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The Science of Deodorants

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Abstract

Deodorants are cosmetic products that are consumed by people regularly and globally. In this thesis, the opportunities to develop a deodorant for the Swedish cosmetics brand IDUN Minerals AB is investigated. The deodorant market in Swedish pharmacies, deodorant formulation and deodorant packaging are studied. Furthermore, controversial ingredients, such as synthetic aluminum compounds, are explored.

The scientific aspects of using synthetic aluminum compounds, which are used as antiperspirant in deodorants, are investigated. There is a general fear that they may increase the risk of developing breast cancer. However, after a full review of exciting scientific evidence, it is clear that there is currently no study that can prove or disprove the suspicions. The use of aluminum-based antiperspirants therefore continues to be a controversial topic.

The conclusion of this thesis is that there is a market opening for IDUN Minerals, especially since they aim for a synthetic aluminum-free, unperfumed and preservative-free deodorant. Furthermore, it is concluded that a Nordic Swan Ecolabel would make their product unique in its product category. Lastly, it is determined that traditional plastic packaging is more accessible and possesses many favorable properties, but that bioplastics should be further researched.

Sammanfattning

Deodoranter är kosmetiska produkter som dagligen används av människor världen över. I denna rapport undersöks möjligheterna att implementera en deodorant i det svenska kosmetikföretaget IDUN Minerals AB:s produktsortiment. I rapporten kartläggs deodorantsortimentet på svenska apotek, samtidigt som deodoranters innehåll och paketering undersökts. Vidare granskas kontroversiella ingredienser, såsom syntetiska aluminiumföreningar.

Syntetiska aluminiumföreningar, vilka används som antiperspiranter i deodoranter, misstänks öka risken för bröstcancer hos människor. Efter en fullständig genomgång av befintliga studier kan det dock fastställas att det inte finns någon studie som kan bevisa eller motbevisa misstankarna. Användningen av aluminiumbaserade antiperspiranter fortsätter därför att vara ett kontroversiellt ämne.

Slutsatsen av denna rapport är att det finns en marknadsöppning för IDUN Minerals, särskilt eftersom företaget strävar mot en deodorant utan syntetiska aluminumsalter, parfym eller konserveringsmedel. Dessutom kan slutsatsen dras att en eventuell Svanen-märkning skulle göra deodoranten unik i sin produktkategori. Slutligen har det fastställts att traditionella plastförpackningar är mer tillgängliga och att de erbjuder fördelaktiga egenskaper, men att bioplaster fortfarande bör undersökas ytterligare.

Acknowledgements

I would like to thank Caroline Thunstedt at IDUN Minerals AB for giving me the opportunity to write my thesis for them and for letting me gain insights into the cosmetics industry.

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1 Introduction

The cosmetic industry is a global multibillion-dollar industry, whose estimated value was 532 billion USD in 2017. [1] Cosmetics is generally divided into the following product categories: skincare, haircare, color cosmetics, fragrances, and personal care. The segmentation between the different product categories is viewed in Table 1. [2]

Table 1. Segmentation between different cosmetics categories. [2]

Product category	**%**
Skincare	30
Haircare	25
Color cosmetics	20
Fragrances	10
Personal care	15

The Swedish cosmetics company IDUN Minerals has an objective to investigate the prospects of introducing a deodorant to their product collection. Deodorants are one of many products that are categorized as personal care products, which correspond to 15 % of all purchased cosmetics [2].

The aim of this thesis is to broadly investigate the deodorant market, product formulation and product packaging, to eventually be able to offer IDUN Minerals a recommendation that would suit the customers as well as the company's values.

IDUN Minerals offers a wide range of cosmetic products, including color cosmetics (make-up), haircare and skincare. The brand logo is viewed in Figure 1. The products are well-suited for people with sensitive skin, since they are based on highly purified minerals and are predominantly unperfumed. Additionally, the company's products are vegan. An example of a product is their mineral foundation, which merely contains highly purified minerals and is recommended by the Swedish *Astma- och Allergiförbundet* (Asthma and Allergy Foundation). [3]

Figure 1. IDUN Minerals logo. [3]

IDUN Minerals mainly sell their products in Swedish pharmacies, where they target a wide range of customers. [3]

This thesis, which can be described as a pilot study, is primarily based on academic resources that can be found on the internet. The market analysis mainly focuses on competing products, market openings and trends. The study of the chemical content includes academic research about controversial ingredients, such as aluminum compounds. Lastly, the chemical product content and product packaging is investigated from an environmental perspective.

2 How to develop a new product

Developing a new cosmetic product takes time. Besides manufacturing the actual formula and packaging, product development requires rigorous research and testing. The general timeline for the development of a new cosmetic product is viewed in Figure 2. On average, it takes a year to complete the timeline. [4]

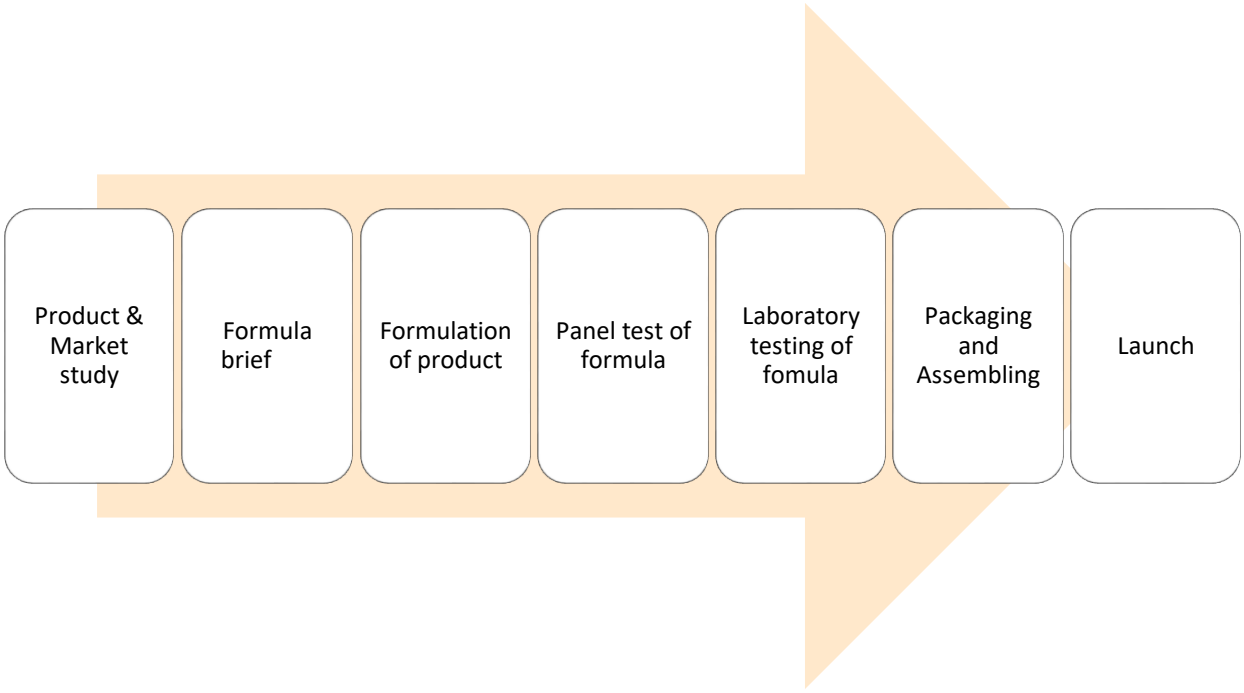

Figure 2. Timeline for cosmetic product development. [4]

2.1 Product and Market study

The first step in the timeline is to do research about the product as well as the market. Common areas to research are competing products, market opportunities and trends. [4]

2.2 Formula Brief

A formula brief is a concise description of the desired product. The purpose of a formula brief is to give the formulation specialists a good overview of what the company is trying to pursue. [4]

Completing a formula brief is an early step in the development of the new product formula. [4] A template of a formula brief, received from a Swedish supplier, is viewed in Figure 3 in Appendix 2 [5].

2.3 Formulation of product

The product formulation is conducted by formulation specialists. In the case of IDUN Minerals, formulation and manufacturing are outsourced to a supplier. Outsourcing is common among smaller companies. [4]

2.4 Panel test of formula

When the formula is finished, it will be sampled and tested by a panel (10 – 30 people). The purpose of the panel test is to get feedback on the formula. Slight modifications of the formula or complete reformulation will be done until the quality is approved. [4]

2.5 Laboratory testing of product

Several tests are performed on the final formula. These include a formula stability test, a formula-packaging compatibility test, a challenge test and a dermatological test, as defined below. [4]

- Formula test

  Studies how the product quality varies with time.

- Formula-packaging compatibility test

  Studies how the chemical content and packaging interact with each other.

- Challenge test

  Studies the effectiveness of the preservatives to make sure bacteria, mold and yeast cannot grow.

- Dermatological test

  A dermatologist studies how the skin reacts to the ingredients in the product.

2.6 Packaging & Assembling

The product packaging may sometimes be offered by the product formula supplier. If not, the packaging needs to be selected and ordered from a separate supplier. The packaging units are thereafter filled with product at the formulation supplier facility. [4]

2.7 Launch

When all of the above have been completed, the product can be launched. [4]

3 The biology of the axilla

Knowledge about the axilla (usually called armpit in everyday language) is crucial when it comes to developing new underarm products.

3.1 Axillary sweat glands

The axilla contains three different types of sweat glands. These are the eccrine, apocrine and apoeccrine sweat glands. Eccrine sweat glands exist nearly everywhere on the human body and are especially present in palms and soles. In contrast to apocrine and apoeccrine sweat glands, eccrine sweat glands are active at birth. [6]

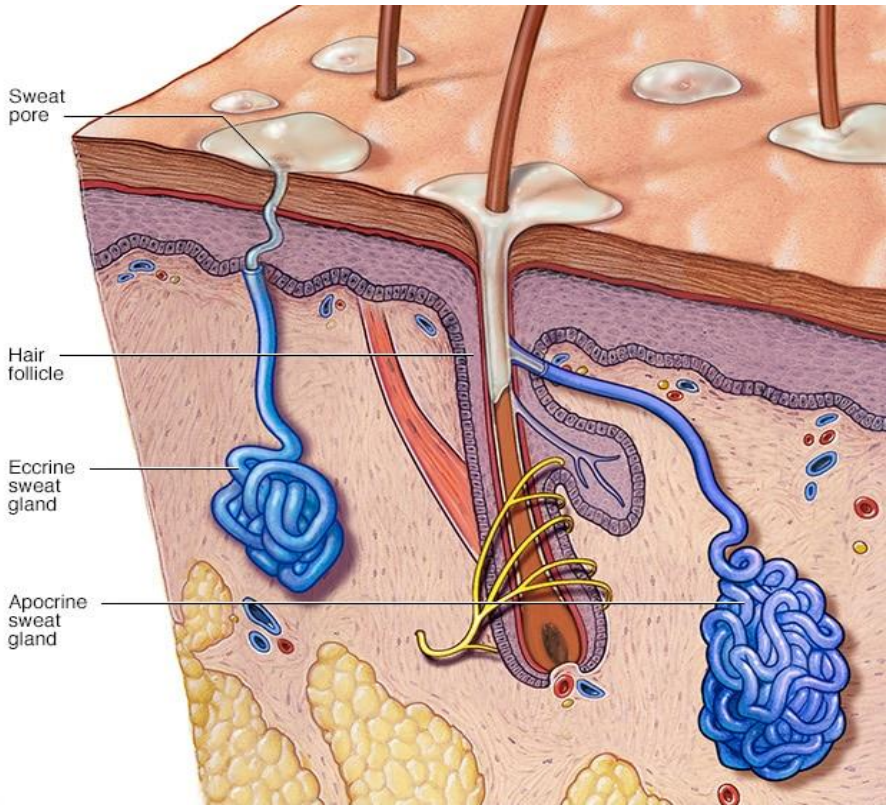

Figure 4. A close-up of the eccrine and apocrine sweat glands. [7]

Apocrine sweat glands become active during puberty. As Viewed in Figure 4, the apocrine sweat gland is connected to a hair follicle. Thus, apocrine sweat glands are limited to the hairy areas of the body, such as the axilla, genitalia, areola and the ear canal. [6][8]

The third and final type of sweat gland, the apoeccrine, is a hybrid of the eccrine and apocrine sweat gland. It develops from eccrine sweat glands during puberty. Usually, a large portion of the axillary sweat glands are apoeccrine. [6]

All three types of sweat glands are coiled tubes, with the apocrine being the largest of them. [6]

3.2 Axillary perspiration

Perspiration is a way for the human body to down-regulate its body temperature. Body temperature down-regulation is essential for survival, since overheating can lead to the life-threatening condition hyperthermia. Besides body temperature, perspiration can also be triggered by emotions, e.g. anxiety, as well as consumption of spicy foods. [6]

The eccrine sweat glands oversee thermoregulation in the form of temperature down-regulation. Eccrine perspiration primarily consists of a water (99%), in which salts, as well as lactate and other organic substances are diluted. [8] When eccrine perspiration occurs on the surface of the skin, the water in the perspiration will start to evaporate. Evaporation is an energy consuming process in which heat is absorbed from the skin, immediately causing cooling of the body. [6]

Apocrine perspiration is different from eccrine perspiration and does not play a role in thermoregulation. The perspiration from the apocrine sweat gland consist of lipids, proteins and steroids. It is oily in the consistency and odorless. [6] The initial purpose of the lipid rich apocrine perspiration is believed to be scent related. [8]

Apoeccrine perspiration has a watery consistency, similar to eccrine perspiration. [6]

3.3 Microflora of the Axilla

The axilla, with its various nutrient rich sweat gland secretions, creates a perfect environment for bacterial growth. [9] Several different bacteria are present in the axilla. The most common species of bacteria in the axilla are Staphylococcus, Corynebacterium and Propionibacterium. Species of bacteria that are less common, although still present in the axilla, are Anaerococcus and Peptoniphilus. [8]

3.4 Formation of body odor

Axillary odor occurs when organic molecules present in perspiration, especially apocrine perspiration, get metabolized by bacteria. The watery eccrine perspiration mostly adds moisture which favors bacterial growth and spreads the apocrine perspiration. [8]

Two main contributors to body odor are medium-chain (6 to 8 carbon atoms) acids as well as thialcohols. Both the medium chain acids and the thialcohols are produced from odorless compounds. For instance, the malodourous medium-chain acids are produced from N-acylglutamine molecules. [8]

One of the most pungent thioalcohols is produced by a bacterium called Staphylococcus Hominis. The exact mechanism in which the odorless molecule (3-methyl-3-sulfanylhexan-1-ol*)* is metabolized into the malodourous thialcohol (S-Cys-Gly-3M3SH) is viewed in Figure 5. [8]

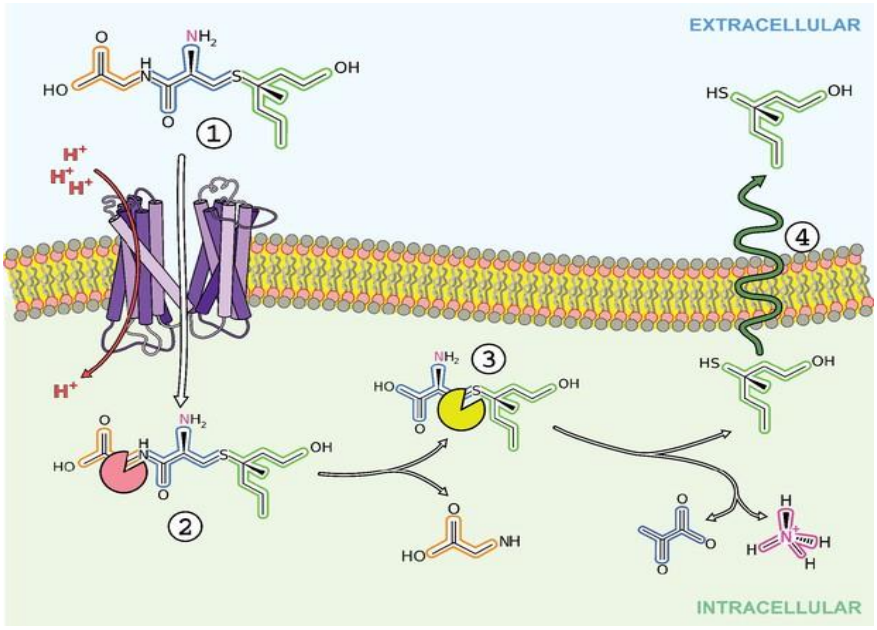

Figure 5. 3-methyl-3-sulfanylhexan-1-ol (3M3SH) is produced from S-Cys-Gly-3M3SH by Staphylococcus Hominis. [8]

4 Underarm products

Prevention of axillary odor is not a modern phenomenon, but rather underarm products have been used for centuries. Even the ancient Egyptians and Romans had their remedies for body odor. [10]

There are countless underarm products on the market today, most of which are focused on preventing axillary odor. Products focused on preventing axillary odor are generally known as deodorants and antiperspirants.

4.1 Deodorants & antiperspirants

Deodorants and antiperspirants counteract malodor in different ways. Deodorants contain antibacterial agents that help to kill bacteria and reduce bacterial growth. [11] Conversely, antiperspirants temporarily prevent perspiration from exiting to the surface of the skin. [12]

According to the FDA (U.S. Food and Drug Administration), antiperspirant is considered a drug and not a cosmetic product. The only FDA approved antiperspirants are aluminum-based, thus containing aluminum compounds. There are several different aluminum compounds that can be used, of which the most common ones are aluminum chlorohydrate, aluminum zirconium and aluminum chloride. [12]

Aluminum-based compounds have an ability to form a temporary plug in the eccrine sweat glands. The plug will create a blockage, preventing sweat from exiting to the surface. A study published in 2017 was able to demonstrate how this plug is formed. In this particular study, the researchers used aluminum chlorohydrate as the active ingredient, which is one of the most commonly used aluminum compound in antiperspirants. [13]

The first step in the plugging process is the formation of a membrane. This membrane is formed by aluminum polycations reacting with proteins present in the eccrine sweat. When this reaction occurs, the proteins are aggregated by the aluminum polycations. After the membrane has formed, proteins will continue to aggregate, eventually leading to a plug. The plug forming process is viewed in Figure 6. [13]

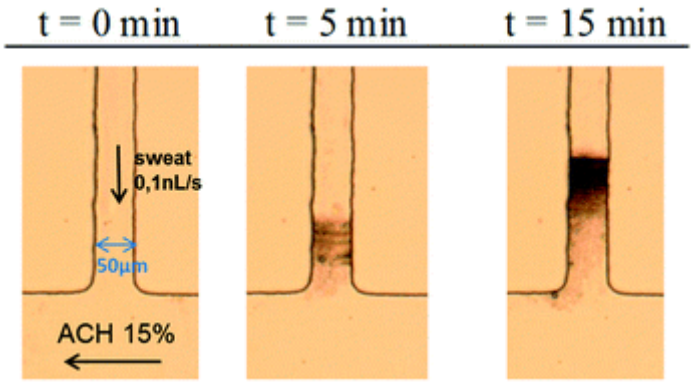

Figure 6. Formation of a plug in a mimic of an eccrine sweat gland. [13]

4.2 Aluminum controversy

The safety of aluminum salts in underarm products has been debated for decades and continues to be a controversial topic. Some people claim that regular usage of aluminum-based antiperspirants can increase the risk of developing certain illnesses, such as breast-cancer and Alzheimer's disease. [12] Due to the controversy, several studies have been conducted in the field. All of the studies mentioned below have been completed relatively recently.

Studies have shown that aluminum can be absorbed through the skin, and that dermal uptake is significantly higher when antiperspirant is applied to damaged skin (e.g. freshly shaved skin). However, it is important to acknowledge that these amounts are still very small. [14]

Several studies have also been performed on the relationship between aluminum-based antiperspirants and breast-cancer. Even though some of them demonstrate alarming results, there is still no study that can prove that there is a direct link between antiperspirant usage and breast cancer.

One study that was published in 2015 demonstrated that aluminum chloride and aluminum chlorohydrate applied *in vitro* caused changes to the DNA repair of human breast epithelial cells. [15] Another Swiss study published in 2016 proved that aluminum chloride caused tumorigenesis and metastasis in mice. [16] The study got a lot of attention and made Switzerland the first country in the world to consider a ban on aluminum-based underarm products. However, since the study was made on mice, and not humans, it is not considered adequate. [17] Consequently, in order to be able to fully claim that aluminum-based antiperspirants can cause physical harm to humans, more research needs to be completed

5 Formulation of deodorants

There are different types of deodorants. The main types are roll-on (liquid), stick (solid) and spray and less common types are creams, wipes and powders. [11] Roll-on deodorant is more popular in Europe, while stick is more popular in North America. [10]

5.1 Ingredients

Many different ingredients are present in deodorants. These are viewed in Table 2. [10]

Table 2. Formulation of deodorants and antiperspirants. [10]

Ingredient	Function	Commonly used substances
Antibacterials	Kill bacteria and prevent bacteria from reproducing	*Triclosan, ethanol*
Antiperspirants	Stop axillary perspiration	*Aluminum chloride, aluminum chlorohydrate*
Solvents	Disperse the ingredients evenly	*Water, propylene glycol*
Fragrances	Add scent and mask odor	*Essential oils, synthetic fragrance oils*
Fixatives	Make fragrance compounds blend with the rest	*Benzyl Salicylate*
Conditioners & Humectants	Make the skin soft and moisturized, and maintain moistness of product	*Glycerin, oils, dimethicone*
Preservatives	Maintain freshness of product	*Potassium sorbate, phenoxyethanol, sodium benzoate, Parabens*
Chelating agents	Boost preservation and stabilize product	*Tetrasodium EDTA, disodium EDTA, hydrogenated castor oil*
pH adjusters	Maintain desired pH	*Citric acid, sodium bicarbonate*
Propellants (spray)	Deliver product to the skin	*Butance, propane, Isobutane*
Surfactants & Gelling agents (roll-on & stick)	Help with product consistency	*Cetyl alcohol, Glycerin, Gums*
Absorbing agents	Absorb moisture and oil	*Silica, talc*
Colorants	Make product aesthetically pleasing	*Brilliant Blue FCF*

5.1.1 Antibacterials

See section *4.1 Deodorant & antiperspirant*

5.1.2 Antiperspirants

See section *4.1 Deodorant & antiperspirant*

5.1.3 Solvents

Solvents help dilute the product ingredients in order to distribute them evenly. Water is a popular polar solvent in cosmetic products. [11]

5.1.4 Fragrances

Fragrance is added to deodorants for two reasons: to add nice scents or to mask unpleasant smells. Unpleasant smells arise from the product ingredients or the axilla. There are different forms of fragrances, in which the main ones are essential oils, natural fragrance oils and synthetic fragrance oils. [11]

Essential oils are derived from plants, usually via a process called steam distillation. The aroma in the end product varies by batch. Essential oils are fully natural, possess a pleasant scent and usually hold skin-beneficial properties. [11]

Synthetic fragrance oils contain compounds that have been produced by scientists in a lab. Unlike essential oils, the aroma in the end product is the same for all batches. Synthetic fragrance oils are cheaper than both essential oils and natural fragrance oils. [11]

The production of natural fragrance oils is similar to the production of synthetic fragrance oils. However, natural fragrance oils are made from compounds that have been naturally derived, e.g. from essential oils and extracts. [11]

5.1.5 Fixatives

Fixatives are used in deodorants to make the fragrance compounds stick to the remaining ingredients. A common fixative is Benzyl Salicylate. [10]

5.1.6 Conditioners

Humectants, emollients and occlusives are all important conditioning and moisturizing agents. [18]

Humectants attract water and therefore help adding and retaining water. Besides adding moisture to the skin, humectants will help prevent products from drying out. Two commonly used humectants are glycerin and hyaluronic acid. [18]

Emollients are different from humectants. They do not add moisture like humectants, but they help improve the texture of the skin by filling in smaller cracks within the skin. Emollients also adjust the product application experience, for example by improving the spreadability of the product. Common emollients are oils and silicones. [18]

Occlusives work by forming a thin film. This film acts as a barrier toward water loss, and therefore helps the skin stay moisturized. Common occlusives are petrolatum, dimethicone and mineral oil, of which petrolatum is especially effective. [18]

5.1.7 Preservatives

Preservatives are used in cosmetic products to prevent growth of bacteria, mold and yeast. Broad-spectrum preservatives are able to act against all three of them simultaneously. The efficacy of preservatives is affected by the product pH level, and it is therefore important to keep the product within a certain pH range, dependent on the preservative that is used. [11]

Commonly used preservatives are potassium sorbate, phenoxyethanol, sodium benzoate and parabens. [10]

5.1.8 Chelating agents

Chelating agents are good for improving product stability, preventing mineral build-up and discoloration, and enhancing the preservation system. They act by binding to metal ions present in the cosmetic product. When the metal ions are bonded to the chelating agent, they become inaccessible for microorganisms, which require them in order to survive. [11] Common chelating agents are tetrasodium EDTA, disodium EDTA and hydrogenated castor oil. [10] [11]

5.1.9 pH adjusters

pH adjusters are used in cosmetic products to make them maintain a desired pH level. Common substances for lowering the pH are citric acid and lactic acid, while common substances for increasing the pH are sodium hydroxide and sodium bicarbonate. [11]

5.1.10 Surfactants & Gelling agents

Surfactants (Surface Active Agents) have various purposes in cosmetics. They can act as detergents, wetting agents, thickening agents, foaming agents and emulsifying agents. A well-known surfactant is soap, but in deodorants, surfactants are mostly used for their thickening and emulsifying properties. [18]

The structure of the surfactant is viewed in Figure 7. [19] It has a polar hydrophilic head and non-polar hydrophobic tail. The polar head is water-soluble, and the non-polar tail is oil-soluble. [18]

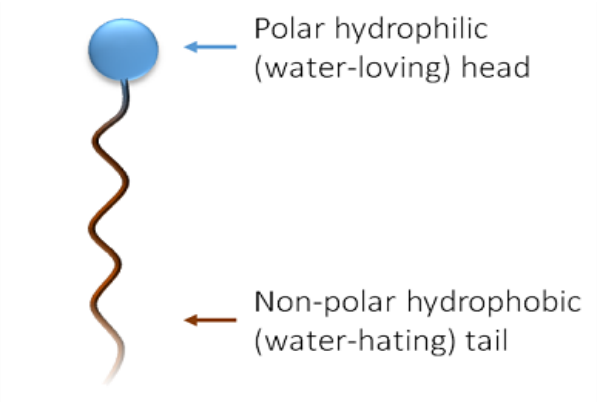

Figure 7. Surfactant structure. [19]

The hydrophobic tail consists of a hydrocarbon chain. The hydrophilic head can either be anionic (negative), cationic (positive), amphoteric (both positive or negative depending on the pH) or nonionic, as viewed in Figure 8. Its charge determines the function of the surfactant, as viewed in Table 3. [18]

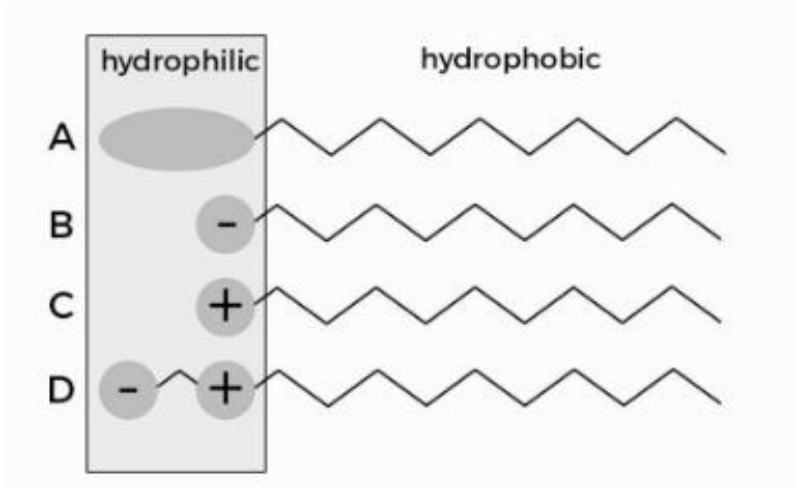

Figure 8. Surfactants with different charges on their hydrophilic head. [11]

Table 3. Functions of different surfactants. [18]

Surfactant	**Function**
Anionic	Deterging, foaming
Cationic	Conditioning
Amphoteric	Deterging, thickening, foaming (form smaller bubbles than anionic)
Nonionic	Emulsifying, foam enhancing, thickening, conditioning, gently deterging

Emulsification plays an important role in cosmetics overall, since most formulations contain substances that will not naturally mix. What an emulsifying surfactant will do is to help form a stable emulsion by interacting with two or more substances simultaneously. [20]

In Figure 9, the surfactants act in an o/w (oil in water) emulsion. Water is a polar substance and oil is non-polar substance. The hydrophobic tails are attracted to the oil, while the

hydrophilic heads are attracted to the water, forming a structure called a micelle. Conversely, if the surfactants act in a w/o (water in oil) emulsion, the micelle will be inversed, pointing the hydrophilic heads inwards towards the water droplet and the hydrophobic tails outwards towards the oil. [20] In the case of thickening of an emulsion, the denser the micelles are packed, the thicker the solution will become. [18]

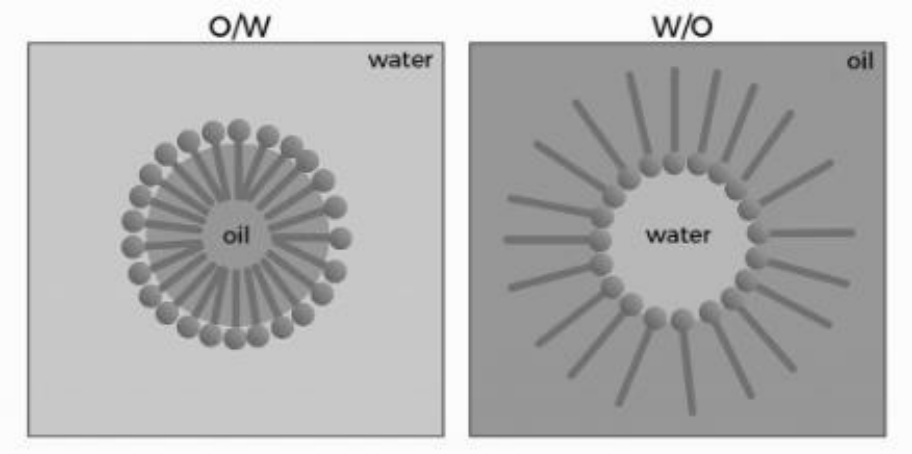

Figure 9. Micelle formation in a o/w emulsion vs. micelle formation in a w/o emulsion. [11]

Another ingredient that is used to thicken or stabilize cosmetic products is a gelling agent. Examples of commonly used gelling agents are gums. Gums are categorized as natural aqueous thickeners and are usually plant-based. However, gums can also be produced from animal and microbial sources. [11]

Plant-based gums are produced from various extracts, such as seed extracts, seaweed extracts and tree extracts. Furthermore, gums are made from shrub and tree exudates. There are many different gums available on the market, of which a few of them are listed in Table 4. [11]

Table 4. Plant-based, microbial-based and animal-based gums.

Gums	
Plant-based	Guar gum
Microbial-based	Xanthan gum
Animal-based	Gelatin

5.1.11 Propellants

Propellants are used in spray deodorants. The propellant helps carry the ingredients from the spray bottle to the skin by forming an aerosol. An aerosol is a fine mist, containing both gas (propellant) and liquid (remaining ingredients). The propellant is present in liquid form in the spray can due to the high can pressure (2 - 8 times higher than atmospheric pressure)

with which it is mixed with the other ingredients. When the spray can pressure is released at application, the propellant quickly evaporates and an aerosol is created. [21]

Common propellants are butane, propane and isobutane. [10]

5.1.12 Absorbing agents

Absorbing agents are particularly useful in deodorants that do not contain antiperspirant, since an aluminum-free deodorant will allow for more eccrine perspiration to exit through the pores. Silica and talc are examples of substances that are able to both absorb moisture and oil. [10]

5.1.13 Colorants

Colorants are used in deodorants for aesthetic purposes. An example of a colorant is Brilliant Blue FCF. [10]

5.2 Blacklisted substances

There are several common cosmetic ingredients that IDUN Minerals does not add to any of their products. Furthermore, the Swedish pharmacies have a blacklist of ingredients that are not permitted. Some of the blacklisted (or less preferred) ingredients are defined below.

5.2.1 Fragrance

Fragrance is a common cosmetic ingredient that IDUN Minerals generally avoids. Only their haircare rinse-off products contain fragrance.

Fragrance gives cosmetic products a nice scent, but unfortunately the majority of fragrances contain allergenic substances. Allergenic substances can cause unpleasant symptoms, such as eczema, shortness of breath, itchy eyes and congestion. [22] [23]

5.2.2 Alcohols (Ethanol & Isopropyl alcohol)

Alcohols fulfil a wide range of tasks in cosmetic products. In the cosmetological field, alcohols usually refer to ethanol or isopropyl alcohol, which are two non-fatty alcohols. Ethanol and isopropyl alcohol are mainly used for their antibacterial properties. [11] IDUN Minerals prefers to avoid these alcohols, since they can cause irritating and dryness. [4]

5.2.3 Cyclomethicone

Another common cosmetic ingredient that is not used by IDUN Minerals and that is excluded from all products sold in Swedish pharmacies is cyclomethicone. [24] Cyclomethicone is a general term for many different silicone molecules. In order to categorize as a cyclomethicone, the silicone molecule needs to have a ring structure, such as the molecule viewed in Figure 10. [25] [26]

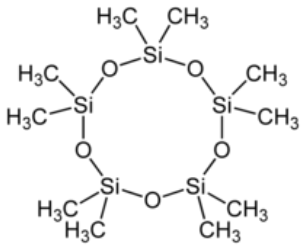

Figure 10. Molecular structure of Cyclopentasiloxane (D5). [26]

Cyclomethicone is used in make-up, haircare and skincare products. It can act as an antistatic, emollient, humectant, solvent, viscosity controller and hair conditioner in those products. Furthermore, cyclomethicone increases spreadability of the product. The most commonly used cyclomethicone molecules in cosmetic products are cyclopentasiloxane (D5) and cyclohexasiloxane (D6). Cyclotetrasiloxane (D4) is also used, but much more rarely. [27]

According to SCCS (Scientific Committee on Consumer Safety) D4 classifies as reprotoxic, while D5 and D6 impose no harm to human health. [27]

5.2.4 Parabens

Parabens is a collective name for a series of chemicals, more specifically para-hydroxybenzoates. The general structure of a paraben is viewed in Figure 11, in which R is an alkyl group. [28] [29]

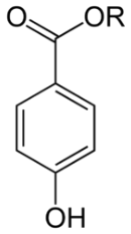

Figure 11. General molecular structure of a paraben. [29]

Parabens are commonly used in cosmetic products as preservatives, preventing growth of bacteria, yeast and mold. The solubility of parabens in water and oil varies and therefore make them suitable for a wide range of product formulations. [28]

There have been suspicions that parabens might have an endocrine disruptive effect in humans, and IDUN Minerals does therefore not use parabens in its products. The EU has banned some parabens, such as pentylparaben and isopropylparaben. However, according to Läkemedelverket (Swedish Medical Products Agency), the most commonly used parabens in cosmetic and hygiene products (methylparaben and ethylparaben) are safe to use. [28]

5.2.5 Triclosan

Triclosan is an antibacterial substance that is blacklisted by Swedish pharmacies. The molecular structure of Triclosan is viewed in Figure 12. [30]

The chemical substance is commonly used in cosmetic products, e.g. toothpaste and deodorants. Triclosan is toxic to aquatic organisms and can disrupt biological processes in humans, by whom it can be absorbed through skin and mucous membranes. Furthermore,

studies have shown that Triclosan can cause bacterial resistance towards itself and antibiotics. [31]

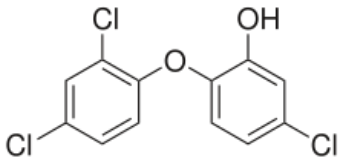

Figure 12. *Molecular structure of Triclosan.* [30]

5.3 Caring substances

Caring substances are often added to cosmetic products, e.g. to improve the condition of skin and hair. A few popular caring substances are Allantoin, Aloe vera and Chamomile.

5.3.1 Allantoin

Allantoin is used in several different cosmetic products and is especially common in skincare products. The substance is anti-irritating, soothing and healing and can be derived from certain plants and animal urines.

5.3.2 Aloe Vera

Aloe vera extract is derived from the aloe vera plant and is used in a wide range of products. It can be consumed orally or applied directly to the skin. Aloe vera has anti-inflammatory, anti-septic, anti-fungus, calming, cooling and moisture-binding properties.

5.3.3 Chamomile

Chamomile is derived from the chamomile plant, which is well-known for its many caring properties. There are 5 – 7 different chamomile plants and the most popular ones are Roman Chamomile and German Chamomile. Similar to aloe vera, chamomile can be consumed orally or applied directly to the skin. It acts as an anti-inflammatory, calming and healing on the skin, benefits digestion and relieves muscle spasms inside the body.

6 How a deodorant is made

When a deodorant is produced, the ingredients are usually divided into different phases. The phases are thereafter added to the mix in a certain order. The number of phases and the order of which these are added varies by formula. Down below, in Table 5, a basic formulation recipe is described of a roll-on deodorant with antiperspirant. [32]

Table 5. Formulary composition of a deodorant with antiperspirant.

Phase	Ingredient	Wt%
A	Steareth-2, Ceteareth-12, Stearyl Alcohol, Ceteareth-20, Distearyl Ether,	5.0
	Dicaprylyl Carbonate	4.5
	Dimethicone	1.5
B	Aqua	48.2
C	Fragrance	0.8
D	Aluminum Chlorohydrate	40.0

- Phase A and phase B are heated to 80 °C separately.
- While stirring, phase B is added to phase A.
- Stirring is continued, while mix is cooled to 45 °C.
- Phase C and phase D are added to the mix.
- Stirring is stopped when mix has reached 30 - 35 °C. At this temperature, viscosity should have increased.

7 Ecolabeling of cosmetic products

IDUN Minerals places a lot of emphasis on creating sustainable cosmetic products. Therefore, the possibility of receiving Nordic Swan Ecolabelling of the final product is something that is investigated by this thesis.

7.1 Nordic Swan Ecolabelling

Nordic Swan (Svanen) is a Swedish ecolabel that verifies that a product fulfils certain environmental and health requirements. The label is viewed in Figure 13. Before a product can be ecolabelled, an extensive LCA (life cycle assessment) is made, in which the internal content as well as the packaging is examined. [33]

Figure 13. Nordic Swan Ecolabel. [34]

Life cycle assessment is a method that investigates the environmental impacts of a certain product. The method studies the product from cradle to grave, which in more detail means it starts at the extraction of raw materials and ends at the waste disposal stage. By using LCA as a tool, the most polluting, energy using, and water consuming parts of a production process can be identified. Thus, once analyzed, more sustainable solutions can be proposed. [35]

7.2 Product requirements

There are numerous requirements for Nordic Swan Ecolabelling. The requirements for the packaging and chemical content are roughly summarized in this thesis.

7.2.1 Packaging

- 1 layer of packaging is allowed. 2 layers of packaging is allowed if the second layer is made from recycled material or if two separate products are sold as a kit.
- The emptying level must be 90% for cream bottles. If not, the lid must be removable without having to use a tool.
- If the packaging is made from different materials, the different materials need to be separable without having to use a tool.
- No metal can be used in the packaging of deodorants.

7.2.2 Chemical content

- A detailed product description and recipe must be completed
- The recommendations from SCCS must be followed

- The cosmetic producer must show an interest in sustainable and renewable raw materials
- The ingoing substances may not fulfil certain classifications, e.g. carcinogenic or mutagenic.
- The product may not contain prohibited substances, e.g. certain cyclomethicons, triclosan and parabens.
- Surfactants must be degradable, anaerobically and aerobically.
- Fragrance guidelines must be followed. These guidelines are set by IFRA (International Fragrance Association)
- Certain fragrance amounts must be followed
- Preservatives, including antibacterial substances, may only be used for a preservation purpose
- Leave on products may contain a maximum of 0.6 wt% aluminum

8 Cosmetic packaging materials

Plastic is a very common material in the packaging of cosmetics and hygiene products. This is due to many reasons, such as good material properties of plastics and low production costs. Other common materials in cosmetic packaging are paper, glass and aluminum. [36]

The majority of the plastic waste generated in Europe is from packaging of various kinds. A very small amount of plastic waste is reused or recycled, which also means most plastic present in packaging is only utilized once. The plastic that is not recycled is either incinerated or goes to landfilling. Incineration, which is used for energy recovery, is a polluting process. When it comes to cosmetic plastic packaging, the recycling process seems to be especially difficult, since the packaging is often contaminated by remains from the product content. [36]

Consumption of plastic has increased drastically since the 1960s and is estimated to continue to do so. At the same time, environmental issues, such as pollution of air and water, have become more and more problematic. [36]

Most plastics consumed today are petrochemical-based. Petrochemical-based plastics consist of polymers that are derived from fossil fuels (petroleum or natural gas). Examples of popular petrochemical-based polymers are polyethylene terephthalate (PET), polyethylene (PE), polypropylene (PP), polystyrene (PS), polyamide (PA) and polyvinyl chloride (PVC). [36] The molecular structures of PE and PP are viewed in Figure 14.

Figure 14. Molecule structure of polyethylene (left) & polypropylene (right). [37]

Petrochemical-based plastics are highly available low-cost materials that offer many excellent properties. Examples of plastic properties are heat sealability, lightness, flexibility and strength. Plastics can easily be formed into different shapes and offers barriers to various molecules (e.g. oxygen, water and carbon dioxide). Barrier protection from the external environment plays an important role in the preservation of a product. [36]

Future potential substitutes to petrochemical-based plastics are biopolymers, often called bioplastics. Bioplastics are compostable and biodegradable, which gives them a sustainability advantage to petrochemical-based plastics. The biodegradability of bioplastics means that they can be broken down into certain compounds, such as methane, carbon dioxide and water. [38]

There are biodegradable materials that are not classified as biopolymers, as viewed in Figure 15. In order to classify as a biopolymer, the polymer needs to be derived from a renewable resource, for example plants and animals. [38]

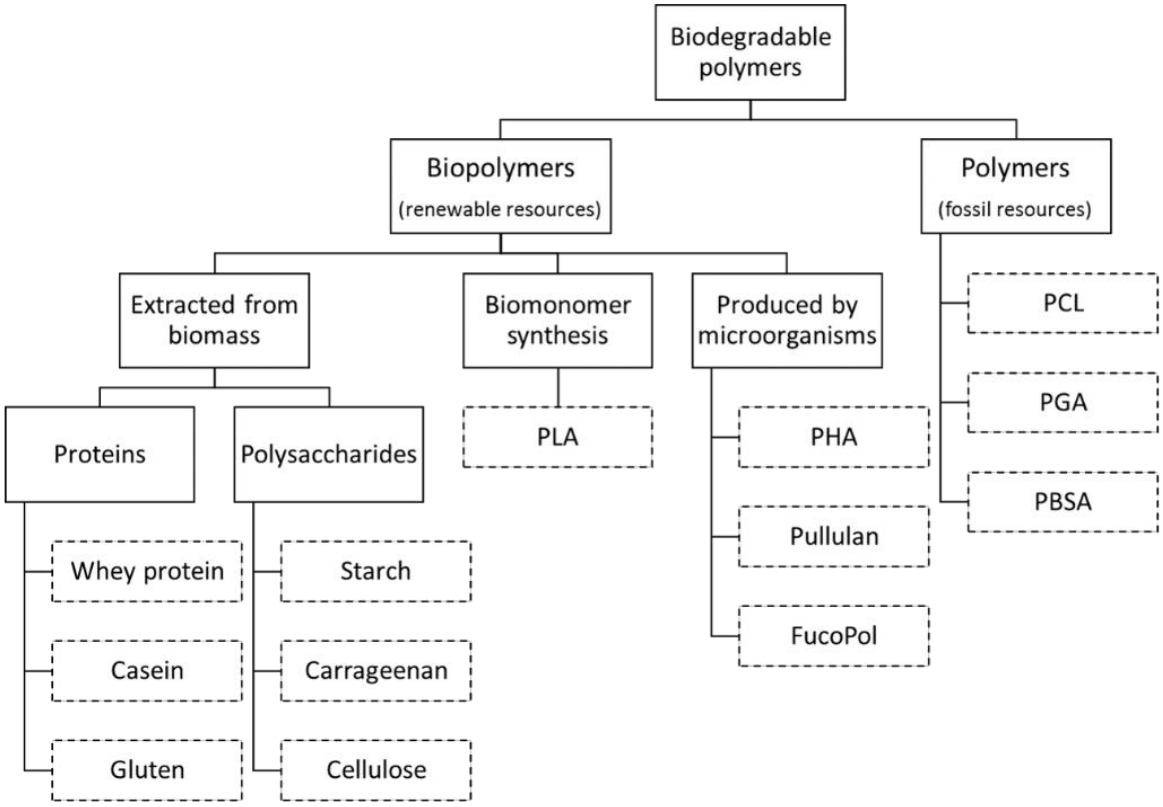

Figure 15. An overview of biodegradable polymers. [38]

Examples of bioplastics are polylactic acid (PLA), polyhydroxyalkanoates (PHAs) and polysaccharides. PLA mostly consists of poly lactic acid and is industrially compostable. This particular bioplastic is especially well-suited for rigid packaging. The biodegradation of PLA is dependent on several factors, such as time, temperature and impurities. Today, the biggest obstacles related to PLA-based bioplastic are low crystallinity and brittleness, which unfortunately gives the product low thermal stability. PHAs are not as well-researched as PLA, but they have promising properties and can be used for a wide range of plastic textures. Furthermore, PHAs have the advantage of being biodegradable in more environments than simply composting plants.

Natural polysaccharidic polymers are abundant in nature. The most common one is cellulose, which also happens to be the most utilized one along with starch. [38] Cellulose is derived from wood pulp and starch is mainly derived from corn, potato and tapioca. Other polysaccharides that have promising properties are chitosan and chitin, which can be obtained from animals. One of the largest challenges regarding polysaccharides, especially cellulose and starch, in packaging is their low water vapor barrier. [39]

As for now, bioplastics are more expensive than traditional plastics. However, with an increasing consumption of plastics, environmental awareness and new rules restricting traditional plastics usage, bioplastics should become increasingly more popular. [38]

9 Methods

In this particular thesis, the market and product study mainly focused on the competitive landscape in Swedish pharmacies and on global trends. A gap analysis was done to try to find an opening in the market, since that would make the product more competitive.

The gap analysis was completed by mapping the current market of deodorants in Swedish pharmacies. The underarm products were sorted by three different characteristics, which were synthetic aluminum content, fragrance content and price.

Current trends and preferences were also investigated along with the market analysis. This was done by reading news articles and blogs, asking people and looking at various rating sites.

Deodorant ingredients, axillary biology and cosmetic packaging were researched throughout the project. Commonly used ingredients were documented by reading a wide range of deodorant content labels. Furthermore, the requirements for Nordic Swan Ecolabelling were investigated.

Lastly, two Swedish suppliers, BIPAC and SALAB, were contacted. From BIPAC, several different packaging samples were ordered. A product brief was also completed by using a formula brief template, which was received from BIPAC. Moreover, a meeting was conducted with BIPAC at their facility in Stockholm, Sweden. In the meeting the formula brief was looked at and potential formulation alternatives were discussed.

10 Results

Underarm products sold in Swedish pharmacies are sorted by different categories in Table 5 in Appendix 2. Products that are only purchasable online are not included. When sorting the deodorants, it is clear that there are many antiperspirant-free options and a few fragrance-free options in Swedish pharmacies. Deodorants neither containing antiperspirant or fragrance is less common.

When researching deodorant trends, it was obvious that many customers and manufacturers are looking into alternative ingredients (preferably natural) that are gentle towards the body, but still effective.

The completed product brief based on a template from SALAB is viewed in Figure 16 in Appendix 2. In the meeting with SALAB, the two ingredients sodium bicarbonate (baking soda) and potassium aluminum sulphate (alum) were particularly suggested. Baking soda increases the pH, which makes it difficult for bacteria to survive. Alum is a much gentler alternative to synthetic aluminum compounds. It is not synthetic, does not plug the sweat glands and contains a very small amount of aluminum, but still absorbs moisture and is antibacterial. Calculations, see Appendix 1, show that a maximum of 10.5 wt% can be added to the formula in order for the formula to fulfill the Nordic Swan Ecolabelling requirement regarding a maximum of 0.6 wt% aluminum.

Furthermore, the supplier recommended a fragrance-free and potentially preservative-free formula, since that would make the product stand out. A volume of 75 ml was suggested. Besides offering production of the formula, the supplier also offered production of the packaging.

From BIPAC, seven different packaging samples were received. All of the packaging samples are viewed in Figure 17 and are completely made from polypropylene (PP) plastic.

Figure 17. Packaging samples.

When reading content labels of various deodorants (deodorants not sold in Swedish pharmacies included), the substances viewed in in Table 6 in Appendix 2 were found. The ingredients with a black background are blacklisted in Swedish pharmacies. The functions of the various substances were given by the Swedish pharmacies. [40]

11 Conclusion

The aims of this thesis were to broadly investigate the deodorant market, product formulation and product packaging, to be able to offer IDUN Minerals a recommendation that would suit the costumers as well as the company's values.

From researching the deodorant selection in Swedish pharmacies, the conclusion is drawn that there is an equal distribution between synthetic aluminum containing deodorants and synthetic aluminum-free deodorants. Although, there is no study today that can prove that there is a direct link between aluminum-based antiperspirant usage and breast cancer, a few recent studies show disturbing results. Therefore, a recommendation for IDUN Minerals is to not include synthetic aluminum in any of their products, until any physical harm can be ruled out.

Furthermore, the conclusion is that there are unfragranced variants, although the majority of deodorants are fragranced. A recommendation would be to create a deodorant that does not contain any synthetic aluminum compounds or fragrances, since that is much rarer. Additionally, if no preservatives are included in the formula, the product would stand out even more. A liquid formula in a roll-on packaging is recommended, since roll-on deodorants are far more popular than other deodorant types in Europe.

Another recommendation for IDUN Minerals would be to seek Nordic Swan Ecolabelling, since no deodorant today carries the label. The formula that was suggested by SALAB should fulfill the requirements.

Regarding the packaging, the conclusion can be drawn that traditional plastics are much more favorable quality wise. However, the opportunities of using biopolymers should be further investigated.

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Appendix 1. The maximum mass percentage of alum in the formula

In the meeting with SALAB, it was decided that the formula sample will approximately contain around 10 wt% alum ($K*Al*(SO_4)_2*12H_2O$). According to the Nordic Swan Ecolabelling requirements, the deodorant may contain a maximum of 0.6 wt% aluminum (Al). The maximum mass percentage of alum that is allowed in the sample is calculated below.

The following calculations are based on a formula whose total mass is 100 grams.

$$m_{Total} = 100\ g$$

$$M_{Al} = 26.982\ g/mole$$

$$M_{K*Al*(SO_4)_2*12H_2O} = 474.372\ g/mole$$

$$0.6\ wt\%\ Al * 100\ g = 0.6\ g\ Al$$

$$n = \frac{m_{Al}}{M_{Al}} = \frac{0.6\ g}{26.982\ g/mole} \approx 0.022237\ mole$$

$$m_{K*Al*(SO_4)_2*12H_2O} = M_{K*Al*(SO_4)_2*12H_2O} * n \mathrel{+}= 474.372 * 0.022237 \approx 10.5\ g$$

$$\frac{10.5}{100\ g} = \mathbf{10.5\ wt\%}$$

Answer: 10.5 wt% alum is allowed.

Appendix 2. Figures and tables

Project:	**Date:**
Type of product:	
Special characteristics:	
Authoritative requirements:	
Packaging:	**Special requirements:**
Test collection, consumer tests, external tests:	
Target price:	**Maximum price:**
Estimated consumption:	
Other comments:	
Client:	**Signature / Date:**

Figure 3. Formula brief template. [5]

Table 5. Underarm products sold in Swedish pharmacies - sorted by content.

Brand name	Type	Synthetic Aluminum	Fragrance	Price [SEK]
Absolut torr	Liquid	Yes	No	59
ACO	Roll-on	Yes	No	55
ACO	Roll-on	Yes	Yes	55
ACO	Roll-on	Yes	Yes	55
ACO	Roll-on	Yes	Yes	55
ACO	Roll-on	Yes	Yes	55
ACO Special care	Roll-on	No	Mild	55
Apoliva	Roll-on	Yes	Yes	49
Apoliva	Roll-on	No	No	49
Apoliva	Roll-on	Yes	No	49
Apoliva	Spray	Yes	Yes	59
Apoliva	Stick	Yes	Yes	59
Apolosophy	Roll-on	Yes	Yes	39
Apolosophy	Roll-on	No	Yes	39
Apolosophy	Roll-on	Yes	Yes	39
Bats	Roll-on	Yes	No	49
Bats	Roll-on	Yes	Yes	39
Bats	Roll-on	Yes	No	39
Bulldog	Stick	No	Yes	109
Bulldog	Roll-on	No	Yes	99
Bulldog	Stick	No	Yes	109
c/o Gerd	Roll-on	No	Yes	149
Dr Hauschka	Roll-on	No	Yes	159
DRYS	Fabric/patch	No	No	79
Emma S.	Roll-on	Yes	Yes	89
Emma S.	Roll-on	Yes	Yes	89
Eucerin	Roll-on	Yes	Yes	49
Hjärtats	Roll-on	Yes	No	39
Hjärtats	Roll-on	Yes	Yes	39
Hjärtats	Liquid	Yes	No	67
Hjärtats	Roll-on	No	Mild	45
L300	Roll-on	Yes	Yes	45
La Roche-Posay	Roll-on	No	Yes	105
Laino	Roll-on	No	Yes	79
Laino	Roll-on	No	Yes	79
Laino	Roll-on	No	Yes	79
Laino	Stick	No	Yes	59
Laino	Stick	No	Yes	59
Laino	Stick	No	Yes	59
Löwengrip	Roll-on	Yes	Yes	139
Löwengrip	Roll-on	Yes	Yes	139

Meraki	Roll-on	Yes	Yes	119
N.A.E.	Roll-on	No	Yes	79
N.A.E.	Roll-on	No	Yes	79
NA14 Absolut doftfri	Stick	No	No	99
NA14 Absolut doftfri	Spray	No	No	139
Neals Yard Remedies	Roll-on	No	Yes	139
Neals Yard Remedies	Roll-on	No	Yes	139
Oliva	Roll-on	Yes	Mild	49
Raw Naturals	Roll-on	Yes	Yes	99
SASCO ECO	Roll-on	No	Yes	69
True organics of Sweden	Roll-on	No	Yes	149
URTEKRAM	Roll-on	No	Yes	35
URTEKRAM	Roll-on	No	Mild	60
Vichy	Roll-on	Yes	Yes	125
Vichy	Roll-on	Yes	Yes	105
Vichy	Roll-on	No	Yes	125
Vichy	Roll-on	Yes	Yes	125
Vichy	Roll-on	Yes	No	105
Vichy	Roll-on	Yes	No	105
Vichy	Roll-on	Yes	Yes	125
Yvonne Ryding	Roll-on	No	Yes	89
Zlatan Ibrahimovic Parf.	Stick	No	Yes	189
Zlatan Ibrahimovic Parf.	Roll-on	Yes	Yes	99
Zlatan Ibrahimovic Parf.	Roll-on	Yes	Yes	99

Type of product:	
Product name: IDUN Gentle Deodorant A vegan, unisex, aluminum-free, alcohol-free and *potentially* unfragranced deodorant. The product should be very gentle towards the skin and contain *several* caring ingredients.	
Special characteristics:	
The product should be fluent in the consistency. Interesting ingredients are peptides (antiperspirant like), chamomile, aloe vera, allantoin and jojoba oil. Scent suggestions (if fragrance is used): Cotton, rose, vanilla and musk.	
Authoritative requirements:	
Shall fulfil the requirements of the Swedish pharmacies and potentially fulfil the requirements for Nordic Swan Ecolabelling.	
Packaging:	**Special requirements:**
Roll-on	Cannot contain aluminum, non-fatty alcohol, cyclo silicones, triclosan, parabens, sulfates and animal products. Hypo allergenic perfume is preferred.
Test collection, consumer tests, external tests:	
Yet to be decided	
Target price:	**Maximum price:**
Yet to be decided	Yet to be decided
Estimated consumption:	
5000 – 10 000 annually.	
Other comments:	
Launch date: 2020	
Client:	**Signature / Date:**
IDUN Minerals	

Figure 16. Completed formula brief.

Table 6. Commonly used ingredients in deodorants.

Ingredient	Function
Alcohol	Anti-bacterial
Allantoin	Soothing
Aloe Vera	Emollient, Cooling
Alum	Anti-bacterial
Aluminium chloride	Anti-perspirant
Aluminium chlorohydrate	Anti-perspirant
C12-13 Alkyl Lactate	Emollient, skinconditioning
Ceteareth-20	Cleansing, emulsifying, surfactant
Citric acid	Anti-bacterial, buffering, gelating, masking
Cyclic silicones	Provide structure
Dextrose (similar to glucose)	Humectant
Dimethicone	Antifoaming, skin protecting, emollient
Dipropylene glycol	Emollient
Ethylhexylglycerine	Preservant
Extracts	
Glycerine	Conditioning
Glyceryl Caprylate	Emollient, emulsifying
Glyceryl laurate	Emollient, emulsifying
Glyceryl stearate	Emollient, emulsifying
Hydroxyethylcellulose	Binding, emulsion stabilising, film forming
Isopropyl Myristate	Binding, emollient, masking, perfuming
Kaolin	Absorbs moisture
Lactic acid	Buffering, humectant, skinconditioning
Magnesium hydroxide	PH-stabliliser, absorbant
Magnesium stearate	Anti-caking, lubricant, release-agent
Octenidine HCl	Anti-microbial
Oils	Skin conditioning
Ozokerite (Earth Wax)	Stabilising
PEG-100 Stearate	Surfactant
PEG-40 HYDROGENATED CASTOR OIL	Emulsifying, surfactant
Piroctone Olamine	Preservant
Polyacrylate Crosspolymer-6	Viscosity controlling
Polyglyceryl-5 Oleate	Emulsifying
Polyhexamethylene biguanide	Anti-bacterial
Potassium sorbate	Preservant
Probiotics	
Propanediol (Propylene glycol)	Emollient, moisture retention
Silica	Abrasive, anti-caking, absorbant
Sodium biocarbonate	Anti-bacterial
Sodium Cocoyl Glutamate	Cleansing, surfactant
Sodium Phytate	Gelating

Sodium stearate	Emollient
Sorbitol	Skin conditioning
Starch (arrowroot powder, corn, potato, tapioca)	Stabilising
Tetrasodium EDTA	Chelating
Tocopherol	Antioxidant, masking
Trethalose	Humectant
Triclosan	Anti-bacterial, preservant
Triethyl Citrate	Masking, perfuming, plasticiser
Vitamins	
Xanthan gum	Emulsion stablising, gelating
Zinc Ricinoleate	Anti-caking, opacifying