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Development of *shrikhand* premix using microencapsulated rice bran oil as fat alternative and hydrocolloids as texture modifier

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ABSTRACT

A premix of *shrikhand* (Indian dessert) was prepared using skim milk powder, skim milk curd, sucrose and microencapsulated rice bran oil (RBO) as fat alternative. RBO was microencapsulated using spray drying under the optimized conditions of air inlet temperature (135 °C), feed rate (15 mL/h) and solid content (17%) in emulsion. Hicap-100 (modified starch) was found to provide best encapsulation (62.83 ± 0.57%) to RBO as compared to that of gum arabic and maltodextrin as wall material. The size and shape of microencapsulated oil was checked using SEM and thermal stability was evaluated using DSC. Addition of 1% α-tocopherol to RBO before microencapsulation enhanced its oxidative stability. The premix was used to prepare *shrikhand* and compared with market sample with respect to composition, texture, colour and sensory profile. Addition of blend of xanthan and gellan gum (80:20) improved the texture of prepared *shrikhand* to the level of market *shrikhand*.

1. Introduction

Of the total milk produced in India, 7% is used for the preparation of fermented milk products which mainly includes *dahi*, *lassi* and *shrikhand* (sweetened concentrated curd) (Swapna & Chavannavar, 2013). *Shrikhand* is consumed as a dessert after meals. It is prepared by fermentation of milk using known strains of lactic acid bacteria followed by draining of whey and addition of sugar and flavours to the drained curd (Boghra & Mathur, 2000). Although there is a rising demand for fermented dairy products like *shrikhand* in the Indian market, there are limitations which prevent it from being manufactured at a large scale. The shelf life of fermented dairy products is limited due to lack of efficient cold storage facilities. Moreover, the presence of saturated fatty acids and cholesterol in milk fat is reported to be associated with health hazards, in particular, cardiovascular diseases (Elwood, Pickering, Fehily, Hughes, & Ness, 2004; German et al., 2009).

These constraints of producing *shrikhand* could be solved by developing a *shrikhand* premix (ready to mix) which may contain curd, skim milk powder, sucrose and microencapsulated rice bran oil (as a fat alternative). The powdered form of premix would be anticipated to have advantages of higher shelf life, minimal requirement of storage conditions, and lower cost of packaging in addition to being consumer friendly. This powder premix should be formulated in way that it can be easily reconstituted in water to prepare a *shrikhand* as and when required.

Rice bran oil (RBO), which has a more acceptable flavour than fish and flaxseed oils (Chen, McGillivray, Wen, Zhong, & Quek, 2013; Kochhar, 2011; Shahidi, 2005) could be used as a healthy fat alternative in *shrikhand* premix and hence could have better organoleptic acceptability in *shrikhand*. RBO is a healthy source of PUFA (polyunsaturated fatty acid) and has potential nutraceutical properties. Animal studies have shown rice bran oil to reduce low density lipoprotein levels without reducing high density lipoprotein (Ausman, Rong, & Nicolosi, 2005). RBO consists of approximately 38% oleic, 34% linoleic, 1% myristic, 22% palmitic, 3% stearic, and 2% α-linolenic acids. Crude RBO is also good source of γ-oryzanol (1.6%) which offers many health benefits, such as ability to lower plasma cholesterol by reducing cholesterol absorption, decrease early atherosclerosis, inhibit platelet aggregation, and decrease fecal bile excretion (Ausman et al., 2005; Fukushima, Fujii, Yoshimura, Endo, & Nakano, 1999).

Protection of PUFA in edible oil against lipid oxidation is necessary to enhance its shelf life which can be done by using an efficient technique of microencapsulation (Calvo, Castaño, Lozano, & González-Gómez, 2012; Charoen et al., 2011; Kolanowski, Ziolkowski, Weibbrodt, Kunz, & Laufenberg, 2006). This technique offers the possibility of controlled release of lipophilic food

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ingredients and can be useful for supplementation of foods with PUFA. Microencapsulation of fish oil and flaxseed oil has been well reported in the literature (Carneiro, Tonon, Grosso, & Hubinger, 2013; Keogh et al., 2001; Kolanowski et al., 2006; Quispe-Condori, Saldana, & Temelli, 2011). However, literature on the microencapsulation of RBO is scant (Charoen et al., 2011). Few applications of microencapsulated fat have been reported in yoghurt and cheese (Singh & Kim, 2009; Ye, Cui, Taneja, Zhu, & Singh, 2009). To the best of our knowledge, the use of microencapsulated oil for the preparation of *shrikhand* premix has also not been found in the literature.

Spray drying is the most efficient and industrially feasible method of microencapsulation, which consists of packing an active ingredient within a wall material (Carneiro et al., 2013; Krishnan, Kshirsagar, & Singhal, 2005; Kshirsagar, Yenge, Sarkar, & Singhal, 2009). It promotes the conversion of liquid oils and flavours in the form of powders. Spray drying is preferred over other techniques of microencapsulation due to low operational cost and ease of availability of equipment. Spray drying is also compatible with gum arabic and modified starch as a wall material for encapsulation of edible oil and oleoresins (Aghbashlo, Mobli, Rafiee, & Madadlou, 2012; Carneiro et al., 2013; Kanakdande, Bhosale, & Singhal, 2007).

In this work, we have developed a *shrikhand* premix using microencapsulated RBO as a fat alternative, curd, sucrose, and skim milk powder. The method of spray drying for microencapsulation of rice bran oil was optimized for the better encapsulation efficiency. The microencapsulated oil was further characterized and used for the preparation of *shrikhand* premix. This *shrikhand* prepared using the premix has been characterized for its oxidative stability, and acceptability as compared to market product.

2. Materials and methods

2.1. Materials

RBO oil was purchased from Kamani Oil Mumbai, India. Modified starch HI-CAP® 100 from National Starch Chemical Corporation, Mumbai and GLUCIDEX® maltodextrins of dextrose equivalent 12 procured from Roquette India. Skim milk curd was purchased from Mother Dairy, India, and skim milk powder was from Nestle India. All other chemicals were of AR grade.

2.2. Preparation of shrikhand premix

The composition of *shrikhand* premix was decided as per the composition of market *shrikhand* (full cream *shrikhand* from Chitale, India, containing 62% solids and 38% water). Mass balance equation was developed (Fig. 1) to find the required quantity of skim milk powder, skim milk curd, added sugar (sucrose) and rice bran oil. According to values obtained from mass balance equation, skim milk powder (9.91 g), curd (41.25 g), RBO (7.08 g) and sucrose (40.77 g) were to be present in the premix. An emulsion was prepared to develop microencapsulated rice bran oil and curd using Hicap-100 as wall material. The wall material was a replacement of one third of sucrose for better encapsulation efficiency by keeping an accurate and proper mass balance of other ingredients. The microencapsulated fat powder was prepared by spray drying the emulsion and mixed with skim milk powder and sucrose to get final *shrikhand* premix.

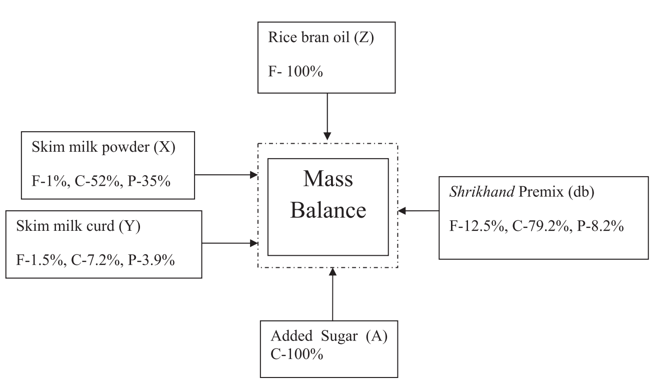

Fig. 1. Mass balance diagram where, F–fat, C–carbohydrate, P–protein and db-dry basis.

2.3. Preparation of emulsion and microencapsulation of oil by spray drying

The wall material was dissolved in water using a high speed blender. Curd was separately dissolved in water and then mixed with wall material solution followed by addition of calculated amount of RBO (according to mass balance equation) in continuous phase to prepare oil in water emulsion. Final volume of emulsion was adjusted to 100 mL using water, then emulsified in a shear homogenizer (Indofrench Industries Engineers, Mumbai, Model type, SPM-9) for 5 min at 3000 rpm until complete dispersion (Krishnan et al., 2005). Emulsion was rehydrated overnight at 10–12 °C. The emulsion was again homogenized for 2 min and kept for 30 min at room temperature (27 ± 2 °C). Resulting emulsion was spray dried using spray dryer (LSD-48 JISL model mini, India) (Spraying chamber dimension: 100 cm height, 60 cm diameter) equipped with 0.5 mm diameter pressure nozzle. Compressed air for the flow of the spray was pressurized at 2 bar. The inlet temperature was maintained at 135 ± 1 °C and outlet temperature was auto-adjusted at 85 ± 4 °C. A peristaltic pump was used to feed the spray dryer at 150 mL/h. The vacuum pressure was 40 kg/cm^2 below atmospheric pressure. Microcapsules were collected from cyclone and spraying chamber were packed in airtight polyethylene laminate packets, and stored in a dessicator containing calcium chloride at room temperature.

2.4. Optimization of process parameters of spray drying

The process parameters were optimized on the basis of encapsulation and entrapment efficiency. The effect of solid contents (15–30%), spray dryer temperature (120 °C to 150 °C with an interval of 5 °C) and feed rate of spray dryer (100–200 mL/h) were used to obtained best conditions for microencapsulation of RBO. All the parameters were studied by using one factor at a time method. The analysis of samples was done in triplicates.

2.4.1. Encapsulation efficiency

Encapsulation efficiency (EE) is the ratio of oil present inside the wall material to the total oil present in microencapsulated powder. Encapsulation efficiency was calculated using the formula as given below (Carneiro et al., 2013; Tonon, Pedro, Grosso, & Hubinger, 2012).

$$EE = \frac{(TO - SO)}{TO}$$

where, TO is total oil present in known weight of sample and SO is surface oil in known weight of sample.

For determination of SO, microcapsules (2 g) were mixed in hexane (15 mL) and shaken for 2 min at room temperature to extract surface oil. The solvent was filtered through Whatman no.1 filter paper after settling microcapsules at the bottom. The collected