pH of the skin. Changes in skin pH play a role in the pathogenesis of skin diseases such as irritant contact dermatitis, atopic dermatitis, ichthyosis, acne, and infections caused by *Candida albicans* and *Malassezia dermatitis*. As a result, the composition of cosmetic

preparations that affect many skin parameters may play a role in prevention and treatment of dermatologic diseases and skin defect. An increase in skin pH up to 6.5-8 acts as an irritant on the protective barrier because of the changes in the skin microbial flora and the activity of enzymes in the upper layers of the epidermis. Impairment of pH homeostasis and lipid composition may have an effect on skin hydration, transepidermal water loss (TEWL) and, as a consequence, lead to dehydration and skin atrophy.

The aim of the study was to compare the effect of different collagen gels on the skin and to demonstrate whether and to what extent they change pH of the skin.

2 | MATERIALS AND METHODS

The study group included 49 women aged 19-23 (mean age 21). Participants were informed about the study procedures. The study was approved by the local Research Ethics Committee. Participants with a history of allergy, atopy, or skin lesions in the examined area, as well as those who smoked, were excluded.

During the experiment, areas on the forehead and left cheek were examined. Each area was divided into four 1-cm^2 subareas for each type of gel. Tested areas were arranged in a line at a distance of 1 cm both on the cheek and forehead. Applications and measurements were performed simultaneously on all tested subareas. The skin pH was measured before application of four different types of collagen gels, then after 20 and 60 minutes. For measurement Skin-pH-Meter® PH 905 (Courage+Khazaka electronic GmbH, Cologne, Germany), certified for medical application and measuring to the nearest 0.001, was used.

The study was carried out with four commercially available collagen gels on the Polish market. Collagen used for production of studied cosmetic preparations was extracted from fish from the Polish Baltic Sea living in special farms in which they have countless feeding areas of healthy and eco-friendly algae. Material for production is excreted from fish skins which are derived during 2-3 hours after fishing and immediately deeply frozen. Hibernation allows for preservation of biological structure of triple-helix bindings. Collagen stored in such environment maintains properties similar to that in living organism. Collagen is produced by hydration so that it retains its spatial structure and entire biological activity of products of its degradation on the contact surface with human skin. Producers claim that their preparations are free of preservatives and have hypoallergenic properties. All preparations were composed of substances such as aqua, collagen, caprylyl glycol, elastin, lactic acid, and Metalli Glycerin, Tuberous Vegetabili among others. The inclusion criteria were Aqua at the first position and Collagen on the second position on the ingredients list. Collagen gel designated herein as 1 is the product of Colway (Koleczkowo

TABLE 1 Mean pH values for forehead and cheek skin at baseline and after 20 and 60 min following of the application of four collagen gels

		n	Mean	SD	Mean	SD
pH forehead	Baseline	49	5.67	0.299		
pH cheek	Baseline	49	5.75	0.298		
After 20 min					After 60 min	
pH forehead	Gel 1	49	4.71	0.321	4.84	0.430
	Gel 2	49	4.63	0.372	4.46	0.256
	Gel 3	49	3.76	0.234	3.97	0.342
	Gel 4	49	5.43	0.281	5.42	0.269
pH cheek	Gel 1	49	4.92	0.351	5.25	0.462
	Gel 2	49	4.68	0.375	4.76	0.304
	Gel 3	49	3.97	0.230	4.28	0.338
	Gel 4	49	5.53	0.294	5.67	0.298

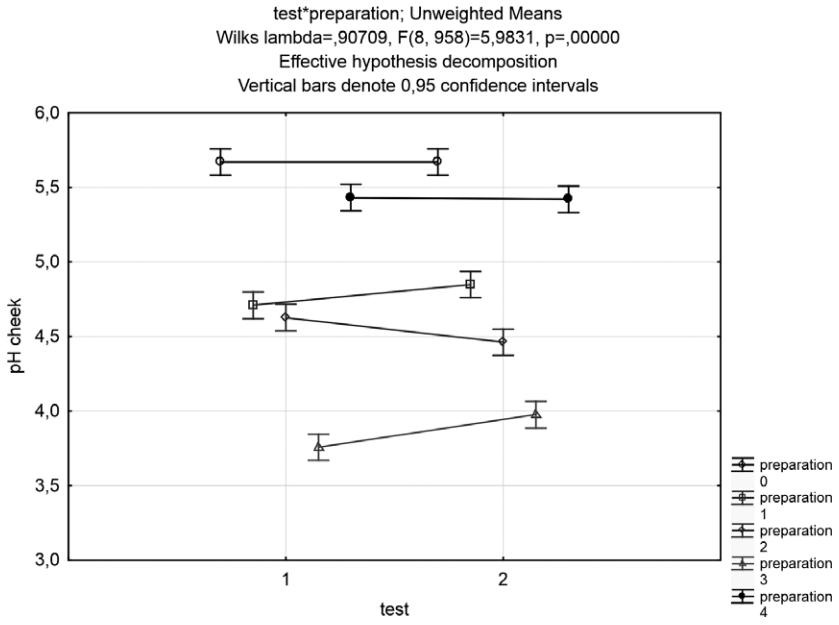

FIGURE 1 Skin pH differences over time after 20 and 60 min following of the application of four collagen gels on the cheek area

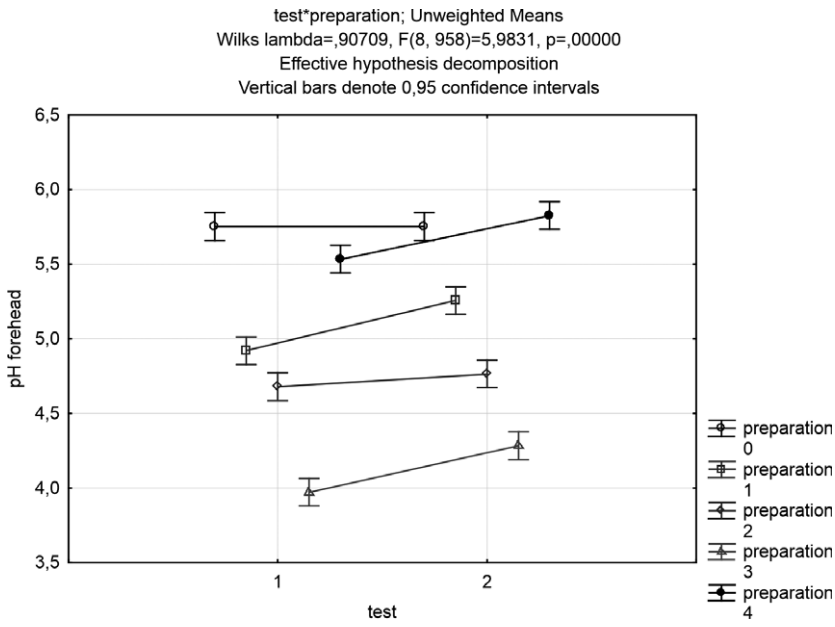

FIGURE 2 Skin pH differences over time after 20 and 60 min following of the application of four collagen gels on the forehead

TABLE 2 Results of analysis of variance after 20 and 60 min following of the application of four collagen gels

		Sum of squares	*df*	Mean square	S	*P*
Examination after 20 min						
Forehead pH	Between groups	111.307	4	27.827	299.611	.000
	In groups	22.290	240	0.093		
	Total	133.597	244			
Cheek pH	Between groups	98.619	4	24.655	250.437	.000
	In groups	23.627	240	0.098		
	Total	122.246	244			
Examination after 60 min						
Forehead pH	Between groups	93.490	4	23.372	220.630	.000
	Within groups	25.424	240	0.106		
	Total	118.914	244			
Cheek pH	Between groups	84.548	4	21.137	178.505	.000
	Within groups	28.419	240	0.118		
	Total	112.966	244			

k/Gdyni, Poland), as 2 is a product of Inventia (Rotmanka, Poland), 3 of Abapol Laudine (Gdańsk, Poland) and 4 of Perfect Coll (Gdynia, Poland).

In the statistical analysis, variables were presented as means with standard deviations. Two-way analysis of variance (ANOVA) was used for comparing means between study groups. The null hypothesis was that the means were independent of the gels and tests. In case the null hypothesis was rejected, a post hoc test with the method of the least significant difference (LSD) was used. Differences between results were considered significant when the *P*-value was <.05.

[Corrections added on April 13, 2017, after first online publication: the last sentence of this paragraph has been changed from "3 and 4 of Abapol Laudine (Gdańsk, Poland)." to "3 of Abapol Laudine (Gdańsk, Poland) and 4 of Perfect Coll (Gdynia, Poland)."]

3 | RESULTS

The mean physiological pH value of the forehead skin was slightly lower than the mean physiological pH value of the left cheek skin (5.67 vs 5.76). The smallest difference was between baseline physiological pH and the pH after the application of gel no. 4 both for forehead and cheek. The mean values of skin pH are summarized in Table 1, with differences over time shown in Figures 1 and 2.

The analysis of variance shows significant differences among each of the study groups (Table 2). Comparing means with the LSD method shows that all gels significantly changed skin pH in comparison with baseline values after 20 minutes both on the cheek and on the forehead. The differences between gels were also significant except for gel no. 1 and gel no 2, which effect was similar. In the 60-minute test, a significant difference in skin pH remained for gel no. 1, gel no. 2, and gel no. 3. For gel no. 4, the skin pH

TABLE 3 Results of LSD test after 20 and 60 min following of the application of four collagen gels

Dependent variable—forehead pH		Difference of means	*P*	Dependent variable—cheek pH		Difference of means	*P*
Examination after 20 min							
Baseline	1	0.960*	.000	Baseline	1	0.831*	.000
	2	1.043*	.000		2	1.073*	.000
	3	1.912*	.000		3	1.780*	.000
	4	0.239*	.000		4	0.219*	.001
Gel 1	0	−0.960*	.000	Gel 1	0	−0.831*	.000
	2	**0.083**	**.180**		2	0.242*	.000
	3	0.952*	.000		3	0.949*	.000
	4	−0.721*	.000		4	−0.613*	.000
Gel 2	0	−1.043*	.000	Gel 2	0	−1.073*	.000
	1	**−0.083**	**.180**		1	−0.242*	.000
	3	0.869*	.000		3	0.707*	.000
	4	−0.804*	.000		4	−0.855*	.000
Gel 3	0	−1.912*	.000	Gel 3	0	−1.780*	.000
	1	−0.952*	.000		1	−0.949*	.000
	2	−0.869*	.000		2	−0.707*	.000
	4	−1.673*	.000		4	−1.562*	.000
Gel 4	0	−0.239*	.000	Gel 4	0	−0.219*	.001
	1	0.721*	.000		1	0.613*	.000
	2	0.804*	.000		2	0.855*	.000
	3	1.673*	.000		3	1.562*	.000
Examination after 60 min							
Baseline	1	0.821 633*	.000	Baseline	1	0.495 510*	.000
	2	1.206 939*	.000		2	0.987 755*	.000
	3	1.693 673*	.000		3	1.467 959*	.000
	4	0.249 184*	.000		**4**	**−0.073 673**	**.290**
Gel 1	0	−0.821 633*	.000	Gel 1	0	−0.495 510*	.000
	2	0.385 306*	.000		2	0.492 245*	.000
	3	0.872 041*	.000		3	0.972 449*	.000
	4	−0.572 449*	.000		4	−0.569 184*	.000
Gel 2	0	−1.206 939*	.000	Gel 2	0	−0.987 755*	.000
	1	−0.385 306*	.000		1	−0.492 245*	.000
	3	0.486 735*	.000		3	0.480 204*	.000
	4	−0.957 755*	.000		4	−1.061 429*	.000
Gel 3	0	−1.693 673*	.000	Gel 3	0	−1.467 959*	.000
	1	−0.872 041*	.000		1	−0.972 449*	.000
	2	−0.486 735*	.000		2	−0.480 204*	.000
	4	−1.444 490*	.000		4	−1.541 633*	.000
Gel 4	0	−0.249 184*	.000	Gel 4	**0**	**0.073 673**	**.290**
	1	0.572 449*	.000		1	0.569 184*	.000
	2	0.957 755*	.000		2	1.061 429*	.000
	3	1.444 490*	.000		3	1.541 633*	.000

*The difference is statistically significant at the level of *P* below .05; lack of significant difference in marked in bold.

was similar to the baseline physiological level and did not show a significant difference. The results of the LSD test are shown in Table 3.

These tests show that collagen gels of acidic pH (pH 3.7-4.5) change the parameters of the skin functioning as a protective barrier. Only gel no. 4 did not change skin pH significantly. Collagen

preparations must be used carefully as the result of their application depends on their composition, and they may contribute to an imbalance of hydro-lipid barrier homeostasis.

4 | DISCUSSION

The present study revealed that the application of collagen gels changes skin pH. Only one preparation (no. 4) did not negatively affect skin homeostasis after an hour; its composition appeared to be stable, and its action was independent of time. Although all tested gels were composed of similar substances, including collagen extracted from fish from the Polish Baltic Sea, they affected skin pH differently.

According to Jung et al., skin pH can be affected by various factors: hydration of the stratum corneum, the rate of sebum excretion, TEWL, the level of sweating and age, all of which are directly associated with skin atrophy. Mean skin pH among the three study groups was 5.510±0.625.[3] In the present study, the effect of applying collagen gels from different producers was tested. Pati et al. analyzed and classified nano-/microfibrous scaffolds using collagen extracted from freshwater fish and assessed their biocompatibility and immunogenicity. Microscopic analysis revealed a significant proliferation rate of cells and full cell confluence within 5 days, indicating high biocompatibility of fish collagen with human body.[4]

Luebberding et al.[5] tested over 300 men and women and reported considerably lower physiological pH in men (below 5) than in women. The differences between men and women existed not only in relation to skin pH but also in sebum production. In a separate study, Tagaki et al. observed fluctuations in the level of skin pH after using detergent.[6] After washing the skin with soap, the pH of the skin increased and then dropped back to a more acidic pH. They concluded that long-term use of detergent based on soap does not significantly affect pH of human skin. The author of the present study, on the basis on available literature, concludes that skincare products and medicinal preparations for topical treatment of the skin —especially those intended for long-term application—should be designed separately for man and women to avoid affecting skin parameters.

Schmid-Wendtner and Korting pointed to the risk of developing dermatoses from detergents having considerably higher basic pH (over 10.5).[7] Selander et al. claim that *Malassezia* yeasts are opportunistic and trigger atopic eczema. The skin pH in patients with atopic dermatitis is higher than in subjects without dermatologic problems; based on this fact, they proved that pH levels similar to those present in the course of atopic dermatitis may influence production and release of *Malassezia* allergens. Their study showed that increased skin pH stimulates the release of allergens.[8]

On the other hand, Duncan et al. examined the relationship between the pH of microflora dwelling on the surface of the skin and products used for washing the skin. They revealed that no significant differences among different detergents and soaps exist. They also discovered that the products used for routine skin care considerably affected skin pH, but had no influence on bacterial colonization in patients from intensive care departments. Bacterial colonization on the skin changed and increased the longer the stay in the hospital.[9]

The impact of aromatherapy massage on itchy skin and skin pH in elderly subjects was assessed by Roh's team. Massages were performed three times a week for 1 month, reducing itching, decreasing the level of skin pH, and increasing skin hydration. It can be concluded that such therapy should be introduced to clinical practice and effective nursing care.[10]

Finally, the correlation between the level of skin pH and the development of wrinkles directly related to aging was assessed by Jung and colleagues. They examined factors responsible for skin aging and compared them with skin pH and other parameters. In their study, skin pH depended on the level of hydration, the rate of sebum excretion, the concentration of melatonin, TEWL, and skin temperature. They also found that wrinkle formation significantly decreased when skin pH was more acidic.[3]

5 | CONCLUSION

Skin pH is a significant parameter indicating skin condition. Collagen gels should be neutral for the skin barrier and should not affect its parameters. This study showed that preparations that included the same collagen and had similar compositions had different effects on skin pH, which may be due to the different methods of processing and stabilizing the source of collagen (fish) used by manufacturers.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

REFERENCES

1. Chantasart D, Chootanasoontorn S, Suksiriworapong J, Li SK. Investigation of pH influence on skin permeation behavior of weak acids using nonsteroidal anti-inflammatory drugs. *J Pharm Sci*. 2015;104:3459–3470.
2. Gfatter R, Hackl P, Braun F. Effects of soap and detergents on skin surface pH, stratum corneum hydration and fat content in infants. *Dermatology*. 1997;195:258–262.
3. Jung YC, Kim EJ, Cho JC, Suh KD, Nam GW. Effect of skin pH for wrinkle formation on Asian: Korean, Vietnamese and Singaporean. *J Eur Acad Dermatol Venereol*. 2013;27:e328–e332.
4. Pati F, Datta P, Adhikari B, Dhara S, Ghosh K, Mohapatra PKD. Collagen scaffolds derived from fresh water fish origin and their biocompatibility. *J Biomed Mater Res*. 2012;100A:1068–1079.
5. Luebberding S, Krueger N, Kerscher M. Skin physiology in men and women: in vivo evaluation of 300 people including TEWL, SC

hydration, sebum content and skin surface pH. *Int J Cosmet Sci*. 2013;35:477–483.
6. Takagi Y, Kaneda K, Miyaki M, Matsuo K, Kawada H, Hosokawa H. The long-term use of soap does not affect the pH-maintenance mechanism of human skin. *Skin Res Technol*. 2015;21:144–148.
7. Schmid-Wendtner MH, Korting HC. The pH of the skin surface and its impact on the barrier function. *Skin Pharmacol Physiol*. 2006;19:296–302.
8. Selander C, Zargari A, Mollby R, Rasool O, Scheynius A. Higher pH level, corresponding to that on the skin of patients with atopic eczema, stimulates the release of Malassezia sympodialis allergens. *Allergy*. 2006;61:1002–1008.
9. Duncan CN, Riley TV, Carson KC, Budgeon CA, Siffleet J. The effect of an acidic cleanser versus soap on the skin pH and micro-flora of adult patients: a non-randomised two group cross-over study in an intensive care unit. *Intensive Crit Care Nurs*. 2013;29:291–296.
10. Roh SY, Kim KH. Effects of aroma massage on pruritus, skin pH, skin hydration and sleep in elders in long-term care hospitals. *J Korean Acad Nurs*. 2013;43:726–735.

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