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Original Article

Influence of Mucilage Viscosity On The Globule Structure And Stability Of Certain Starch Emulsions

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Abstract: A study was carried out to determine the influence of mucilage viscosity on the globule structure (i.e. size and number) of certain starch emulsions. The starches investigated were cassava, potato and maize. The emulsions were prepared by mixing the starch mucilage of a predetermined concentration 4%w/v with arachis oil in the ratio 50:50, using a silverson mixer fitted with a dispersator head. The emulsions were stored at room temperature ($28\pm 2^\circ\text{C}$) for 7 days. Changes in globule size were monitored by photomicroscopy. Viscosities of the mucilage and those of resulting emulsions were determined using a capillary flow method. The viscosities of the emulsions

expressed as time of flow (seconds), were 680 (cassava starch), 369 (potato starch) and 270 (Maize starch), and for the mucilage 510 (cassava), 336 (potato) and 248 (maize). The corresponding mean globule sizes of the fresh emulsions were (μm) 28 ± 6 , 42 ± 6 and 45 ± 5 respectively. The increase in globule size during storage (measure of globule coalescence rate) was $1.8\pm 0.2\mu\text{m day}^{-1}$ (cassava), $3.5\pm 0.2\mu\text{m day}^{-1}$ (potato) and $4.6\pm 0.3\mu\text{m day}^{-1}$ (maize). Thus, a higher viscosity of the dispersion medium is associated with the production of finer and more stable emulsions.
Key Words: Globule structure, Mucilage viscosity, Stability, Starch emulsions.

Introduction

An emulsion is a disperse system consisting of at least two immiscible liquid phases, one of which is dispersed as globules (the disperse phase) in the other (the continuous phase). The dispersion is stabilized by the presence of an emulsifying agent or emulgent.(1) Oil-in-water (o/w) emulsion is formed when the oil phase is dispersed as globules throughout an aqueous continuous phase. The opposite type, water-in-oil (w/o) is also possible depending on the type of emulgent used.(1,2) Starch mucilage stabilizes o/w emulsions and it does so primarily by imparting viscosity to the dispersion medium. Starch emulsions have been used as enemas.(3) Starch mucilage forms coarse emulsions, which are unstable and are therefore intended as extemporaneous preparations only. Simple emulsions of this type serve as primary emulsions for the more complex multiple emulsions if they can be suitably stabilized.

Water-in-oil-in-water (w/o/w) multiple emulsions are systems where small water droplets are entrapped within larger oil droplets that are in turn dispersed in a continuous aqueous phase.(4) Such w/o/w multiple emulsions have applications in controlled drug delivery. The viscosities of the internal and external aqueous phase are important to the stability of such systems.(5)

Hence, in this present study we have examined the relationship between the viscosities of certain starch mucilages and the globule structure/stability of emulsions derived from them.

Materials and Methods

The starches used were extracted from the tubers of cassava plant (*Manihot utilissima*), potato tubers (*Solanum tuberosum*) and maize grains (*Zea mays*) following standard procedures for starch extraction.(3) The starches were used to form mucilages at a predetermined concentration of 4%w/v. Lower concentration of the cassava starch mucilage (<4%w/v) formed emulsions that creamed readily while concentration

>4%w/v were too thick and could not form emulsions. This point 4%w/v was used to compare the emulsifying property of all three starch mucilages.

To form the starch mucilages, 4g were dispersed in 20ml of distilled water. Boiling water (80ml) was added to cause gelling. The mucilage was allowed to cool and then made up to 100ml. The mucilages were slightly acidic with pH 5.3 (cassava), 6.4 (potato) and 5.7 (maize). Methylparaben was added to the mucilages 0.2%w/w as preservative.

The interfacial tension at the oil-mucilage interface of the different starches was measured with the Du Nuoy Tensiometer (Model No 0/36365f, White Elec. Inst. Co. Ltd, England). The measurement was done in triplicate and the mean value was reported.

To form the emulsions, arachis oil (50ml) was added gradually to the mucilage (50ml), whilst stirring (1500rev min⁻¹) for 10min with a silverson mixer/emulsifier fitted with a dispersator head (Silverson machine England, No 18214). The resulting emulsion was identified as o/w type by staining test. The fresh emulsions were evaluated for viscosity, globule size and coalescence rate.

Evaluation of the emulsions:

The viscosities of the starch mucilages and those of the emulsions were determined by measuring the time of flow of a sample of the mucilage or emulsion (10ml) through a plastic tube of stem orifice 1.5mm and length 11.5cm (6) at room temperature 28±2°C. The viscosity of a fluid is directly proportional to the time (seconds) of flow(2); since the present determination was of comparative value only, the time of flow was taken as the viscosity index. Each determination was carried out in triplicate and the mean result presented.

Globule structures of the emulsions were determined by photomicrocopy at a magnification x 40. Photomicrographs were taken and all globules appearing in each

micrograph were counted and sized with the aid of a photomicrograph of a calibrated stage slide, also taken at magnification x40.

Mean globule size ($\bar{\chi}$) was calculated from the expression:

$$\bar{\chi} = \frac{\sum f\chi}{\sum f} \dots\dots\dots (1)$$

where f is the frequency of each size χ . For each emulsion sample, 3 representative photomicrographs were used in the size analysis. These parameters (i.e. viscosity and globule structure) were evaluated at selected time intervals for 1 week. These emulsions were stored at room temperature $28 \pm 2^\circ\text{C}$. The average rate of increase in globule size per day was taken as a measure of the globule coalescence rate and hence a measure of instability of the emulsions.

Results And Discussion

The results on starch mucilage/emulsion viscosity (Table 1) showed that cassava starch mucilage or emulsion were considerably more viscous than those of the other two starches.

Table 1: Viscosity index (seconds) of freshly made mucilages and emulsions

| Type of starch | Viscosity index (seconds) | |
|----------------|---------------------------|-----------|
| | Mucilages | Emulsions |
| Cassava | 510 | 680 |
| Potato | 336 | 369 |
| Maize | 248 | 270 |

Photomicrographs of the emulsion globules revealed that cassava starch formed a more homogenous emulsion characterized by small size globules of even distribution (Fig 1a). By comparison potato or maize starch formed coarse emulsions characterized by large globules (Fig 1a) and uneven size

distribution. The mean globule sizes in the starch emulsions were (μm) 28 ± 6 (cassava starch), 42 ± 6 (Potato starch) and 45 ± 5 (Maize starch). The interfacial tension (at the oil-mucilage boundary) were (N/m) 0.058 (cassava) 0.032 (Potato) and 0.028 (Maize starch). Cassava starch mucilage thus displayed the higher interfacial tension than the two other mucilages.

A lower interfacial tension will be expected to facilitate dispersion of the oil globules in the continuous phase to produce fine emulsions. The results of the present study however showed that this was not the likely determinant factor because cassava starch mucilage with the highest interfacial tension produced the finest emulsion. More probably the difference in globule structure of the three emulsions relate to the difference in their viscosities. It is thought that during emulsification all three emulsions formed small size oil globules of a homogenous distribution initially, but upon withdrawal of the mixing and shearing forces, globules in the system with the lower viscosities (i.e. potato and maize starch emulsions) coalesced very rapidly to produce coarse emulsions, while in the case of the cassava starch emulsions, the high viscosity discouraged rapid coalescence. Thus, the difference in viscosity accounted for the observed difference in the globule structure of the fresh emulsions. On the other hand, the oil phase was difficult to disperse when the mucilage viscosity was excessive (>510 seconds, viscosity index) resulting in coarse and unstable emulsion. The application of this finding is that the viscosity of the aqueous phase can be optimized to obtain the desirable globule size distribution and hence stability of the emulsion. Thus, certain multiple water-in-oil-in-water (w/o/w) emulsions have been stabilized by polymerization of the aqueous phase (5) to increase the viscosity of the aqueous phase in order to discourage globule coalescence.

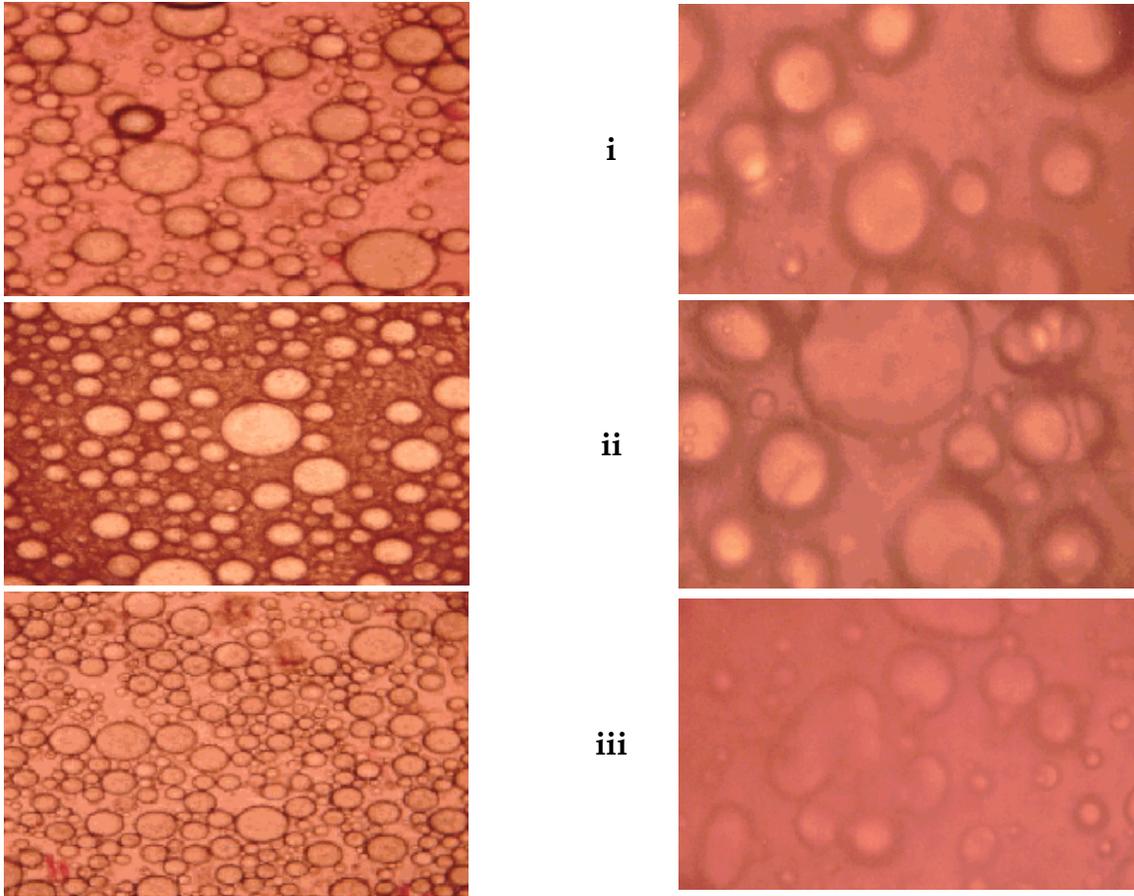


Figure 1(a and b): Photomicrographs of freshly made and aged emulsions (showing oil globules) with potato (i), maize (ii) and cassava starch (iii) as emulsifying agent at concentration 4%w/v (magnification x40)

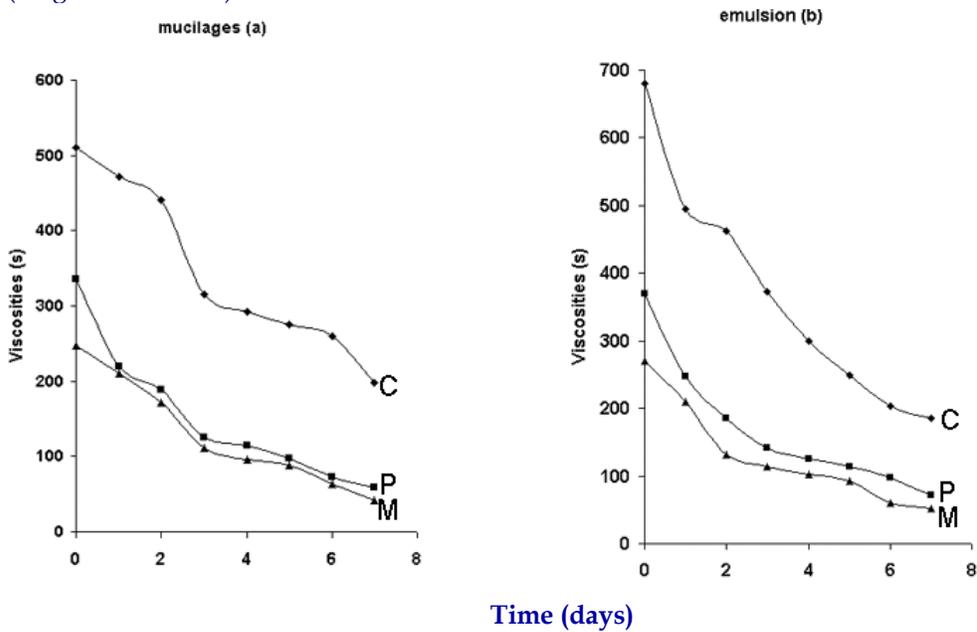


Fig 2: Changes in the viscosities of the starch mucilage (a) and their emulsions (b) during storage: cassava starch (C), potato starch (P) and maize starch (M).

During storage of the emulsions their viscosities decreased generally (Fig 2) while the globule sizes increased (Fig 1b and Fig 3).

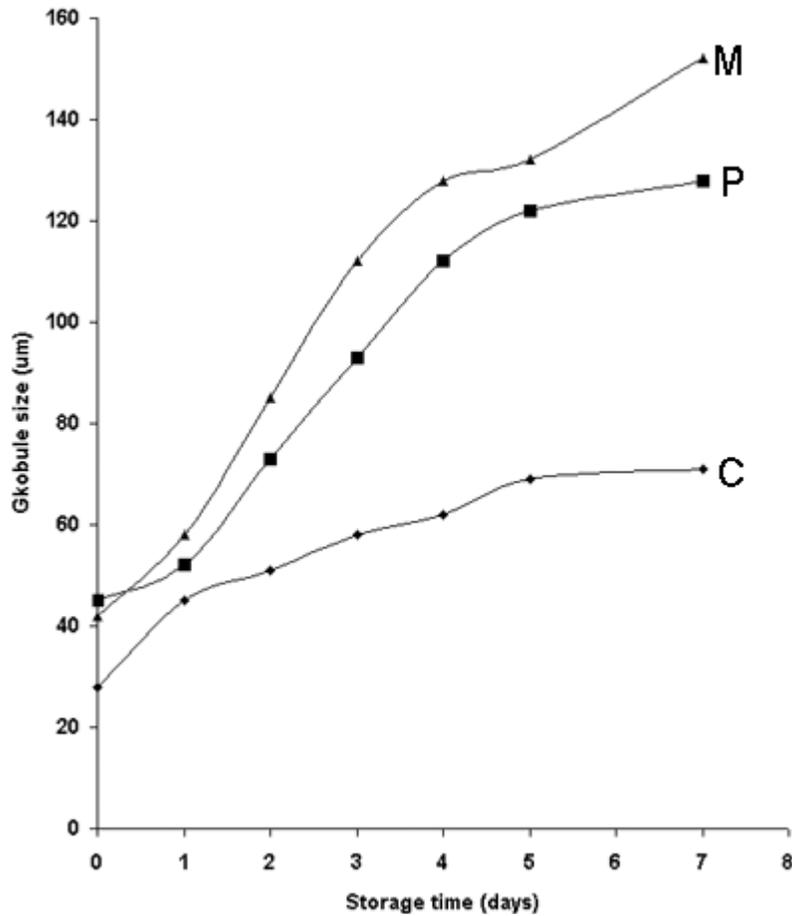


Figure 3: Effect of storage time on the globule size of emulsion, prepared with cassava starch (C) potato starch (P) and maize starch (M) as emulsifying agents at concentration 4%w/v.

The rate of coalescence of the globules (as measured by the average increase in globule size per day were ($\mu\text{m day}^{-1}$) 1.8 (cassava starch emulsion) 3.5 (potato) and 4.6 (maize). Also at the end of the 7 days storage period, the percentage increase in the mean globule size was lowest in the cassava starch emulsion and highest in the maize starch emulsion (Table 2).

Table 2: Globule structure (mean and size) of fresh and aged emulsions

| Starch emulsion | Globule structure (mean and number) of fresh and aged emulsion | | | | | |
|-----------------|--|--------|---------------|--------|--------------------|----------------------|
| | Fresh emulsion | | Aged emulsion | | % increase in size | % decrease in number |
| | Size (mm) | Number | Size (mm) | Number | | |
| Cassava | 28.3± 6.1 | 5015 | 70.6± 3.5 | 4540 | 154 | 9.5 |
| Potato | 42.2± 6.4 | 4985 | 128.4± 5.2 | 2814 | 205 | 43.5 |
| Maize | 44.8± 5.2 | 4875 | 152.4± 4.6 | 2345 | 238 | 51.9 |

The globule numbers decreased correspondingly. These are indications that the cassava starch emulsion was more stable than those of the other two starches. The viscosities of the cassava starch mucilages and their emulsions decreased during storage, but the values were persistently higher than the corresponding values for the other two starches (Fig 2), which explains the greater stability of the cassava starch emulsions. This means that cassava starch mucilage is superior to maize starch mucilage in the extemporaneous preparation of starch emulsion.

Conclusion

The study has shown that the viscosity of the dispersion medium of aqueous emulsions is important in determining the globule structure of the resulting emulsions. Although the study was carried out on starch emulsions, the principle is applicable to the formulation of the more complex multiple emulsion. Also, cassava starch is superior to maize starch BP in the formulation of starch emulsions for extemporaneous use.

References

1. Martin A. Coarse Dispersion. In Physical Pharmacy, 4th ed. Philadelphia: Lea and Febiger; 1993. p. 477-506.
2. Richard JH. Dispersed Systems. In S.J Carter (ed). Tutorial Pharmacy. 6th ed. London: Pitman; 1972. p 54-88.
3. Trease GE, Evans WC. Carbohydrates In Trease, Evans. Textbook of Pharmacognosy. 12th ed. Oxford: Aiden Press; 2002. p. 345-365.
4. Jiao J, Burgess DJ. Rheology and stability of water-in-oil-in-water multiple emulsions containing Span83 and Tween 80. *Pharm Sci.Tech* 5 2003 1: article 7. DOL: 10. 1208/ps050107.
5. Florence AT, Whitehill D. Stabilization of water-in-oil-in-water multiple emulsion by polymerization of the aqueous phases. *J Pharm. Pharmacol.* 1982;32(11):687-91.
6. Okor RS, Obaduni J. Reversibility of cohesive interactions in certain polymeric dispersions. *J Macromol Sci.* 1982;3:281-89.