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FOAM DENSITY CHARACTERISTICS OF SWEET POTATO PASTE USING GLYCERYL MONOSTEARATE AND EGG ALBUMIN AS FOAMING AGENTS

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ABSTACT: *Foaming characteristics of sweet potato paste were investigated. Glyceryl monostearate (GMS) and Egg albumin (EG) were used as the foaming agent. The foams were produced using different level of stabilizers concentration at level of 5%, 7.5%, 10%, 12.5%, 15%. Glyceryl monostearate stabilized foam was found to be stable after whipping of air into the mixture for 3, 6, 9, 12, 15, 18, 21 minutes at 10°C, 20°C and 30°C respectively. The foam density of egg albumin stabilized foam decreased with decreased in temperature while foam density of glyceryl monostearate decreased with increased in temperature. The foams formed by the egg albumin are relatively stable and must be dried as quickly as possible to avoid collapse. Generally, the foam density was found to be inversely proportional to the glyceryl monostearate and egg albumin concentration. Minimum foam density was observed at 6 minute whipping time after which the foam begins to increase.*

KEYWORDS: Foam, Foam density, Sweet potato, EG, GMS.

INTRODUCTION

The sweet potato (Ipomoea batata) is a gamopetalous dicot belonging to the order polemoniales of the morning glory family, convolvulaceae. It is the only member of the genus Ipomoea whose roots are edible. It is hardy and nutritious staple food crop, which is grown throughout the humid tropical and subtropical regions of the world. It is the most valuable food crop following after rice, wheat, maize and 'irish' potatoes in the developing countries (Whoolf, 1992). In Nigeria, sweet potato is grown as a secondary crop in most places and typically produced for food eaten by the grower's family or locally marketed in an unprocessed form (Akoroda et al., 2000). The production, marketing and utilization of sweetpotato have expanded in the last decade to almost all ecological zones of Nigeria, presently between 381,000 and 510,000ha of land area under sweetpotato cultivation in Nigeria (FAO 2008). Nigeria today is the 1st largest producer of sweet potato in Africa with 3.46mt annually. Globally, Nigeria is now the 2nd largest producer, China topping the list with 106, 197, 100MT. (FAO 2008). Relatively small research effort has been applied to the development of sweet potato, compared with other crops of similar importance. Although a large proportion of the research effort has been directed towards breeding and selection of improved cultivars.

In the dehydration of fruit and vegetable juices and pastes a principal problem lies in the difficulty of obtaining products, which will reconstitutes readily. The mere subjection of juices to conventional dehydrating conditions such as exposing them to hot air or to the heated surface of a drum drier will yield a dense, leathery product which has no practical value as it is virtually impossible to reconstitute (Oguntude and Adeojo, 1992). Drying is one of the most used processes to improve food stability because it considerably reduces the water activity of the

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material, reduces the microbiological activity and minimizes physical and chemical alterations during storage (Mayor; Sereno, 2004). Drying by foam is a process in which a liquid is beaten by various means to form stable foam that is then dehydrated by evaporation of the water in the form of a thin layer (Lewicki, 2006). The main advantages of foam drying are lower temperatures and shorter drying times compared to drying non-foamed materials in the same dryer type (Thuwapanichayanan et al., 2012).

Foam density and the type of foaming agent indeed play a key role in determining the drying kinetics, textural property and food diffusivity as well as the quality in terms of microstructure, texture and volatile of foamed food (Radvanyi *et al*., 2012). Quality of foam food is described by properties such as foam expansion, stability and density because they provide an important function in the movement of the moisture during drying (Bag et al., 2011; Thuwapanichayanan et al., 2011). A stable foam formation enhances dehydration by expanding internal structure and increase exposure of the surface area to the drying chamber. In contrast, the collapse of the foam increases the drying time, reduces the rehydration and deteriorates the color, texture, flavor and nutritional value (Ratti; Kudra, 2006). This method of dehydration is described as foam-mat drying process. Success of foam mat drying depends on the production of stable foam and is affected by many factors such as pulp concentration, concentration of foaming and stabilizing agent, whipping time and whipping speed (Bag et al., 2009). Foam is a two-phase system having a disperse phase and a continuous phase. Foam is highly fragile and very delicate in nature and the high level of surface energy at the air-water interface makes them thermodynamically unstable during drying (Muthukumaran *et al*., 2008). Various products are used to aid in foam formation, such as protein and monoglycerides, as well as in the stabilization of the emulsions formed, such as gums, methylcellulose and jellies. Egg albumin is an example of an efficient foaming agent that has been used in various studies (Falade et al., 2003; Raharitsifa et al., 2006; Kadam et al., 2012).

Consequently, the objectives of this work will include determination of foaming characteristics of sweet potato paste using glyceryl monostearate and egg albumin as foaming agents at different foaming conditions temperature, whipping time, paste concentration and foaming agent concentration.

MATERIALS AND METHODS

Sweet potatoes (Ipomoea batatas) red skinned variety were purchased from killa market along Abeokuta road, Ibadan. Glyceryl monostrarate (GMS) used was manufactured by Sigma Chemical Company, England. Fresh eggs used were carefully identified and purchased at bodija market, Ibadan.

Preparation of Glyceryl monostearate (GMS)

Glyceryl monostearate (GMS) powder was used as foam stabilizer. The foam stabilizer suspension was obtained by adding the required quantity of glyceryl monostearate (GMS)powder, with continuous stirring, into a measured amount of distil water at 100^{o}C to obtain a 20% suspension of glyceryl monostearate. The suspension was then whipped in the compact blender, initially at the low speed for one minute and then at high speed for 2 minutes in order to obtain a homogenous glyceryl monostearate solution which was then kept at room temperature until ready for use.

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Preparation of Egg White (EG)

Fresh eggs were carefully opened at the tapered end and allow the albumin to flow outward into a sterilized and clean stainless container then kept at room temperature until required for use.

Preparation of sweet potato Paste

Fresh, unblemished sweet potatoes were wet-cleaned using tap water and peeled. The peeled and diced sweet potatoes were immersed in a solution of 1000 ppm sodium metabisulphite solution. 2 kg per batch of diced potatoes were transferred into a waring blender and blended at varying speed for 5mins; from the lowest to medium and high speed.

Preparation of foam and determination of foam density

Known amount of the 20% glyceryl monostrearate solution were added to 400g of the paste, likewise, egg albumin were also added to 400g of the paste so as to attain concentration levels of 5,7.5, 10, 12.5, and 15% glyceryl monosteatrate (GMS) and egg albumin EG) respectively on a w/w basis. Each of the mixtures was initially whipped at low speed for 2 minute and then at high speed for 3 minutes interval until 21 minutes was attained. Moreover, during this interval foam densities were periodically determined by filling a standard density bottle with the foam. Excess foam was carefully wiped off the outer surface of the density bottle and foam density was calculated by dividing the weight of the foam by the volume of the density bottle. The determination of the foam density for each of the mixtures mentioned above was done in triplicates.

$$Foam\ Density = \frac{\text{Weight of Foam(g)}}{\text{Volume of Foam(ml)}}$$

Result and Discussions

Foaming characteristic of sweet potato paste in the absence foaming agent

Sweet potato paste at different level of concentration was whipped without the incorporation of foam stabilizer. Foam was initially observed in the first 3 minutes of whipping, on a continuous whipping coarse foam formed collapsed rapidly as the whipping time increases until 21 mins where no foam was obvious. Oguntude and Adeojo (1992) reported a similar observation for soyamilk without the incorporation of foam stabilizing agent.

Effect of Glyceryl Monostearate (GMS) and Egg Albumin (EA) Concentration and Whipping Time on Foam Density of Sweet Potato Paste.

The incorporation of glyceryl monostearate (GMS) and egg albumin (EG) as the foam stabilizer at 5%, 7.5%, 10%, 12% and 15% levels yielded coarse foam at the initial whipping speed. As the whipping continued coarse bubbles initially formed, became rapidly subdivided thereby causing decreases in form density with whipping time as shown in fig. 4.1 and 4.2 respectively. Fernandez R.V.B et al., (2013) reported a similar trend in foam density with the incorporation of egg albumin for tomato paste dehydration. Expectedly, foam density is a factor commonly used to evaluate whipping properties. Higher amounts of air incorporated during whipping results in lower foam densities with more air present within the foam

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(Falade et al., 2003;Thuwapanichayanan et al., 2012). It can be observed that the 15% of glyceryl monosearate (GMS) stabilized foam exhibited a minimum foam density at about 5 min of whipping and thereafter increased as the whipping time progresses, the increase in the foam density observed was not highly significant. Fig. 4.1 also indicated a general decrease in foam density as the concentration of the stabilizer increases in the glyceryl monosteareate foam with no appreciable increase after 6 min of whipping. Egg albumin stabilized foam in fig 4.2 indicated a minimum foam density exhibited after about 6 minutes of whipping after which no appreciable increase in foam density as the whipping time progressed, 10% and 15% egg stabilized foam were implicated for these. Raharitsifa et al. (2006) also reported similar trend for foam density variation with increased whipping times in which longer times may have caused excessive whipping and led to the collapse of the structure. (Falade et al., 2003) explain that higher degrees of aeration result in the liquid between the bubbles being thinner and mechanical deformation can cause the foam to rupture. Generally, it would also be observed that the decrease in foam density does not vary with the concentration as shown by the figures. This behaviour is contrary to glyceryl monostrate foam. Observation also showed that egg stabilized foam was not stable compared to glyceryl monosearate stabilized foam. Therefore glyceryl monostearate foam can be dried without collapse which is contrary to egg albumin foam. Fernandez R. V. B. et al., (2013) explained that using foam stabilizing agents (usually high molecular weight and water soluble biopolymers) can help prevent the collapse of the structure during drying by changing the rheological properties of the product. For example, the inclusion of glyceryl monostearate contributes to the formation of more stable foam in banana pulp (Falade; Okocha, 2010).It was also observed that foam density of glyceryl monostearate stabilized foam was lower compared to egg stabilized foam.

Effect of Sweet Potato Paste Temperature and Concentration on Foam Density.

The effect of temperature on foam densities of glyceryl monostearate and egg albumin stabilized foam was indicated in fig 4.3 and 4.4 respectively. In fig 4.3, using 15% glyceryl monostearate indicated that 30°C (ambient) condition resulted to lowest foam density while at 10°C, it gives a moderate foam density but at 20°C the foam density was highest. The decrease in foam density may be as a result of expansion of the foam molecule. Temperature causes molecules to speed up and spread slightly further apart, occupying a larger volume that results in a decrease in density. Falade et al., (2003) observed similar trend during foam mat drying of cowpea. In the case of egg albumin, it was shown that foam density decreases with decrease in temperature with 15% egg albumin.

The effect of sweet potato paste concentration on glyceryl monostearate (GMS) and egg albumin (EG) stabilized foam was shown in fig.4.5 and 4.6 respectively. Fig.4.5 indicated that foam density decrease as the concentration of the paste decreases for glyceryl monostearate (GMS) stabilized foam. The foam density was lowest at about 4mins of whipping after which there was no significant changes in the density with increase whipping time. This may be due to high consistency, viscosity and high soluble solid of the paste which does not allow for further aeration of the sweet potato paste. Similar results were witnessed on foaming of bael (*Aegle marmelos* L) fruit pulp (Bag et al., 2011).

However, the reverse is the case for the egg albumin stabilized foam which gave an increase in the foam density as the concentration of the paste reduces.

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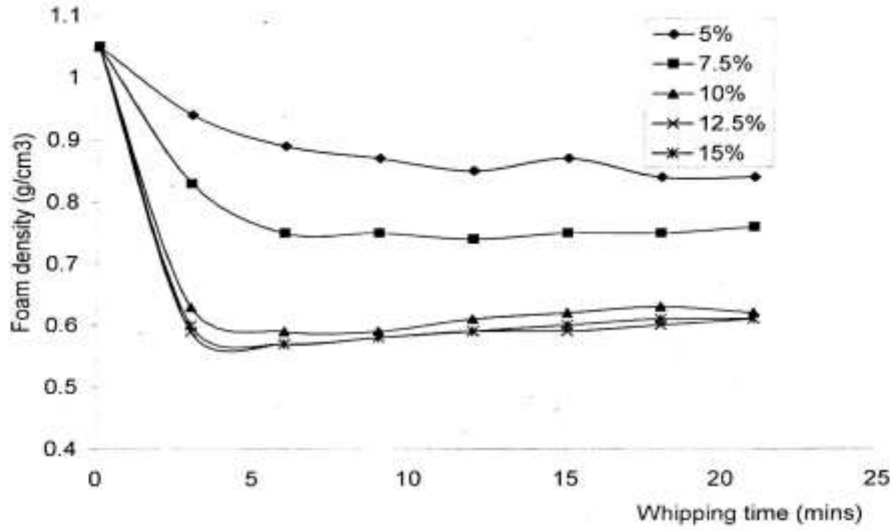

Fig. 4.1 Effect of glyceryl monostearate concentration on foam density of sweet potato paste.

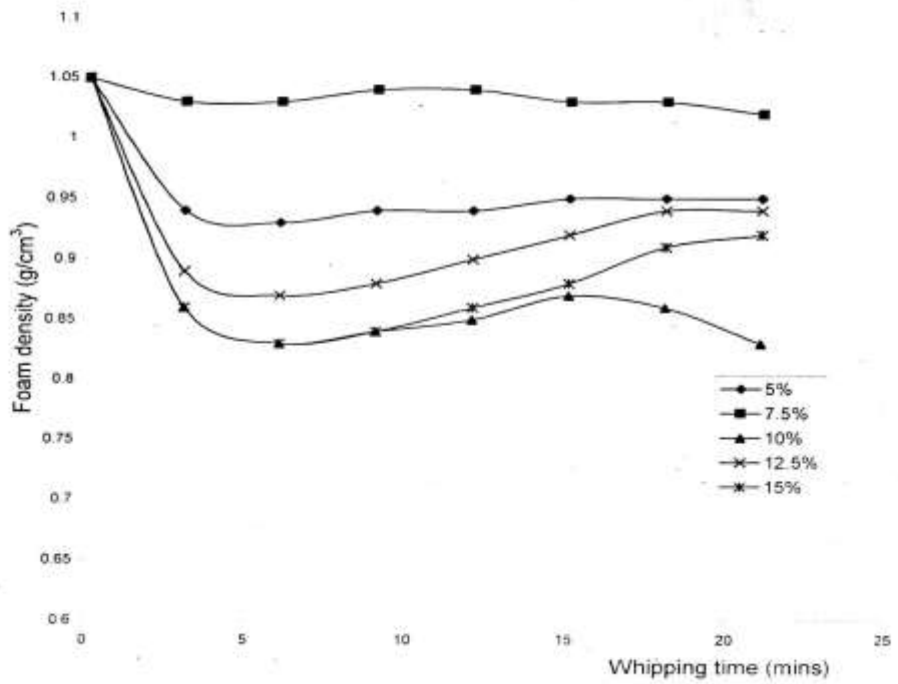

Fig. 4.2 Effect of Egg Albumin concentration on foam density of sweeet potato paste.

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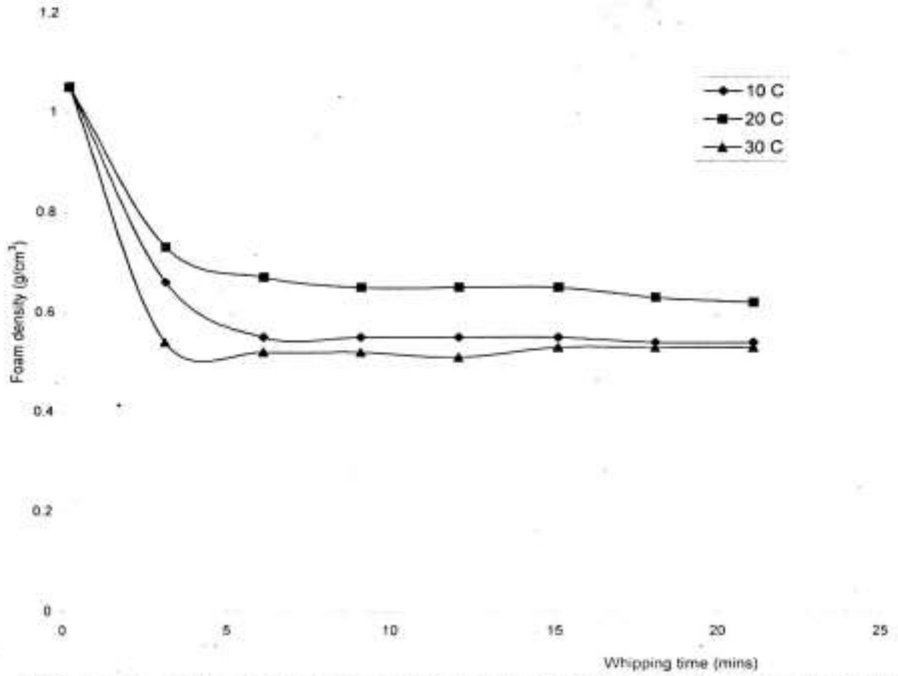

Fig. 4.3 Effect of temperature on foam density of sweet potato with 15% glyceryl monostearate at 30°C.

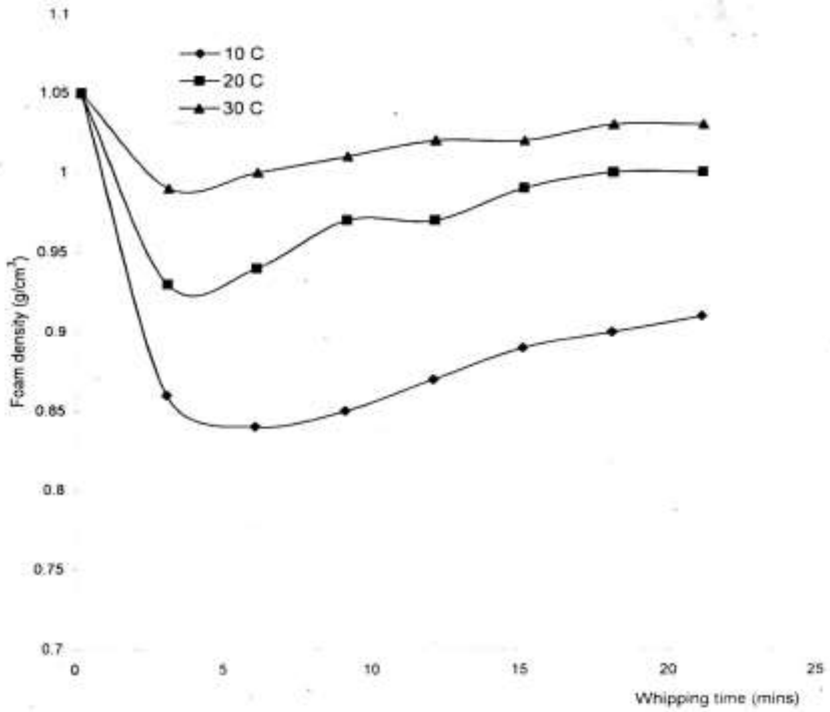

Fig. 4.4 Effect of temperature on foam density of sweet potato with 15% Egg Albumin at 30°C.

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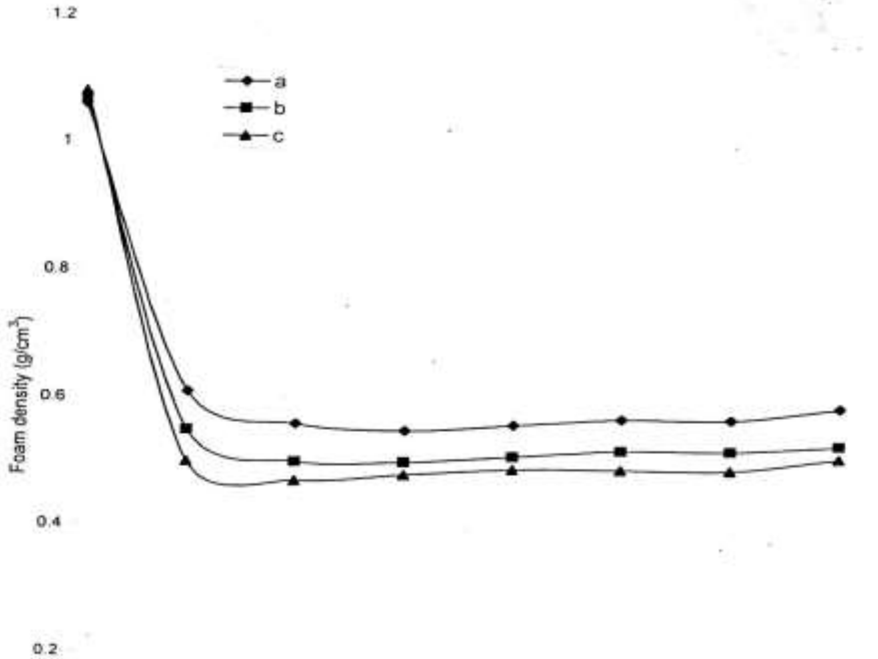

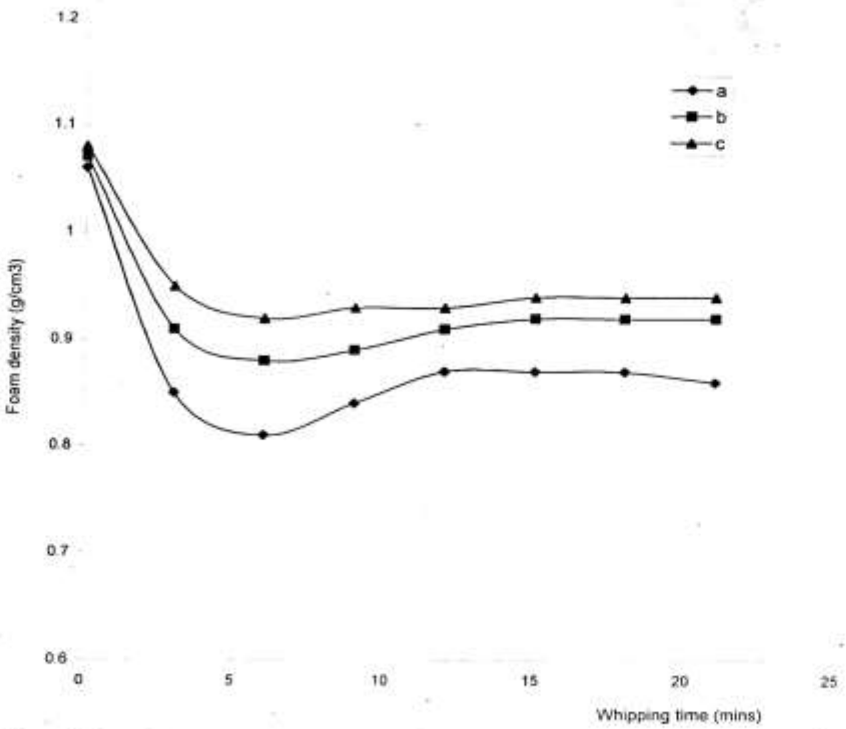

Effect of sweet potato paste on foam density 15% Egg Albumin at 30°C.

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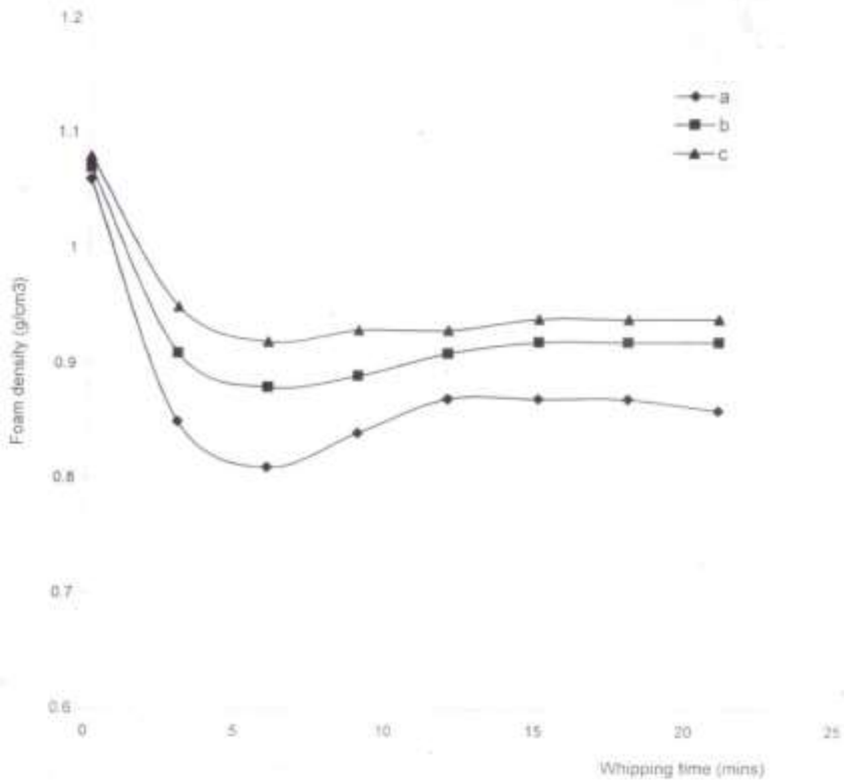

Fig. 4.5 Effect of Sweet Potato Paste on Foam density 15% Glyceryl Monostearate at 30°C

CONCLUSION

The incorporation of glyceryl monostearate (GMS) and egg albumin (EG) into sweet potato paste prior to whipping enabled foam formation. The use of glyceryl monostearate (GMS)stabilizers at different concentration level 5%, 7.5%, 10%, 12.5% and 15% indicated a stable foam which can be extruded without collapse. Increasing the level of glyceryl monostearate (GMS) and egg albumin (EA) concentration caused corresponding reduction in foam density and a minimum foam density was attained after 6min. of whipping. Egg albumin should be dried as quickly as possible to avoid collapse after extrusion. This is because egg stabilized foam was relatively less stable compared to glyceryl monostearate stabilized foam. The glyceryl monostearate (GMS) was found to reduce foam density of sweet potato paste more rapidly than egg albumin (EG). Glyceryl monostearate a non-protein based whipping agent is recommended in preference to egg albumin in foaming of sweet potato paste, since it reduces the foam density of sweet potato paste and more readily produces stiff stable foam.

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