

Development of Coconut Milk Based Spray-Dried Herbal Porridge

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Abstract

Herbal porridge is an industry having a good potential to be developed into commercial scale in Sri Lanka. This study tested the application of spray drying technology on local herbal porridge mixture. The framework of this research was the selection of best formulation of herbal porridge for spray drying based on sensory evaluation and performance during spray drying. The total soluble solids of the herbal porridge mixture were maintained at 20% by adding non-fat milk powder and reducing the fat content of feed solution up to 4 - 4.5%. The herbal porridge mixture was spray dried at an inlet temperature of 165°C and an outlet temperature of 65°C. The spray dried product was evaluated for powder properties such as dissolution and the dissolution time for developed spray-dried herbal porridge was 74 ± 7.01 seconds. The spray-dried herbal porridge was further evaluated for sensory properties and was compared with a market available instant herbal porridge of same herb species (product X). It was observed that the developed product had better sensory properties than those of the product X. In the evaluation of shelf life, the developed product did not show a rapid change in free fatty acids, peroxide value, moisture, water activity and total plate count over the evaluation period of six months and all parameters were below the critical level ensuring that the spray dried herbal porridge could be stored for more than six months without losing its quality.

Keywords: Herbal Porridge; Spray Drying; Shelf Life; Sensory Evaluation; Drying Aid

Introduction

Herbal porridge is a popular beverage having a high potential to be developed into commercial scale as it has a good demand, nutritive value, sensory qualities and availability of raw materials. Despite all these facts herbal porridge industry is almost limited to household or cottage level and the major problem associated with this industry is the high level of perishability. The shelf life is short as five to six hours at ambient temperature and it can be extended maximum up to 10 - 12 hours under refrigerated condition. Beyond that time, it loses its quality with respect to taste and texture. Spoilage is mainly caused by properties of coconut milk [1,2]. According to Thampen, *et al.* [3] coconut milk contains fat (38 - 40%), protein (5.8%) and carbohydrate (9 - 11%). Therefore, fresh herbal porridge is susceptible to oxidization due to high fat content, microbial contamination during manual preparation and rapid microbial growth due to high nutrient media [2]. However, herbal porridge industry remains underutilized due to incapability of preserving it for a longer time period. Pasteurization, concentration and drying techniques such as freeze drying, hot air drying, vacuum drying and spray-drying are possible preservation methods. Spray-drying is the commercially used method to preserve a wide variety of liquids. It is considered to be the most efficient

method of preserving due to easiness of handling, transportation and prolonged shelf life as well as maintaining the product at hygienic condition as discussed by Jaya., *et al.* [4], Jayasundera [5], Phisut [6]. It was worth focusing on the application of spray drying technology to preserve herbal porridge mixture without changing its preparation method which has not been possible so far.

Aim of the Study

This study was aimed at developing a successful preservation method to increase the shelf life of herbal porridge, to evaluate powder properties and keeping quality of porridge powder and to evaluate sensory qualities of reconstituted spray dried porridge mixture.

Materials and Methods

Development of the product

Experiments on product development were carried out based on "Trial and Error Method". Main screening process was carried out through sensory analysis and spray-dried herbal porridge samples from different trials were continuously evaluated by semi-trained panellists for taste, color, odor and overall acceptability. Product formulation consisted of "Preliminary experiments" and "Secondary experiments" and altogether 21 formulating trials were conducted to formulate the final product.

Spray-dried samples from each trial were subjected to sensory evaluation by reconstituting 20g in 140 ml (1 cup) of water and cooking for 2 - 3 minutes. At the end of the product development stage, the final product was reconstituted to find out the best reconstitution ratio and it was compared with a market available instant herbal porridge sample.

Basic formula

A common recipe (Table 1) for herbal porridge was used as the base for formulating spray-dried herbal porridge and a number of trials were conducted by changing the amount and the composition of ingredients until the final product reached an acceptable level.

Herbs (g)	Coconut milk (L)	Rice (cooked) (g)	Garlic (g)	Ginger (g)	Salt (g)	Lemon (ml)
250	1	50	10	5	5	5

Table 1: Basic recipe for herbal porridge.

Source: Yapa, 2000.

Selection of herb species

Selection of herb species was based on the suitability of porridge preparation as well as market availability during the product formulation period. Selected herb species were Karapincha (*Murraya koenigii*), Mukunuwenna (*Alternanthera sessilis*) and Gotukola (*Centella asiatica*).

Selection of drying additives

Non-fat milk powder and skim milk powder were selected as the drying aids.

Preparation of coconut milk

Coconut milk was prepared by mixing 150 ml of concentrate milk with 1000 ml of coconut skim milk [7].

Preparation of spray-dried herbal porridge

Herbs, garlic and ginger were cleaned, washed, weighed and cut into small pieces. Then chopped herbs, garlic and ginger were blended with coconut milk by using an electrical blender. The cooked and chopped rice or rice flour and salt were mixed with the blended mixture and it was cooked for 10 - 15 minutes. Once the cooking was complete 5 ml of lime was added into herbal porridge mixture and allowed

to cool. The total soluble solid content was adjusted at 20 by adding the drying aid. Then sample was strained through a cheese cloth to remove fibrous materials and large particles.

Powder production

Spray drying of solutions was carried out on a pilot scale spray dryer (L-8, Ohkawara Kakohki Co Ltd., Yokohama, Japan) with a water evaporating capacity of 1 L/hr. The inlet and outlet temperatures were maintained at 165°C and 65°C, respectively. The powders were collected from cyclone and the cylindrical part of the dryer chamber by lightly sweeping the chamber wall [8]. The yield was calculated as the ratio of the mass of solids collected to the mass in feed solution on a dry basis. Depending on the powder recovery the best formulation was selected for further studies.

Sensory evaluation

Sensory evaluation was performed several times during the product development stage to make the output more closely fitted to the consumer need. Product development was based mainly on sensory evaluation. Semi-trained panellists of 16 to 18 members were selected as the sensory panel. Experiments of product development stage were arranged as preliminary and secondary experiments. Sensory evaluation of powder samples of preliminary and secondary experiments were carried out by reconstituting 20g of powder in 140 ml (1 cup) of water separately and cooking them for 2 - 3 minutes. Each sample was labelled with a sample code i.e. T₁, T₂ or 100, 101 etc. Samples were evaluated by using a “Five point hedonic scale” and samples were ranked according to the degree of liking or disliking on several attributes such as taste, color, odor and the overall acceptability.

Preliminary experiments

Preliminary experiments were conducted to select the best drying additive between “Non-fat milk powder” and “Skim milk powder” and to select the most preferred herb species. The other ingredients were mixed according to the basic recipe (Table 1). Formulations used in preliminary trials are shown in table 2.

Trial no	Herbs spp. (250 g)	Drying aid (up to 20% Brix value)	Coconut milk (L)	Cooked rice (g)	Garlic (g)	Ginger (g)	Salt (g)	Lemon (ml)	Powder recovery %
T ₁	Murraya koenigii	Non-fat milk powder	1	50	10	5	5	5	91.34
T ₂	Murraya koenigii	Skim milk powder	1	50	10	5	5	5	88.56
T ₃	Alternanthera sessilis	Non-fat milk powder	1	50	10	5	5	5	82.41
T ₄	Alternanthera sessilis	Skim milk powder	1	50	10	5	5	5	86.21
T ₅	Centella asiatica	Non-fat milk powder	1	50	10	5	5	5	87.64
T ₆	Centella asiatica	Skim milk powder	1	50	10	5	5	5	88.21

Table 2: Types of formulations used in preliminary trials.

According to previous researches [5,9,10] a high powder recovery beyond 50% indicates a successful spray drying operation. All treatments showed good powder recovery percentage above 50%.

According to the sensory evaluation, both T₅ and T₆ had significantly higher ($p < 0.05$) rank with respect to taste, color and odor attributes than the rest of treatments. However, T₅ was the highest accepted formulation with respect to overall acceptability. Therefore, non-fat milk powder was selected as the drying additive and *Centella asiatica* was selected as the herb species to be subjected for further product improvement.

Secondary experiments

A number of trials were conducted by changing the amount of ingredients in order to develop the product. Formulations used in the secondary experiments are shown in table 3.

Trial no	Herbs (Centella asiatica) amount (g)	Rice (cooked/flour) 50g	Coconut milk (L)	Garlic (g)	Ginger (g)	Salt (g)	Lemon (ml)	Brix value
T ₇	250	Cooked	1	10	5	5	5	20
T ₈	250	Flour	1	10	5	5	5	20
T ₉	500	Cooked	1	10	5	5	5	20
T ₁₀	500	Flour	1	10	5	5	5	20
T ₁₁	750	Cooked	1	10	5	5	5	20
T ₁₂	750	Flour	1	10	5	5	5	20

Table 3: Types of formulations used in secondary trials.

Sensory panellists provided significantly higher ($p < 0.05$) preference for T₉ during the evaluation with respect to taste, color, odor and the overall acceptability. Therefore, T₉ treatment was selected for further experiments. T₁₃ to T₂₁ trials were conducted to find out the most suitable amount of cooked rice and other minor ingredients (Table 4).

Trial no	Herbs (Centella asiatica) amount (g)	Cooked rice Amount (g)	Coconut milk (L)	Garlic (g)	Ginger (g)	Salt (g)	Lemon (ml)	Brix value
T ₁₃	500	50	1	10	5	5	5	20
T ₁₄	500	50	1	20	10	5	5	20
T ₁₅	500	50	1	30	15	5	5	20
T ₁₆	500	100	1	10	5	5	5	20
T ₁₇	500	100	1	20	10	5	5	20
T ₁₈	500	100	1	30	15	5	5	20
T ₁₉	500	150	1	10	5	5	5	20
T ₂₀	500	150	1	20	10	5	5	20
T ₂₁	500	150	1	30	15	5	5	20

Table 4: Formulations used in secondary trials.

Spray-drying of samples T₁₆ - T₂₁ were not possible due to high amount of cooked rice which caused clogging in nozzles. Sensory evaluation was carried out for trials T₁₃, T₁₄ and T₁₅. Sensory panellists had provided significantly higher ($p < 0.05$) preference for T₁₄ with respect to all attributes such as taste, color, odor and the overall acceptability. Therefore, T₁₄ was selected as the final product based on better sensory qualities and spray drying performance.

Reconstitution studies

Experiments were carried out to find the best reconstitution ratio for the developed product and to compare it with the market available instant herbal porridge. Reconstitution series was prepared for sensory evaluation by reconstituting 20g of instant herbal porridge powder separately in 100 ml, 120 ml, 140 ml, 160 ml and 180 ml of water. The market available instant herbal porridge mixture of the same herb species (product X) was also presented to the sensory panel by reconstituting it in the recommended ratio (20g in 180 ml).

Sample code	Amount of instant porridge powder (g)	Amount of water (ml)	Description
100	20	180	Market available product (X) The developed product
101	20	100	
102	20	120	
103	20	140	
104	20	160	
105	20	180	

Table 5: Reconstitution ratios used for sensory evaluation.

Evaluation of the developed product

Final product was subjected to dissolution and the keeping qualities. Further, it was compared with market available instant herbal porridge sample of the same herb species (product X).

Dissolution

Dissolution was evaluated by reconstituting 2g of spray dried powder in 50 ml of distilled water and stirring at 892 rpm by using a magnetic stirrer. Time duration was recorded until the sample was fully reconstituted where no particles appeared to be seen by naked eye. Three replicates were analysed and mean reading was recorded as dissolution time of the product [5,10]. At the same time dissolution property of market available product (X) was also analysed and compared with the developed product.

Keeping qualities

Spray-dried herbal porridge samples were packed in triple laminated aluminium sachets and the powder was subjected to shelf life studies. Samples were tested for peroxide value (PV), free fatty acid content (FFA), moisture content, water activity and total plate count (TPC) once in four weeks for 6 months.

Peroxide value (PV)

The peroxide values of the spray-dried herbal porridge samples were measured by using soxhlet extraction method [11] and titration [12] once in four weeks for a period of six months.

Free fatty acid content (FFA)

The free fatty acid values of the spray-dried herbal porridge samples were measured by using Soxhlet extraction method [11] and titration [12] once in four weeks for a period of six months.

Moisture content

Moisture content of spray dried sweet toddy samples was determined according to standard oven method [13].

Water activity (a_w)

Water activity of powder samples was determined by using Hygro-thermometer data logger (water activity meter). The temperature was maintained at $24.5 \pm 0.5^\circ\text{C}$.

Total plate count (TPC)

Total plate count of herbal porridge samples was determined by the standard pour plate method according to SLS 516 [14].

Statistical analysis

Statistical analysis was performed by using MINITAB 14 computer software. Sensory data from preliminary, secondary and reconstitution experiments were analysed by Kruskal Wallis one -way ANOVA non-parametric statistical test. Results of shelf life studies were analysed by one-way ANOVA and dissolution by T-test.

Results and Discussion

Preliminary experiments

During the evaluation of preference of panellists for initial six trials which were conducted to select the best drying additive between non-fat milk powder and skim milk powder and to select the best herb species among *Murraya koenigii*, *Alternanthera sessilis* and *Centella asiatica*, it was noticed that the preference was significantly different ($p < 0.05$) among six samples. It is graphically illustrated in figure 1.

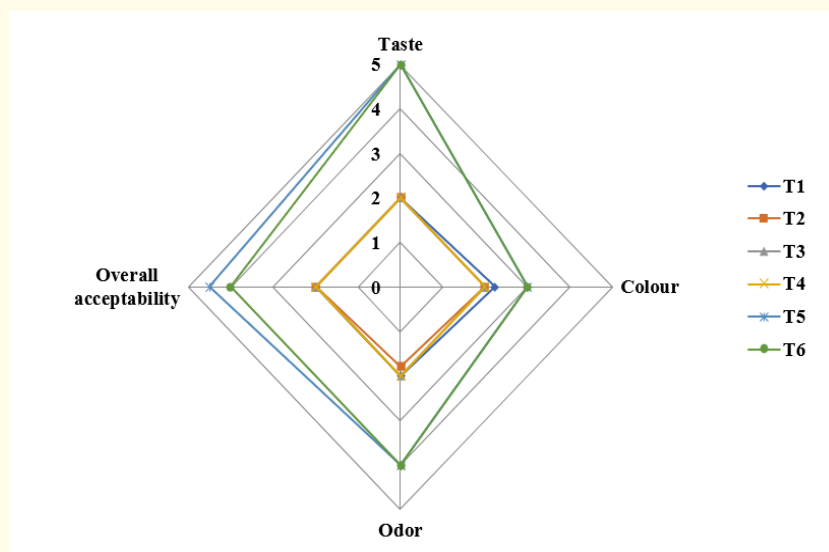


Figure 1: Sensory profile of preliminary trials.

Both T_5 and T_6 samples which were prepared with *Centella asiatica* showed significantly higher ($p < 0.05$) preference with respect to taste, color, odor and the overall acceptability. This result indicated that herb species offer significant effect on sensory properties of spray dried herbal porridge and *Centella asiatica* was the best herb species to be subjected for spray drying in terms of sensory properties.

In contrast, there was no significant difference between T_5 and T_6 with respect to any attribute tested. But the highest rank for overall acceptability was recorded for T_5 sample. This emphasized that the effect of non-fat milk powder or skim milk powder on sensory properties of spray dried product was not significantly different. Therefore, it was fair to select either non-fat or skim milk powder as drying additives. Similarly, T_5 and T_6 samples showed equal chance to be selected for further improvements. But T_5 sample showed higher overall acceptability than T_6 . Therefore, T_5 trial was subjected for further improvements during secondary experiments.

Secondary experiments

Trials (T_7 to T_{12}) were carried out to select the most suitable amount of herb among 250 g/L, 500 g/L and 750 g/L and to select the best form of rice between cooked rice and rice flour. Results gathered from secondary experiments are shown in figure 2.

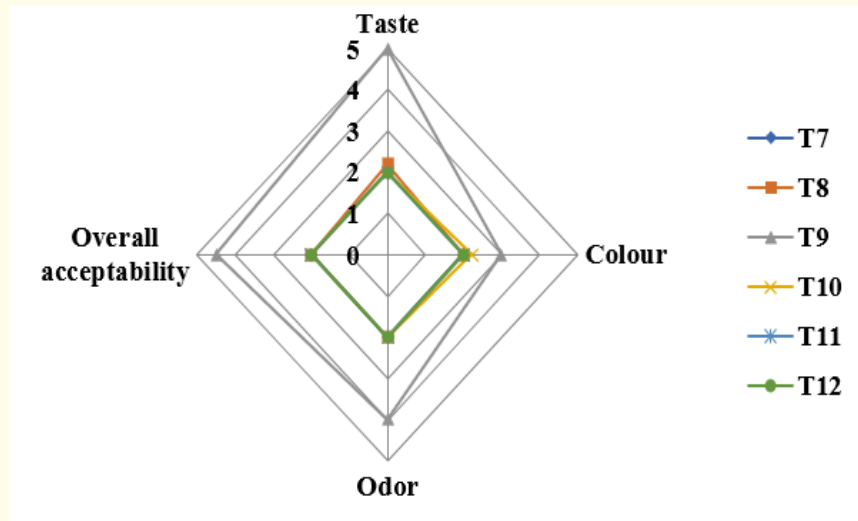


Figure 2: Sensory profile of secondary experiments.

Sample (T_9) was recorded to have a significantly higher ($p < 0.05$) preference from panellists in terms of taste, color, odor and the overall acceptability. It proved that the amount of herb used to prepare feed solution and the form of cereals used had significant effect on sensory properties of spray-dried herbal porridge. Furthermore, T_9 trial containing cooked rice and herb 500 g/L was the best trial to be subjected to continuous product formulation process. Figure 2 shows significant acceptability expressed for T_9 trial.

During further improvements in secondary experiment stage T_{11} to T_{15} trials were evaluated to observe whether there was an effect of minor ingredients on sensory properties of spray dried herbal porridge. There was a significant difference ($p < 0.05$) among samples and the highest acceptability was recorded for T_{14} trial indicating that it had the most preferable combination of minor ingredients. It was fair to select T_{14} sample as the final product since it had been subjected to a series of subsequent trials where it was tested for the best formulation of both major and minor ingredients in terms of sensory properties after spray drying. Sensory evaluation results are graphically illustrated in figure 3.

Powder recovery

Results revealed that the powder recovery of the developed spray-dried herbal porridge was 87.64%. According to Jayasundera [5], Bhandari, *et al.* [8] powder recovery should be beyond 50% for a successful spray-drying trial. Therefore, it is fair to state that this product showed good spray-drying performance with respect to powder recovery.

Reconstitution studies of spray-dried herbal porridge

Experiments were carried out to find out the best reconstitution ratio for developed product and to compare it with the market available instant herbal porridge mixture of the same herb species (product X). Sensory evaluation results were significantly different ($p < 0.05$) among the six samples as shown in table 6.

Many reconstitution ratios (sample 101 - 105) of developed product showed higher ranks of panellists' preference for taste, colour and the overall acceptability than those of product X (sample 100). Results showed that the developed product had better sensory properties

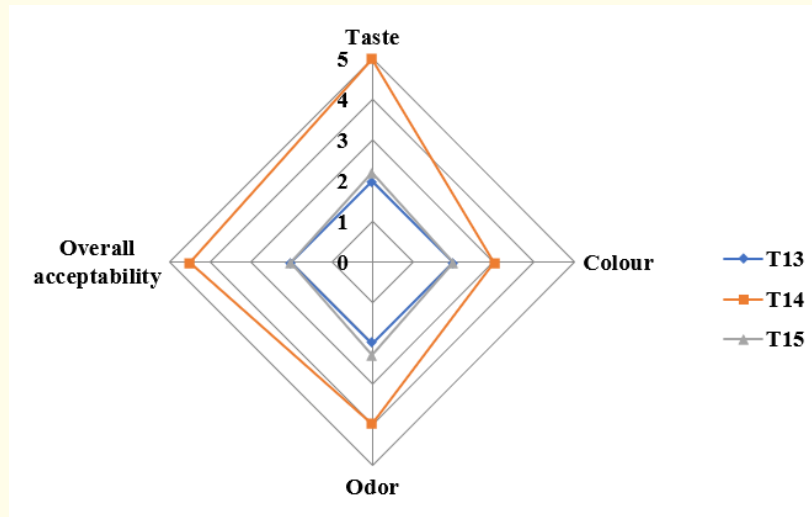


Figure 3: Sensory profile of secondary experiments.

Attributes	Ranking order (according to significance $p < 0.05$)
Taste	102 > 101, 103, 104, 105 > 100
Colour	102 > 101, 104 > 100, 103, 105
Odour	102, 100, 104, 105 > 101, 103
Overall acceptability	102 > 101, 104, 105 > 103 > 100

Table 6: Sensory properties of reconstituted herbal porridge.

Market available product (X) - 100: 20g/180 ml (Recommended ratio).

Developed product - 101: 20g/100 ml, 102: 20g/120 ml, 103: 20g/140 ml, 104: 20g/160 ml, 105: 20g/180 ml.

than the product (X). The most preferred reconstitution ratio for the developed product was 20 g/120 ml in the sense of all the sensory attributes tested namely, taste, colour, odour and the overall acceptability.

Properties of the developed spray dried herbal porridge

Dissolution

Dissolution indicates the time for powder to fully reconstitute in water. According to Farminin and Nordin, [10] good quality powders indicate dissolution time below 2 minutes. The dissolution time for developed spray-dried herbal porridge was 74 ± 7.01 seconds and it was within the required range representing good powder quality.

Dissolution is an essential property for powdered products. According to SLS 668 [15], solubility should be higher than 95% to assure a better powder quality. Results presented in table 7 indicated that the developed product possessed better dissolution compared to that of market available product X.

Product	Dissolution (sec.)
Developed instant herbal porridge	74 ± 7.01
Market available porridge mixture (Product X)	Not fully dissolved and got precipitated with time

Table 7: Dissolution of different instant herbal porridge samples.

Keeping quality of the developed spray-dried herbal porridge

Peroxide value (PV)

Peroxide value was observed as zero for the developed product since there was no peroxide formation during the six months of storage. This result indicates that the product could be stored for more than six months.

Free fatty acid content (FFA)

FFA content was not significantly different during the first four months but it was significantly higher ($p < 0.05$) during the 5th month (Figure 4). This is probably due to the increment of moisture content as free fatty acids rise due to hydrolytic rancidity which is caused by the hydrolysis of the triglycerides in the presence of moisture [16]. Significant difference ($p < 0.05$) of both moisture (Figure 5) and water activity (Figure 6) in the 5th month proves that phenomenon. However, FFA level was far behind the critical level of 0.1% [17] even on 6 months of storage. Therefore, there is great possibility of extending the storage time period for more than 6 months.

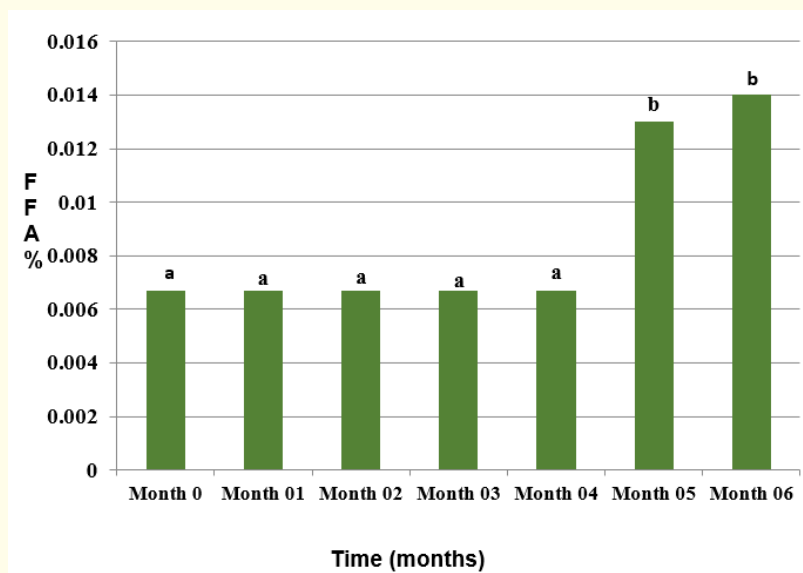


Figure 4: Changes in free fatty acid content of spray-dried herbal porridge on storage.

Moisture content

Moisture is the most important factor affecting shelf life as it triggers other quality parameters such as FFA, water activity and microbial load as discussed by Nielsen [16], Phisut [6]. It can be seen from figure 5 that moisture content did not change up to 4th month but it showed a significant difference ($p < 0.05$) in the 5th month. However, the moisture content has not reached the critical limit of 5% [18] even on 6 months of storage. This provides better evidence of the possibility of extended storage period for more than 6 months.

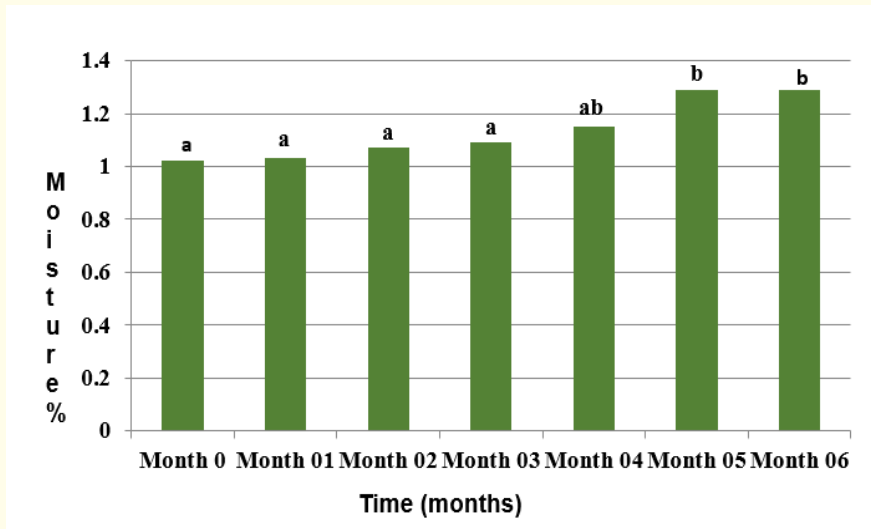


Figure 5: Changes in moisture content of spray-dried herbal porridge on storage.

Water activity (a_w)

Water activity measures the activity of free water in a food system which is responsible for any biochemical reaction [6,10]. Therefore, it is an important index in determining the shelf life of the powder. The developed product showed slow increment of water activity up to the 3rd month and it was significantly higher ($p < 0.05$) in the 4th month (Figure 6). Since a_w did not exceed the critical level of 0.6 [10] on 6 months of storage where there was less free water available for biochemical reactions. Therefore, there is a high possibility to keep the product for longer than 6 months of storage.

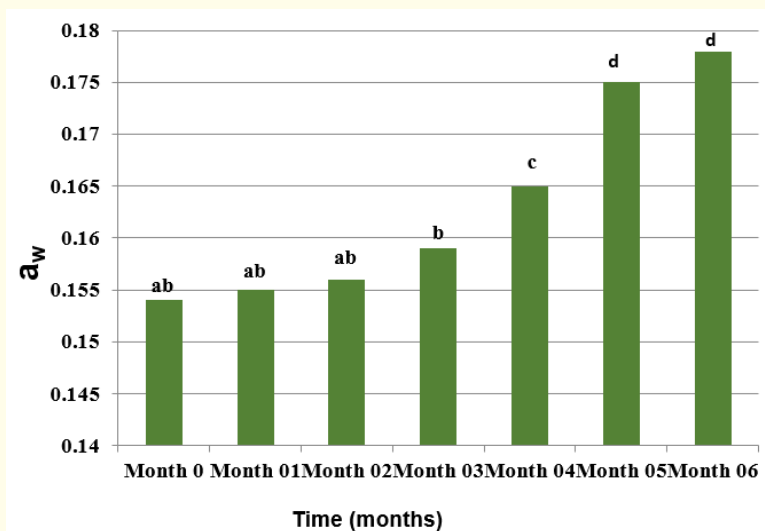


Figure 6: Changes in water activity of spray-dried herbal porridge on storage.

Total plate count (TPC)

Total plate count is one of the most common tests applied to indicate the microbiological quality of a food. Figure 7 shows a significant difference ($p < 0.05$) of TPC on the 5th month of storage. TPC may have been influenced by the initial microbial load that entered during manual product handling and the nutrient rich media of the developed product. However, TPC did not exceed the critical level of 1×10^5 [14] during the 6 months of storage. Therefore, the developed spray-dried herbal porridge can be kept for more than 6 months [19,20].

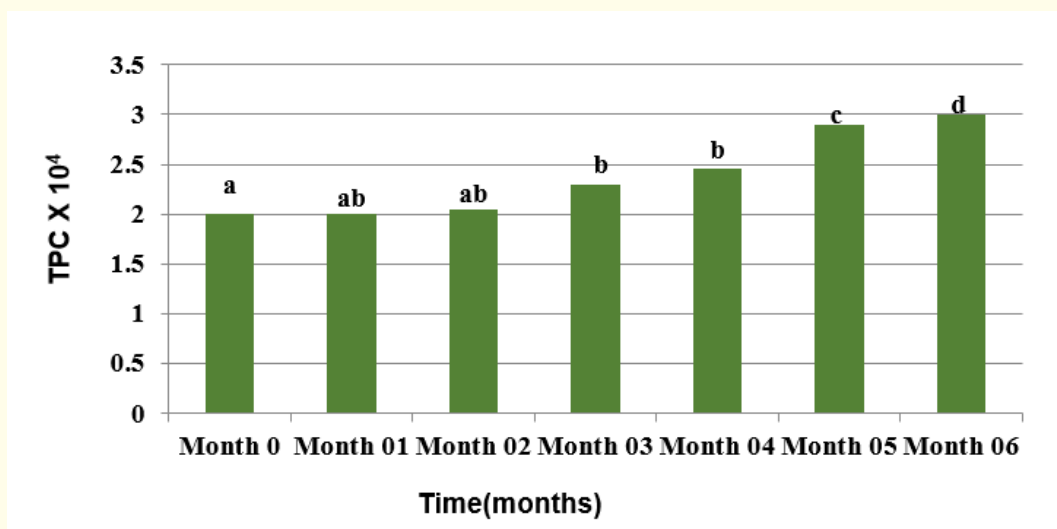


Figure 7: Changes in total plate count of spray-dried herbal porridge on storage.

Conclusion

Spray drying technology could be used to produce instant herbal porridge powder and the spray-dried powder could be stored in triple laminated aluminium sachets for more than 6 months. Non-fat milk powder could be used as an alternative to conventional drying additives. Most preferred herb species for spray dried herbal porridge was *Centella asiatica* and the best reconstitution ratio was 20g herbal porridge powder in 120 ml of water.

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