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RESEARCH COMMUNICATION

Changes in levels of omega-O-acylceramides and related processing enzymes of sun-exposed and sun-protected facial stratum corneum in differently pigmented ethnic groups

Anthony V. Rawlings[1] | **Rotraut Schoop**[2] | **Christian Klose**[3] | **Jean-Marc Monneuse**[4] | **Beverley Summers**[5] | **Rainer Voegeli**[2]

[1]AVR Consulting Ltd, Northwich, UK

[2]DSM Nutritional Products, Kaiseraugst, Switzerland

[3]Lipotype GmbH, Dresden, Germany

[4]Phylogene SA, Bernis, France

[5]Sefako Makgatho Health Sciences University, Medunsa, South Africa

Correspondence
Rainer Voegeli, DSM Nutritional Products, Kaiseraugst, Switzerland
Email: rainer.voegeli@dsm.com

Funding information
DSM Nutritional Products

Abstract

Introduction: We report on the differences in ceramide composition and levels of omega-O-acylceramide processing enzymes of sun-exposed and sun-protected facialstratum corneum (SC) among Albino African, Black African and Caucasian women living in South Africa.

Methods: Tape strippings were taken from the sun-exposed cheek and the sun-protected postauricular site (PA). In two subsets proteomic (n = 18) and lipidomic (n = 24) analysis were performed using mass-spectrometry-based shotgun platforms.

Results: No significant differences in total ceramide levels or ceramide subtypes were found between the Black African and Caucasian women in either the cheek or PA samples. Compared to the other two groups the levels of total ceramide as well as selected omega-O-acylceramide species were increased in Albino Africans. On the cheek, ceramide (CER) EOS, EOH along with CER AS were increased relative to the Caucasian women, while CER EOP and EOdS were elevated relative to the Black African women. Moreover, on the PA site CER EOP and EOdS were elevated compared with the Black African women and CER EOdS in Caucasians. Decreasesin masslevels of 12R-LOX and eLOX3 were observed on cheeks compared with the PA sites in all ethnic groups. On the PA sites 12R-LOX was particularly lower in the Albino Africans compared with the Black African and Caucasian women. On the cheeks mass levels of SDR9C7 was also lower in the Albino Africans.

Conclusion: The mass levels of the ceramides were similar between Black African and Caucasian women. However, elevated total ceramides and excessively elevated selected omega-O-acylceramides were apparent in the Albino African women. The findings in the Albino African women were unexpected as these participants suffer from impaired skin barrier function. However, the elevated levels omega-O-acylceramides can contribute to barrier insufficiency by directly

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impacting SC lipid phase behaviour and/or secondly elevated omegaO-acylceramide levels may indicate a reduced attachment of ceramides to the corneocyte lipid envelope and reduced corneocyte maturation that can also impair the barrier. Indeed, differences in the mass levels of omega-O-acylceramide processing enzymes were observed for 12R-LOX and SDR9C7 for the Albino Africans. This indicates a corneocyte lipid scaffold disorder in this population.

KEYWORDS

chemical analysis, corneocyte envelope, ethnic, lipidomics, proteomics, skin barrier, skin physiology/structure

Résumé

Introduction: Nous décrivons les différences de composition en céramides et de niveaux des enzymes du métabolisme des oméga-O-acylcéramides du stratum corneum facial (SC) photo-exposé et photo-protégé chez des femmes Albinos Africaines, Noires Africaines et Caucasiennes vivant en Afrique du Sud.

Méthodes: Les prélèvements ont été effectués sur la joue photo-exposée et sur le site post-auriculaire (PA) photo-protégé à l'aide de disques adhésifs. Dans deux sous-groupes, des analyses protéomiques (n = 18) et lipidomiques (n = 24) ont été réalisées à l'aide de plateformes de spectrométrie de masse non-ciblées.

Résultats: Aucune différence significative de quantité globale de céramides ou dans les différentes classes de céramides n'a été observée entre les femmes Noires Africaines et les femmes Caucasiennes, quels que soient les échantillons (Joue ou de PA). Comparativement aux deux autres groupes, les quantités de céramides totales, ainsi que certaines espèces d'oméga-O-acylcéramides, étaient plus élevés chez les femmes Albinos Africaines. Sur la joue, les céramides (CER) EOS, EOH et CER AS étaient plus élevés que chez les femmes Caucasiennes, tandis que les CER EOP et EOdS étaient plus élevés que chez les femmes Noires Africaines. De plus, sur le site PA, les CER EOP et EOdS étaient plus élevés que chez les femmes Noires Africaines et les CER EOdS chez les Caucasiennes. Des diminutions des niveaux d'enzymes 12R-LOX et eLOX3 ont été observées sur les joues par rapport aux sites PA dans tous les groupes ethniques. Sur les sites PA, le niveau de 12RLOX était notablement plus faible chez les femmes Albinos Africaines comparativement aux femmes Noires Africaines et Caucasiennes. Sur les joues, le niveau de SDR9C7 était également plus faible chez les Albinos Africaines.

Conclusion: La masse des céramides totaux était similaire entre les femmes Noires Africaines et Caucasiennes. Cependant, des niveaux élevés de céramides totaux et excessivement élevés des oméga-O-acylcéramides sélectionnés, ont été observés chez les femmes Albinos Africaines. Les résultats obtenus chez les femmes Albinos Africaines étaient surprenants car ces participantes souffrent d'une altération de la fonction de la barrière cutanée. Néanmoins, les niveaux élevés d'oméga-O-acylcéramides peuvent en premier lieu contribuer à l'insuffisance de la barrière en ayant un impact direct sur le comportement de la phase lipidique du SC et/ou, deuxièmement, peuvent indiquer une fixation réduite des céramides à l'enveloppe lipidique des cornéocytes et une maturation réduite des cornéocytes pouvant aussi altérer la barrière. En outre, des différences

dans les niveaux d'expression des enzymes de transformation de l'oméga-O-acylcéramide ont été observées pour 12R-LOX et SDR9C7 chez les femmes Albinos Africaines. Ceci indique une désorganisation de l'échafaudage lipidique des cornéocytes dans cette population.

INTRODUCTION

The molecular anatomy together with the cellular and lipid architecture of stratum corneum (SC) is now well established for healthy skin barrier function [1]. Ethnic differences in SC structure, biochemical composition and function were recently reviewed with the aim of identifying the need for ethnically targeted skin care solutions [2–4]. However, there are limited data on ethnic differences in facial skin, especially in relation to the biochemistry of the SC.

We have recently published on the physiology of facial skin (photodamaged cheek and postauricular (PA) sites) among mainly Albino African, Black African and Caucasian women using a variety of bioinstrumental and biochemical approaches (Figure 1) as well as a unique colour-mapping approach examining 30 carefully selected sites on the faces of Black African, Chinese, Indian and Caucasian women for skin barrier function, skin hydration and skin surface pH [5–9]. These studies highlighted the complexity of barrier function, barrier repair and hydration of facial skin and that the darkly pigmented skin does not necessarily have a better barrier physiology or a lower skin surface pH but has a higher hydration status [5–9]. In contrast, Albino Africans had both a weaker skin barrier and much lower skin hydration and yet faster barrier recovery [5]. Black African women had more pyrrolidone carboxylic acid (PCA) levels on their cheek SC compared with Caucasian women, consistent with their better skin hydration status, but the Albino African women had a low skin hydration despite elevated PCA levels [8]. Moreover, cheek samples in all ethnic groups had a greater prevalence of more immature corneocyte envelopes (CEf) as measured by reduced Nile red/involucrin staining compared with the PA site, possibly indicating lowered lipid hydrophobicity of the corneocyte protein envelope (CPE), due to alterations in linoleoyl-omega-O-acylceramide processing. However, Albino Africans had dramatically reduced levels of mature corneocyte envelopes on both test sites together with corneocyte parakeratosis [8,13–18]. As a result, we were interested

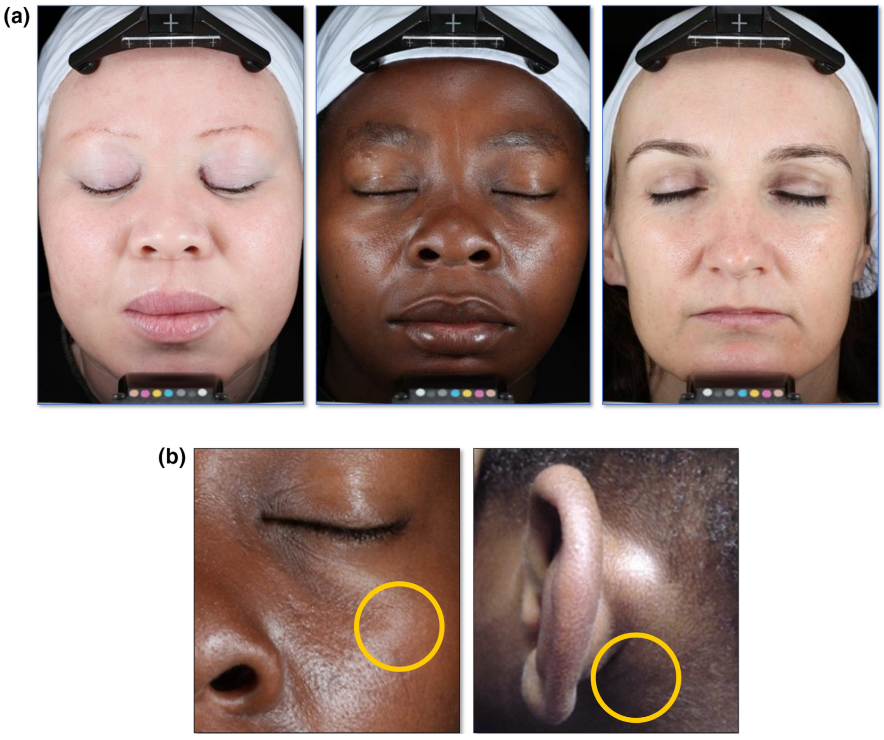


FIGURE 1 (a) Selection of representatives of the three study groups, from left Albino Africans, Black Africans, Caucasians. (b) Test sites for tape strippings, left sun-exposed cheek and sun-exposed postauricular area

in the SC omega-O-acylceramides and associated lipid processing enzyme biochemistry in Albino African, Black African and Caucasian women living in South Africa.

The 12 main intercellular ceramides observed in human SC are depicted in Figure 2 [10]. These are classified according to the original nomenclature of Motta et al [11]. The omega-O-acylceramides (CER EOS, CER EOP, CER EOds and CER EOH) have their linoleoyl esterified fatty acid components modified, de-esterified and the resulting omega-hydroxy acylceramide is attached to the corneocyte protein envelope, e.g. CER OS, etc. [12]. The enzymes responsible for linoleoyl-omega-hydroxy acylceramide processing are shown in Figure 3 [10,13–18]. 12R-lipoxygenase (12R-LOX) oxygenates the linoleic acid attached to the omega-O-acylceramide species (CER EOX) [14,15], epidermal lipoxygenase-3 (e-LOX3) then isomerizes the resulting hydroperoxide [16], which is then dehydrogenated by short-chain dehydrogenase/reductase family 9C member 7 (SDR9C7) [17] or converted to a linoleoyl triol by (EPHX3) [18] and cleaved by an unknown esterase. The latter two products are then attached to the corneocyte envelope by transglutaminase 1 (TG1) [13,17]. The SDR9C7 product may also attach to the corneocyte protein envelope (CPE) through a reversible covalent binding [17].

Decreased ceramide levels and altered biochemistry together with lamellar ultrastructure are known to occur in seasonally dry, diseased and aged skin [19–29]. Equally, seasonal and dry skin-induced changes in CE maturation and associated covalently bound ceramide content are also described [30–33]. However, as far as we are aware there is a no study examining facial ceramide biochemistry on SC among different ethnic groups. Nevertheless, some report differences in SC lipid levels on the forearms among different ethnic groups, with reduced levels in African American women compared with Asian and Caucasian women living in the United States while others report on subjects of African and Asian descent together with Caucasian women living in Denmark [34–36]. The largest study of these studies identified a reduction in a highly selective class of ceramides (C18 phytosphingosine ceramides and the assumption was that all other ceramide species declined) in African American women [35]. Similar findings were observed by Sugino et al. [34]. The most recent study in Europe found no ethnic differences in the ceramide subtypes measured at that time, but there was a reduced total ceramide/cholesterol ratio in the African and an increase in this ratio in Asian study participants [36]. However, these analyses again were based on forearm SC samples, and we have recently shown no differences in the major 12 classes of ceramides on cheek samples from Black African and Caucasian women living in South Africa (the same subjects in this study) [37]. There are no studies examining SC ceramides in Albino African SC.

On photodamaged cheeks of Caucasians, we have previously reported decreased mass levels of 12R-LOX and eLOX3 but increased mass levels of TG1 and SDR9C7 measured by proteomics [38]. However, like 12R-LOX activity, transglutaminase activity was reduced despite its increased mass levels [39,40]. These lowered activities of these enzymes are likely contributing to the presence of immature corneocyte envelopes on their cheek samples compared with the PA site [8,41]. To date, there is no information on the levels and/or activities of these SC enzymes in Black African especially Albino African women who have the most dramatically lowered levels of mature corneocyte envelopes as far as we are aware [8].

Here, we report on the ceramidomic and proteomic analysis of SC samples taken from the cheek and PA areas of Albino African, Black African and Caucasian women living in South Africa. Proteomics data from the cheeks of Black African and Caucasian participants previously reported are included for completeness [37].

Omega-O-acylceramides

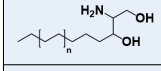
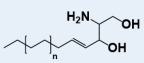
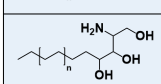
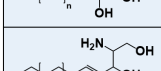
Sphingoid base ($C_{18}-C_{22}$) \ Fatty acid	Non-hydroxy fatty acid [N] ($C_{16}-C_{32}$)	α-hydroxy fatty acid [A] ($C_{16}-C_{32}$)	Esterified ω-hydroxy fatty acid [EO] ($C_{48}-C_{52}$)
 Dihydrosphingosine [DS]	CER[NDS]	CER[ADS]	CER[EODS]
 Sphingosine [S]	CER[NS]	CER[AS]	CER[EOS]
 Phytosphingosine [P]	CER[NP]	CER[AP]	CER[EOP]
 6-hydroxy sphingosine [H]	CER[NH]	CER[AH]	CER[EOH]

FIGURE 2 Structure and nomenclature of the major ceramide classes of human SC quantified with the current lipidomics method. Reproduced with permission from IFSCC Magazine [10]

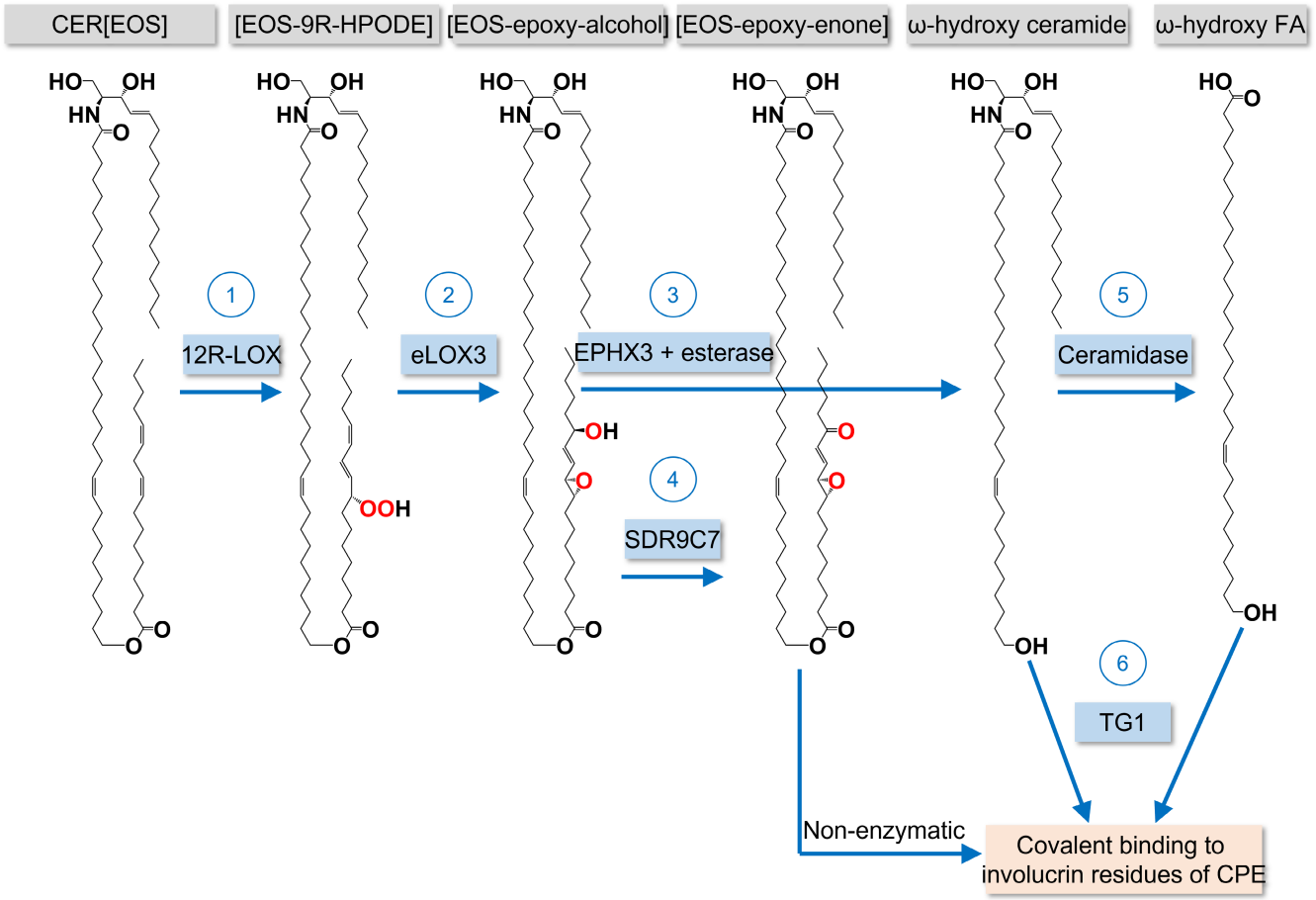


FIGURE 3 Enzyme cascade responsible for the formation of the cornified lipid envelope. (1) oxygenation, (2) isomerization, (3) ester cleavage, (4) dehydrogenation, (5) deamidation and (6) protein binding.
Reproduced with permission from IFSCC Magazine [10]

METHODS

Study population and methods

The study was a cross-sectional study and was approved from the School of Health Care Sciences Research and Ethics committee (SREC) together with the Medunsa Campus Research and Ethics Committee (MREC), South Africa, and was conducted in accordance with the Declaration of Helsinki Principles. Written, informed consent was obtained from all participants before enrolment as previously reported [5].

As part of a larger study, sixty healthy female volunteers, living in Pretoria, South Africa, participated in this observation [5]. There were three age- and count-matched groups (twenty subjects per group) of Albino African (40.3 ± 2.9 years old), Black African (38.2 ± 2.3 years old) and Caucasian women (44.6 ± 3.1 years old). The participants did not apply any dermatological or cosmetic products to their faces for 3 days before the start of the study. For the 3-day conditioning phase, the subjects cleansed the face with tepid water in the morning as well as in the afternoon. Before the evaluation, the skin was cleaned by gentle swabbing with a cotton pad soaked with distilled water of ambient temperature and allowed to dry for 20 min. Before any measurements and tape strippings, the participants were acclimatized for 30 min in a room at a temperature of 21 ± 1°C and 35 ± 10% relative humidity [5].

A subset of 24 participants (eight per ethnic group) was selected for the lipidomics and one of 18 participants (six per ethnic group) for proteomics analysis. One standard D-Squame® disk (Cuderm Corporation, Dallas, US) with a diameter of 2.2 cm was taken on the cheek (3 cm below the outer corner of the eye) and the PA area for the lipidomic analysis [42], and nine were taken for the proteomic analysis [38]. The tapes were applied with 225 g cm^{-2} of pressure with a pressure device (Cuderm Corporation, Dallas, US) for 5 s and then removed by a single stroke movement. To minimize variations, the procedure was conducted by the same technician for all volunteers, throughout the study. In order to enable the normalization of the samples, the SC protein content of the tape

strippings was quantified by infrared absorption measurements at 850 nm with SquameScan^{TM} 850A (Heiland electronic, Wetzlar, DE) [43].

The tape strippings of each participant were analyzed by a mass spectrometry–based shotgun lipidomics platform to define the facial ceramidome together with mass spectrometry–based proteomics to define the facial SC corneome, but in this case, only corneocyte envelope lipid processing enzymes are reported [38,42]. Omega-esterified hydroxy acylceramide fatty acids cannot be determined using the lipidomics method.

Ceramide measurements were normalized using the respective participant's SC protein mass of the facial site of the measurement (check or PA). A linear mixed model was fit to the log-transformed normalized data (pmol/μg protein) with ethnic group, facial site and its interaction as fixed effects and participant as random effect. We tested the impact of facial site per ethnic group, and the difference between ethnic groups per facial site and pooled across both sites. Due to the small sample size and the exploratory nature of the research, we refrained from any adjustments for multiplicity.

RESULTS AND DISCUSSION

SC lipidomics and ceramidomics

The total ceramide levels of the Albino Africans were higher than those from normally pigmented Black African and Caucasian women with the differences being statistically significant ($p < 0.05$) (Figure 4). This is in marked contrast to the increased basal TEWL in the Albino African group as reported earlier [5] and points to abnormalities in ceramide composition, localization and/or utilization for corneocyte lipid envelope (CLE) attachment as we

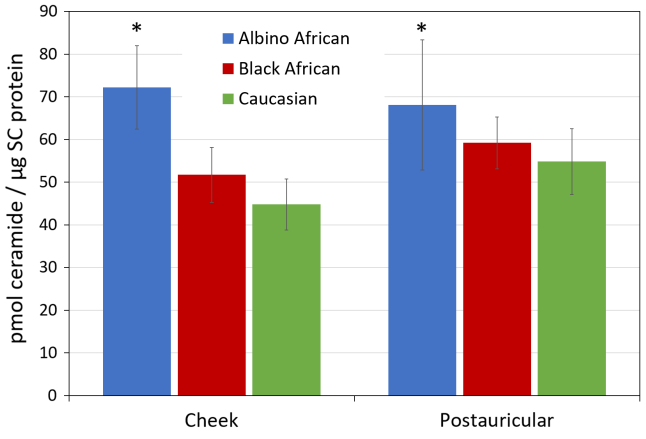


FIGURE 4 Total ceramide levels on cheek and PA sites for the three ethnic groups. Data are mean ±SEM. * $p < 0.05$ Albino Africans vs Black Africans and Caucasians

previously observed in our corneocyte maturation studies [8]. There were minor differences between the PA and the cheek sites, but these were not statistically different.

The findings between the Black African and Caucasian women are similar to that of Jungersted et al. [36] but completely different to that of Sugino et al. [34] and Muizzudin et al. [35]. The differences to the latter two studies may be due to effects of the exposome on the skin and differences in test sites and ethnicity, but methodological differences may also be contributing. Although the study of Muizzuddin et al. was larger, it was conducted on forearm SC [35]. Aside from the anatomical location differences, they used a highly selective approach to measuring just C18 phytosphingosine ceramide bases. Phytosphingosine bases represent approximately 30–35% of ceramides [12] and the C18 sphingoid chain length is only 25% of these [44]. As a result, these findings are not representative of both the total SC ceramides as well as their subtypes levels. Nevertheless, the findings of elevated total ceramides in the Albino Africans cannot account for their impaired barrier function.

Comparing the different 12 types of ceramides between the Black African and Caucasian women, their profiles were largely similar on both testing sites, but on examining to the Albino African women, CER AS was elevated compared with the Caucasian women ($p < 0.05$). However, greater differences were observed for the long-chain omega-O-acylceramides. On the cheek compared with the Black African women, CER EOP and EOds were elevated, whereas CER EOS and EOH were elevated compared with the Caucasian women ($p < 0.05$). On the PA sites, only CER EOP when compared with the Black African women and EOds compared with both ethnicities reached significance ($p < 0.05$) (Figure 5).

Comparing within the cheek and PA sites for each ethnicity, differences were also observed with decreasing CER NP and AdS levels for the Caucasian and Black African participants together with decreasing CER NdS for the Black Africans ($p < 0.05$) (not shown). Although not statistically significant, numerical increases in the levels of all omega-O-acylceramides in the Albino Africans together with CER EOP and EOdS in the Black Africans were observed on their cheeks. No differences in ceramide chain lengths were observed in any comparison.

The lack of statistical differences for the ceramide subtypes between the Black African and Caucasian women is similar to that of Jungersted et al. [36], even though the methodology at that time could only measure seven ceramide subtypes but the findings of elevated levels in the Albino Africans are novel. They did, however, find reduced ceramide/cholesterol levels in the participants of African descent in their study compared with the other ethnic groups. Nevertheless, although the ratios were

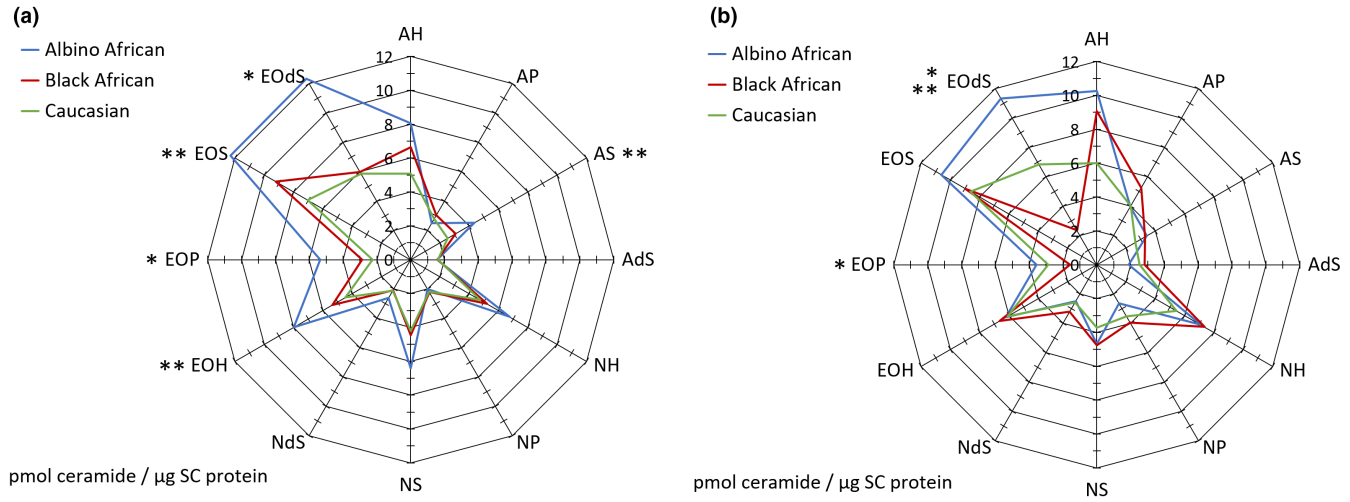


FIGURE 5 Distribution of the 12 major ceramide classes in cheek and PA sites among the three ethnic groups. a: Cheek site. b: PA site. * $p < 0.05$ Albino Africans vs Black Africans, ** $p < 0.05$ Albino Africans vs Caucasians

raised in the Albino and Black Africans, they were not significantly different (not shown).

The importance of CER EOS levels for barrier function is well established [45]. However, if CER EOS is replaced with CER EOP, a disrupted barrier structure is apparent [46]. Indeed, CER EOP is reported as a weaker barrier component [47]. Moreover, too high a concentration of acyl ceramide levels is also associated with a weaker barrier [48,49]. Furthermore, the types of fatty acids esterified to the omega-hydroxy groups of such omega-O-acylceramides also dictate their behaviour [50,51]. However, this was beyond the scope of our analysis.

SC proteomics of corneocyte lipid envelope processing enzymes

The elevated omega-O-acylceramides observed in the Albino African women may indicate one of the reasons for additional corneocyte lipid scaffold and corneocyte maturation abnormality we observed in the Albino Africans previously, namely elevated levels of immature corneocytes [8]. Omega-O-acylceramides, especially the linoleate-containing ones, are used in a complex enzymatic process to attach ceramides to the corneocyte protein envelope (CPE) [13–18]. Reduced levels of 12R-LOX and eLOX3 were reported in photodamaged cheek SC previously from Caucasian women and 12R-LOX in Chinese subjects [38–40]. In this study, we observed that the mass levels of 12R-LOX and eLOX3 were equivocal in all three ethnic groups indicating a lipoxygenase-relevant corneocyte maturation insufficiency in all ethnicities (Table 1A-C). Not only can these differences possibly contribute to the presence of immature and fragile CEs on the photodamaged SC site from all three ethnicities that we reported previously [8], but the excessive amounts of fragile CEs in the Albino Africans are not solely related to these particular enzyme levels. SDR9C7 is also purported to be involved in the linoleoyl-omega-O-acylceramide transformation process, and its mass levels were equally reduced in the Albino African subjects compared with the other two ethnicities (Table 1C) [13–18]. A reduction of at least these three enzymes involved in the process of corneocyte lipid envelope (CLE) formation are probably contributing to the clear lipid scaffold disorder in the Albino African subjects. These changes could be related to the extra photodamage on these subjects [5]. Indeed, similar to our previous results [5], a thickening of the SC is known in subjects with Albinism [52]. Moreover, following UV irradiation, Meguro et al. [53] has shown elevated TEWL associated with reduced covalently bound ceramides while Takagi et al. [54] has shown increased levels of CER EOS and EOH together with CER AS and AP and also reductions in corneocyte covalently bound ceramide levels.

Takagi et al. [54] have shown decreased TG1 expression following UV irradiation, but Lee et al. have shown increased activity [55]. However, overall, 12-LOX expression is reported to be decreased [56]. This latter study did not consider 12R-LOX. Reductions in 12R-LOX are expected to be associated with reduced filaggrin processing [57], but at the phenotype levels the Albino Africans have greater quantities of NMF [8]. These increases are more likely to be associated with their excessive photodamage that is known to increase filaggrin levels [55]. Activity measurements of the enzymes need to be conducted to decipher these differences as well as the fatty acid composition of

TABLE 1 Fold changes in 12R-LOX, eLOX3, SDR9C7 and TG1 between (A) cheek and postauricular sites for each ethnicity; (B) differences among postauricular site for all ethnicities; and (C) differences among cheek site for all ethnicities. Data are mean ±SEM

		Albino African			Black African			Caucasian		
Protein names	**Gene names**	**Fold change**	***p*-value**	***q*-value**	**Fold change**	***p*-value**	***q*-value**	**Fold change**	***p*-value**	***q*-value**
(A) Comparison cheek vs postauricular										
Arachidonate 12-lipoxygenase (12R-LOX)	ALOX12B	0.72	n.s.	<0.05	0.25	<0.001	<0.001	0.31	<0.001	<0.001
Hydroperoxide isomerase (eLOX3)	ALOXE3	0.73	n.s.	<0.05	0.56	n.s.	<0.05	1.02	n.s.	n.s.
Short-chain dehydrogenase/reductase family 9C member 7 (SDR9C7)	SDR9C7	0.97	n.s.	n.s.	0.97	<0.05	<0.01	1.52	<0.001	<0.001
Transglutaminase 1 (TG1)	TGM1	1.48	n.s.	n.s.	1.93	n.s.	n.s.	1.47	<0.01	<0.01
		Albino African vs Black African			**Albino African vs Caucasian**			**Black African vs Caucasian**		
Protein names	**Gene names**	**Fold change**	***p*-value**	***q*-value**	**Fold change**	***p*-value**	***q*-value**	**Fold change**	***p*-value**	***q*-value**
(B) Comparison A vs B vs C, postauricular										
Arachidonate 12-lipoxygenase (12R-LOX)	ALOX12B	0.30	<0.01	<0.01	0.37	<0.05	<0.05	1.24	n.s.	n.s.
Hydroperoxide isomerase (eLOX3)	ALOXE3	0.68	n.s.	n.s.	1.00	n.s.	n.s.	1.48	n.s.	n.s.
Short-chain dehydrogenase/reductase family 9C member 7 (SDR9C7)	SDR9C7	0.58	n.s.	n.s.	0.85	n.s.	n.s.	1.46	n.s.	n.s.
Transglutaminase 1 (TG1)	TGM1	1.14	n.s.	n.s.	1.05	n.s.	n.s.	0.92	n.s.	n.s.
(C) Comparison A vs B vs C, cheek										
Arachidonate 12-lipoxygenase (12R-LOX)	ALOX12B	0.86	n.s.	n.s.	0.86	n.s.	n.s.	1.00	n.s.	n.s.
Hydroperoxide isomerase (eLOX3)	ALOXE3	0.88	n.s.	n.s.	0.72	n.s.	n.s.	0.81	n.s.	n.s.
Short-chain dehydrogenase/reductase family 9C member 7 (SDR9C7)	SDR9C7	0.58	<0.05	n.s.	0.55	<0.05	n.s.	0.94	n.s.	n.s.
Transglutaminase 1 (TG1)	TGM1	0.88	n.s.	n.s.	1.05	n.s.	n.s.	1.20	n.s.	n.s.

the omega-O-acylceramides that are found to be increased in these study participants.

One of the limitations of this study is its small sample size, but it is the first, to our knowledge, comparing the SC ceramidome among these three ethnic groups living in South Africa. More work is needed to study other facial locations especially as these are reported to be different physiologically and biochemically [5–9,41]. Moreover, intercellular lipid structure and lipid biophysical behaviour need to be determined. Nevertheless, to fully understand the impact of our findings, we need to determine the precise composition of the corneocyte lipid envelope (CLE), resolve the composition of esterified fatty acid component of the omega-O-acylceramides and measure the enzyme activities, rather than just their mass levels, of the relevant enzymes in the different ethnicities.

CONCLUSIONS

Using shotgun mass spectrometry lipidomics, we demonstrate that there is no ethnic difference in facial ceramide levels or ceramide subtypes between Black African and Caucasian women living in South Africa. However, elevated total ceramides and excessively elevated omega-O-acylceramides are apparent in the Albino African women. The former was unexpected as these participants have an impaired skin barrier function, but the latter can contribute to this deficiency by directly impacting SC lipid-phase behaviour for the worse or indicating a reduced lipid attachment and corneocyte maturation process. Indeed, differences in the mass levels of omega-O-acylceramide processing enzymes were observed for 12R-LOX and SDR9C7 for the Albino Africans. These differences are likely to account for the reduced corneocyte maturation in these subjects. This indicates that induction/activation of these enzymes is required to correct the corneocyte lipid scaffold disorder in these subjects and topical use of all omega-O-acylceramide subtypes may not be advisable for all skin types.

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CONFLICT OF INTEREST

There is no conflict of interests.

ORCID

Anthony V. Rawlings https://orcid.org/0000-0003-4740-6502
Rainer Voegeli https://orcid.org/0000-0002-3951-0329

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