novonesis

White paper

Enabling greener detergents with enzymes – better for cleaning, planet and business

A study on powder detergents
Latin America
2022

A global call for biological detergents

Across the globe, there is an increased focus on the environmental impact of the products we consume. The same goes for laundry products, where there is a steadily growing concern among consumers, public authorities and NGOs, driving the detergent industry to bring greener products to the market, that are gentler to the environment and to the end-users. Today, a detergent mainly consists of petrochemical based ingredients. Novonesis has embarked on an ambitious journey towards enabling 100% biological detergents. The aim is to completely replace conventional chemical ingredients[1] with enzymatic solutions and biological[2] alternatives – without compromising the washing performance. This would have a significant impact on the environment, if Novonesis achieves its target of reaching four billion people around the globe with laundry solutions that replace chemicals by 2022. However, the key challenge in the industry is to make a high-performing detergent, which is both greener and less vulnerable to fluctuating raw material prices.

The study

This white paper aims to demonstrate how enzymes can replace some of the surfactants in a detergent in terms of stain removal as well as environmental footprint and cost. Due to an increased focus on emerging markets, we have based our study on a traditional Latin America mid-tier powder detergent[3] which has been optimized with the most advanced enzyme technology available today. First, we will explain and illustrate what surfactants and enzymes are for a common understanding of the study.

[1] Surfactants, polymers, perfumes and builders

[2] Detergent ingredients produced from a biological and renewable basis

[3] A medium expensive and medium quality detergent

Surfactants

Surface active agents (in brief “surfactants”) are primary substances of most cleaning detergents today. Surfactant molecules have hydrophilic (water-loving) heads and a hydrophobic (water-hating) tails. See Figure 1. The hydrophobic tails of surfactants are attracted to soils on fabrics when used for instance in laundry washing. Surfactants then create micelles around soils when the concentration of surfactants in the wash water is sufficient. The micelles with the soil in the middle are pulled off the fabric by the hydrophilic heads’ attraction to the water and laundry gets clean.

The starting point for surfactant production can be either petrochemical (for instance crude oil or natural gas) or plant-based (for instance palm oil or coconut oil).

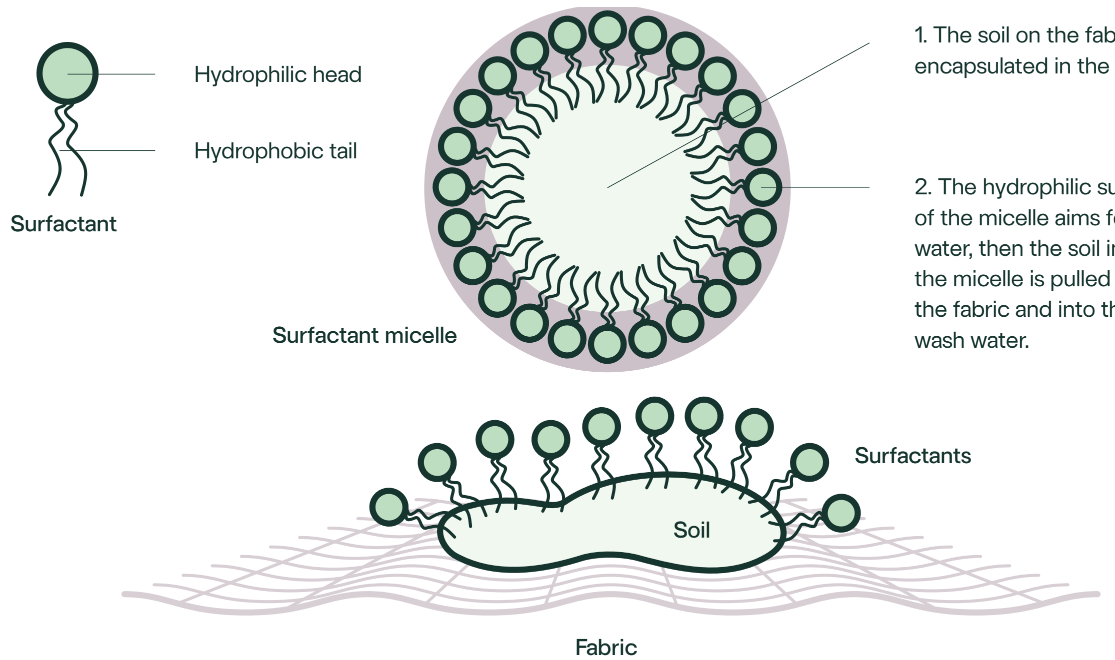


__Figure 1.__ The function of a surfactant.

Enzymes

An enzyme is a biological catalyst which can speed up biological processes. In laundry, enzymes help speed up the function of surfactants. Enzyme products are produced by microorganisms in fermentation processes. Enzymes are proteins and they are readily biodegradable in the environment. The main feedstock for enzyme production is starch and sugar derived from agriculture. Enzymes act like small Pac-men when they cut stains into pieces. By having smaller pieces of molecules, stains on laundry are easier removed. See Figure 2. In laundry, one type of enzyme is good at one type of stain. For instance, an amylase enzyme is good at starch-rich stains (rice and many sauces). Lipase enzymes are good at fatty stains (butter and vegetable oils), protease enzymes are good at protein-rich stains (blood and egg), mannanase enzymes are good at mannan-rich stains (ice cream and yoghurt) and cellulase enzymes are good at removing protruding fiber ends on cotton fabrics limiting fading and formation of “pills” after wear and wash.

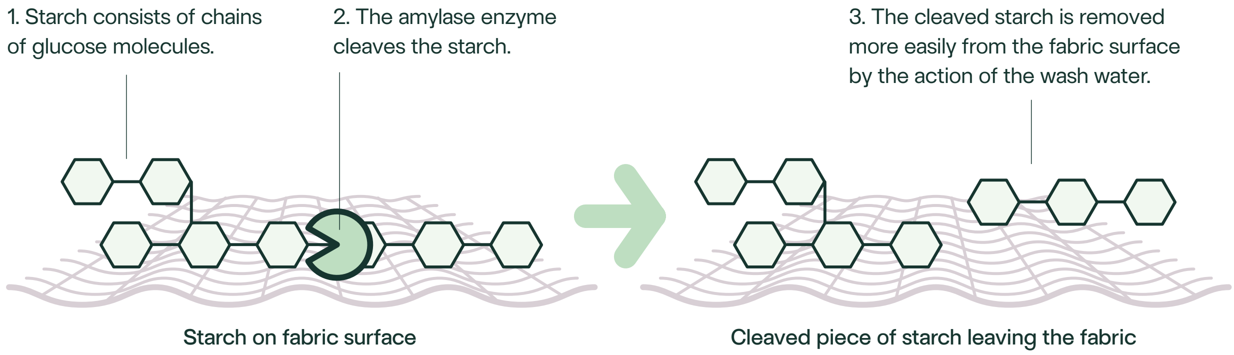


__Figure 2.__ The function of an amylase enzyme.

The detergents tested

The study refers to a detergent with a traditional surfactant and builder system with a single protease enzyme (Detergent A). See Figure 3. For the comparison, we have adjusted the level of surfactants and enzymes in three different ways.

In Detergent B, we have lowered the surfactant content by 30% without adding additional enzymes. In Detergent C, the surfactant level is the same as in Detergent B, whereas we have added a multi-blend of five enzymes. In Detergent D, we have lowered the surfactant level by 45% compared to Detergent A and added a stronger enzyme-blend.
See Appendix 1 for the full list of ingredients in the four detergents.

Detergent A
Conventional detergent with a single enzyme.

Detergent B
Same as A except that surfactant content is reduced by 30%.

Detergent C
Same as B except that enzyme use is extended to five different enzymes.

Detergent D
Same as C except that surfactant content is reduced further (45% of A) and a stronger blend of five enzymes is added.

Figure 3. *Composition of experimental detergents, by percent.*

The washing conditions

Twelve washes were conducted to demonstrate the effect of the surfactant replacement on the stain removal. Washes were performed at full scale in automatic top-loading washing machines[4] with three repetitions (25 °C, 15 minutes main wash, 27 minutes soak, 41 L wash volume, 2 rinses, 2.0 kg mixed ballast, 5.6 °dH water hardness), using 82 g detergent per wash. These washing conditions were aimed at resembling the washing habits in many private households in Latin America.

Stain-set

A comprehensive set of stains were used to cover a broad range of aspects of wash performance, as enzymes and surfactants act differently on different types of stains. The stain-set consisted of 36 stains and aimed at covering the stains most commonly known to the consumers in Latin America. See the complete stain-set in Appendix 2.

Stain removal evaluation

All swatches used in the wash experiments were air-dried overnight after wash. The remission of the dry swatches was measured at 460 nm using a Datacolor reflectometer.

[4] *Whirlpool, WTW5300VW*

Improved stain removal with enzymes

The stain removal in the four considered detergent scenarios are here illustrated in Figure 4 as the sum of remissions from the 36 stains after wash. High remission indicates high stain removal and vice versa. The results show that reducing surfactant concentration in the detergent without adding any additional enzyme-blend (Detergent B) leads to a decline in stain removal. This is not surprising and demonstrates the importance of surfactants in the considered detergent.

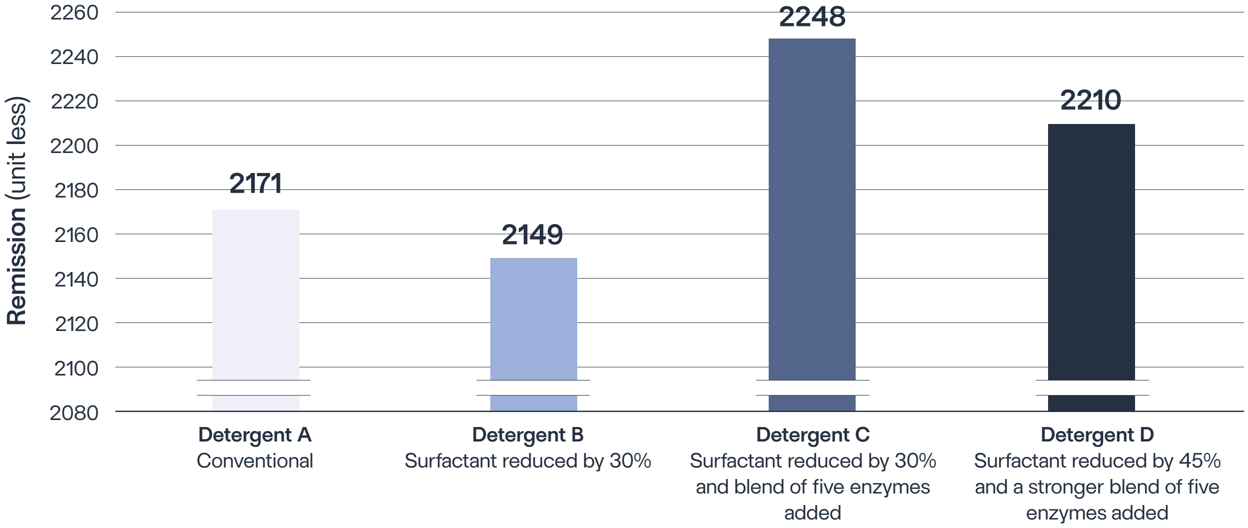


Figure 4. *Total stain removal of the conventional versus the three reformulated detergents.*

The results also show that adding a blend of five enzymes to the detergent and reducing the surfactant with 30% or 45% more than compensates for the lost total performance. This achievement is driven by the action of the broad spectrum of enzymes added, as these cleave different groups of substrates into pieces and enable the wash system to act more efficiently. Results obtained on each stain are reported in Appendix 3.

Wash results on the different stain groups

We also split the stain removal results into groups to visualize the effect of the different detergents on the various groups of stains. Figure 5 below shows that a surfactant replacement with the blend of five enzymes (Detergent C and D) improve or maintain the average stain removal performance on six out of seven stain groups. The grouping of stains is reported in Appendix 2.

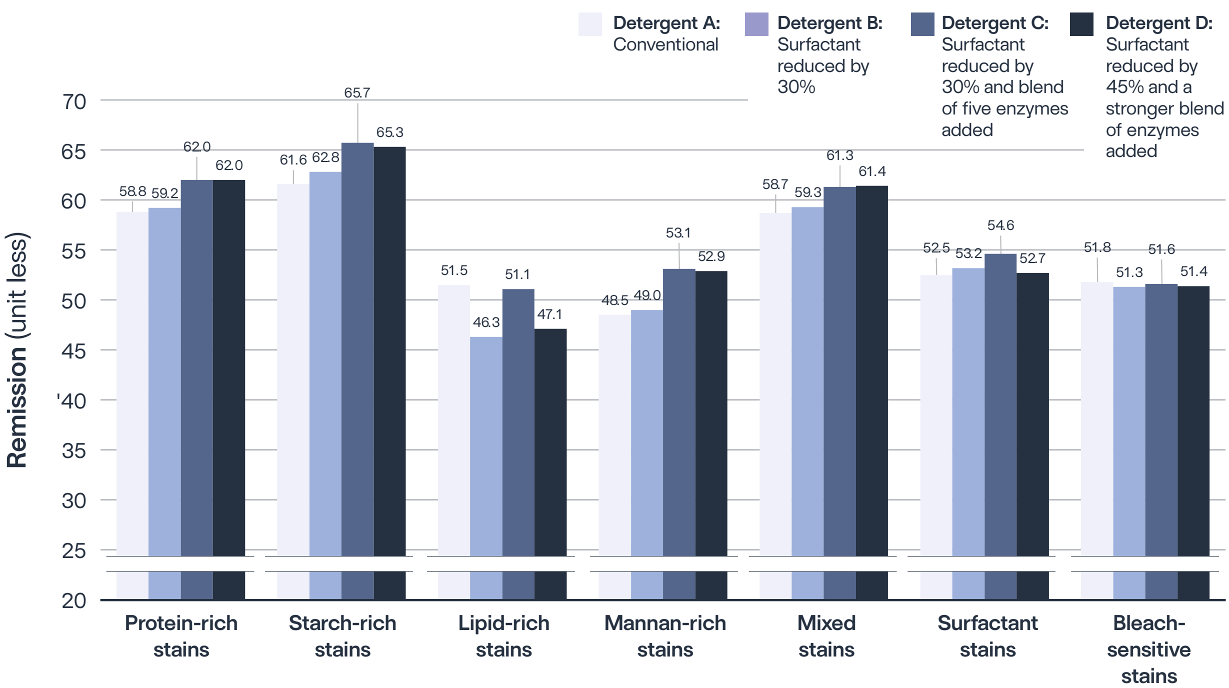


Figure 5. *The average stain removal of the four different detergents on seven stain groups.*

Improved average stain removal is observed on “protein-rich stains”, “starch-rich stains”, “mannan-rich stains” as well as “mixed stains” because specific enzymes target these stains efficiently.

The stain removal performance is nearly the same in the group of “surfactant-sensitive stains."”. This is because the surfactant concentration is sufficient in all the considered detergents.

The considered detergents do not contain any agents with bleaching effect and the performance on bleachable stains is therefore not impacted by the reformulations.

In the group of lipid-rich stains, enzymes demonstrated capacity to raise the stain removal performance when the surfactant content was reduced by 30% and enzymes were added. However, the enzyme addition was not enough to raise the wash performance when the surfactant level was reduced by 45%. Lard (swine fat), which was represented by three stains in the lipid-sensitive stains group, explains the declined performance in the lipid group. See Appendix 2.

Summary on washing performances

Overall and across most stains, we observe an improvement of the washing performance with the enzyme-rich detergent with 30% less surfactant. Even with a 45% surfactant reduction, the detergent outperformed on all stain groups, except from the lipid stain group.

Cost perspectives of surfactant replacement

The cost-savings obtained by reducing the use of surfactants in the detergents have been partly reinvested in adding enzymes to the detergent. In the 30% surfactant reduction case for instance, we are able to add five different enzymes, i.e., protease, amylase, lipase, mannanase and cellulase, compared to only one enzyme in conventional detergent, but still arrive at 10% savings on overall formulation cost. See Figure 6.

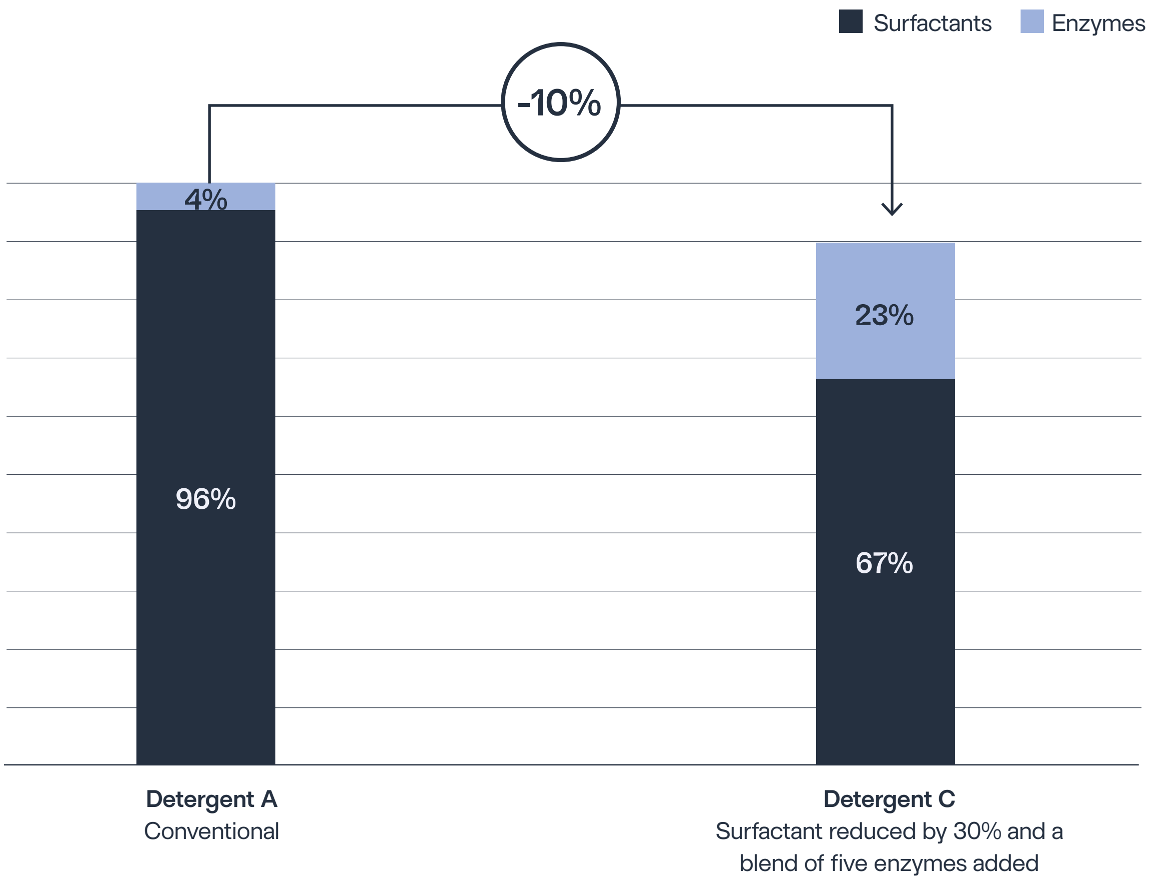


Figure 6. Development of cost when 30% of surfactants in the conventional detergent are replaced by five enzymes. Data refer to the cost of the surfactant and enzyme system only – not the entire detergent. Prices used for calculations are Novonesis' estimated market prices.

12 Responsible consumption and production

13 Climate action

12 Life below water

Reducing environmental footprints by producing greener detergents

At Novonesis, we commit to growing the positive impact from our biological solutions and reducing the negative impact from our operations. At the same time, we aim to help solve global challenges, such as climate and water issues.

The following section aims to demonstrate the environmental benefits of replacing surfactants with enzymes. The study compares the environmental impact of producing and disposing used enzymes versus the saved surfactants in a shift from Detergent A to Detergent C. We have compared these two detergents, as the detergent with 30% lower level of surfactants and extended use of enzyme (Detergent C) had superior total stain removal compared to the conventional detergent (Detergent A).

Saving chemical ingredients

Detergents are used by billions of people daily and large amounts of detergent ingredients are manufactured, transported and stored throughout the value chain every year. When replacing surfactants with enzymes, the mass of active detergent ingredients can be reduced because the enzymes are very efficient due to their catalytic nature. Figure 7 shows that the quantity of enzyme used is ten times lower than the surfactant saved when the surfactant level is reduced by 30%. This means that a considerable amount of detergent ingredient can be saved on every wash if the high-intensity enzyme system is adopted. This could benefit many detergent formulators in terms of compacting their products to enable online distribution and save costs on packaging, transport and storage.

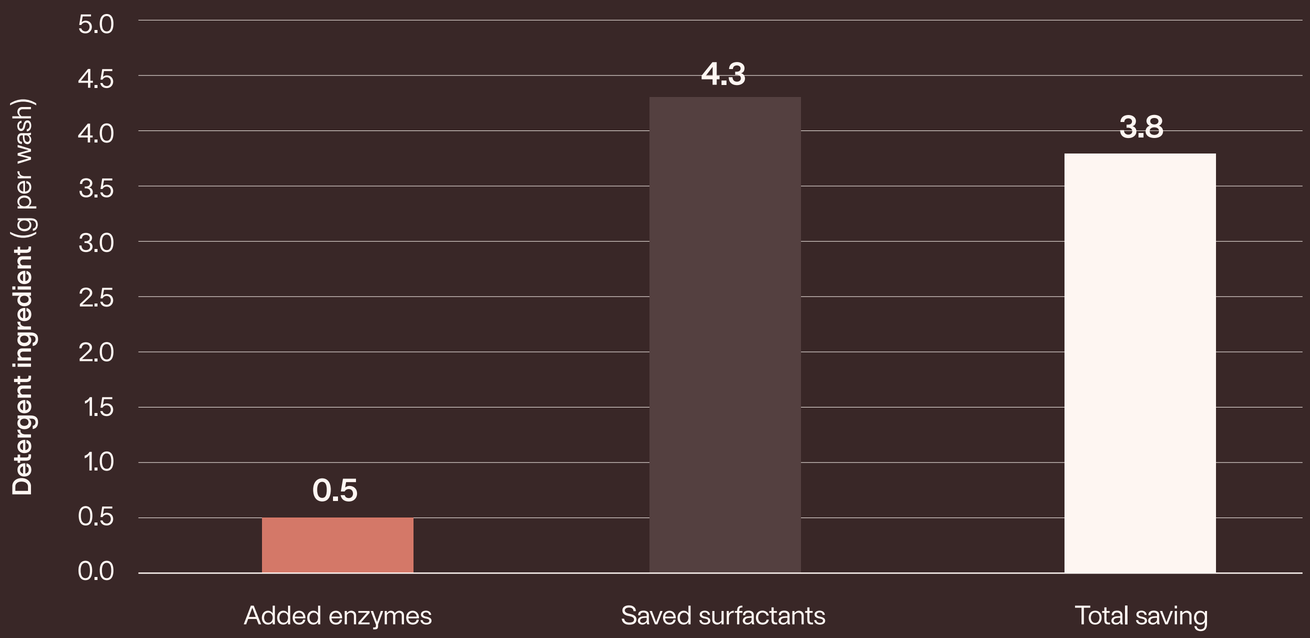


Figure 7. *Used and saved detergent ingredients when surfactant concentration of the conventional detergent (A) is reduced by 30% and replaced by a blend of five enzymes (Detergent C).*

Chemical consumption perspectives for Latin America

The annual number of total laundry washes in private households in Latin America is estimated at approximately 25 billion[5].

If, say, 50% of all washes in Latin America were done using a detergent rich in enzymes with 30% less surfactants, this could lead to saving the planet from 50.000 tonnes of chemicals annually[6]. This corresponds to the load of approximately 2.000 trucks[7].

[5] 600 million people in Latin America (2019) / 3.5 members per household ~ 170 million households (www.population.un.org – visited in 2020).
[6] 25 billion washes · 50% · 3.8 g detergent ingredient saved per wash /1000000 g/tonne ~ 50.000 tonne.
[7] 50.000 tonne detergent / 25 tonne load per truck ~ 2.000 truck-loads.

Replacing surfactants with enzymes lower CO_2 emissions

Production of enzymes as well as surfactants have an impact on climate because energy is used for producing and transporting throughout the value chain. Either way CO_2 and other greenhouse gasses are emitted. The impact on climate when replacing surfactants with enzymes is estimated using lifecycle assessment (LCA) which include greenhouse gas emissions in all significant processes from raw-material extraction to the gate of the enzyme factory and the surfactant factory, respectively.

Figure 8 shows that the CO_2 emission coming from producing enzymes is approximately 11 times lower per wash than the CO_2 emission of producing surfactants. The reason is again that enzymes act catalytically, and can repeat their job over and over, whereas surfactants act by forming micelles and are used up during the wash processes.

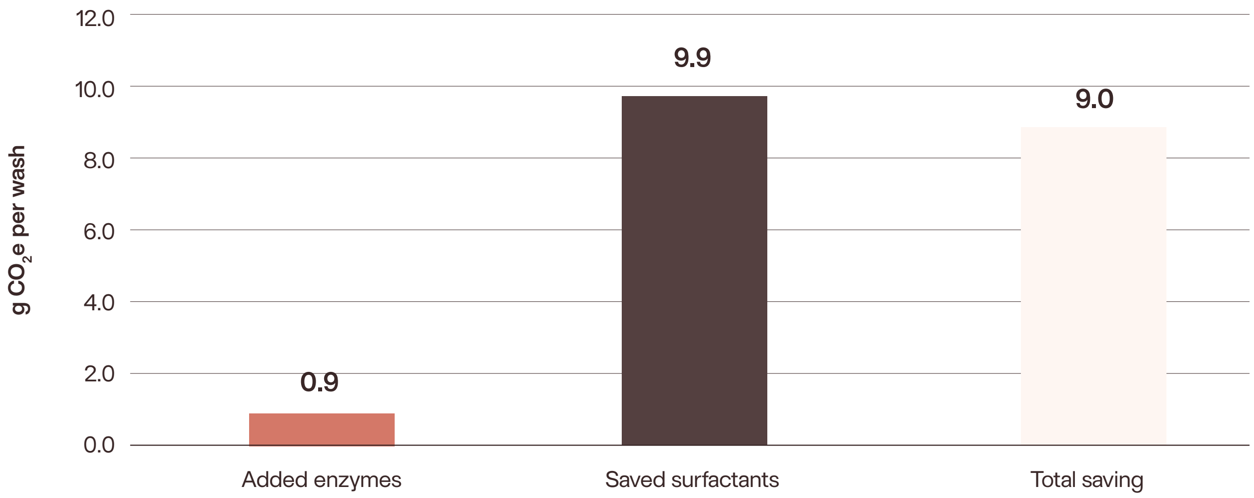


Figure 8. *Greenhouse gas emissions (CO_2 equivalents) of enzymes and surfactants when surfactant concentration of the conventional detergent (A) is reduced by 30% and replaced by a blend of five enzymes (Detergent C).*

Estimates of greenhouse gas emissions from enzyme production refer to Novonesis' production in 2017. Greenhouse gas emissions from surfactant production refer to literature data. More details on method can be found in Appendix 4.

Climate perspectives for Latin America

It has been estimated that approximately nine grams of CO_2 can be saved for every wash if enzymes replaced 30% of surfactants. See Figure 8. Nine grams of CO_2 saved per wash may not sound like a lot, but it could add up to a substantial positive impact on the climate if many formulators adopted the concept and many people began to wash with enzyme-rich detergent instead of detergents resembling the conventional detergent in this experiment.

Latin American households could for instance save 110.000 tonnes CO_2 annually[8] if enzyme-rich detergents were used in 50% laundry washes instead of conventional detergents. This corresponds to the annual emissions of CO_2 from approximately 45.000 cars[9].

[8] 25 billion washes per year · 50% · 9 g CO2 saved per wash / 1.000.000 g/tonne ~ 110.000 tonnes CO2

[9] 110.000 tonne CO2/2.4 tonne CO2/car ~ 45.000 cars.

Reducing surfactants can reduce impact on life below water

Depending on the presence and efficiency of public wastewater management systems, some of the detergent ingredients from laundry washing may end up in local lakes and rivers after use. The substances may cause unwanted effects on life in the water (algae, daphnia, fish, etc.) because the substances may be toxic and biodegrade slowly.

These potential effects of chemicals in the environment are referred to as aquatic toxicity and are measured in the volumes of water that is needed to dilute the considered ingredients to a non-toxic level, the critical dilution volume (CDV). See Figure 9.

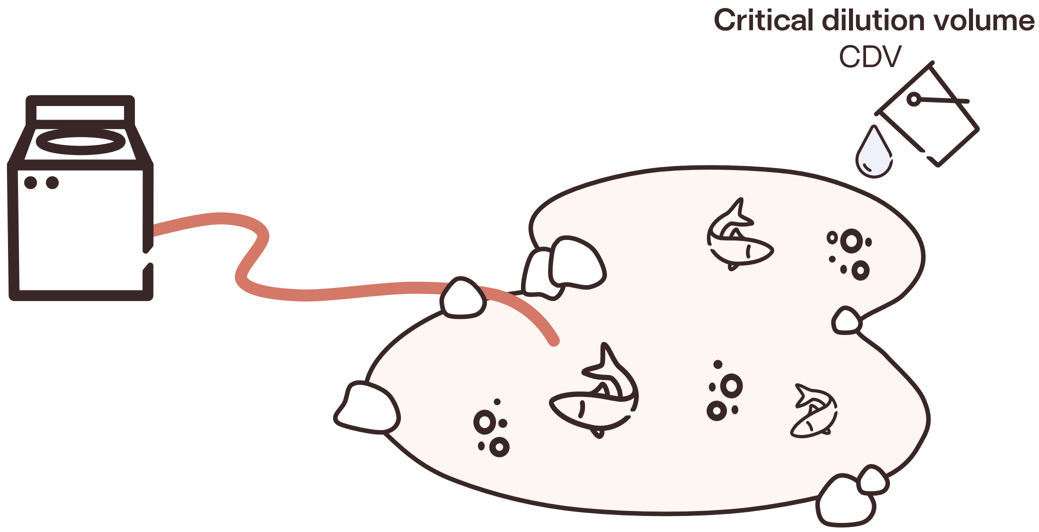


__Figure 9.__ Detergents that end up in lakes, rivers and coastal zones have an impact on life below water. Critical dilution volume, CDV, indicates the toxicity of the detergent ingredients. CDV is the volume of water necessary to dilute the used detergents to a level where the water living species were unaffected.

Figure 10 shows that 0.3 m^3 water is potentially required to dilute the added enzymes to eliminate toxicity whereas 5.8 m^3 water is potentially needed for the saved surfactants. This means that the saved surfactants have approximately 20 times higher aquatic toxicity potential than the added enzymes. The main reasons are that enzymes are more readily biodegradable than the surfactants and that quantities of enzymes used are small (see Figure 7).

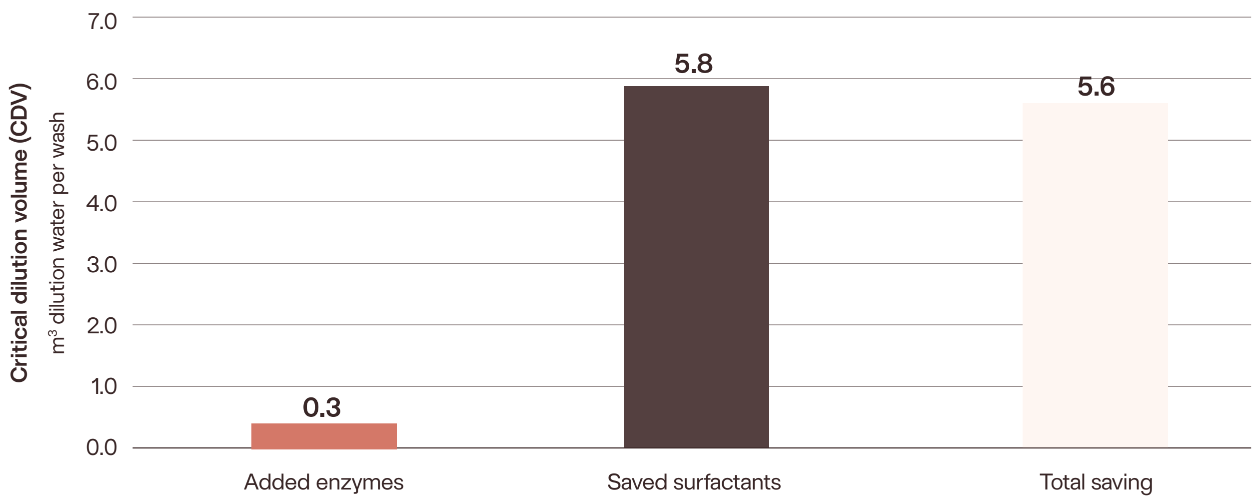


__Figure 10.__ Detergents that end up in lakes, rivers and coastal zones have an impact on life below water. Critical dilution volume, CDV, indicates the toxicity of the detergent ingredients. CDV is the volume of water necessary to dilute the used detergents to a level where the water-living species were unaffected.

It has been estimated that aquatic toxicity corresponding to 5.6 m^3 dilution water can be saved per wash if enzymes replaced surfactants.

CDV of the used enzymes and saved surfactants are estimated using a screening method from the European Eco-labeling system[11] where quantity, active ingredient content as well as degradability and toxicity of each substance is considered. Data on degradability and toxicity is derived from the detergent ingredients database (DID) (2016) from the same source. More details on the method applied can be found in Appendix 5. The outcomes of toxicity assessments are uncertain. However, the difference between the enzymes and surfactants are considerable and the general observation that enzymes are preferable from an aquatic toxicity point of view appears robust.

Perspectives for natural waters in Latin America

With approximately 25 billion laundry washes annually in private homes in Latin America, this adds up to a total saving at 70 billion m^3 dilution water annually[10] if 50% of laundry washes used a detergent with more enzyme and less surfactant. This corresponds to a cube of clean water at more than 4 km on each side.

[10] 25 billion washes per year · 50% · 5.2 m^3 dilution water saved ~ 65 billion m^3 dilution water saved annually.

[11] EU Ecolabel for detergents and cleaning products – user manual (v. 1.2 – October 2018). https://ec.europa.eu/environment/ecolabel/

Summary

The present study shows that the use of enzyme as replacement of surfactants can improve the stain removal and the sustainability profile of detergents without compromising cost.

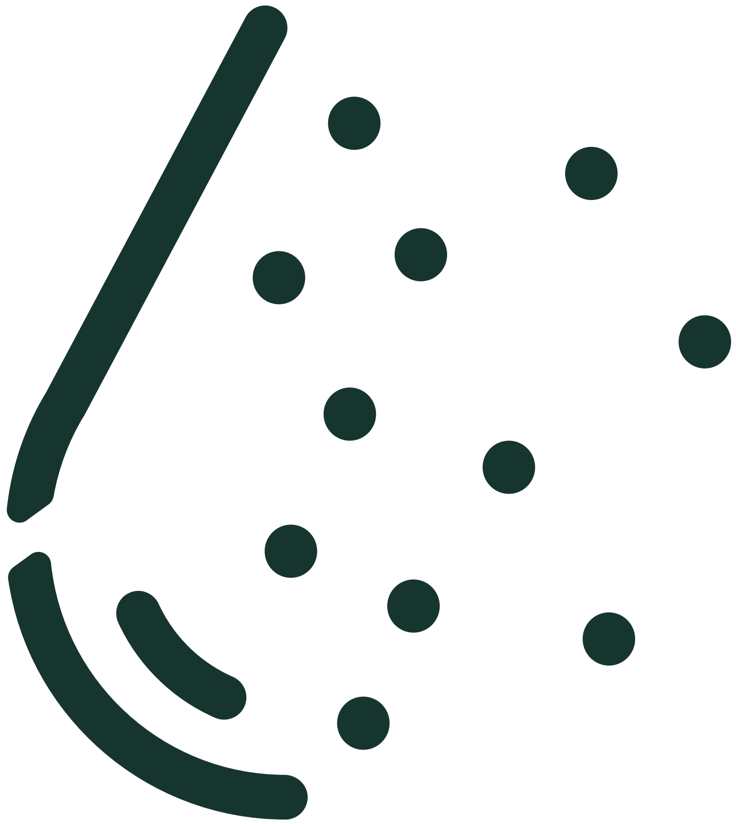
The reason is that enzymes can be used at much smaller doses than the surfactants they replace, as well as the fact that enzymes can be produced and used with much less impact on the climate and the water environment.

This means that detergent formulators have a space of opportunity for improving the customer appeal on cleanliness on both the laundry and the environment – without asking for a higher price. In this particular study, these observations apply up to a surfactant replacement level at 30% whereas at a higher surfactant replacement level at 45% the performance on lipid stains starts to lack.

Novonesis has been developing new and increasingly efficient enzymes for the detergent market for decades. This development continues, so that surfactant replacement can be extended further in the coming years. Detergent formulators are encouraged to join in this development and optimize their surfactant/enzyme systems for the optimal performance on stains, cost and environment – to the benefit of customers, businesses and the planet.

Appendix 1:

Details of detergent compositions, by weight %



Ingredients		**Detergent A** Conventional	**Detergent B** Surfactant reduced by 30% compared with A	**Detergent C** Surfactant reduced by 30% compared with A and a blend of five enzymes added	**Detergent D** Surfactant reduced by 45% compared with A and a stronger blend of five enzymes added
Surfactants	LAS	15	10	10	8
Surfactants	AEO	2.5	1.8	1.8	1.4
Builders	Sodium silicate	25	25	25	25
Builders	Sodium carbonate, Na_2CO_2	14	14	14	14
Builders	Polycarboxilate, co-polymer	0.15	0.15	0.15	0.15
Enzymes	Savinase® 12 T	0.2	0.2	-	-
Enzymes	Savinase® Evity 12 T	-	-	0.31	0.44
Enzymes	Stainzyme® Evity 12 T	-	-	0.08	0.1
Enzymes	Lipex® Evity 100 T	-	-	0.19	0.19
Enzymes	Mannaway® Evity 4.0 T	-	-	0.043	0.08
Enzymes	Celluclean® Evity 4500 T	-	-	0.036	0.052
Filler	Sodium sulfate	37	43	43	45

Data do not add up not 100% because impurities are ignored.

Table 1. *Composition of reference and experimental detergents. All data in the table are in weight % of the total detergent.*

Appendix 2:

No.	Stain name	Producer	Group
1	C-10 Pigment, oil, milk	CFT	Protein-rich stains
2	C-S-01 Blood (aged)	CFT	Protein-rich stains
3	C-S-02 Cocoa	CFT	Protein-rich stains
4	C-S-06 Salad dressing with natural black	CFT	Mixed stains
5	C-S-08 Grass	CFT	Protein-rich stains
6	C-S-25 Spinach	CFT	Protein-rich stains
7	C-S-28 Rice starch, colored	CFT	Starch-rich stains
8	C-S-47 Tea	CFT	Bleach-sensitive stains
9	C-S-49 Coffee	CFT	Bleach-sensitive stains
10	C-S-55 Orange juice	CFT	Bleach-sensitive stains
11	C-S-62 Lard	CFT	Lipid-rich stains
12	C-S-65 DMO	CFT	Surfactant-sensitive stains
13	C-S-68 Chocolate ice cream	CFT	Mixed stains
14	C-S-87S Chinese garlic chili sauce	CFT	Mixed stains
15	C-S-103 Wine (not aged)	CFT	Bleach
16	C-S-216 Lipstick diluted	CFT	Surfactant-sensitive stains
17	E-111 Blood on cotton	Swissatest	Protein-rich stains
18	PC-09 Pigment with oil (below 60 °C)	CFT	Surfactant-sensitive stains
19	PC-10 Pigment, oil, milk	CFT	Protein-rich stains
20	W-10 D Pigment/sebum on cotton	wfk Testgewebe	Surfactant-sensitive stains
21	W-10 PF Pigment/vegetable fat on cotton	wfk Testgewebe	Lipid-rich stains
22	W-10 T Ketchup on cotton	wfk Testgewebe	Mixed stains
23	TS-KC CS Tofu stew	Warwick Equest	Protein-rich stains
24	MGC(WHM)KC CS Gongbao chicken	Warwick Equest	Starch-rich stains
25	TVSKC CS Totole vegetable spice	Warwick Equest	Starch-rich stains
26	MSP-KC CS Stewed pork	Warwick Equest	Protein-rich stains
27	YGM-KC CS Yili grain milk	Warwick Equest	Starch-rich stains
28	LKKSS CS Lee kum kee seafood sauce	Warwick Equest	Starch-rich stains
29	SCM CS Sanyuan chocolate milk	Warwick Equest	Protein-rich stains
30	Lard	Novozymes	Lipid-rich stains
31	Lard	Novozymes	Lipid-rich stains
32	Beef fat	Novozymes	Lipid-rich stains
33	CS-10 Butter fat with colorant	CFT	Lipid-rich stains
34	KCH126 Vegetable oil with colorant	CFT	Lipid-rich stains
35	CS-73 Locust bean gum, with pigment	CFT	Mannan-rich stains
36	CS-43 Guar gum with pigment	CFT	Mannan-rich stains
Tracer	CN-42 Cotton tracer preaged	CFT	-
Tracer	PN-01 Polyester tracer preaged	CFT	-

Table 2. *Details of stains used in wash performance evaluation.*

Appendix 3:

No.	Stain name	Detergent A	Detergent B	Detergent C	Detergent D
			Change in wash performance relative to Detergent A		
1	C-10 Pigment, oil, milk	52.4	0.4	3.5	4.9
2	C-S-01 Blood (aged)	44.8	0.8	0.9	1.4
3	C-S-02 Cocoa	40.2	1.1	7.1	8
4	C-S-06 Salad dressing with natural black	54.9	0.5	3.9	2.9
5	C-S-08 Grass	48.9	-1.3	0.2	-0.9
6	C-S-25 Spinach	57.2	1.3	1.2	-1.1
7	C-S-28 Rice starch, colored	35.8	1.2	6.6	8.5
8	C-S-47 Tea	30.8	-1.3	-0.4	-1.1
9	C-S-49 Coffee	47.9	-0.6	-0.1	-0.4
10	C-S-55 Orange juice	72.9	-0.3	-0.9	-0.2
11	C-S-62 Lard	46.2	-7.3	-0.4	-4.5
12	C-S-65 DMO	47	0.2	0.5	1.5
13	C-S-68 Chocolate ice cream	50.1	2.4	6.1	8
14	C-S-87S Chinese garlic chili sauce	56.2	-0.7	-0.4	-0.4
15	C-S-103 Wine (not aged)	55.7	0	0.4	0,1
16	C-S-216 Lipstick diluted	44.1	2.7	4.1	1,6
17	E-111 Blood on cotton	72.9	0.2	0	-0.2
18	PC-09 Pigment with oil (below 60 °C)	57.5	-0.9	0.3	-1.8
19	PC-10 Pigment, oil, milk	63.5	-0.5	6.2	7
20	W-10 D Pigment/sebum on cotton	61.5	1	3.4	-0.3
21	W-10 PF Pigment/vegetable fat on cotton	53.8	0.5	-0.4	-3.4
22	W-10 T Ketchup on cotton	73.7	0	0.4	0.3
23	TS-KC CS Tofu stew	51.4	-0.1	4.9	5.4
24	MGC(WHM)KC CS Gongbao chicken	71.6	0.4	2.4	1.5
25	TVSKC CS Totole vegetable spice	42	1.8	3.6	2.3
26	MSP-KC CS Stewed pork	79.8	1.8	6.3	6.2
27	YGM-KC CS Yili grain milk	84.5	-0.7	1.1	0.6
28	LKKSS CS Lee kum kee seafood sauce	74	3.5	7	5.9
29	SCM CS Sanyuan chocolate milk	76.4	1.2	2.1	1.3
30	Lard	52.2	-17.7	-0.7	-11.9
31	Lard	40.4	-3.7	1.5	-2.3
32	Beef fat	63	-4.2	0.3	-1.7
33	CS-10 Butter fat with colorant	62.2	-1.7	1.6	0.1
34	KCH126 Vegetable oil with colorant	42.6	-2.5	-4.8	-7.3
35	CS-73 Locust bean gum, with pigment	48.1	0.4	7.7	8.5
36	CS-43 Guar gum with pigment	48.9	0.5	1.4	0.2
Tracer	CN-42 Cotton tracer preaged	92.6	-0.3	0.2	0
Tracer	PN-01 Polyester tracer preaged	73.3	-0.3	-0.2	0

Table 3. *Details of wash performance results [unit less data].*
a) Negative number indicates that the specific wash performance has reduced and vice versa.

Appendix 4:

Method used for climate change impact assessment

Surfactants:
Estimation of greenhouse gas emissions of surfactants in a cradle-to-gate perspective is based on EcoInvent database (v. 3.5).

Enzymes:
Estimation of greenhouse gas emission of enzyme products is based on principles described in “Cradle-to-Gate Environmental Assessment of Enzyme Products Produced in Denmark by Novozymes”, International Journal of LCA, although primary data on heat and electricity as well as database and impact assessment method have been updated.

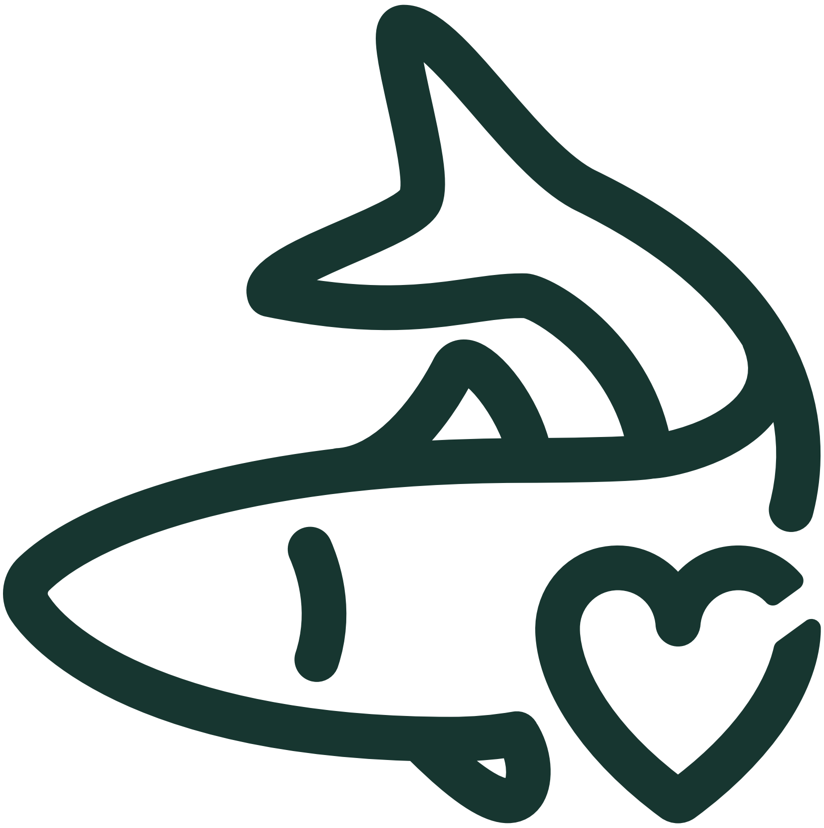
The assessment includes all heat and electricity consumed in production and handling of all production side streams (biomass and used water). More than 90% of ingredients used in production as well as the most important ingredients’ transportation processes. Data refer to production at Novonesis in 2017. Secondary data on materials and utilities are mostly derived from EcoInvent database (v. 3.3).

Direct land use is included in carbon footprint calculations, but effects of indirect land use are not. Enzymes have a lifetime of a few years and no effects of carbon storage in products are included. Biogas produced from wastewater and biomass and used for energy purposes at some of Novonesis’ production sites is included in the assessment.

Transport of the enzymes/surfactants from producer to the customer is not included because it is considered insignificant. Adding transport in a specific case would probably add to the benefit of enzyme use because a small quantity of enzyme replaces a large quantity of surfactants.

LCA tool: SimaPro.
Impact assessment method: ReCiPe.

Appendix 5:



Estimation of critical dilution volume, CDV

Critical dilution volume of used enzymes and saved surfactants is estimated using the formula:

$$CDV = \sum \text{dosage}\ (i)\ \frac{\text{Degradation factor}\ (i)}{\text{Toxicity factor}\ (i)}$$

Where,
Dosage is the quantity of each enzyme or surfactant ingredient (i) added or saved in the detergent per wash (active ingredient), see Appendix 1.

Degradation factors and toxicity factors for each enzyme or surfactant are derived from the “Detergents Ingredients Database (DID-list) Part A. List of ingredients 2016.” All toxicity factors used are "chronic."

Full documentation is available in “EU Ecolabel for detergents and cleaning products – user manual”

Novonesis is leading the era of biosolutions.

By leveraging the power of microbiology with science, we transform the way the world produces, consumes and lives. In more than 30 industries around the world, our biosolutions are already creating value for thousands of customers and benefiting the planet. Our 10,000 people worldwide work closely with our partners and customers to transform business with biology. Let's better our world with biology.

Novozymes A/S
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