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Healthier pineapple tart pastry using oleogel-based solid fat replacement

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ABSTRACT

Introduction: Pineapple tarts are a commonly consumed Southeast Asian pastry made using solid fats like butter and palm shortening. These solid fats predominantly contain high amounts of saturated fats which have been implicated in negative health effects. However, solid fats impart important textural properties in pastry formation and is not easy to replace. To overcome this challenge, a concept to enhance the nutritional value whilst maintaining the textural properties of pineapple tart pastry formed the basis of this study. **Methods:** This short study explored the use of "healthy" avocado-olive oil-based oleogels structured with food-grade ethylcellulose (EC), monoglycerides (MG) or its combination (EC-MG) as solid fat replacements to butter and palm shortening. The textural properties of the pastry dough and tart were determined using a texture analyser, while the nutritional content of the pastries was compared. **Results:** The firmness of pastry dough decreased in the order: EC >> EC-MG > butter ~ MG ~ shortening, while tart hardness decreased: EC > shortening ~ butter > MG > EC-MG. The combination EC-MG oleogel had positive effects on the textural properties by improving the dough workability and reducing the tart hardness compared to EC. Remarkably, the oleogel tart pastries had up to 70% less saturated fat compared to the butter or palm shortening pastries. **Conclusion:** This study confirms the ability to create healthier pastries whilst maintaining its texture.

Keywords: oleogels, fat mimetics, ethylcellulose, monoglyceride, pastry

INTRODUCTION

Pineapple tarts are a popular pineapple jam-filled pastry commonly consumed in Southeast Asia. Like many pastries, these tarts are often made using solid fats such as butter and vegetable shortening to impart desirable texture, mouthfeel and structure. Consequently, these snacks usually contain high saturated fat content (Yeo *et al.*, 2020), which is undesirable as diets rich in saturated fats have been associated with increased risk of cardiovascular diseases and the development of other health complications (Tan *et al.*, 2018). Therefore, there is an opportunity to modify pastry recipes to produce healthier alternatives without compromising the palatability of the product (Guinard *et al.*, 2020).

In our study, cardio-protective oils rich in monounsaturated fatty acids and phytochemicals, such as avocado and olive oil (Dreher & Davenport, 2013; Gorzynik-Debicka *et al.*, 2018), were used to negate the ill effects of

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saturated fats, which are extensively used in pastry manufacturing. However, liquid oils do not possess the physical properties of solid fats, thus limiting their applications in pastry. To tackle this problem, we proposed structuring these plant oils into oil gels (oleogels) that could behave as solid fats in pastry application (Rogers *et al.*, 2014).

Food gels like jellies, jams and tofu are typically made by the entrapment of water by various gelling agents. These are known as hydrogels. Replacing the continuous water phase by oil leads to the formation of oil gels or oleogels. In general, the liquid oil is entrapped through physical interactions within supramolecular structures or polymeric networks formed by structuring agents (Co & Marangoni, 2018). These structuring agents can include small molecules like monoglycerides or polysaccharides such as ethylcellulose (Maya Davidovich-Pinhas, 2019). Furthermore, from our previous work, ethylcellulose is able to reduce postprandial lipemia (Tan *et al.*, 2018), while monoglyceride is already present in many food products as emulsifiers (Valoppi *et al.*, 2017).

Therefore, to explore the potential replacement of saturated fats with healthy oils in pastry, we investigated the effect of substituting butter or palm shortening with avocado-olive oil oleogels structured by ethylcellulose (EC) or monoglyceride (MG) on pastry dough and pineapple tart texture. As different oil gelling agents have distinct properties, we also examined the combination of both structuring agents (EC-MG). Finally, nutritional comparisons of the various pineapple tart pastries were made.

MATERIALS AND METHODS

Materials and baking ingredients

Extra virgin avocado oil (Grove Avocado Oil Ltd, New Zealand), pure olive oil (Naturel, Lam Soon Pte Ltd, Singapore), unsalted Danish butter (RedMan, Phoon Huat Sdn Bhd, Malaysia), and refined palm fat shortening (RedMan, Phoon Huat Sdn Bhd, Malaysia) were obtained from a local supermarket. Ethylcellulose was obtained from Dow Wolff Cellulosics GmbH (ETHOCEL™ 45 premium, viscosity 45 cP, Germany). Commercial food-grade mixture of monoglycerides was kindly donated by Palsgaard Asia-Pacific Pte Ltd (DMG 0093, Singapore). The monoglyceride powder contained > 90% monoglycerides and had maximum free glycerol, free fatty acids, and iodine values of 1.0%, 1.5%, and 2 g/100 g powder, respectively from the technical data sheet provided by the manufacturer. Analysis by other workers showed that the DMG 0093 MG powder was composed of ~38% 1-mono-stearoyl-*rac*-glycerol and ~54% 1-mono-palmitoyl-glycerol (López-Martínez *et al.*, 2014).

The remaining baking ingredients, also obtained from a local supermarket, included condensed milk (Milkmaid, F&N Foods Pte Ltd, Singapore), skim milk powder (NTUC Fairprice Co-operative, Singapore), eggs (Seng Choon, Singapore), plain flour (RedMan, Phoon Huat Sdn Bhd, Malaysia), and vanilla essence (RedMan, Phoon Huat Sdn Bhd, Malaysia).

Preparation of oleogels

From preliminary works done to optimise the sensory profile, a 1-part avocado oil to 1.1-part olive oil was mixed to form an oil blend. To prepare the oleogels, ethylcellulose and/or monoglyceride powders were added to the blended avocado-olive oil under constant stirring and heated at 150°C (or 80°C for the samples containing only monoglyceride) for 10 minutes to achieve full dissolution. Three oleogel compositions were made containing 12% (w/w) ethylcellulose (EC), 12% (w/w) monoglyceride (MG), or 6% (w/w) ethylcellulose with 6% (w/w) monoglyceride (EC-MG). The mixtures were then poured into containers and stored at ~23°C to set.

Preparation of pastry dough

The tart-making was adapted from a traditional recipe. The pastry formulation included 130 g plain flour, 110 g butter/shortening/oleogel, 30 g condensed milk, 20 g skim milk powder, 15 g egg yolks, 10 g egg white, and 1 g vanilla essence. Condensed milk and butter/shortening/oleogel were creamed together for 5 minutes under low speed using a stand mixer. Eggs and vanilla essence were added and mixed for 1 minute. Plain flour and skim milk powder were then added and mixed for 1 minute to form a smooth dough. In total, five different types of pastry doughs were prepared (butter, shortening, EC, MG and EC-MG).

Mechanical properties of pastry dough and tarts

Texture analyses were conducted using a TA.XT plus texture analyser (Stable Micro Systems Ltd, Surrey, England) equipped with a 30 kg load cell. All tests were performed at 22±1°C. To measure dough firmness and stickiness, 20 g each of the various pastry doughs was first shaped in a round aluminium tart shell (4.5 cm top diameter x 2 cm bottom diameter x 2 cm height). The shaped dough was then penetrated to 75% depth using a ½ inch stainless steel spherical probe (P/0.5S, Stable Micro Systems, Surrey, UK) at a test speed of 1 mm/s. The maximum force required for 75% penetration and to lift the probe was defined as firmness and stickiness, respectively.

To measure tart hardness, 20 g each of the various pastry doughs was first shaped in a round aluminium tart shell (4.5 cm top diameter x 2 cm bottom diameter x 2 cm height) and baked in a pre-heated oven at 160℃ for 27 minutes and allowed to cool. Each tart was removed from the tart shell and compressed to 50% displacement using a 75 mm flat, circular compression plate (P/75, Stable Micro Systems, Surrey, UK) at a test speed of 1 mm/s. The peak force during compression was defined as hardness, while the total amount of energy per second required to break the tart (as measured by total area under the curve) was defined as the work of failure.

All textural parameters were evaluated using the Texture Expert software (version 6.1). Six replicates were prepared and measured for each of the pastry dough and tart.

Nutritional analysis

The nutritional data was compiled using nutritional information provided on the ingredients packaging and calculated based on the proportions used in the recipe. As the monoglycerides used were saturated fats, they were assumed to have similar nutritional content to lipids (9 kcal/g). As the nutritional information for ethylcellulose is currently not known, it was assumed to behave like cellulose fibre.

Statistical analysis

Statistical analysis was conducted using R v. 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria). A one-way analysis of variance (ANOVA) was performed for texture measurements to determine if the mean values of measured parameters differed significantly with formulation. The significance was established using Tukey HSD (honest significant difference) post-hoc tests. A probability level of $p<0.05$ was considered significant. All values were expressed as mean ± 1 standard deviation.

RESULTS AND DISCUSSION

Mechanical properties of the pastry doughs and tarts

The various pastry doughs' firmness and stickiness values are presented in Figure 1. Notably, the trends for dough firmness and stickiness values were similar in the order: EC >> EC-MG > butter ~ MG ~ shortening. The firmness of the dough reflects the maximum force needed to break intermolecular interactions for plastic deformation to occur and indicates its ease of workability. Dough stickiness relates to the adhesion between the dough and the spherical probe due to the formation of molecular interactions between the dough and probe surface (Dobraszczyk, 1997). EC dough was significantly firmer and stickier than all other doughs, reflecting its hard texture and difficulty to work with. At the other spectrum, shortening dough had the lowest

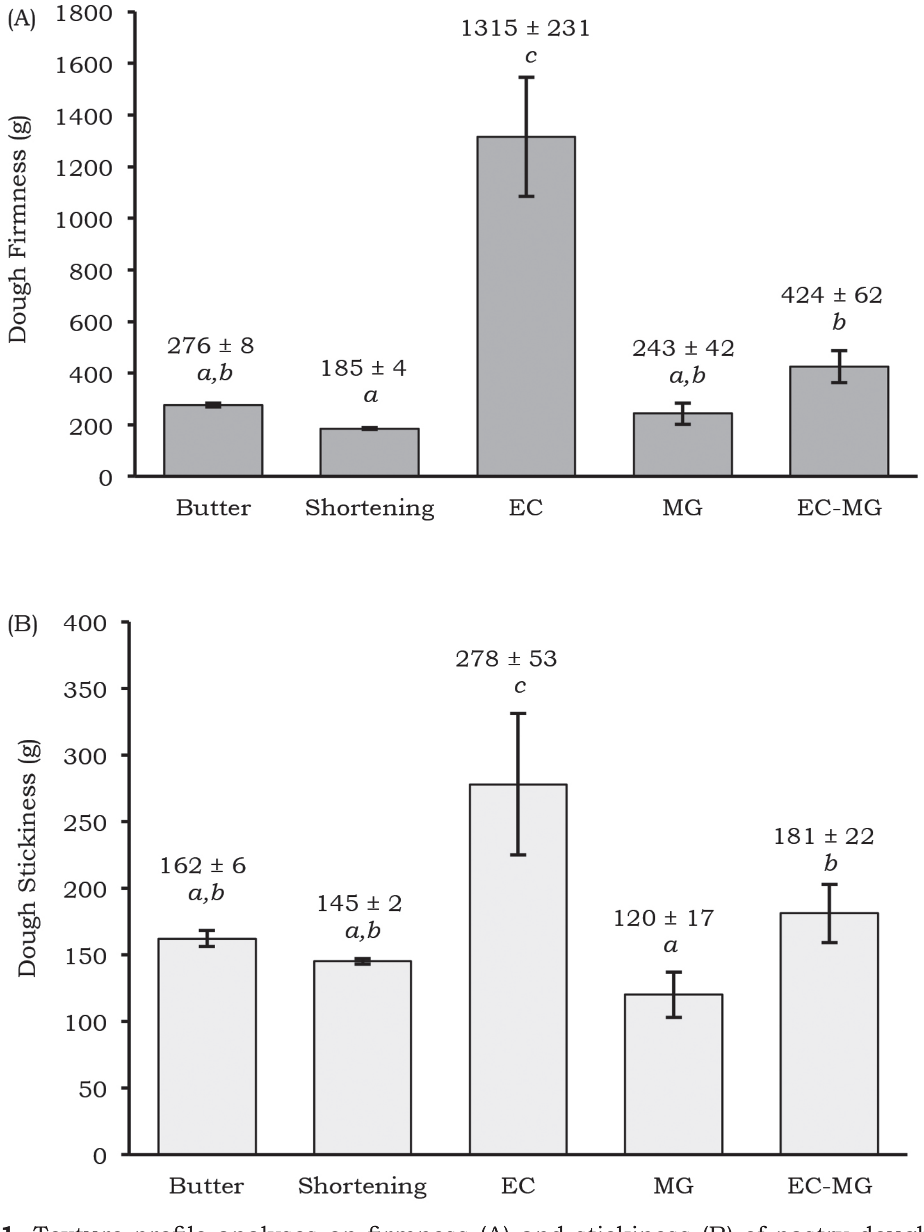

Figure 1. Texture profile analyses on firmness (A) and stickiness (B) of pastry dough made using butter, palm shortening, ethylcellulose oleogel (EC), monoglyceride oleogel (MG) or mixed oleogel (EC-MG). Data expressed as mean ± 1 standard deviation (n=6). Data points connected by the same letter are not significantly different from each other (p>0.05)

firmness reflecting its soft consistency. The firmness and stickiness of MG dough were not significantly different to butter dough and they had similar workability. EC-MG dough had intermediate firmness and stickiness to EC dough and MG dough. Previous studies demonstrated that monoglycerides had a plasticising effect on ethylcellulose (Davidovich-Pinhas, Barbut & Marangoni, 2015). In this study, both MG and EC-MG oleogels were comparable in texture to softened

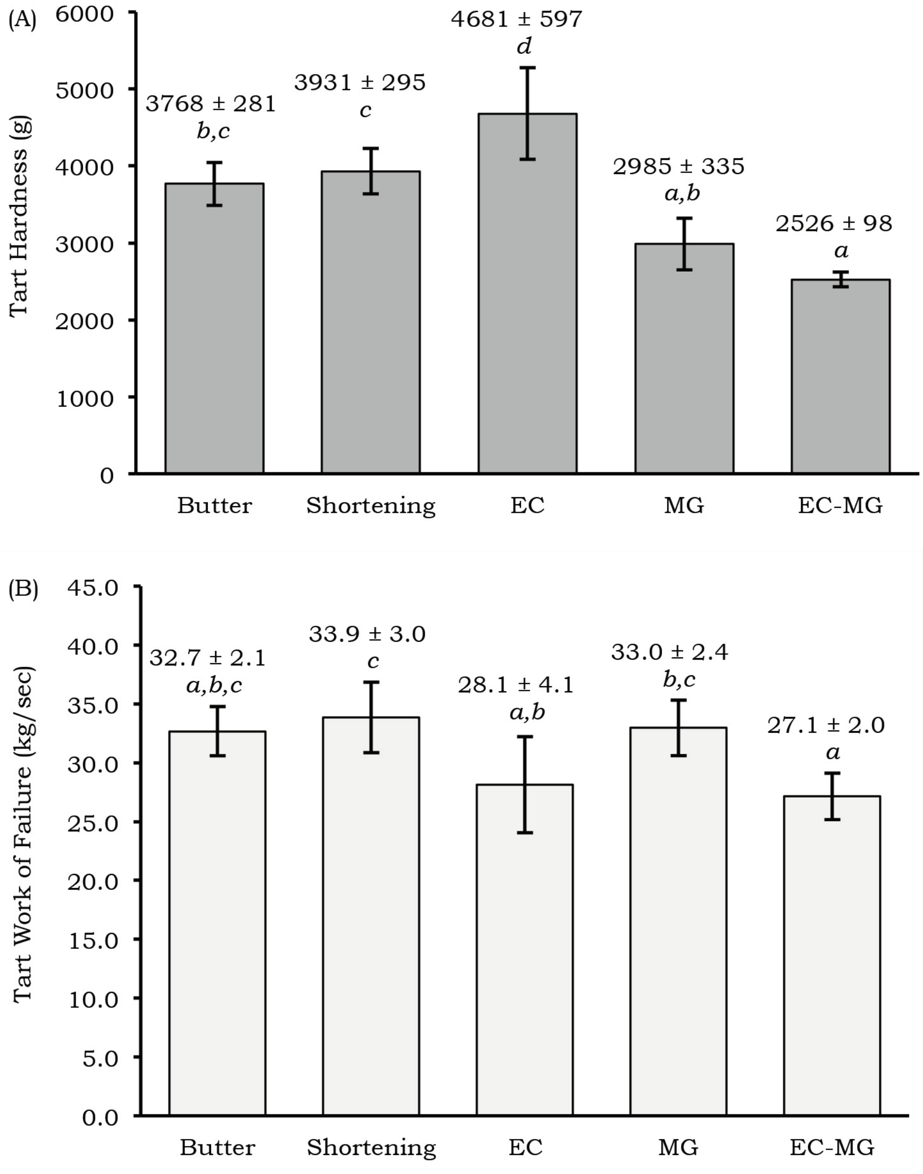

Figure 2. Texture profile analyses on hardness (A) and work of failure (B) of pastry tart made using butter, palm shortening, ethylcellulose oleogel (EC), monoglyceride oleogel (MG) or mixed oleogel (EC-MG). Data expressed as mean ± 1 standard deviation (n=6). Data points connected by the same letter are not significantly different from each other (p>0.05)

Table 1. Nutritional comparisons, calculated from the nutritional data of ingredients, between uncooked pineapple tart pastry made using ethylcellulose oleogel (EC), monoglyceride oleogel (MG), mixed oleogel (EC-MG), butter or palm shortening

Nutritional parameters	*EC*	*MG*	*EC-MG*	*Butter*	*Palm shortening*
Serving size (g)	100	100	100	100	100
Energy (kcal)	486	523	504	460	523
Protein (g)	8.3	8.3	8.3	8.6	8.3
Carbohydrate (g)	38.4	38.4	38.4	38.5	38.4
Total fat (g)	33.2	37.3	35.2	30.7	37.3
Saturated fat (g)	5.1	9.3	7.2	18.3	16.6

butter, so it was unsurprising that their respective doughs were comparable.

From Figure 2, there were significant differences in the hardness of the oleogel tart samples compared to butter and shortening controls. Tart hardness was in the order: EC > shortening ~ butter > MG > EC-MG. The work of failure was more equivocal, with only EC-MG and shortening differing significantly. Although EC tart was relatively hard, its work of failure was relatively low compared to butter and shortening tarts as EC tart fractured easily. Despite the comparable work of failure, the MG tart's hardness was significantly lower than the butter and shortening tarts. Interestingly, while EC tarts were considerably harder than MG tarts, EC-MG tarts had the lowest hardness and work of failure values. Overall, there was no significant difference in the dough and tart texture between MG and butter. Although EC was not able to mimic the properties of butter, combining EC and MG improved the pastry dough and tart texture.

Nutritional comparisons between the tart pastries

As calculated from the ingredients, the nutritional data between the uncooked tart pastries made using oleogels, butter or palm shortening are shown in Table 1. The protein and carbohydrate contents of the pastries were similar as only the lipid profile was altered. The energy content of the pastries decreased in the order: shortening ~ MG > EC-MG > EC > butter, mirroring its total fat content. However, the pastries made using the oleogels had markedly lower saturated fat content – up to 70% reduction – compared to the pastries made using butter or palm shortening. Furthermore, the avocado-olive oil blend contains healthful phytochemicals with anti-inflammatory and anti-atherogenic properties (Dreher & Davenport, 2013; Gorzynik-Debicka *et al.*, 2018). Additionally, as we noted from our previous work, ethylcellulose is able to reduce postprandial lipemia (Tan *et al.*, 2018). Thus, we speculate that the ethylcellulose oleogels (EC and EC-MG) are further able to restrict lipid absorption, consequently reducing the effective energy content of the pastries. Based on the nutritional and textural data, the EC-MG oleogel enabled both the nutritional benefits of the ethylcellulose oleogel and the textural properties of the monoglyceride oleogel to be harnessed. Further work is needed to fine-tune the balance between both oleogelators.

CONCLUSION

This short study evaluated the effects of replacing butter and palm shortening with potentially health-promoting avocado-olive oil-based oleogels structured with EC, MG and EC-MG on pineapple pastry dough and tart texture. While EC led to brittle pastry dough and tart, MG oleogel led to relatively comparable properties to butter and shortening. The combination EC-MG oleogel had positive effects on textural properties, reducing the dough and tart's brittleness, and improving the workability of the dough compared to EC. The EC-MG oleogel may also deliver the nutritional benefits of EC oleogels. Importantly, the oleogel pineapple tart pastries had up to 70% less saturated fat compared to the butter or palm shortening tart pastries. The monounsaturated fatty acid-rich avocado and olive oils may further confer cardio-protective effects. This brings us a step closer to the paradigm where pastries not only bring us delight but also could enhance our health.

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Authors' contributions

SYJS, conceptualised and designed the experiments, analysed the data and prepared the manuscript; KXW, performed the experiments and collated the data, analysed the data and prepared the manuscript; CJH, conceptualised and designed the experiments, reviewed the manuscript.

Conflict of interest

All authors declare no conflict of interest.

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