Popular Science Summary

Do you realize that starch is everywhere in our daily life? Starch is not just foods to satisfy our hungry belly. It is part of the cloths we wear, medicine we eat, cream lotion for our face, the paper that we write on, the glue to stick things, to thicken our delicious puddings or soups and it is even useful when preparing our salad dressing. Starch is the most common carbohydrate in human food intake. It is abundant, cheap, naturally existing and easily found among our staple foods. As mentioned, starch is not only served as foods, but has wide applications in other industries such as textile, pharmaceuticals, paper making, printing, adhesive, bioplastic and many more. The highlight of starch application in this thesis is in food processing where it can act as stabilizer or emulsifier in food products. Different types of starches such as quinoa, oat, barley, potato and maize have been studied to evaluate their potential as emulsifiers based on the important characteristics of size, shape and structure.

Investigating these starches is mainly to improve the quality of food products. The challenge in food industry today is how to produce foods that are not only nutritious, but also fresh looking, have longer shelf life and stay in good structure or stability from production until it reaches consumer's hand. Furthermore, and maybe most important of all, it should also be cheap. When we buy food products in the supermarket, the appearance of the products is what we perceive the most, as well as the expiry date. The appearance is based on freshness, good condition, structure and the stability. Stability is the condition when the ingredients do not get separated individually resulting in collapsed structure, which is very important especially for oil- and water based food products like mayonnaise, vinaigrette, salad dressing, butter, margarine but also for non-food products like body lotion and moisturizers. Oil and water is not mixed by nature except in milk that was created naturally stable with protein (casein) present around fat droplets that disperse in the liquid. As we do not favour our mayonnaise when it becomes oily on top layer or when our salad dressing gets separated into individual components of oil, water and herbs it is very important for oil and water to be mixed and stable for a certain period of time. That is why an emulsifier is needed.

Emulsifier holds both oil and water phase together and form a structure called emulsion. The most common emulsifying agent that we use in food is egg yolk, mainly in making homemade mayonnaise. Egg yolk contains lecithin, a substance called a surfactant that has two different characteristics: one part is loving oil (hydrophobic) and the other part is loving water (hydrophilic). Emulsifier is therefore actually a 'middle-man' between two different parties and is also called amphiphilic, it stays in between the interface of oil and water and bind both components. To mix all components well, energy from mixing, blending, or homogenization processes is often required to form emulsions. This emulsion is the building block of all oil-water based products. The capacity in stabilizing emulsions highly depends on certain emulsifiers. Most emulsifiers are amphiphilic due to dual characteristics.

Starch is neutral by nature, not favouring either oil or water. Modification is sometimes needed to make it more oil-loving either by heat treatment or patching the outer part with hydrophobic element. This will enable starch to sit in between the oil/water interface. To be able to emulsify certain products, the classical way is to use emulsifiers that contain both the 'loving oil- and loving water' parts. Depending on the amount of oil (O) and water (W), we can produce O/W emulsions when oil is dispersed in water as background liquid or vice versa. In this case, starch particles will sit around oil droplets and act as a barrier layer and prevent meetings with other oil droplets. Due to this, coalescence, a process where two oil droplets meet and combine can be avoided which in turn will inhibit separation of oil and water. This type of emulsion is also known as a Pickering emulsion named after S.U. Pickering, who is among the first scientists that found this phenomenon of solid particle stabilization in emulsions around 1907, although record mentioned Walter Ramsden as discoverer already in 1903.

Starch shows strong attachment between the O/W phases that is found to be irreversible due to high energy of detachment. The energy is defined as the amount of work that is required to take away starch particles from the interface that is subjected to the particle size. The bigger the particles, the higher the energy needed to remove the emulsifier. This is an indication of how stable an emulsion is and the higher energy needed for detachment the higher is the stability. However, this stabilization energy does not only dependent on the size, it is also subjected to the properties of the starch particles. Starches at a certain level, even with or without addition of hydrophobic elements, could position themselves in between both the oil and water phase due to the presence of protein on the surface, or due to favourable sizes and shapes. This study has revealed a great deal of information about the feasibility of starches. Quinoa with the size of 1-2 microns has been an interesting particle to explore due to their small and edgy shape that can maximize the packing at the interface of oil and water with higher volume and create strong binding. Also, oat with the average size of 7-8 microns and a round edgy shape may stabilize emulsions even without hydrophobic treatment since it has a naturally occurring thin protein layer. Barley has bimodal sized particles with the size of less than 10- but up to 30 microns. The particles have round and smooth surfaces with a size less than 10 microns that have been found to sufficiently stabilize emulsions. However bigger barley particles seem to sediment by gravity and not be able to stay successfully at the interface. Maize particles on the other hand have slightly larger sizes than oat with rough surfaces and sharp edges and were observed to have less affinity to attach at the interface unlike most of the other starches investigated.

There are many interesting aspects to look at starches as they naturally exist in such uniqueness and variations. We can use it as it is after applying slightly hydrophobic elements and it is already good to go. Another step in current research work is to generate starch nanoparticles through a process of dissolving starch in high temperature and regenerate it by precipitation methods using alcohol. This will result in extremely small starch particles (less than 1 micron) that highly maximize packing in volume and bind effectively the interface of emulsions. Starch is not only a naturally existing ingredient but the application as emulsifier is regarded as novel and new innovation. By understanding starch characteristics, functions, mechanisms and its potential as stabilizer, the technology used will hopefully be implemented in all emulsion based products to benefit the use of starch as a natural ingredient in replacing synthetic and chemically processed stabilizers in the future.