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Effect of Raw Material and Processing Factors on the Production of Effervescent Artichoke (*Cynara scolymus* L.) Tea Tablets

Van Tang Nguyen and Quang T. Pham

Abstract

An investigation was carried out to determine the effects of some factors on the production of effervescent artichoke tea tablets from dried artichoke (*Cynara scolymus* L.): extraction solvent composition, extraction temperature, extraction time, ratios of leaf, flower, stalk and root of dried artichoke, concentration of spray-drying solution, spray-drying temperature, spray-drying carrier, concentration of spray-drying carrier, proportion of effervescent agent, and components proportion of effervescent agent. The recommended extraction solvent was water with 10 percent of ethanol 96 percent (v/v), with an extraction temperature of 100°C, soak time of 14 hours, first extraction time of one hour, second extraction time of three hours. The dried artichoke raw material consisted of 1.0 parts leaf, 0.5 parts flower, 1.0 parts stalk and 1.5 parts root. The recommended concentration of spray-drying solution was 20 percent, spray-drying temperature of 150°C, spray-drying carrier was maltodextrin at a concentration of 10 percent. The recommended effervescent agent consisted of 1.0 parts citric acid, 1.0 parts tartaric acid and 2.44 parts sodium bicarbonate, added at 45 percent of total weight of effervescent tablet.

KEYWORDS: effervescent tablets, effervescent agent, artichoke tea, cynarine, spray-drying

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Introduction

Cynara scolymus L., is commonly known as Globe artichoke, is a thistle-like perennial herb and is a member of the family *Asteraceae*. Its extract, is commonly known as artichoke tea, is a popular drink.

Various methods to make an instant artichoke drink have been investigated. Spray-drying was a good method to prepare microspheres containing artichoke extract (Gavini et al. 2005). Xiong et al. (2001) described a natural product formulation containing a green tea plant extract in combination with other ingredients which created an effervescent liquid composition upon dispensing the formulation in a liquid. The formulation might include additional components such as other plant extracts, vitamins, ionic minerals, and other substances purported to be of a health benefit. The formulation might be delivered in the form of effervescent tablets which included a core portion containing an effervescent agent and an outer coat containing a sugar alcohol, such as sorbitol (Witzel and Clark 1978). The required ingredients for effervescent granules were at least one acid and at least one base, which reacted and released carbon dioxide. The acid might be tartaric acid or citric acid, while the base might be sodium carbonate, potassium bicarbonate or sodium bicarbonate. Effervescent granules were usually prepared from a combination of citric and tartaric acid rather than from a single acid, because the use of either acid alone caused difficulties. When tartaric acid was the sole acid, the resulting granules readily crumble and lack mechanical strength. Citric acid alone resulted in a sticky mixture which was difficult to granulate during the manufacturing process (Gothoskar and Kshirsagar 2004). Besides, an effervescent tablet for direct use as an additive in hot coffee or hot water included one or more additives such as creamers, pH stabilizing agents, effervescence agents and solubility agents. Various other ingredients and agents might be included in the tablet to enhance flavor, improve mouth feel, enhance foam production, or achieve other desired properties or results (Singh 2009).

In this work, we develop a process to produce effervescent artichoke tea tablets and investigate the effects of raw material composition, additives and processing conditions. From these results, process conditions will be recommended for the optimization of extract concentration, powder yield, total phenolic content (a quality indicator) and sensory properties.

Materials and methods

Materials

Plant material

Artichoke material was collected from different parts (leaf, flower, stalk and root) of artichoke plants in Dalat city, Vietnam. It was dried to a moisture content of 13% and stored in plastic bags at room temperature until processed.

Chemicals

All chemicals used in this research were of analytical grade include citric acid, tartaric acid, sodium bicarbonate, vitamin C, glycerol, sucrose, dextrin, maltodextrin and aspartame.

Analytical techniques

Extract concentration analysis

Extract concentration was determined by an ATAGO WM-7 refractometer with range 0-60% and resolution 0.1%.

Moisture analysis

The moisture content of artichoke powder and of effervescent artichoke tea tablets were analysed according to AOAC (AOAC Official Method 925.19, 1998).

Sensory evaluation

Sensory properties of artichoke powder comprising texture, color, odor, taste, solution texture and overall acceptability were evaluated by method of Larmond (1937). A ten-member panel was placed in testing booths in such a way that there would not be any interference between the evaluators. Evaluation was based on a hedonic scale of 1-9 (1 = dislike extremely, 9 = like extremely).

Statistical analysis

All experiments were run in triplicate. The data were analyzed by SAS software (version 9.0). Differences between treatments were determined by using one-way

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analysis of variance (ANOVA) and the Tukey HSD test, values of $p < 0.05$ being considered as significantly different ($\alpha = 0.05$).

Experimental design

Effect of solvent on total phenolic content of extract

Two kinds of solvent were studied in this experiment: water and 10% of 96% (v/v) ethanol in water. 5 g of dried artichoke leaf was extracted with 50 mL solvent for 60 min at 100 ^{0}C. Total phenolic content of extract was determined by Folin-Ciocalteu reagent according to method of Slinkard and Singleton (1977), using gallic acid as a standard phenolic compound. The total phenolic content in the extracts was shown as microgram of gallic acid equivalent by using an equation that was obtained from standard gallic acid graph.

Effect of extraction temperature on extract concentration

In these tests, 20 g of each dried artichoke component consists of leaf, flower, stalk and root was weighed on a balance with range of 0-500 g and accuracy 0.5 g, then put in a inox pan of 3 L volume with a cover, 200 mL distilled water was added, then the sample was heated on a gas oven to extract for 45 min. at 90, 95 and 100 ^{0}C. Temperature was measured by digital thermometer with range of 0-500 ^{0}C and resolution 0.1 ^{0}C. Extract concentration was determined by refractometer.

Effect of extraction time on extract concentration

30 g of each dried artichoke component consists of leaf, flower, stalk and root was weighed on a balance with range of 0-500 g and accuracy 0.5 g, put in a inox pan of 3 L volume with a cover, 450 mL solvent with 10% of 96$^{\%}$ (v/v) ethanol in distilled water was added, left to soak at room temperature for 14 hours, then heated on a gas oven to extract first time at 100 ^{0}C for 20 min.. The extract was filtered through fine textile, residual solid was extracted a second time by 450 mL solvent with 10% of 96$^{\%}$ (v/v) ethanol in distilled water at 100 ^{0}C for 60 min.

Effect of artichoke components ratio on extract concentration

These experiments were to determine suitable ratios of leaf, flower, stalk and root. Four tests were carried out, each with 30 g of leaf, flower, stalk and root in the following mass ratios: TN1: 1.0/0.5/1.5/1.0, TN2: 1.0/0.5/1.0/1.5, TN3: 1.5/0.5/0.5/1.5, and TN4: 1.5/0.5/1.0/1.0. The dried artichoke was put in a inox pan

of 3 L volume with a cover, 450 mL solvent with 10% of 96$^{\%}$ (v/v) ethanol in distilled water was added, left to soak at room temperature for 14 hours, then heated on a gas oven to extract first time at 100 ^{0}C for 60 min. The extract was filtered through fine textile, residual solid was extracted a second time by 450 mL solvent with 10% of 96$^{\%}$ (v/v) ethanol in distilled water at 100 ^{0}C for 180 min.

Effect of spray-drying conditions

In these experiments, extract samples were prepared as follows: 200 g of dried artichoke components consisting of leaf, flower, stalk and root at mass ratios of 1.0/0.5/1.0/1.5 was put in an inox pan of 3 L volume with a cover, 2000 mL solvent with 10% of 96$^{\%}$ (v/v) ethanol in distilled water was added, then left to soak at room temperature for 14 hours, and then heated on a gas oven to extract first time at 100 ^{0}C for 60 min. The extract was filtered through fine textile, residual solid was extracted second time by 2000 mL solvent with 10% of ethanol 96$^{\%}$ (v/v) in distilled water at 100 ^{0}C for 180 min, the extract was filtered through fine textile. The extracts from both extraction stages were mixed, then concentrated to 10-30% concentration at 90 ^{0}C.

Effect of air temperature

170 mL samples of extract prepared as above with 20% concentration were dried in a SD-05 spray-drier (LabPlant of England) at 400 mL/h feed rate, 1.2-1.3 bar air pressure. Spray-drying samples were carried out at air temperatures of 130, 140, 150, 160 and 170 ^{0}C. Moisture content, sensory properties and weight of artichoke powder were evaluated.

Effect of spray-drying carriers

Spray-drying carriers were added in the solution in order to increase the drying ability. 170 mL samples of extract prepared as above with 20% concentration were dried in a SD-05 spray-drier (LabPlant of England) at 400 mL/h feed rate, 150 ^{0}C air temperature, and 1.2-1.3 bar air pressure. Dextrin and maltodextrin were used as spray-drying carriers at concentration of 10%. The ability of spray-drying, sensory properties and weight of artichoke powder were determined.

Effect of artichoke extract concentration

170 mL samples of extract prepared as above were dried in a SD-05 spray-drier (LabPlant of England) at 400 mL/h feed rate, 150 ^{0}C air temperature, and 1.2-1.3 bar air pressure. Spray-drying samples were done at extract concentrations

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of 10, 20 and 30%. The ability of spray-drying and sensory properties of artichoke powder were evaluated.

Effect of effervescent agent ratio

Machoczek (2000) indicated that the effervescent tablet consisted of at least one active substance, of at least one binder, of possibly carriers as sweeteners, flavors, colorings, scents, softeners, bleaches, and of sherbets. Tablet contained calcium cyclamate as a sweetening agent (Endicott and Dalton 1957). Stanish (1962) determined that a tablet contained cyclohexylsulfamic acid.

The artichoke powder was prepared with preparation of extract and spray-drying as at section 2.3.5, spray-drying temperature was 150 ^{0}C, spray-drying carrier was maltodextrin at concentration of 10%, and extract concentration was 10%. The effervescent agent used in these experiments was a mixture of citric acid, tartaric acid and sodium bicarbonate at mass ratios of 1.0/1.0/2.44. The effervescent agent to total tablet weight ratios were 35, 40, 45, 50 and 50%, respectively. Effervescent time and gas keeping time were recorded by a chronometer. Effervescent time was the time for tablet to dissolve completely, and gas keeping time was the time at which gas has disappeared completely.

Effect of effervescent agent composition

Two experiments TX1 and TX2 were carried out at ratio of citric acid, tartaric acid and sodium bicarbonate of 1.0, 1.0, 2.44 and 1.0, 2.0, 3.44, respectively. The artichoke powder was prepared as at section 2.3.6, ratio of effervescent agent to total tablet weight was 45%. Effervescent time was also recorded by a chronometer.

Results and discussion

Effect of solvent on total phenolic content of extract

Phenolic compounds in the artichoke (*Cynara scolymus* L.) were known as bioactivity compounds because of their anti-oxidation activity (Llorach et al. 2002; Wang et al. 2003), anti-fungal, anti-microbial activities (Zhu et al. 2004, 2005). Table 1 showed that total phenolic content extracted by 10% of 96% (v/v) ethanol in water was significantly higher ($p < 0.05$) than that extracted by water. The reason for this was due to the solubility of phenolic compounds in ethanol was higher than in water. However, if ethanol concentration in the solvent was much higher, many undesirable compounds were also extracted into the solution such as

wax, saps and colors. Therefore, 10% of 96% (v/v) ethanol in water was chosen for extraction.

Table 1. Effect of solvent on total phenolic content of extract

Solvent	Total phenolic content of extract (μg GAE/mL)
Water	76.2 ± 0.1 (b)
10% of 96% (v/v) ethanol in distilled water	108.8 + 0.1 (a)

GAE: Gallic acid equivalent. Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters.

Effect of extraction temperature on extract concentration

Extraction temperature affects directly the diffusivity and solubility of solutes. The diffusivity and solubility of solutes increase with extraction temperature, hence the extract concentration is higher at higher extraction temperature. However, we can not increase the extraction temperature beyond a certain limit.

Table 2 showed that the extract concentration at 100 ^{0}C extraction temperature was higher than at 90 and 95 ^{0}C, and at 100 ^{0}C, cynarine, which belongs to bioactivity compounds was still preserved at maximum level, so an extraction temperature of 100 ^{0}C was the best.

Table 2. Effect of extraction temperature on extract concentration

Extraction temperature (^{0}C)	Extract concentration (%)			
	Leaf	Flower	Stalk	Root
90	3.0 ± 0.1 (d)	4.9 ± 0.1 (c)	7.6 ± 0.1 (b)	9.3 ± 0.1 (a)
95	3.1 ± 0.1 (d)	5.1 ± 0.1 (c)	7.8 ± 0.1 (b)	9.5 ± 0.1 (a)
100	3.3 ± 0.1 (d)	5.3 ± 0.1 (c)	8.0 ± 0.1 (b)	9.7 ± 0.1 (a)

Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters in the same column.

Effect of extraction time on extract concentration

The amount of extraction increases with extraction time but only until equilibrium is attained. From Figures 1 to 4 indicated that the extract concentration of each

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artichoke part and of different artichoke ratios was less significantly different in the short time compared with that in the long time. Therefore, suitable extraction times for first and second extractions were 1 hour and 3 hours, respectively.

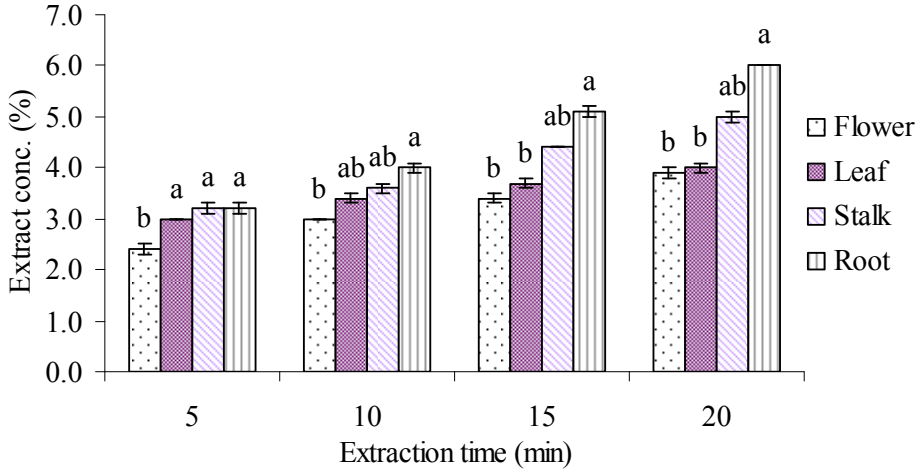

Figure 1. Extract concentration at first extraction. a, b indicated significant differences between treatments by the Tukey HSD test ($p < 0.05$)

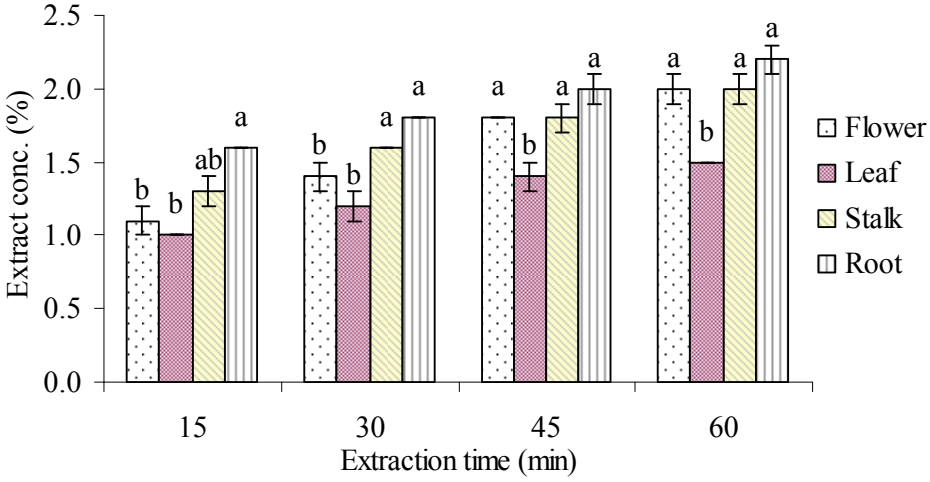

Figure 2. Extract concentration at second extraction. a, b indicated significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Effect of artichoke components ratio on extract concentration

Figures 3 and 4 indicated that the extract concentration at component ratio TN2 was highest compared with TN1, TN3 and TN4 under the same conditions (see section 2.3.4 for the definitions of the component ratios), and these differences in the long time were more significant than those in the short time. This results can be explained by the fact that the soluble content in the stalk and root was higher than that in the leaf and flower (Table 2) and the total ratio of stalk and root at TN1 and TN2 was at 2.5 while it was only at 2.0 at TN3 and TN4, especially the ratio of root at TN2 was at 1.5 compared to 1.0 at TN1. Therefore, artichoke components ratio at TN2 was chosen for extraction.

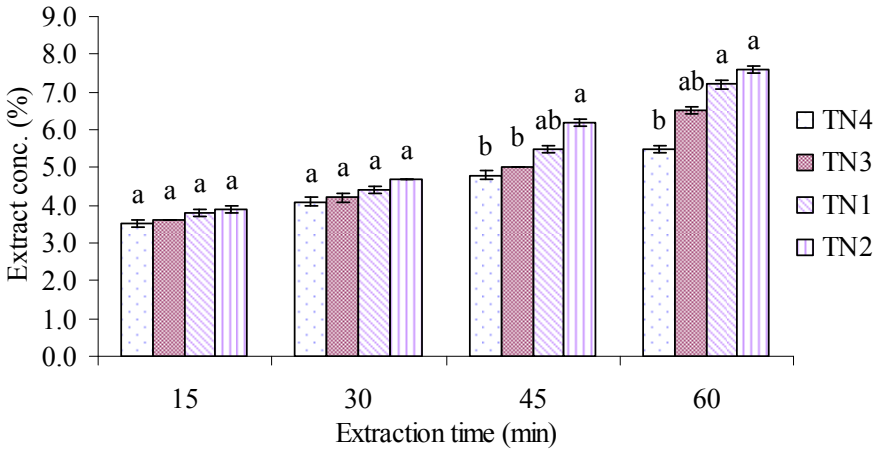

Figure 3. Extract concentration with different artichoke ratios at first extraction. a, b indicated significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Effect of spray-drying conditions

Effect of air temperature

Table 3 showed that when air temperature increased from 130 to 170 ^{0}C, the moisture content of artichoke powder decreased from 16.96 to 10.75% and the powder weight rose from 9.8 to 30.0 g, respectively. The yield of powder was less at low temperature probably because of losses in the spray-dryer: at low temperature, the moisture of artichoke powder remains high and it adhered on the wall and outlet pipes of the spray-dryer. At high temperature, more cynarine and phenolic compounds were destroyed, so the bitter taste of the product decreased. In addition, the overall acceptability at 150 ^{0}C was the best and

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significantly different with almost of other temperatures. For this reasons, 150 ^{0}C was chosen for spray-drying.

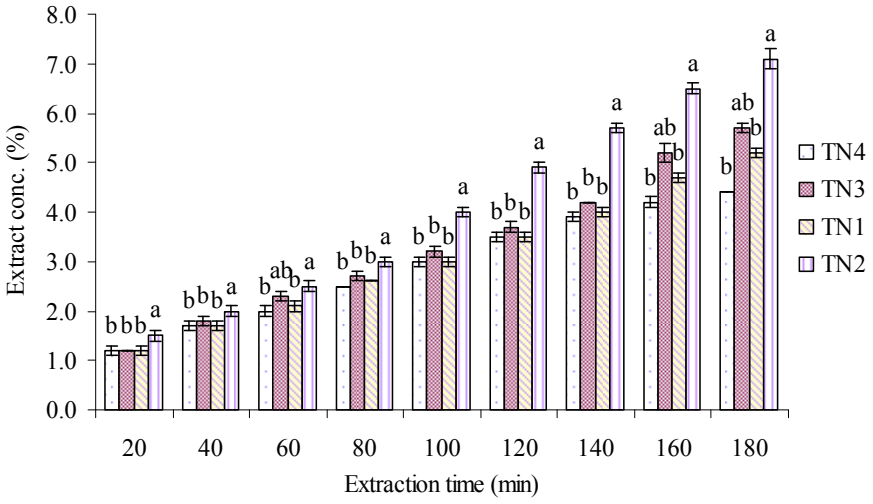

Figure 4. Extract concentration with different artichoke ratios at second extraction. a, b indicated significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Effect of spray-drying carriers

From Table 4, when the dextrin concentration rose from 10 to 30%, the solution became difficult to dry, because the viscosity of solution increased, so the spray nozzle was frequently blocked. In addition, the high dextrin concentration caused a reduction in the color and flavor of the artichoke powder. In particular, the color of the solution became more turbid, because the molecular length and weight of dextrin were high, the dextrose equivalent (DE) of dextrin was low, so its glucose chains were long and its solubility was low. The overall acceptability at dextrin ratio of 10% was best and significantly different with that of 20 and 30%.

Table 5 indicated that spray-drying with maltodextrin as a spray-drying carrier was easier than that with dextrin. Moreover, artichoke powder yield a quality with maltodextrin were also better than those with dextrin. The overall acceptability with maltodextrin was almost significantly higher than that with dextrin. A possible reason is that the molecular length and weight of maltodextrin were smaller than those of dextrin, so that the solubility of maltodextrin was higher than that of dextrin. Therefore, 10% maltodextrin was chosen for spray-drying of artichoke extract.

Table 3. Effect of spray-drying temperature on moisture, sensory properties and weight of artichoke powder

Evaluation parameters		Spray-drying temperature (^{0}C)				
		130	140	150	160	170
Moisture (%)		16.96 ± 0.13 (a)	14.72 ± 0.21 (b)	12.14 ± 0.18 (c)	11.52 ± 0.15 (d)	10.75 ± 0.11 (d)
Sensory properties	Texture	4.93 ± 0.37 (c)	6.12 ± 0.32 (b)	7.45 ± 0.24 (a)	7.42 ± 0.22 (a)	7.33 ± 0.27 (a)
	Odor	7.02 ± 0.24 (ab)	7.37 ± 0.21 (a)	7.46 ± 0.19 (a)	6.22 ± 0.30 (b)	4.15 ± 0.29 (d)
	Taste	7.23 ± 0.15 (a)	7.31 ± 0.12 (a)	7.42 ± 0.13 (a)	6.57 ± 0.16 (ab)	5.32 ± 0.15 (c)
	Overall acceptability	7.02 ± 0.22 (ab)	7.25 ± 0.19 (a)	7.41 ± 0.17 (a)	6.35 ± 0.22 (b)	5.32 ± 0.21 (c)
Weight (g)		9.82 ± 0.12 (d)	14.06 ± 0.15 (cd)	20.53 ± 0.11 (bc)	26.07 ± 0.14 (ab)	30.05 ± 0.20 (a)

Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters in the same line.

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Effect of artichoke extract concentration

Table 6 showed that when artichoke extract concentration was increased from 15% to 20%, the sensory properties of artichoke powder improved, but with a further increase from 20% to 25%, the sensory properties became worse, especially flavor. The overall acceptability at 20% artichoke extract was almost significantly higher than that at 10 and 30% artichoke extract. For this reason, an artichoke extract concentration at 20% was chosen for the spray-drying process.

Table 4. Effect of different dextrin ratios on the ease of spray-drying and sensory properties of artichoke powder

Evaluation parameters		Dextrin ratio (%)		
		10	20	30
Ease of spray-drying		Easy	Easy	Difficult
Sensory properties	Color	7.42 ± 0.19 (a)	6.93 ± 0.21 (ab)	5.25 ± 0.22 (c)
	Odor	7.53 ± 0.23 (a)	7.24 ± 0.16 (a)	5.32 ± 0.19 (c)
	Solution texture	7.46 ± 0.17 (a)	6.88 ± 0.20 (ab)	4.88 ± 0.24 (d)
	Overall acceptability	7.41 ± 0.18 (a)	6.88 ± 0.17 (ab)	5.25 ± 0.17 (c)

Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters in the same line.

Table 5. Effect of spray-drying carriers on the ease of spray-drying, sensory properties and weight of artichoke powder

Evaluation parameters		Spray-drying carrier	
		Dextrin	Maltodextrin
Ease of spray-drying		Difficult	Easy
Sensory properties	Color	6.93 ± 0.21 (ab)	7.42 ± 0.19 (a)
	Odor	7.24 ± 0.16 (a)	7.53 ± 0.23 (a)
	Taste	6.35 ± 0.23 (b)	7.27 ± 0.15 (a)
	Solution texture	7.46 ± 0.17 (a)	7.46 ± 0.17 (a)
	Overall acceptability	6.97 ± 0.19 (ab)	7.30 ± 0.20 (a)
Weight (g)		20.57 ± 0.17 (b)	22.81 ± 0.13 (a)

Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters in the same line.

Effect of effervescent agent ratio

From Figure 5, Figure 6 and Table 5, when spray-drying carrier was maltodextrin, the yield of artichoke powder was higher, the spray-drying process was easier, gas-keeping time was longer than those by using dextrin. To reduce effervescent time, increase gas-keeping time, decrease the price of final product and maintain food safety, the optimal ratio of artichoke powder to effervescent agent was 55% to 45%.

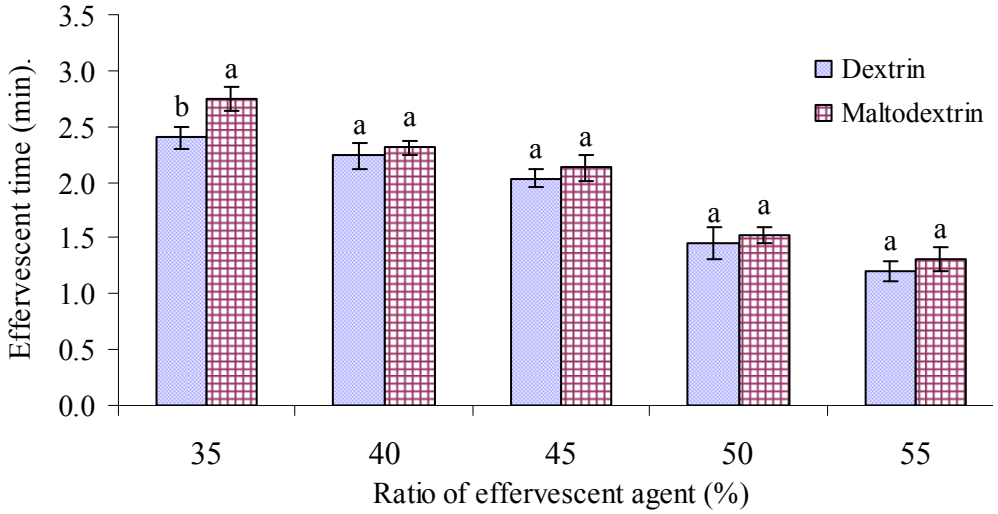

Figure 5. Effervescent time depend on ratio of effervescent agent. a, b showed significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Table 6. Effect of artichoke extract concentration on sensory properties of artichoke powder

Sensory properties of artichoke powder	Extract concentration (%)		
	15	20	25
Color	4.93 ± 0.37 (c)	7.45 ± 0.24 (a)	7.45 ± 0.24 (a)
Odor	7.24 ± 0.16 (a)	7.32 ± 0.16 (a)	6.22 ± 0.30 (b)
Taste	7.27 ± 0.15 (a)	7.34 ± 0.15 (a)	7.31 ± 0.15 (a)
Overall acceptability	6.96 ± 0.22 (ab)	7.32 ± 0.16 (a)	7.02 ± 0.16 (ab)

Mean and standard deviation were of three replicates. Significant differences between treatments determined by the Tukey HSD test ($p < 0.05$) were indicated by different letters in the same line.

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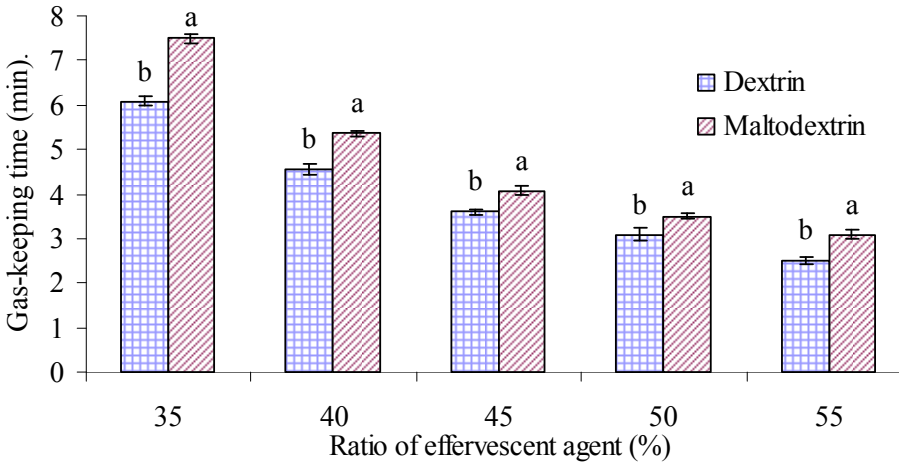

Figure 6. Gas-keeping time depended on ratio of effervescent agent. a, b showed significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Effect of effervescent agent composition

Figure 7 indicated that the effervescent time of TX1 was shorter than TX2, but sensory properties were not significantly different between two.

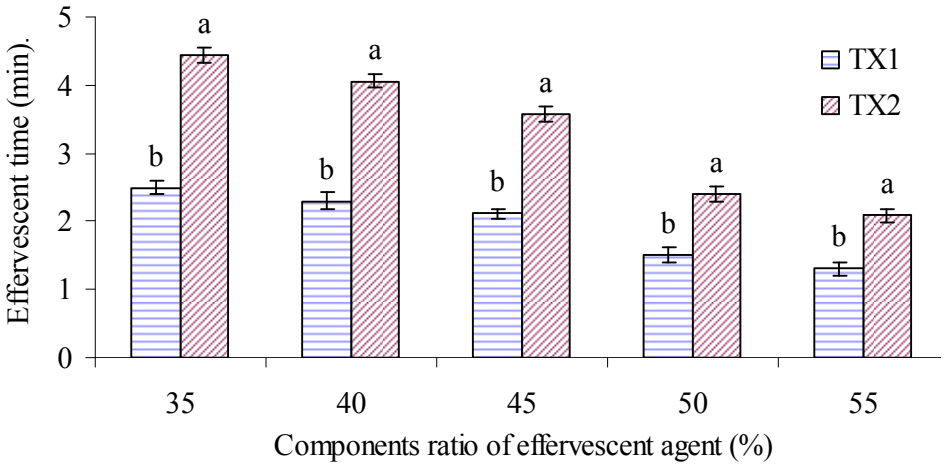

Figure 7. Effervescent time depended on components ratio of effervescent agent. a, b showed significant differences between treatments by the Tukey HSD test ($p < 0.05$)

Therefore, to make effervescent artichoke tablets which retain the special flavor and taste of artichoke and to minimize effervescent time, the

recommended effervescent agent composition was TX1, i.e. citric acid, tartaric acid and sodium bicarbonate were in the ratio 1.0: 1.0: 2.44.

Conclusion

This research indicated that total phenolic content extracted by 10% of 96% (v/v) ethanol in water was significantly higher than that extracted by water. The extract concentration at 100 ^{0}C extraction temperature was higher than at 90 and 95 ^{0}C extraction temperature and it also depends on the ratio of different artichoke components. During spray drying, as air temperature increased, the moisture content of artichoke powder decreased and the yield of artichoke powder rose. When dextrin concentration increased, the extract solution became difficult to dry, and spray-drying with maltodextrin as a spray-drying carrier was easier than that with dextrin. When artichoke extract concentration increased, the sensory properties of artichoke powder improved up to a certain point then decreased. With maltodextrin as a spray-drying carrier, the yield of artichoke powder was significantly higher, the spray-drying process was easier and gas-keeping time was significantly longer than those by using dextrin. An optimum composition of effervescent agent was found for minimising effervescent time at 45%. In the further research, we continue to determine the effects of the binders, and the sweeteners on the production of effervescent artichoke (*Cynara scolymus* L.) tea tablets.

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