DRUM DRIED PEANUT MILK POWDER: A BETTER ALTERNATIVE TO DAIRY PRODUCT

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ABSTRACT

A novel concept of drum drying of low fat peanut milk was adopted to produce high quality, stable, low fat, easy to rehydrate and free-flowing peanut powder by optimizing different process variables to meet the consumers' demands. The low fat peanut milk was prepared by soaking peanut halves in 0.5% $NaHCO_3$ at 1:2 peanut to water ratio followed by grinding with 60 °C hot water at 1:5 peanut to water ratio, filtering, milk cream separation, homogenization (1000 psi) and pasteurization (100 ^{0}C). The peanut milk was biochemically analyzed in terms of fat content, protein content, titratable acidity, pH, total solid content and total sugar content. Drum drying of peanut milk was carried out at different milk (feeding) temperature (55^{0}C, 65^{0}C, 75^{0}C), different drum surface temperature (95^{0}C, 105^{0}C, 115^{0}C), and different drum speed (0.33 rpm, 0.66 rpm) using laboratory scale single drum dryer. The drum dried peanut milk powder obtained by 18 different treatments was evaluated on the basis of physical parameters (viz., recovery, bulk density), biochemical parameters (viz., moisture content, fat content, protein content, total sugar content, ash content and titratable acidity), functional properties (viz., water solubility index, water absorption index, foaming capacity), microbial parameters (viz., yeast and mould, E. coli, salmonella and total plate count) and organoleptic parameters (viz., colour, flavour, taste, appearance, texture, overall acceptability). The best quality of drum dried peanut milk powder on the basis of quality evaluation with highest values of recovery (4.41 %), bulk density (0.42 %), protein content (86%), titratable acidity (1.86 %), water solubility index (72.36 %), water absorption index (227.97 %), flavor (6.95), taste (6.86) and texture (7.36) and lowest fat content (5.25 %) and ash content (1.73 %) were obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75°C feeding temperature + 105°C drum surface temperature + 0.66 rpm drum speed among all the treatments.

KEY WORDS: Drum drying, peanut, peanut milk, peanut powder, milk powder

INTRODUCTION

Peanut or groundnut, botanically known as *Arachis hypogaea* is an important crop globally as well as in our country belonging to family *Leguminosae* (Hymowitz, 1990). The cultivation of peanut originated in South America and spread in Brazil, Southern Bolivia and North-Western Argentina. Peanut was introduced by the Portuguese from Brazil to West Africa and then to South-Western India in the 16th century (Maiti *et al.,* 2012).

Global production of peanut was 45 million tonnes during year 2013. India is the second largest producer of peanut after China. In India, peanut production was around 9.67 million tons from area 5.53 million hectares during 2013-14 (Anonymous, 2015a). Gujarat is the leading state in production of peanut (4.92 million tons), it shares about 50% of India's total peanut production. In Gujarat, Saurashtra region has the largest share of production, around 85 per cent. Five major peanut producing districts in Saurashtra region are Junagadh, Rajkot, Amreli, Bhavnagar and Jamnagar. Among all of these districts, Junagadh district ranks first in peanut production (Anonymous, 2015b).

For ages, it has been well known that peanut milk and peanut milk products have nutritional benefits for young and old alike because of their extreme richness in protein, minerals, and essential fatty acids, such as linoleic and oleic acids, which are considered to be highly valuable in human nutrition. Peanut milk and its products can serve a very good alternative of dairy products to people who have lactose intolerance. In Belgian Congo, peanut milk was used as a substitute for cow's milk to save the lives of many undernourished babies (Diarra *et al*., 2005).

Presently, peanut milk is most promising alternate to convert peanut kernel in milk form. Several processing operations, *viz*., blanching, soaking, cooking, grinding, homogenization, pasteurization, etc. are carried out for preparing peanut milk from kernel. These processing operations minimizes the fat (lipid) content of peanut kernel, i.e., from 48–50 per cent to 4-7 per cent, depends upon peanut flour to water ratio. These also help to reduce toxin levels, removes oily off odour as well as offers some protection against aflatoxin. Recent investigation suggested that soaking of peanuts in $NaHCO_3$ solution may reduce off-flavor and heat inactivates enzymes that are partly responsible for off-flavor development in peanut milk, both treatments are incorporated into peanut milk preparation.

Recently, several methods, *viz*., spray drying, drum drying, vacuum drying, freeze drying, etc. are used to prepare milk powder. Among these methods, drum drying is comparatively low cost, high drying rates, high energy efficient, short residence time and suitable for concentrated food in liquid form in which the large size of particles in peanut milk as well as higher cost of spray drying restricts the use of spray dryer. The drum dried milk powder contains less amount of fat, free-flowing in nature and high homogeneity.

The best process for the peanut milk was adopted on the basis of previous findings to produce low fat peanut milk. A novel concept of drum drying of peanut milk will be adopted to produce high quality, stable, low fat, easy to rehydrate and free-flowing peanut powder. The best operational conditions (i.e. process variables, *viz*., peanut milk feeding temperature, drum surface temperature and drum speed) were identified on the basis of best quality drum dried peanut milk powder. Finally, the drum dried peanut milk powder was packed in best packaging material followed by vacuum packaging to extend the shelf life of the products as well as to prevents the deterioration of the product by micro-organism, bacteria, yeast, etc. during the long term storage.

METHODS AND MATERIALS

Gujarat Groundnut 2 (GG 2) variety is local and most popular variety in Saurashtra region. Considering the large scale growing in the Saurashtra region, the *'GG-2'* variety of peanut was selected for the experimental work. Hence, the halves of *GG-2* variety were procured from Rachna Seed Industries, GIDC, Junagadh for the experimental work. Peanut halves of *GG-2* variety were without skin, first grade white with germ attached, without any chemical treatment.

Cleaned and well graded peanut haves were weighed 1 kg (Roy electronics top pan balance, 10 kg capacity) for each batch of peanut milk. Peanut halves were soaked in 2 litre (1:2 peanut to water ratio) of 0.5% (w:v) $NaHCO_3$ distilled water solution for 8 hours. After completion of soaking period, water was completely removed and peanuts were washed twice with distilled water. Soaked and cleaned peanuts were mixed with 60°C hot water (1:5 peanut to water ratio) and coarsely ground with mixer grinder (Bajaj, Model: Fx-11). Mixture of water and coarsely ground peanut was filtered through muslin cloth using manual filter press. The peanut milk cream obtained after filtration was separated using centrifugal separator (Manual milk cream separator machine, Model: 700E, 1425 rpm). Skimmed peanut milk was homogenized (Raj homogenizer) at 1000 psi pressure. This prepared peanut milk was pasteurized at 100°C (TCL induction stove, Model: MI-chef) (Plate 1).

Five respective samples of peanut milk were prepared for biochemical analysis in terms of fat content, protein content, titratable acidity, pH, total solid content and total sugar content. The biochemical parameters of peanut milk were determined as per the standard methods. The mean values of biochemical parameters with their standard deviation for these samples were recorded and tabulated (Table 1).

Plate 1: Filtration, homogenization and pasteurization of peanut milk.

Drum drying of peanut milk

The laboratory scale drum dryer (Mechair Co., 90 kg/h capacity) was used for drying of prepared low fat peanut milk as shown in Plate 2. The drum dryer consists of control and display panel, drum and satellite/feed rollers, boiler, doctor blade, feeding and collecting hoppers. A steam boiler is located underneath of rotating drum for heating of inside surface of drum (Plate 2).

Plate 2: Drum drying of peanut milk

The clearance between drum surface and feeding roller was adjusted to about 1 mm minimum. The control and display panel unit displayed the temperature of drum surface and rpm of drum during the drying of peanut milk.

The steaming of drum was continued till the desired temperature was obtained. It was observed that steaming period of 1.5 h, 2.0 h and 2.5 h was required to obtain the temperature of drum surface to 95^0C, 105^0C and 115^0C, respectively. As the desired temperature was achieved, feeding of low fat peanut milk through feeding hopper was carried out at three different levels of temperature, i.e., 55^0C, 65^0C and 75^0C. Once drum surface temperature (95^0C, 105^0C and 115^0C) reached up to required level. Peanut milk was heated up to three different levels of feeding temperature (55^0C, 65^0C and 75^0C) then applied on drum surface. The drum speed for drying of peanut milk was adjusted at two levels, i.e., 0.33 rpm and 0.66 rpm. The speed of drum could be adjusted on the basis of current frequencies displayed on control. After complete one revolution of each level of speed, the dried layer of peanut milk was scrapped by doctor blade. Then scrapped powder was collected on collecting pan below the doctor blade by gravity force.

Total 18 experiments were conducted for drying of peanut milk using drum dyer i.e., D_1 ($F_1D_1R_1$) to D_{18} ($F_3D_3R_2$) as mentioned in Table 2. Thus, total 18 samples of drum dried peanut powder were obtained for 18 respective treatments. The all the experiments were repeated two time as per above method. The drum dried peanut powder obtained after drying of peanut milk by 18 treatments was immediately transferred to desiccators. Powder stored in desiccators was further ground to fine particles using commercial mixer grinder. The powder was sieved using 100 mesh sieve.

Packaging of drum dried peanut milk powder

The high value low fat drum dried peanut powder obtained by different treatments were white creamish in colour, free flowing in crispness, crystalline in consistency and highly hygroscopic. Finally, these samples were packed at 700 mm Hg of vacuum pressure in 50 μm thick laminated aluminium foil pouches (LAFP) using vacuum packaging machine, “Powervac”-254 single chamber trolley machine and packed powder was stored at room temperature.

Quality evaluation of drum dried peanut milk powder

The drum dried peanut milk powder obtained by 18 different treatments was evaluated on the basis of physical parameters (*viz*., recovery, bulk density), biochemical parameters (*viz*., moisture content, fat content, protein content, total sugar content, ash content and titratable acidity), functional properties (*viz*., water solubility index, water absorption index, foaming capacity), microbial parameters (*viz*., yeast and mould, *E. coli*, *salmonella* and total plate count) and organoleptic parameters (*viz*., colour, flavour, taste, appearance, texture, overall acceptability) as per standard methods. Finally, the treatment producing the best quality drum dried peanut milk powder was identified on the basis of different quality parameters.

The observations taken for various treatment combinations for drum dried peanut milk powder were subjected to analysis of variance technique considering two factors Completely Randomized Design. All the treatments were compared at 5 per cent level of significance using the Critical Difference test.

RESULTS AND DISCUSSION

Quality evaluation of peanut milk

The biochemical properties of these 18 samples of peanut milk, *viz*., water content, total solid content, fat content, protein content, total sugar, titratable acidity and pH were determined and reported in Table 2.

The mean value of water content, total solid content, total sugar content, titratable acidity and pH with their standard deviation were found 95.53 ± 1.51 %, 4.47 ± 0.071, 0.08 ± 0.001, 0.128 ± 0.002 and 6.83 ± 0.108, respectively.

The fat content of peanut milk was ranged from 0.98 % to 1.01 %. Data presented in Table 2 revealed that the mean value of fat content with their standard deviation was 0.99 ± 0.016 %. Fat content of peanut milk was found to be lower than that reported by Bucker *et al.* (1979), Whistler and Daniel (1985), Lee and Beauchat (1992) and Jain *et al*. (2011) with 4.40 %, 5.23 %, 4.55 % and 2 %, respectively. This might be attributed to removal of milk cream as fat is the major constituent of milk cream. Low fat content of peanut milk is desirable.

Protein content of peanut milk was ranged from 3.51 % to 3.65 % (Table 2). The data revealed that the mean value of protein content with their standard deviation was 3.58 ± 0.057 %. The lower values of protein content were reported by Bucker *et al.* (1979), Whistler and Daniel (1985) and Lee and Beauchat (1992) i.e. 1.95 %, 2.48 % and 2.12 %, respectively. Higher amount of protein content for present investigation might be attributed to grinding of peanut halves with 60^0C hot water, which could be able to precipitate soluble proteins. Similar kinds of results for protein content of bean meals at 60^0C hot water treatment was reported by Occena *et al.* (1997) during his experimental work. Furthermore, results of protein content (3.8 %) are in agreement with that reported by Jain *et al*. (2011).

The objective of present investigation aimed to reduce fat content of peanut milk. The low fat content of peanut milk ultimately results in low fat content in final product, i.e., drum dried peanut milk powder. The removal of milk cream by centrifugation during peanut milk preparation could be able to reduce the fat content of peanut milk up to 0.99 %. According to previous findings, Bucker *et al.* (1979), Whistler and Daniel (1985) and Lee and Beauchat (1992), reported fat content of peanut milk 4.40 %, 5.23% and 4.55 %, respectively. This indicated that fat content of peanut milk for present investigation is too much lower as compared other. Low fat peanut milk enable to reduce fat content of drum dried peanut milk powder prepared by drum drying carried out at different process variables.

Quality evaluation of drum dried peanut milk powder

The drum dried peanut milk powder obtained by 18 different treatments was evaluated on the basis of physical parameters (*viz*., recovery, bulk density), biochemical parameters (*viz*., moisture content, fat content, protein content, total sugar content, ash content and titratable acidity), functional properties (*viz*., water solubility index, water absorption index, foaming capacity), microbial parameters (*viz*., yeast and mould, *E. coli*, *salmonella* and total plate count) and organoleptic parameters (*viz*., colour, flavour, taste, appearance, texture, overall acceptability).

Physical parameters

Recovery

Highest recovery (Table 3) of 4.41 % was found in treatment D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm drum speed, whereas lowest recovery of 1.21 % was obtained in treatment D_1 ($F_1D_1R_1$), i.e., 55^0C feeding temperature + 95^0C drum surface temperature + 0.33 rpm drum speed. It indicated that recovery of drum dried peanut milk powder increased with increase in peanut milk temperature and drum surface temperature. This might be attributed to lower temperature of peanut milk resulted into rolling of peanut milk over drum surface more quickly (i.e., take more time to stick over drum surface). It was observed (Table 2) that individual effect of milk (feeding) temperature (F), drum surface temperature (D), drum revolution per minute (R), interaction FxD and DxR on recovery of drum dried peanut milk powder were found significant.

Bulk density

Bulk density of drum dried peanut powder was ranged from 0.35g/cm^3 to 0.42 g/cm^3, It can be seen (Table 3) that highest bulk density of 0.42 g/cm^3 was found in treatment D_{16} ($F_3D_3R_2$), i.e., 75^0C feeding temperature + 115^0C drum surface temperature + 0.66 rpm drum speed, whereas lowest bulk density of 0.35g/cm^3 was obtained in treatment D_6 ($F_1D_3R_2$) i.e., 55^0C feeding temperature + 115^0C drum surface temperature + 0.66 rpm drum speed. The statistical analysis of data (Table 2) revealed that the bulk density of peanut powder was only affected by drum revolution per minute (R) and found significant.

Biochemical parameters

Moisture content

It can be seen (Table 3) that the highest moisture content of 3.14 % (wb) was found in treatment D_1 ($F_1D_1R_1$), i.e., 55^0C feeding temperature + 95^0C drum surface temperature + 0.33 rpm drum speed, whereas the lowest moisture content of 1.44 % (wb) was obtained in treatment D_{18} ($F_3D_3R_2$), i.e., 75^0C feeding temperature + 115^0C drum surface temperature + 0.66 rpm drum speed. It indicated that the moisture content of drum dried peanut milk powder decreased with increase in peanut milk temperature and drum surface temperature. The individual effect (Table 2) of feeding temperature (F), drum surface temperature (D) and drum revolution per minute (R) on moisture content of drum dried peanut milk powder were found significant. Effect of parameters were found to be in agreement with Pua *et al.* (2010) that moisture content of drum-dried jackfruit powder decreased with increasing the drum surface temperature.

Fat content

It can be seen (Table 3) that lowest fat content of 5.25 % was found in treatment D_{16} ($F_3D_2R_2$), i.e., 75^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed, whereas the highest fat content of 9.59 % was obtained in treatment D_1 ($F_1D_1R_1$), i.e., 55^{0}C feeding temperature + 95^{0}C drum surface temperature + 0.33 rpm drum speed. Fat content of drum dried peanut milk powder decreased with increased in drum surface temperature. The reduction in fat content might be due to formation of starch lipid complexes during the drum drying process at higher temperature. The effect (Table 2) of feeding temperature (F), drum surface temperature (D) and drum revolution per minute (R), F x D, F x R, D x R and F x Dx R on fat content of drum dried peanut milk powder were found significant.

Protein content

The highest protein content of 86% was found (Table 3) in treatment D_{16} ($F_3D_2R_2$), i.e., 75^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed, whereas the lowest protein content of 54.62 % was obtained in treatment D_2($F_1D_1R_2$), i.e., 65 °C feeding temperature + 95 °C drum surface temperature + 0.66 rpm drum speed. Protein content of drum dried peanut milk powder increased with increase in milk (feeding) temperature and drum surface temperature. The effect of milk (feeding) temperature (F) and drum surface temperature (D) and drum revolution per minute (R), F x D, F x R, D x R and F x D x R on protein content of drum dried peanut milk powder were found significant.

Ash content

The lowest ash content of 1.73% was found (Table 3) in treatment D_{16} ($F_3D_2R_2$), i.e., 75^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed, whereas the highest ash content of 3.49 % was obtained in treatment D_1 ($F_1D_1R_1$), i.e., 55^{0}C feeding temperature + 95^{0}C drum surface temperature + 0.33 rpm drum speed. Ash content of drum dried peanut milk powder decreased with increased in milk (feeding) temperature and drum surface temperature. Effect of drum surface temperature (D), milk (feeding) treatment (F) and drum revolution per minute (R), F x D and F x D x R on ash content of drum dried peanut milk powder were found significant.

Titratable acidity

The titratable acidity (Table 3) of drum dried peanut milk powder was not found to be influenced by any process parameter. The lowest titratable acidity of 0.34 % was found in treatment D_{10} ($F_2D_2R_2$), i.e., 55^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed, whereas the highest titratable acidity 1.86 % was obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed.

Functional parameter

Water solubility index (WSI)

The lowest water solubility index of 10.64 % (Table 3) was found in treatment D_1 ($F_1D_1R_1$), i.e., 55^{0}C feeding temperature + 95^{0}C drum surface temperature + 0.33 rpm drum speed, whereas the highest water solubility index of 72.36 % was obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^{0}C feeding temperature + 105^{0}C drum surface temperature + 0.66 rpm drum speed. WAI of drum dried powder increased with increase in milk (feeding) temperature and drum surface temperature. Thus, excellent solubility of drum dried peanut milk powder was obtained in treatment D_{16}

($F_3D_2R_2$) among all the treatments. The effect of milk (feeding) treatment (F), drum surface temperature (D) and drum revolution per minute (R), F x D and D x R on WAI of drum dried peanut milk powder were found significant (Table 2).

Water absorption index (WAI)

The lowest (Table 3) water absorption index of 111.50 % was found in treatment D_1 ($F_1D_1R_1$), i.e., 55^0C feeding temperature + 95^0C drum surface temperature + 0.33 rpm drum speed, whereas the highest water absorption index of 227.97 % was obtained in treatment D_{16} ($F_3D_2R_2$) i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.33 rpm drum speed. The excellent water holding capacity of drum dried peanut milk powder was obtained in treatment D_{16} ($F_3D_2R_2$), i.e., in accordance to excellent water solubility index (WSI) for same treatment. The effect of milk (feeding) treatment (F), drum surface temperature (D) and drum revolution per minute (R), F x D, F x R, D x R and F x D x R on WSI of drum dried peanut milk powder were found significant (Table 2).

Foaming capacity

The lowest foaming capacity of 6.67 % (Table 3) was found in treatment D_7 ($F_2D_1R_1$), i.e., 65^0C feeding temperature + 95^0C drum surface temperature + 0.33 rpm drum speed, whereas theb highest foaming capacity of 24 % was obtained in treatment D_{18} ($F_3D_3R_2$), i.e., 75^0C feeding temperature + 115^0C drum surface temperature + 0.66 rpm drum speed. The effect of drum surface temperature (D) and drum revolution per minute (R), F x D, F x R and D x R and F x D x R on foaming capacity of drum dried peanut milk powder were found significant (Table 2).

Microbial analysis

The microbial analysis of drum dried peanut milk powder was carried out on the basis of different microbial parameters, *viz*., yeast and mould, *E. coli*, *salmonella* and total plate count. It was noticed that there was no any deterioration or microbial growth observed in drum dried peanut milk powder prepared by different treatments.

Sensory analysis

The sensory evaluation of drum dried peanut milk powder prepared by different treatments was carried on the basis of colour, flavor, taste, appearance, texture and overall acceptability.

Overall acceptability

The maximum overall acceptability score of 7.71 was observed in treatment D_4 ($F_1D_2R_2$), i.e., 65^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm drum speed followed by second highest score was observed in D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm drum speed. Minimum overall acceptability score of 6.14 was observed in D_8 ($F_2D_1R_2$), i.e., 65^0C feeding temperature + 95^0C drum surface temperature + 0.66 rpm drum speed.

CONCLUSION

The peanut milk could be successfully prepared with low fat content of 0.99 ± 0.016 %.b On the basis of physical properties of drum dried peanut powder, highest values of recovery (4.41 %) and bulk density (0.42 %) were obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm. On the basis of biochemical properties of drum dried peanut powder, lowest value of fat content (5.25 %), highest value of protein content (86 %), ash content

(2.89 %) and highest value of titratable acidity (1.86 %) as well as reasonable value of moisture content (1.54 %) and total sugar (1.28 %) were obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm. On the basis of functional properties of drum dried peanut powder, highest value of water solubility index (72.36 %), highest value of water absorption index (227.97%) well as reasonable value of foaming capacity (21.67 %) were obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm. On the basis of sensory evaluation of drum dried peanut powder, highest scores of flavour (8.06), taste (6.86) and texture (6.86), as well as reasonable scores of colour (7.86), appearance (7.69), overall acceptability(7.64) were obtained in treatment D_{16} ($F_3D_2R_2$), i.e., 75^0C feeding temperature + 105^0C drum surface temperature + 0.66 rpm. Optimizing the overall studies, the low fat peanut milk could be successfully prepared by soaking peanut halves in 0.5% $NaHCO_3$ at 1:2 peanut to water ratio followed by grinding with 60°C hot water at 1:5 peanut to water ratio, filtering, milk cream separation, homogenization and pasteurization. The best quality peanut milk powder could be efficiently obtained by drying of low fat peanut milk using laboratory scale drum dryer at 75^0C peanut milk (feeding) temperature, 105^0C drum surface temperature, and 0.66 rpm drum speed on the basis of different quality parameters, *viz*., physical, biochemical, functional, microbial and organoleptic among all the treatments.

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Table 1: Biochemical properties of peanut milk

Sample Number	Water Content (%)	Total Solid Content (%)	Fat Content (%)	Protein Content (%)	Total Sugar (%)	Titratable Acidity (%)	pH
1	95.53	4.43	0.98	3.51	0.080	0.131	6.69
2	93.62	4.47	1.01	3.58	0.079	0.125	6.83
3	97.44	4.56	0.99	3.62	0.082	0.128	6.97
4	96.49	4.51	1.00	3.65	0.081	0.129	6.76
5	94.57	4.38	0.97	3.54	0.078	0.127	6.90
Mean	95.53	4.47	0.99	3.58	0.08	0.128	6.83
SD	1.510	0.071	0.016	0.057	0.001	0.002	0.108

Table 2: Effect of milk (feeding) temperature (°C), drum surface temperature (°C) and drum speed (rpm) on physical parameters, biochemical parameters & functional properties of drum dried peanut milk powder (statistically analyzed data)

Treatment	Physical Parameters		Biochemical Parameters						Functional Properties		
	Recovery (%)	Bulk Density (g/cm^3)	Moisture Content(%)	Fat (%)	Protein (%)	Total Sugar(%)	Ash (%)	Acidity (%)	WSI (%)	WAI (%)	Foaming Capacity (%)
Feeding Temperature (F) (°C)											
F_1 (55 °C)	1.92	0.38	2.20	8.22	62.69	2.03	2.86	0.68	16.29	143.72	14.45
F_2 (65 °C)	2.81	0.39	1.72	6.00	77.72	1.48	2.10	0.64	37.06	189.38	16.67
F_3 (75 °C)	3.56	0.40	1.54	5.63	80.45	1.30	1.98	0.80	62.16	206.57	16.22
S.Em.±	0.09	0.01	0.02	0.02	0.27	0.01	0.04	0.18	0.12	1.50	0.27
C.D. at 5 %	0.27	NS	0.05	0.06	0.79	0.04	0.11	NS	0.37	4.44	0.81
Drum Surface Temperature (D) (°C)											
D_1 (95 °C)	2.29	0.38	2.00	7.35	70.10	1.81	2.64	0.52	33.96	154.85	11.11
D_2 (105 °C)	2.93	0.40	1.80	6.55	73.51	1.62	2.25	1.04	39.72	185.16	16.95
D_3 (115 °C)	3.07	0.38	1.67	5.95	77.26	1.38	2.04	0.56	41.83	199.67	19.28
S.Em.±	0.09	0.01	0.02	0.02	0.27	0.01	0.04	0.18	0.12	1.50	0.27
C.D. at 5 %	0.27	NS	0.05	0.06	0.79	0.04	0.11	NS	0.37	4.44	0.81
Drum Speed (R) (rpm)											
R_1 (0.33 rpm)	2.61	0.39	2.12	6.74	71.81	1.66	2.36	0.67	36.19	172.85	12.59
R_2 (0.66 rpm)	2.91	0.38	1.52	6.49	75.43	1.55	2.26	0.74	40.81	186.94	18.96
S.Em.±	0.08	0.01	0.01	0.02	0.22	0.01	0.03	0.15	0.10	1.22	0.22
C.D. at 5 %	0.22	0.02	0.04	0.05	0.65	0.03	0.09	NS	0.30	3.63	0.66
C.V. %	11.54	5.66	2.94	1.03	1.25	2.90	5.79	88.69	1.12	2.88	6.00
F x D											
S.Em.±	0.16	0.01	0.03	0.03	0.46	0.02	0.07	0.31	0.22	2.59	0.47
C.D. at 5 %	0.47	NS	0.08	0.10	1.37	0.07	0.20	NS	0.64	7.70	1.41
F x R											
S.Em.±	0.13	0.01	0.02	0.03	0.38	0.02	0.05	0.25	0.18	2.12	0.39
C.D. at 5 %	NS	NS	0.06	0.08	1.12	NS	NS	NS	0.52	NS	1.15
D x R											
S.Em.±	0.13	0.01	0.02	0.03	0.38	0.02	0.05	0.25	0.18	2.12	0.39
C.D. at 5 %	0.39	NS	0.06	0.08	1.12	NS	NS	NS	0.52	6.29	1.15
F x D x R											
S.Em.±	0.23	0.02	0.04	0.05	0.65	0.03	0.09	0.44	0.30	3.66	0.67
C.D. at 5 %	NS	NS	0.11	0.14	1.94	NS	0.28	NS	0.90	NS	1.99

Table 3: Mean values of physical parameters, biochemical parameters & functional properties of drum dried peanut milk powder for different treatments

Treatment	Physical Parameters			Biochemical Parameters					Functional Properties		
	Moisture Content (%)	Recovery (%)	Bulk Density (g/cm3)	Fat Content (%)	Protein Content (%)	Total Sugar Content (%)	Ash Content (%)	Acidity (%)	Water Solubility Index (%)	Water Absorption Index (%)	Foaming Capacity
$D_1(F_1D_1R_1)$	3.14	1.21	0.39	9.68	53.85	2.36	3.45	0.42	10.75	111.50	8.34
$D_2(F_1D_1R_2)$	1.59	1.31	0.38	9.80	54.62	2.44	4.05	0.41	12.50	145.00	10.00
$D_3(F_1D_2R_1)$	2.85	1.25	0.38	9.75	57.53	2.38	3.64	0.44	12.00	135.00	15.00
$D_4(F_1D_2R_2)$	1.54	2.69	0.38	7.07	69.05	5.11	2.85	1.73	16.51	183.80	16.67
$D_5(F_1D_3R_1)$	2.57	2.65	0.39	5.65	84.66	3.00	1.95	0.65	11.16	200.15	13.33
$D_6(F_1D_3R_2)$	1.52	2.61	0.35	9.46	76.73	7.21	3.23	0.42	33.57	186.21	23.34
$D_7(F_2D_1R_1)$	2.51	2.35	0.38	6.52	75.01	1.69	3.88	0.63	33.50	194.50	6.67
$D_8(F_2D_1R_2)$	1.53	2.65	0.38	8.34	68.22	2.79	2.05	0.43	29.00	217.50	11.67
$D_9(F_2D_2R_1)$	1.74	2.98	0.40	8.45	72.10	1.69	1.92	1.22	7.47	218.42	13.33
$D_{10}F_2D_2R_2)$	1.55	2.87	0.38	7.25	79.50	3.68	2.71	0.34	44.99	196.67	23.33
$D_{11}(F_2D_3R_1)$	1.49	2.84	0.37	8.14	82.53	3.57	2.48	0.77	36.93	226.60	21.67
$D_{12}F_2D_3R_2)$	1.49	4.01	0.42	8.20	79.63	2.44	2.55	0.44	20.48	203.77	23.33
$D_{13}(F_3D_1R_1)$	1.70	2.70	0.37	6.05	74.05	2.38	3.33	0.60	33.50	222.50	13.33
$D_{14}(F_3D_1R_2)$	1.50	2.49	0.40	7.20	82.03	8.37	4.18	0.62	50.00	211.00	16.67
$D_{15}(F_3D_2R_1)$	1.54	2.78	0.38	6.39	81.48	2.25	1.94	0.63	50.50	226.00	11.67
$D_{16}(F_3D_2R_2)$	1.56	3.15	0.38	6.62	86.00	4.49	2.88	1.86	71.90	205.20	21.67
$D_{17}(F_3D_3R_1)$	1.71	4.26	0.38	8.52	80.66	2.86	1.48	0.64	8.85	231.86	10.00
$D_{18}(F_3D_3R_2)$	1.44	4.02	0.38	7.39	60.38	3.14	2.82	0.43	32.80	215.52	23.33

Where, peanut milk feeding temperature F_1 (55 ℃), F_2 (65 ℃), F_3 (75 ℃); drum surface temperature D_1 (95 ℃), D_2 (105 ℃), D_3 (115 ℃) and drum speed R_1 (0.33 rpm), R_2 (0.33 rpm)

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