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# Stable Emulsion And Gel Of Coconut Oil Using Different Combination Of Surfactants.

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***Abstract:*** Coconut oil, a lauric acid-based oil, holds significant importance in industries such as pharmaceuticals and cosmetics due to its desirable properties. Emulsifying coconut oil presents challenges due to the varying chain lengths and degrees of saturation in the fatty acids. Non-ionic surfactants, including sorbitan esters (Span), polyoxyethylene sorbitan esters (Tween), and polyoxyethylene ethers are used in this study, as these surfactants are commonly used in pharmaceutical and cosmetic applications due to their low toxicity and irritational potential. Co-surfactants such as short- to medium-chain alcohols or propylene glycol are added to lower interfacial tension. This research paper aims to provide a comprehensive study of coconut oil emulsions, focusing on the role of surfactants and various factors influencing emulsion systems. The data collected and analyzed in this study involved the emulsion formation, the selection and characteristics of surfactants, and the parameters affecting emulsion stability.

***Index Terms* – Coconut oil, emulsion, gel, surfactants.**

**I. INTRODUCTION** Emulsions, colloidal dispersions consisting of immiscible phases, play a vital role in numerous industrial processes, ranging from pharmaceutical and cosmetic formulations to food and beverage production. These systems, composed of oil and water phases stabilized by emulsifiers or surfactants, offer unique properties and functionalities that make them essential in a wide range of applications. Understanding the fundamental principles of emulsion formation and stability is crucial for developing effective emulsification systems and optimizing their performance.

Emulsions are formed by dispersing one phase (dispersed phase) within another phase (continuous phase) through emulsification mechanisms. The presence of emulsifiers or surfactants is crucial in reducing the surface tension between the oil and water phases, allowing the formation of stable interfacial film around the dispersed oil droplets. This film acts as a barrier, preventing droplet coalescence and maintaining the colloidal stability of the emulsion (Talegaonkar et al. 2008). In addition, emulsion is a thermodynamically stable, transparent, and isotropic dispersion with particle sizes ranging from 100-1000 nm (Joshi & Bhagwat 2013). It is composed of oil, water, and surfactants, along with the combination of a co-surfactant (Mohd Nadzir et al. 2017).

The choice of surfactants plays a significant role in emulsion formulation. Synthetic surfactants, such as polysorbates (e.g., Tween 80), are commonly employed due to their low toxicity and ability to form monomolecular films around the dispersed phase droplets (Spernath & Aserin 2006). However, their sensitivity to heat and incompatibility with certain substances restrict their applicability in specific formulations. To address these limitations, natural molecules, including polysaccharides, have emerged as alternative emulsifiers due to their biocompatibility and eco-friendliness, offering enhanced stability and performance (Zainuddin et al. 2017). Short-to-medium chain alcohols (C3-C8) are commonly used as co-surfactants to lower down the interfacial tension at the interface (Azeem et al. 2008). Due to irritancy from usage of alcohol, propylene glycol normally used as a co-surfactant as it is relatively tolerable to skin (Syed & Peh 2014). Emulsion can provide a well-controlled way to incorporate active ingredients and may protect the solubilized components from undesired degradation (Ramli et al. 2015).

Factors influencing emulsion stability encompass a wide range of variables, including phase volume ratio, temperature, surfactant concentration, and the nature of the continuous phase. Understanding the effects of these variables on emulsion systems is crucial for formulating stable and reliable products. The research conducted in this study investigates the impact of these factors on emulsion stability and provides insights into strategies for enhancing stability and preventing emulsion breakdown. By examining the interplay between surfactants, formulation variables, and process conditions, this research paper aims to contribute to the existing knowledge on emulsion systems and provide practical guidelines for the design and optimization of emulsification processes in various industries.

## II. EXPERIMENTAL METHODS

### Materials

Pure edible refined coconut oil was purchased from retail market of M/S Marico Industries Ltd (India), Non-ionic surfactant Polysorbate 80(Tween 80) Sorbitan monolaurate (Span 20), propylene glycol, Polyoxyethylen Castor oil having 36 mole of Ethylene oxide, Polyoxyethylen Glycerol having 26 mole of Ethylene oxide was purchased from Loba Chemie. The oil and surfactants were used in the experimentation as received without further purification. Deionized water was used for the experimentation.

### Laboratory procedure for the preparation of emulsion or gel

Considering the HLB value of the surfactants made the two different phases i.e., oil phase and water phase for the emulsion or gel formation. As Span 20 is having 8.6 HLB value which is lower and Propylene glycol is also having lower HLB value and having oil soluble characteristics, so it also included in oil phase. So, the oil phase consists of coconut oil, span 20 and propylene glycol and rest of the surfactants accompanied with water phase as they are having the high HLB value. Separately heated up to 70 deg C to the oil and water phase in separate beaker and after getting the desired temperature added the oil phase to the water phase beaker dropwise under continuous stirring by magnetic needle and continuous heating. After complete addition of oil phase continued the heating for 30 min and then stopped the heating and continuously stirred both phases to make the emulsion or gel up to attain the room temperature. Then stored the sample at respective temperature to observe the phase separation or gel formation or emulsion formation.

## III. RESULTS AND DISCUSSION

The aim of this research study was to investigate the emulsification of coconut oil using different surfactants and to evaluate the stability of the resulting emulsion systems. The experiments were conducted by varying the components and their concentrations, and the obtained formulations were analyzed for clarity and turbidity.

Table 1 presents the composition of three different experiments (Exp 1, Exp 2, Exp 3) using varying amounts of coconut oil, Span 20, Propylene glycol, Tween 80, Polyoxyethylen Castor oil having 36 mole of Ethylene oxide and water. The total weight of each formulation was maintained at 25 grams. Coconut oil, surfactants and water composition was 10%, 38% and 52% respectively. After heating and stirring the components, the mixtures were allowed to cool to room temperature, and the clarity or turbidity of the formulations was observed. With the clear picture 1 of the experimental samples, the prepared samples come in the category of gel as they are transparent with no phase separation.

| **Components** | **Exp 01** | **Exp 02** | **Exp 03** |
|---|---|---|---|
| Coconut Oil | 2.5 | 2.5 | 2.5 |
| Span 20 | 3 | 2.5 | 2 |
| Propylene glycol | 1 | 1.5 | 2 |
| | | | |
| Tween 80 | 2 | 2.5 | 3 |
| Castor oil 36 EO | 3.5 | 3 | 2.5 |
| | | | |
| Water | 13 | 13 | 13 |
| Total Weight | 25 gm | 25 gm | 25 gm |

Table 1

| **Components** | **Exp 04** | **Exp 05** | **Exp 06** |
|---|---|---|---|
| Coconut Oil | 2.5 | 2.5 | 2.5 |
| Span 20 | 0.5 | 0.5 | 0.5 |
| Propylene glycol | 0.25 | 0.25 | 0.25 |
| | | | |
| Tween 80 | 1 | 0.25 | 0.25 |
| Castor oil 36 EO | 0.25 | 1 | 0.5 |
| Glycerol 26 EO | 0.5 | 0.5 | 1 |
| Water | 20 | 20 | 20 |
| Total Weight | 25 gm | 25 gm | 25 gm |

Table 2


Picture 1


Picture 2

Table 2 demonstrates the composition of three additional experiments (Exp 4, Exp 5, Exp 6) with variations in the amounts of coconut oil, Span 20, Propylene glycol, Tween 80, Polyoxyethylen Castor oil having 36 mole of Ethylene oxide with addition of another non-ionic surfactant Polyoxyethylen Glycerol having 26 mole of Ethylene oxide, and water. The total weight of each formulation remained constant at 25 grams. Keeping the concentration of coconut oil and surfactants at 10% and remaining 80% concentration water. From the Image 2 all experimental samples have the phase separation.

Similarly, Table 3 illustrates the composition of six more experiments (Exp 7, Exp 8, Exp 9, Exp 10, Exp 11, Exp 12) with different proportions of Span 20, Propylene glycol, Tween 80, Castor oil 36 EO, Glycerol 26 E Polyoxyethylen Castor oil having 36 mole of ethylene oxide, Polyoxyethylen Glycerol having 26 mole of ethylene oxide, and water. Keeping the coconut oil proportion constant. The total weight of each formulation was 25 grams.

| **Components** | **Exp 07** | **Exp 08** | **Exp 09** | **Exp 10** | **Exp 11** | **Exp 12** |
|---|---|---|---|---|---|---|
| Coconut Oil | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Span 20 | 1 | 1 | 1.25 | 1.5 | 1.75 | 2 |
| Propylene glycol | 1 | 1 | 1.25 | 1.25 | 1.25 | 2 |
| | | | | | | |
| Tween 80 | 0.5 | 1 | 1.25 | 1.5 | 2.25 | 2 |
| Castor oil 36 EO | 0.75 | 1 | 1.25 | 1.75 | 1.5 | 2 |
| Glycerol 26 EO | 0.5 | 1 | 1.25 | 1.5 | 2 | 2 |
| Water | 18.75 | 17.5 | 16.25 | 15 | 13.75 | 12.5 |
| Total Weight | 25 gm | 25 gm | 25 gm | 25 gm | 25 gm | 25 gm |
| Surfactant % | 15% | 20% | 25% | 30% | 35% | 40% |
| Surfactant in gm | 3.75 gm | 5 gm | 6.25 gm | 7.5 gm | 8.75 gm | 10 gm |

Table 3


Picture 3


Picture 4

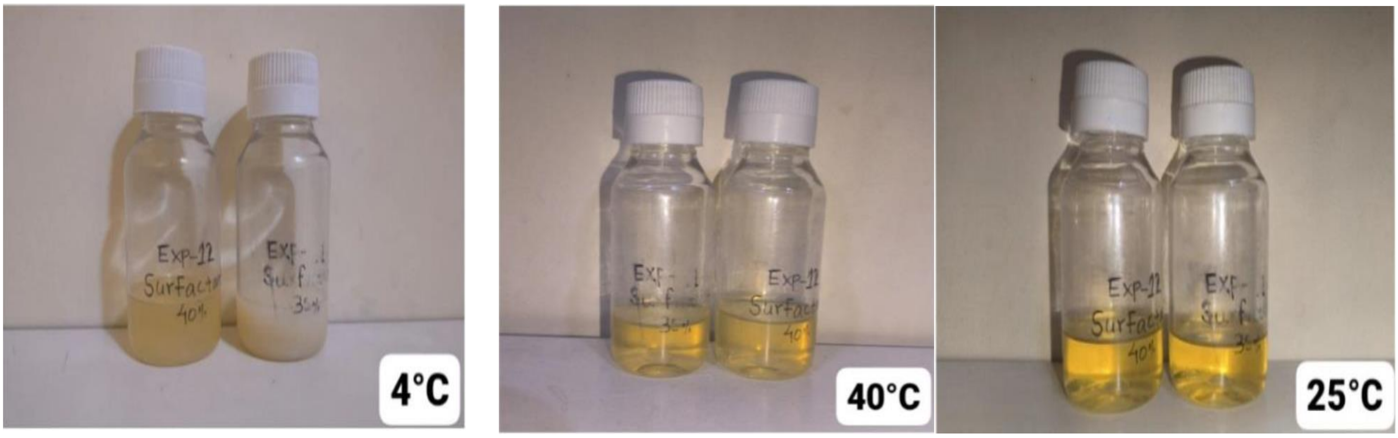
The experiments aimed to assess the influence of surfactant concentration on emulsion stability. Surfactants, such as Span 20, Tween 80, and Propylene glycol, were used in varying percentages (15%, 20%, 25%, 30%, 35%, and 40%) to examine their impact on emulsion formation. From the image 3 and 4 Exp. 7,8,9,10 is in the emulsion category as there is no phase separation and milky white color appearance. While the Exp 11 and 12 are the gel category. To form the gel of coconut oil having 10% concentration, the surfactant concentration should be above 30% of total composition.

The results obtained from the experiments indicate that the stability of the emulsion systems varied based on the composition of the formulations. The clarity or turbidity of the emulsions was observed after the cooling process. Stable gel appeared clear, while stable emulsions exhibited milky white turbidity. It was observed that the emulsion system consisting of Tween 80, coconut oil, and water (at a ratio of oil : surfactant = 1:9) produced a larger emulsion area compared to the system with the addition of propylene glycol. The presence of propylene glycol as a co-surfactant helps to formation of emulsion and gel indicating the stabilization effect.

Further investigations were conducted on the stability of the gel of exp. 11 and 12 systems upon storage at 45°C for one month. The results showed that the coconut oil gel system was stable under these conditions, suggesting that it may not be suitable for long-term storage or certain applications. Overall, the findings highlight the importance of surfactant selection and concentration in emulsion stability. Surfactants such as Tween 80 exhibited stronger stabilizing effects, while variations in the composition of oil, co-surfactants, and water influenced the emulsion formation and stability. These results contribute to the understanding of emulsion science and provide insights for the development of emulsion-based products in various industries, including cosmetics, pharmaceuticals, and food. Further research and optimization can be conducted based on these findings to enhance emulsion stability and performance in specific applications.

**Stability Studies**

Three different temperatures (4°C,25°C, and 40°C) were imposed on emulsion system for four weeks to examine their stability. Based on the observation as showed in figured. Coconut oil gel of 5-25 wt. % water remained clear and stable at 25 and 40°C without any phase separations upon one-month storage. Unfortunately, the coconut oil gel system was unstable and became turbid when stored at 4°C. This is because coconut oil has low range of melting point and causing the microemulsion system to solidify and become cloudy and turbid at low temperature.




## IV. Conclusion

The research study focused on the emulsification of coconut oil using various surfactants and investigated the stability of the resulting emulsion systems. Different combinations of surfactants, such as Span 20, Tween 80, and Propylene glycol, were used in varying concentrations to create the emulsions. The formulations were analyzed for clarity or turbidity to assess their stability. The experimental results revealed that the composition of the surfactants combination, co-surfactants and the oil in emulsion systems significantly influenced their stability. Emulsions with higher concentrations of Tween 80 exhibited greater stability, the addition of propylene glycol as a co-surfactant helps to stabilizes the coconut oil emulsion. The emulsion systems containing coconut oil were found to be stable, especially when subjected to storage at elevated temperatures.

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