

#### Context

In our ChE 180 Chemical Engineering Design Studio, we have developed a unique soap design while working with constraints, articulated rationales for our design and become increasingly familiar with the engineering design process. We have also gained knowledge about the saponification process and the molecular composition of oils to determine the requirements of sodium hydroxide to ensure the occurrence of the saponification process.

Saponification is a process by which triglycerides are reacted with sodium or potassium hydroxide (lye) to break the bonds within the triglyceride to produce glycerol and a fatty acid salt, commonly called soap.



## Ingredients

The defining softness and conditioning of ghee and Crisco is derived from their bent, unsaturated fatty acid chains. We believe that hardness is one of the many essential properties of a soap as hardness prevents the soap from deteriorating quickly after a few uses.

Corn oil contributes heavily to our soap by increasing the properties of conditioning, hardness, and creamy lather. Coconut oil is one of the most common ingredients used in skincare products. It contributes many properties, specifically bubbly lather and cleansing which amplify the component of soap that is enjoyable for most.

Sodium hydroxide is chosen because lipids that contain fatty acid ester linkages can undergo hydrolysis. Sodium hydroxide was chosen as the strong base because a hard soap will be produced whereas potassium hydroxide would produce a liquid soap.







# **Properties of Our Soap**

#### ≻ Hardness

To balance our desire for a conditioning soap, it was necessary to ensure that our soap would provide sufficient hardness, as to not leave behind messy residue on soap dishes and countertops

 $\succ$  Cleansing

The fundamental of any soap, we ensured that our soap will leave you clean and feeling fresh.

#### ➤ Conditioning

Our soap is meant to make you <u>feel good</u>, and what better way to leave you feeling good than by <u>hydrating and refreshing your skin</u>.

It isn't enough that our soap cleans you. When you're constantly washing yourself, it's important to ensure that your skin stays healthy and moisturized

#### **Properties of Lavender Essential Oil**

- As university students, we often experience stress and anxiety, causing destressors to be highly valued in our day to day lives that don't reduce the amount of time available for studying
- ➤ Other properties include
  - Insomnia
  - Anxiety
  - $\circ$  Depression
  - Eczema
  - Wound Healing



# Mould Selection and Packaging



We chose a bell shaped silicone mould with ridges all around to enhance usability and the overall consumer experience. Since silicone has high elasticity and does not react with most chemicals, we were able to use a silicone mould without fear of a side reaction while it was cooling and able to easily take the soap out of the mould after solidifying.

Many other packaging designs were thought of, however not all of the possible designs were both economically and environmentally friendly. Eventually, we decided to package our soap using wax paper and twine. Wax paper is used to package the soaps as it is compostable, recyclable, and the components used to coat the wax paper is biodegradable. It also allows us to package our soaps to protect it from the elements without compromising the minimalist design.

Another environmentally friendly feature of our packaging is the twine used to secure the soap. Twine is biodegradable which reduces the possibility of endangering the environment when discarded.

#### **Soap Calculator**

When initially designing our soap, we decided to prioritize the properties of hardness and conditioning, due to personal experience from using soaps. This was reflected in our recipe by the use of oils such as ghee and crisco which contribute heavily to these properties. The values of conditioning and hardness were respectively, 49 and 40, both on the higher end of their recommended ranges.

Our value for bubbly lather was safely in the middle of its range as 24. However, after testing our prototype, the amount of bubbles was a pleasant surprise, allowing our soap to have multiple prominent features.

Mass of NaOH (g)	Mass of KOH (G)	Hardness	Cleansing	<b>Bubbly Lather</b>	<b>Creamy Lather</b>	Conditioning	Cost	
69.825	103.1	40	24	24	16	49	\$	4.57
Recommended Ranges		29-54	12-22	14-46	16-48	44-69		
	Targets	41.5	17	30	32	52		

### Raw data affiliated with the ingredients

Corn oil and Crisco both contribute to our soap by enhancing the properties of hardness and conditioning. Their defining softness and conditioning is derived from their bent, unsaturated fatty acid chains.

Ghee is a highly-clarified butter that has multiple uses. We decided to use ghee in our soap to prioritize hardness and creamy lather in our soap. We believe that hardness is one of the many essential properties of a soap as hardness prevents the soap from deteriorating quickly after a few uses.

Corn oil contributes heavily to our soap by increasing the properties of conditioning, hardness, and creamy lather.

Coconut oil is one of the most common ingredients used in skincare products. It contributes many properties, specifically bubbly lather and cleansing which amplify the component of soap that is enjoyable for most.





Corn oil



Coconut Oil

#### Iterations of our soap

An idea was to use a silicone mould that would shape the soap into flowers and while the decision to use a silicone mould was unanimous, we felt that the design would not appropriately convey the purpose of our soap to destress and relax.

Another idea that was thought of was to create a minimalistic soap that lacked any identifying features, such as scent, colour and shape. This initial soap idea would contain the basic ingredients that are necessary when making a soap and would be void of any essential oils.

Eventually, we changed our idea due to the agreement that we would not be interested in using a soap that had food products in it since the shelf life and cleansing abilities of the soap would be questioned. We wanted to make a purposeful soap that we would want to use as a beneficial component to our day, to do more than just clean.





# **Manufacturing Process**

We began to create our soap by measuring the lye, water, and oils that were used in our soap.









The oils were then mixed in a metal tin on a hot plate until they were completely melted

#### **Manufacturing Process**

Next, the lye (NaOH) was mixed in water until it was completely dissolved



Once desired thickness was achieved, the solution was poured into the silicone moulds and left to solidify for approximately a week



Then, the oils and lye solution were mixed using an emulsion blender



#### **Economics**

The economics of our soap design revolves around the consumer's' demand for a soap which has hardness and conditioning features, along with a pleasant scent to increase our soap selling point. However, including features to our soap will result in an increase in the soap's manufacturing cost.

Our team decided to make a tradeoff of adding these features by choosing coconut oil as one of the major ingredients of our soap. While coconut oil increases the conditioning features of our soap, this oil, which costs \$1.63/100 ml, has a higher cost relative to the other oils in our soap. Besides improving the scent of our soap, lavender scent has healing and stress-reducing properties. On the other hand, lavender oil costs \$0.6/100 ml and it adds a sum of \$0.17 to the soap's cost.

The cost of the soap including the cost of the sodium hydroxide (\$14.93) is \$19.50. Then the cost of our soap per gram is \$0.039. After including the cost of the packaging and multiplying by the approximate mass of each bar of soap leads to our final cost of each bar being \$3.50.

