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The effects of maltodextrin as a drying aid and drying temperature on production of tamarind powder and consumer acceptance of the powder

*Ekpong, A., Phomkong, W. and Onsaard, E.

Indigenous Food Research and Industrial Development Unit, Department of Agro-Industry, Faculty of Agriculture, Ubon Ratchathani University, Warinchumrap, Ubon Ratchathani, 34190, Thailand

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Abstract

Tamarind pulp with varying levels of added maltodextrin was foam-mat dried to improve the stability of the tamarind and to study consumer acceptance and attitudes towards the tamarind powder. Tamarind foam-mats were prepared using hydroxypropyl methycellulose (HPMC) as a foaming agent and maltodextrin at either 0%, 5%, 10%, or 15% as a drying aid. The resulting mixtures were foamed and dried at either 55^{O}C, 60^{O}C, or 70^{O}C. Increasing the maltodextrin content resulted in a lighter colour, with a decrease in redness and yellowness. Also the pH increased and the total acidity decreased with increasing maltodextrin. Dispersibility of the tamarind powder was improved by adding maltodextrin. A consumer test (n = 114) found increasing the amount of added maltodextrin also improved the overall acceptance score. The sample with 15% maltodextrin added, then dried at 70^{O}C had the highest overall acceptance score. Investigation into the buying behaviour of the consumers found participants would consider purchasing the tamarind powder if the price range was USD 0.16-0.19 per 10 g (c.a. 5-6 Baht). Moreover, the product being approved by the Food Standard Institute was the most important variable affecting buying decisions, with secondary considerations being product characteristics such as colour, odour and taste. The consumers suggested that the tamarind powder could replace tamarind pulp for cooking; be used as an instant juice powder; added to Thai curry paste, or; used as an ingredient in cosmetics.

Introduction

Tamarind is a versatile fruit that is used as an ingredient in a number of different consumer products. It comes in two main varieties; sweet and sour. The former is harvested ripe and usually consumed fresh, while the latter is processed into a range of value added products (Joshua and Dudhade, 2006). Examples of products typically produced from tamarind include juice, pulp, powder, chutney, pickles, sauces, and sugar coated candies. Tamarind is a mild laxative, but has been reported to provide healthy benefits to human digestive systems (Williams, 2006). The colour of tamarind pulp becomes undesirable because of browning during the storage due to non-enzymatic browning such as Maillard reaction, resulting in quality loss of the pulp (Kotecha and Kadam, 2003; Obulesu and Bhattacharya, 2011). The brown-red colour of the fresh pulp progressively darkens and becomes black within a year. Therefore improved processing and/or storage techniques are required to minimize quality deterioration and to provide a consistent and convenient ready-to-use product for consumers (Ramana *et al*., 2006).

The foam-mat drying process is simple and inexpensive process by spreading stable foams as a thin porous sheet and exposing them directly to hot air drying. Foaming of liquid and semi-solid materials has long been recognized as one of the efficient methods to shorten drying time. However, foam stability is required before drying by decreasing surface tension in the gas-liquid phase. A short drying period will be obtained without the foam collapsing. This method is suitable for any heat sensitive, sticky and viscous material which cannot be dried by spray drying. Renewed interest in foam-mat drying could be due to its simplicity, cost-effectiveness, rapid drying rate and enhanced product quality. The foam-mat dried products have better reconstitution properties because of their honeycomb structure. In recent years, foam-mat drying technology has revamped and renewed attention for its added ability to process hard-to-dry materials to produce products of desired properties and retaining volatiles that otherwise would be lost during the drying of non-foamed materials (Karim and Wai,1999; Kudra and Ratti, 2006; Kandasamy *et al*., 2012). However, if the foam does not remain stable during the heating cycle,

*Corresponding author.
Email: *apinya.e.ubu.ac.th, a_ekpong@hotmail.com*
Tel: (66) 45-353500(3569); Fax (66) 45-288373

the cellular structure will break down, which causes a significant impairment to the drying operation. Variables affecting foam formation, density and stability include the chemical nature of the fruit, the soluble solids content of the pulp, the pulp fraction and the type and content of the foaming agent and foam stabilizer (Karim and Wai, 1999).

The foam-mat drying technique can be used for heat sensitive, sticky, viscous and high-sugar content food products (Rajkumar *et al*., 2007). Tamarind pulp contains a high content of low molecular weight sugars and organic acids (Bhandari *et al*., 1997a), making foam-mat drying a potential option. Foam-mat drying of tamarind pulp using different foaming agents such as ovalbumin, mesquite gum and a low molecular weight surface active blend has been reported by Vernon-Carteret *et al.* (2001). For most food products, however, hydroxypropyl methycellulose (HPMC) has been successfully used for foam stabilization (Karim and Wai, 1999; Raharitsifa *et al*., 2005, Rajkumar *et al*., 2007). In addition, drying aids such as maltodextrin, tricalcium phosphate and silicon dioxide have been used to make the powder free-flowing and non-sticky (Peleg and Hollenbech, 1984, Roos, 1995, Bhandari *et al*., 1997b, Jaya and Das, 2004). Bhandari *et al.* (1993) and Silva *et al*. (2006) observed that maltodextrin could improve the stability of fruit powder with high sugar content because it reduced the stickiness and agglomeration problems commonly found with drying these products. Maltodextrin was used as a drying aid for tamarind powder produced by drum-drying and gave preferred sensory scores for appearance, colour and overall liking (Jittanit *et al*., 2011).

Consumers are the centre of product development in the food industry, directly in the design of retail products and indirectly in the design of commodity and industrial products (Earle *et al*., 2001). Consumers buy and consume products for a number of reasons, predominantly, relating to product organoleptic characteristics such as appearance, flavour and texture (Van Trijp and Schifferstein, 1995; Linnemann *et al*., 2006). At present there are no reports on consumer studies regarding foam-mat tamarind powder. The objectives of this work were 1) to produce tamarind powder by using maltodextrin as a drying aid; 2) to evaluate consumers' acceptance, intention to purchase, and their opinion toward tamarind powder.

Materials and Methods

Raw materials and foam-mat preparation

Sour tamarind (*Tamarindus indica* L.) compressed pulp was obtained from a local market nearby Ubon Ratchathani University, Ubon Ratchathani, Thailand. The compressed tamarind pulp was mixed with water, blended in the ratio 1:2 (w/w) before using a pulper and refiner (Didacta TA16/D, Italy) to remove seeds and stems. Maltodextrin DE10 (Shandong Duqing Inc., China) at either 0, 5, 10, or 15% (w/w) was added to samples of 400 g tamarind pulp (total solids 21.7%) and then a solution of 4% HPMC was added, such that the final concentration of HPMC was 0.1% of the total solids of the sample (includes both tamarind and maltodextrin solids). Each sample was then whipped in a Kitchen Aid mixer (Kitchen Aid, model no. 5K5SS, Belgium) at maximum speed (220 rpm) for 10 minutes to create a foam. Whipping was continued until the foam density was between 0.2 to 0.5 g/cm^3 and the foam remained stable, without drainage, for 1 hour at room temperature (Beristan *et al*., 1993). The optimum levels of 4% HPMC gel required for foam stability were 0.9%, 0.9%, 2.6% and 5.1% of the total solids of the tamarind pulp mixed with 0%, 5%, 10% and 15% maltodextrin, respectively.

Foam-mat drying

A hot air dryer (Nu-Vu, ES-18, U.S.A) was used at either 55±0.5^{o}C, 60±1^{o}C, or 70±0.7^{o}C. The air velocity for all treatments was fixed at 0.13±0.06 m/s in a counter current flow. Each tamarind foam was gently spread onto an aluminium tray covered with a polyethylene film sheet to achieve a foam thickness of 3.2 mm (1/8 inch). During drying the weight of tamarind foam was recorded every 30 min using a digital balance and stored in real time using an interface system (Mettler Toledo, PB3002-S/FACT, Germany). Drying proceeded until the final moisture content of the foam was approximately 10% (dry basis). The dried foam mat was converted to tamarind powder using a blender (National, MIK-C300N, Thailand), then packed in an aluminium bag before being kept in a desiccator at ambient temperature (27 ± 3^{o}C) until further analysis. The experimental design involved four maltodextrin levels and three foam-mat drying temperatures–a total of 12 experimental trials. Each of these 12 experimental trials was replicated 3 times.

Chemical and physical analyses

The AOAC method (AOAC, 1984) was used for determining moisture content. The water activity of the powder was measured using a Thermoconstanter (Novasina, PS200 S/N 9809020, Switzerland), calibrated with a standard sample of a known value (Range 0.11-0.99).

Total acidity as tartaric acid was measured using 50 g of tamarind powder (AOAC, 1984). 10 g of tamarind powder was mixed with 90 ml of distilled water and the solution pH was measured using a standard pH meter (Mettler Toledo, Seven Easy, Germany).

The structure of dried tamarind foam was analysed using a scanning electron microscope (JEOL, JSM-5410LV, Japan). Before being pulverized to a powder, the dried tamarind foam sheet was cut in cross-section and mounted on a metal stub using electrically-conductive double-sided adhesive tape. The sample was sputter coated with gold (90 s., 0.2 mbar and 20-25 mA). A SEM micrograph was obtained at 15kV and a magnification of 35x.

The colour of samples was determined using a CIE colour system (Hunter, Colour Flex, U.S.A). Colour values: L^* (lightness-darkness), a^* (redness-greenness) and b^* (yellowness-blueness) were measured.

Dispersibility was assessed by mixing 2 g of tamarind powder with 150 ml distilled water (26°C) using a magnetic stirrer for 5 sec. The solution was then centrifuged at 1735 x g for 3 min before collecting the supernatant. The optical density was measured using a spectrophotometer (Biochrom Libra, S12, UK) at 520 nm (Al-kahtani and Hossan, 1990). Viscosity of the reconstituted samples (tamarind powder: water at 1: 3 w/v) was measured using a viscometer (Brookfield, DV-II, U.S.A) (Al-kahtani and Hossan, 1990).

Consumer testing

Consumers (n = 114) were recruited for their willingness to participate in this research. They were asked to sign the consent forms before testing the samples. The consumer test was designed using a balanced design (MacFie *et al.*, 1989). The presentation order of samples was randomly assigned to each subject. All 12 samples were evaluated by all consumers over 2 sessions, evaluating 6 samples/session. The questionnaire used nine-point hedonic scales (1= dislike extremely; 9 = like extremely). The participants were asked to reconstitute 3 g tamarind powder with 15 ml potable water and then evaluate the reconstituted samples. Then, they were asked about personal information, purchase intention and rating the variables affecting their buying decision (1= the lowest important; 5 = the most important).

Statistical analysis

The experimental design was a 4 x 3 factorial in complete randomized design, with three replications. There were two factors; four levels of maltodextrin (0%, 5%, 10% and 15%) and three foam-mat drying temperatures (55°C, 60°C and 70°C). The physical, chemical and consumer acceptance data were analysed using analysis of variance (ANOVA). Duncan's test was used to establish the significant difference among mean values at 95% significance level ($p < 0.05$). Relationships between instrumental and sensory data were analysed using Pearson's correlation. Descriptive statistics as percentages were calculated for the other consumer data.

Results and Discussion

Drying rates of foam-mats

Increasing the drying temperature from 60 to 70 °C resulted in a significant reduction in the drying time. Similarly, increasing the maltodextrin content made very significant reductions in drying times at a given temperature as shown in Table 1. At temperatures below 55°C, the foam-mat structure collapsed, the drying times increased considerably and the finished product was not acceptable as a powder. The HPMC content of each sample was adjusted to reflect the total solids content of each sample. Because 400 g of tamarind pulp was taken for every sample, more HPMC was used to create a stable foam in samples with added maltodextrin, as the sample total solids content had increased. This may have confounded the results with the added maltodextrin as the increased HPMC may have been responsible for a greater stability in the foam-mat. SEM microscopy analysis showed a much more stable foam, with more open pores, did exist in the foam-mat as maltodextrin content increased and the temperature of drying increased. These micrographs are shown in Figure 1. Clearly an increased maltodextrin content (and concomitant increase in HPMC), or a higher drying temperature (70°C versus 55°C) resulted in a better pore structure and emulsion stability of the tamarind foam which did not collapse. In addition, thermally stable foams retain their porous structure, which aids in the reconstitution properties of the dried product (Bag *et al*., 2011).

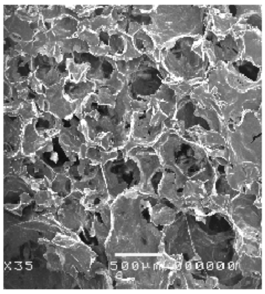
Moisture and water activity of the tamarind powders

The moisture contents and water activities of the tamarind powders are given in Table 1. While the moisture content of majority of samples is not significantly different, there was a trend towards a decreasing moisture content as the maltodextrin

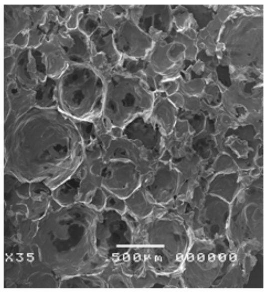
Table 1. The effect of maltodextrin and drying temperature on physical and chemical properties of tamarind powder

Sample	Malto-dextrin(%)	Temp. (°C)	DryingTime (hr)	Moisture (%, dry basis)	Water activity	pH	Total acidity (%)	L* (lightness)	a* (redness)	b* (yellowness)
1	0	55	65	10.48 ± 0.35^{a}	0.214 ± 0.016^{a}	3.01 ± 0.01^{f}	25.54 ± 0.02^{d}	48.6 ± 5.1^{e}	10.8 ± 1.3^{ab}	27.5 ± 3.6^{bc}
2	0	60	53	10.36 ± 0.07^{a}	0.177± 0.027^{abcd}	3.07 ± 0.02^{f}	26.09 ± 0.04^{b}	53.4 ± 2.8^{cd}	11.5 ± 0.5^{ab}	32.0 ± 0.7^{a}
3	0	70	32	10.39 ± 0.15^{a}	0.165 ± 0.030^{bcd}	3.11 ± 0.01^{f}	26.80 ± 0.07^{a}	52.7 ± 1.6^{de}	11.3 ± 1.3^{ab}	31.1 ± 2.2^{ab}
4	5	55	56	10.43 ± 0.02^{a}	0.204 ± 0.015^{ab}	3.32 ± 0.01^{de}	24.24 ± 0.05^{e}	56.9 ± 6.8^{cd}	9.7 ± 1.0^{ab}	28.8 ±3.9^{abc}
5	5	60	45	10.40 ± 0.41^{a}	0.169 ± 0.016^{bcd}	3.36 ± 0.01^{cd}	25.41 ± 0.02^{d}	56.9 ± 5.1^{cd}	10.8 ± 1.4^{ab}	31.3 ± 2.1^{ab}
6	5	70	20	10.17 ± 0.13^{a}	0.149 ± 0.012^{cde}	3.41 ± 0.01^{c}	25.68 ± 0.05^{c}	59.5 ± 2.3^{c}	10.2 ± 0.9^{ab}	30.6 ± 1.9^{ab}
7	10	55	40	10.14 ± 0.12^{a}	0.175 ± 0.024^{bcd}	3.71 ± 0.01^{bc}	20.89 ± 0.05^{h}	66.9 ± 0.6^{b}	8.2 ± 0.3^{ab}	25.0 ± 2.6^{cd}
8	10	60	29	9.99 ± 0.58^{ab}	0.171± 0.024^{bcd}	3.75 ± 0.03^{b}	21.97 ± 0.05^{g}	66.5 ± 3.5^{b}	8.1 ± 0.2^{ab}	22.2 ± 1.1^{d}
9	10	70	7	9.98 ± 0.68^{ab}	0.140 ± 0.009^{de}	3.82 ± 0.02^{b}	22.69 ± 0.01^{f}	68.4 ± 2.1^{b}	8.3 ± 1.2^{ab}	24.6 ± 4.5^{cd}
10	15	55	24	10.24 ± 0.28^{a}	0.179 ± 0.034^{abc}	4.14 ± 0.01^{a}	16.58 ± 0.05^{k}	69.3 ± 1.6^{ab}	14.7 ± 1.7^{a}	22.2 ± 1.8^{d}
11	15	60	18	10.08 ± 0.22^{ab}	0.163 ± 0.008^{cd}	4.18 ± 0.01^{a}	17.23 ± 0.04^{j}	70.7 ± 1.8^{ab}	7.4 ± 1.0^{b}	20.9 ± 1.4^{d}
12	15	70	5	9.51 ± 0.23^{b}	0.126 ± 0.006^{e}	4.21 ± 0.01^{a}	17.33 ± 0.03^{i}	74.1 ± 2.8^{a}	5.4 ± 1.0^{b}	15.8 ± 1.1^{e}

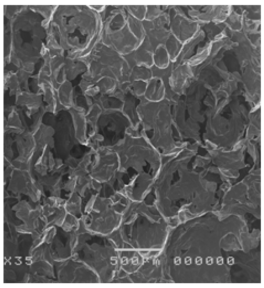
Note: Values are the mean (± SD) of triplicate analyses. Numbers in the same column with different letters are significantly different ($p < 0.05$).



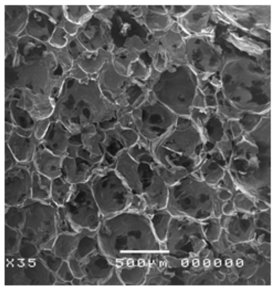
(a) 0% maltodextrin at 55°C



(b) 15% maltodextrin at 55°C



(c) 0% maltodextrin at 70°C



(d) 15% maltodextrin at 70°C

Figure 1. SEM micrographs of dried tamarind foams (magnification of 35x– 15kV)
(a) 0% maltotextrin at 55°C (b) 15% maltotextrin at 55°C
(c) 0% maltotextrin at 70°C (d) 15% maltotextrin at 70°C

content and temperature of drying increased. Indeed, the highest added maltodextrin sample dried at 70°C was significantly drier than most other samples. This is consistent with other studies (Fazaeli *et al*., 2012) and may be explained by the fact that increasing the maltodextrin content resulted in an increase in sample solids and a reduction in the total amount of moisture to be evaporated. The variation in final powder moisture content reflects the challenge in stopping the drying process at a consistent point when relying upon total sample weight alone.

Water activities (a_w) of tamarind powders varied significantly, ranging from 0.13 to 0.21. In terms of microbial stability, water activities of all treatments were sufficiently low to ensure safe storage stability as microbial activities are inhibited below aw 0.6, most fungi below 0.7, most yeast below 0.8 and most bacteria below 0.9 (Fellow, 2000). Both drying temperature and added maltodextrin levels affected the moisture content and water activity of the powders, but there was no observed or consistent interaction between these two variables. Generally,

Table 2. The effect of maltodextrin and drying temperature on the dispersibility, viscosity and consumer acceptance scores

Sample	Maltodextrin (%)	Temperture (°C)	Dispersibility[a] (OD)	Viscosity[a] (Centipoises)	Colour liking score[b]	Odour liking score[b]	Overall acceptance score[b]
1	0	55	0.0033 ± 0.0002^{h}	633.66 ± 21.39^{h}	4.36 ± 0.22^{c}	5.47± 0.21^{a}	4.97± 0.22^{b}
2	0	60	0.0038 ± 0.0001^{gh}	641.33 ± 20.01^{gh}	4.66 ± 0.23^{c}	5.55 ± 0.21^{a}	5.09 ± 0.23^{b}
3	0	70	0.0034 ± 0.0002^{h}	655.00 ± 14.80^{g}	4.57 ± 0.23^{c}	6.17± 0.20^{a}	5.39 ± 0.22^{b}
4	5	55	0.0048 ± 0.0001^{ed}	833.67 ± 5.59^{f}	5.92 ± 0.21^{ab}	5.78 ± 0.20^{a}	6.11± 0.18^{a}
5	5	60	0.0045 ± 0.0003^{f}	840.00 ± 3.46^{f}	5.67 ± 0.21^{ab}	6.23 ± 0.21^{a}	6.08 ± 0.20^{a}
6	5	70	0.0043 ± 0.0001^{fg}	849.00 ± 7.00^{f}	5.59 ± 0.20^{b}	5.96 ± 0.19^{a}	5.96 ± 0.18^{a}
7	10	55	0.0052 ± 0.0001^{de}	1050.67 ± 10.41^{e}	6.24 ± 0.19^{a}	5.92 ± 0.20^{a}	6.39 ± 0.18^{a}
8	10	60	0.0054 ± 0.0002^{d}	1030.67 ± 9.45^{d}	6.11 ± 0.19^{ab}	5.88 ± 0.19^{a}	6.12 ± 0.18^{a}
9	10	70	0.0060 ± 0.0002^{c}	1105.00 ± 1.00^{c}	6.17 ± 0.19^{ab}	5.92 ± 0.18^{a}	5.97± 0.20^{a}
10	15	55	0.0065 ± 0.0003^{b}	1866.33 ± 8.50^{b}	6.19 ± 0.21^{ab}	5.98 ± 0.21^{a}	6.22 ± 0.20^{a}
11	15	60	0.0071 ± 0.0007^{a}	1880.67 ± 11.72^{b}	5.97 ± 0.21^{ab}	5.91± 0.19^{a}	6.32 ± 0.21^{a}
12	15	70	0.0073 ± 0.0004^{a}	1918.67 ± 15.14^{a}	6.22 ± 0.22^{a}	5.75± 0.21^{a}	6.40 ± 0.21^{a}

Note: [a] Values are the mean ± SD of triplicate analyses. Numbers in the same column with different letters are significantly different ($p < 0.05$). [b] Values are the mean ± SE (n =114). Numbers in the same column with different letters are significantly different ($p < 0.05$).

increasing the drying temperature at a given maltodextrin content, or increasing the maltodextrin content at a given drying temperature resulted in a decreased water activity. Such effect of temperature on water activity and moisture content was observed by Franco *et al*., (2015) regarding to foam-mat drying of yagon juice.

pH and total acidity of the tamarind powders

The pH and total acidity of the powders were significantly affected by the maltodextrin and drying temperature ($p < 0.05$) as shown in Table 1. The pH increased and the total acidity decreased as the maltodextrin content increased (at a constant temperature). While the pH also increased as the temperature of drying increased (at a constant maltodextrin content), the total acidity also increased with increasing temperature of drying, which would appear to be at odds with the pH result. Given the small differences in pH and acidity over the temperature range used, this may be understandable. However, there was no significant interaction between maltodextrin content and the drying temperature on either the pH or the acidity. The changes in the pH and acidity with the maltodextrin would likely reflect a dilution effect of the original tamarind pulp. Therefore, a degradation of tartaric acid can be minimised (Gregory, 1996).

Colour of the tamarind powders

Table 1 shows the impact of different maltodextrin levels and drying temperatures on the colour characteristics of tamarind powders. Colour was represented by L^*, a^*, and b^*, where L^* values range from black (0) to white (100), a^* values range from green (−) to red (+), and b^* values range from blue (−) to yellow (+). Addition of maltodextrin to the pulp resulted in a significant increase in the lightness of the powders, which is most likely a reflection of the dilution of the original tamarind pulp with a pale, white powder (maltodextrin). Similar results have been reported in spray-dried Gac powder, sweet potato powders and pineapple juice powders (Kha *et al*., 2010; Grabowski *et al*., 2006; Abadio *et al*., 2004). There was no significant difference in lightness of samples when the temperature increased from 55 to 70°C at a constant maltodextrin content. While there were trends in the data for 'redness' (a) and 'yellowness' (b) the significance of these was inconsistent. In general, however, the highest addition of maltodextrin (15%) resulted in powders that were significantly less red and less yellow than the other samples. Apart from that result, there were no significant changes in redness or yellowness of the powders with maltodextrin contents from 0 to 10% addition, or with differing drying temperatures. Grabowski *et al.* (2006), using maltodextrin contents between 0 and 20% in sweet potato powder, reported that a^* and b^* values decreased with increasing maltodextrin, indicating a loss in redness and yellowness of their samples.

Table 3. Pearson's correlations between sensory and instrumental data

instrumental data	Sensory data	
	Colour liking	Overall acceptance
Maltodextrin content	**0.858****	**0.852****
Drying temperature	-0.013	0.011
Moisture	**- 0.623***	**-0.590***
Water activity (a_w)	-0.435	-0.449
pH	**0.816****	**0.813****
Acidity	**- 0.699***	**-0.709****
L*	**0.866****	**0.838****
a*	-0.409	-0.442
b*	**-0.637***	**-0.614***
Dispersibility	**0.810****	**0.799****
Viscosity	**0.648***	**0.690***

Note: Significant correlations are in bold
* $p < 0.05$; ** $p < 0.01$

Dispersibility of the tamarind powders and viscosity of the reconstitute samples

Both maltodextrin content and drying temperature significantly influenced the dispersibility and viscosity of samples as shown in Table 2. Increased levels of maltodextrin increased the dispersibility of the powder, which is consistent with powders in general (Roos, 1995). Maltodextrin is most used in spray drying because of its physical properties, including high solubility in water (Cano-Chauca *et al*., 2005). The tamarind foam-mat with 15% maltodextrin, dried at 70°C, had the highest dispersibility (OD 0.0073 ±0.0004) and also the highest viscosity (1918.67 cP). It is important to note that HPMC increased in concentration with an increase in maltodextrin and therefore changes in viscosity may have been related to HPMC rather than maltodextrin. In addition, HPMC could reduces particle adhesion and improves the powder recovery during spray drying because of the particles' reduced hygroscopicity and increased glass transition temperature (Rowe *et al*., 2009; Wang *et al*., 2014). Foam-mat drying at 70°C with 10 or 15% maltodextrin also improved dispersibility of the powders and increased viscosity of the resulting solutions. From Figure 1 it can be seen that the higher temperature gave a better porous structure after drying, generally as a result of a significantly reduced processing time. This has been shown to improve the reconstitution properties of food products (Franco *et al*., 2015;Bag *et al*., 2011). There was also a significant interaction between maltodextrin content and drying temperature for both dispersibility and viscosity.

Consumer testing

The consumer participants were mostly female (78%) and 56% were currently being employed. The ages of all consumer participants ranged from 20 to 60 years old and those who worked earned between USD 156 and USD 938 per month (c.a. 5,000-30,000 Baht). There were 12 samples in this study and all 114 participants evaluated every sample.

The consumer acceptance results for colour, odour and overall acceptability are provided in Table 2. Importantly, the colour liking score increased with increasing maltodextrin content. There was no significant impact of drying temperature on the colour. There were no difference among samples on odour liking score which indicated that the two factors had no impact on this attribute. The consumer results showed no significant impact of the drying temperature on overall acceptability. The only significant improvement in overall acceptability was achieved with the addition of maltodextrin. Increasing from 5 to 15% maltodextrin had no significant impact on overall acceptability, which has important ramifications for future use of this research on an industrial scale. Similar results were reported by Jittanit *et al.* (2011) who studied the processing of tamarind powder by drum-drying using maltodextrin and Arabic gum as drying aids. Sensory evaluation of the drum-dried powder indicated that added maltodextrin, in comparison to Arabic gum, improved the product appearance, colour and overall liking.

Correlations between sensory and instrumental data are provided in Table 3. Colour liking and overall acceptability had positive correlations with maltodextrin content, pH, lightness colour value, dispersibility and viscosity and negative correlations with moisture content, acidity and yellowness colour values. The other measurements (drying temperature, water activity and redness colour value) were not significantly related to sensory scores.

Following the sensory testing procedure, consumer participants were asked to complete a questionnaire regarding purchase intentions. Participants were first asked whether, or not they would buy this powder if it was made available, and if so, to recommend a reasonable price expectation. A total of 100 participants (88%) said they would purchase the powder. The biggest group of participants (44%) suggested a reasonable price range was USD 0.16 to USD 0.19 per 10 g (c.a. 5-6 Baht).

Participants were asked to rate ten variables likely to affect their buying decisions and results are

Table 4. Average scores given by consumers for factors influencing their buying decisions

Buying decision variables	Number of participants scoring each level (%)[a]					Overall mean [c]
	5[b]	4	3	2	1	
1) Colour, odour and taste of product	68.1	16.0	15.0	0.9	0.0	4.5
2) No preservative ingredients	61.4	23.7	9.6	1.8	3.5	4.4
3) The product should be approved by the Food Standard Institute	71.4	21.4	6.3	0.0	0.9	4.6
4) Convenience to prepare and use	35.7	48.2	14.3	0.9	0.9	4.2
5) Convenience to eat	40.2	42.8	15.2	1.8	0.0	4.2
6) Convenience to buy	38.8	37.2	20.4	1.8	1.8	4.1
7) Price	29.1	30.0	37.3	1.8	1.8	3.8
8) Long shelf life	46.0	30.1	16.8	6.2	0.9	4.1
9) Packaging style	26.8	31.3	36.6	5.4	0.0	3.8
10) Many sizes of package	18.6	25.7	44.2	8.8	2.7	3.5

Note: a Each participant was asked to rate each of these 10 variables from 1 to 5, indicating the importance towards influencing their purchasing behaviour.
b Score 5 = the most important, 4 = very important, 3 = moderate important, 2 = low important and 1 = the lowest important
c Average of 114 participants

summarised in Table 4. The three most important variables were: 1) the product should be approved by the Food Standard Institute, 2) the sensory attributes of the product such as colour, odour and taste 3) no preservative ingredients. Similarly, Ekpong *et al*. (2012) found that 428 consumers rated "the product should be proved by the Thai FDA" was the most important factor affecting rice snack buying intentions.

Finally, participants were asked about the ways they might consider using the product. The major suggestions included tamarind powder could be used as tamarind pulp replacements for cooking (93%), an instant juice powder (84%), an ingredient of Thai curry paste (79%), or using the powder as an ingredient for the cosmetic industry (74%).

Conclusion

Tamarind foam-mats can be produced using hydroxypropyl methycellulose (HPMC) as a foaming agent and maltodextrin as a drying and dispersing aid. A minimum of 55°C is required to ensure the foam-mat does not collapse, but the best drying temperature from this study was 70°C. Increasing the maltodextrin content to 15% resulted in an increase in L^*(lightness), a decrease a^* (redness) and b^*(yellowness), an increase in pH and decrease in total acidity. However, the addition of maltodextrin and increasing drying temperatures up to 70°C had no significant impact on overall consumer acceptance of the powder and a solution made from that powder. In fact, addition of 5% maltodextrin alone had a significant and positive impact on acceptability. Tamarind powder dispersibility was significantly improved by using maltodextrin, while the differences in drying temperatures generally had limited effect. The pore structure and stability during drying was positively assisted by increasing the maltodextrin content of the foam-mat and also increasing the drying temperature. However, some of that effect might have been caused by an increased amount of HPMC which was used with increasing amounts of maltodextrin. Maltodextrin content was significantly and positively correlated to the overall acceptance score, whereas the drying temperature was not correlated. These results, together with the consumer participants' opinions on the use and appropriateness of this tamarind powder, suggest there is considerable potential for this as a commercial product. Foam-mat drying, using HPMC and maltodextrin and a relatively high drying temperature (70°C) produces a very acceptable powder, with potentially long shelf life. The product development opportunities for using this powder to create novel and unique food and cosmetic products shows great potential.

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