IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 3, June-July, 2014
ISSN: 2320 – 8791 (Impact Factor: 1.479)
www.ijreat.org

Studies on Drying Characteristics of Ginger and Rheological Properties of Superfine Ginger Powder"

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Abstract

In the investigated study, three varieties of ginger viz. Rio-de-Janeiro, Maran, Himachal were taken with a view to study the drying characteristics and thereby the production of ginger flakes for powder production. The drying characteristics of ginger was studied using tray drier (at temperatures 50^0C and 60^0C), combined tray and vacuum drier (at temperatures 50^0C and 60^0C for tray drier and 60^0C at 450 mm Hg pressure for vacuum drier) and natural circulation solar drier. The superfine grinding could produce a narrow and uniform particle size distribution in dry ginger. The physico-chemical properties of five types of ginger powders with particles size of 300, 149, 74, 37 and 8.34 µm were investigated. The size was smaller for ginger powders, greater for the surface area (from 0.331 to 1.320 m^2/g) and bulk density (from 0.3069 to 0.3426 g/ml) and smaller for the angle of repose (from 51.50°to 46.33°) and slide (from 45.80 ° to 39.50 °). The values of water absorption index (WAI), water solubility index (WSI) and protein content significantly increased with decreasing the size of ginger particles ($p < 0.05$). Interestingly, the values of WAI, WSI and protein content of ginger powder with a particle size of 8.34 µm during soaking reached 0.52 g/g, 33.70% and 84.93% for 60 min, respectively.

Keywords: Drying characteristics, Water absorption index, Water solubility index.

1. Introduction

Ginger belongs to *Zingiberaceae officinale Rosc.,* species which is a monocotyledon, belonging to the family Zingiberaceae in the order Zingiberales. The subfamily Zingiberoideae includes the most important spice crop - Ginger.

Ginger can be dried after cutting into ½ "slice without peeling under sun at 34°C for 50 hrs. This method will help to get more volatile oil (2%) from dried ginger, which may add more flavor and medicinal value for products (**Mani *et al.,* 2000).** Storage of ginger is very important in order to extent the shelf life of the produce/products without spoilage and also to overcome the marketing problems. Different methods/techniques of the storage are being adopted in ginger to minimize the storage loss based on its end use/purposes namely, fresh ginger, seed ginger and dry ginger (**P.N Ravindran *et al.***).

Drying reduces the moisture content and hence inhibits microbial growth and forestalls certain biochemical changes but, it does lead to loss of aroma and has an adverse effect on the nutrients, physical properties. **Phoungchandang and Saentaweesuk (2010).**

Rheological properties may give a quantitative contribution to texture characterization and control when using different formulations. **Batista and Worrasinchai (2006).** Superfine grinding technology is a new technology, which is a useful tool for making superfine powder with good surface properties like dispersibility and solubility. **Tkacova and Stevulova (1998).**

2. Materials and methods

The main objective of this experiment is to study the drying characteristics of ginger flakes for ginger powder production. The experiments were carried out in the Laboratory of the department of Food Process Engineering, Vaugh School of Agricultural Engineering and Technology, S.H.I.A.T.S., Allahabad. The method used for conducting the experiments, equipments used, processing steps, methods used for conducting qualitative analysis of the developed product are discussed in this chapter.

2.1 Raw material preparation

Fresh, good quality ginger of three varieties namely Maran, Himachal and Rio-de-Janeiro were taken from the stored ginger. They were washed thoroughly to remove the soil sticking with the rhizome and subjected to various pre processing operations such as, trimming, peeling and pre treatment. The pre treated samples were subjected to two different peeling such as hand and abrasive peeling. Peeled ginger was then kept for drying in two different forms such as whole and three millimeter thick circular slices. The control was the one which was kept without peeling. From the drying data, peeling method and the form of the product which took minimum drying time was chosen and subjected to three different drying methods.

2.2 Pre-treatment

The sliced ginger was subjected to pre-treatment. In this, the ginger slices were dipped in calcium oxide solution at 1.5g of CaO in 1000ml water for 10 minutes. The slices were then removed from the solution and were subjected to drying.

2.3 Drying methods The pre-treated ginger were dried using three different methods, viz. tray drier, combined tray vacuum drier and natural circulation solar drier.

2.3.1 Tray drying: The known quantities of samples were loaded in the perforated trays of tray dryer and the surface area covered by the sample was noted down for the purpose of calculating the drying rate. The initial weights of the samples were noted and the samples were subjected to drying at 50 ± 2^0C. The readings were taken at regular intervals of 15 minutes for the entire drying period. The same process was carried out at 60 ± 2^0C of tray drier temperature.

2.3.2 Combined tray vacuum drying: The samples were initially dried using tray drier at two different temperatures *viz.* 50±2^0C and 60±2^0C. The samples were spread on a perforated tray (1cm depth) of a tray drier. The drying was carried for a period of one hour. The samples were then loaded on to the vacuum drier after noting their weights. In vacuum dryer the samples were subjected to a temperature of 60 ± 2^0C at 450mm Hg vacuum. The readings were noted at fifteen minutes interval.

2.3.3 Natural circulation solar drying: The sample was spread on the black sheet which is present inside the drier. The entire drying process was achieved during the day between 9 am to 4 pm in the evening when the intensity of solar radiation was maximum. After this, the dried ginger slices were removed from the drier and stored in packages. The temperature varies according to the climatic conditions. The maximum temperature was found out to be 47^0C.

2.4 Physical Analysis

2.4.1 Diameter: The diameter measurements of the ginger rhizomes were done using vernier caliper with an accuracy of 0.02 mm.

2.4.2 Thickness: Ginger slices were measured at four places to an accuracy of 0.01 mm using a micrometer to have a mean average thickness.

2.4.3 Weight: Ginger samples were weighed accurately using an electronic balance with an accuracy of ±1g.

2.5 Chemical analysis

2.5.1 Determination of protein content by Micro-kjeldhal method (By Ranganna, 1986)

2.5.2 Determination of Carbohydrate

This was essentially performed by method suggested by **Dubois *et al.* (1956).**

2.5.3 Determination of fiber

The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight gives the crude fiber (**Sadasivam and Manickam, 1992**).

2.5.4 Determination of Calcium

The calcium content was observed according to **AOAC method (2000).**

2.5.5 Determination of Phosphorus

The phosphorus content was observed by **AOAC method (2000).**

2.6 Rheological analysis

2.6.1 Bulk density

The bulk density (g/ml) was the density including pores and interparticle voids.

2.6.2 Test procedure for the angle of repose and slide

The angle of repose (h) was defined as the maximum angle subtended by the surface of a heap of powder against the plane which supported it **(Taser et al., 2005).**

2.6.3 Test procedure for water holding capacity

This parameter was determined using the method of **Anderson (1982).**

2.6.4 Test procedure for water solubility index (WSI)

The WSI was reported as percentage, and determined by using AACC method of No. 44-19 **(AACC, 1995).**

2.6.5 Test procedure for solubility of protein

Total nitrogen of the ginger powder was estimated by Kjeldahl's method **(Wathelet, 1999).**

2.6.6 Scanning electron microscope (SEM)

Morphological characterization of ginger particles was performed on images acquired using a scanning electron microscope (SEM).

2.7 Sensory Analysis

Sensory evaluation was carried out for the developed products. The panel of 10 semi trained judges of faculties and students conducted the sensory analysis of the product. Three samples of different combinations were prepared and were kept for sensory evaluation. Best combination was evaluated on the basis of mean overall acceptability. The sensory characteristics like color, flavor, texture and overall acceptability on 9-point Hedonic scale was followed (**Amerine *et al.*, 1965**)

2.8 Statistical Analysis

The experiment was conducted by adopting completely randomized design the data recorded during the course of investigation were statistically analyzed by the Analysis of variance- Two way classification or single factor ANOVA'. This technique was developed by **Dr. R. A. Fisher** in **(1923).**

3. Results and Discussion

Table [a] Effect of temperature of on the final product

Average time taken by the three driers to dry the ginger to a final moisture content of 4% (db) **Method**	**Time (min)**
Solar drier Temperature 47^0C - 60^0C	300
Tray drier Temperature 50^0C Temperature 60^0C	360 420
Combined tray vacuum drier Temperature 50^0C Temperature 60^0C	420 420

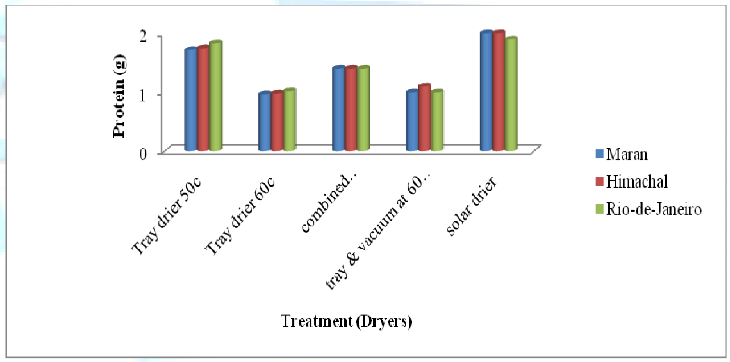
3.1 Effect of drying methods on the bio chemical components of ginger powder

Biochemical components present in the dried ginger powder are tabulated below. The values denoted are for 100 gm of ginger powder.

3.1.1 Protein (g)

Samples	**Tray drier at 50^0C**	**Tray drier at 60^0C**	**Combined tray & vacuum at 50^0& 60^0C**	**Combined tray & vacuum at 60^0& 50^0C**	**Natural circulation solar drier**
Maran	1.72	0.97	1.4	1.0	2.0
Himachal	1.75	0.98	1.4	1.1	2.0
Rio-de-Janeiro	1.83	1.02	1.4	1.0	1.9
	Result	S. Ed. (±)	C.D. at 5%		
Due to samples	**S**	0.031	0.066		
Due to tray	**NS**	0.040	0.085		

Effect of drying methods on the protein contents of ginger powder



3.1.2 Carbohydrates (g)

Samples	**Tray drier at 50^0C**	**Tray drier at 60^0C**	**Combined tray & vacuum at 50^0& 60^0C**	**Combined tray & vacuum at 60^0& 50^0C**	**Natural circulation solar drier**
Maran	8.6	7.57	7.6	6.8	10.2
Himachal	7.83	7.53	7.6	6.8	10.2
Rio-de-Janeiro	8.02	7.49	7.8	6.7	10.2
	Result	S. Ed. (±)	C.D. at 5%		
Due to samples	**S**	0.120	0.255		
Due to tray	**NS**	0.155	0.329		

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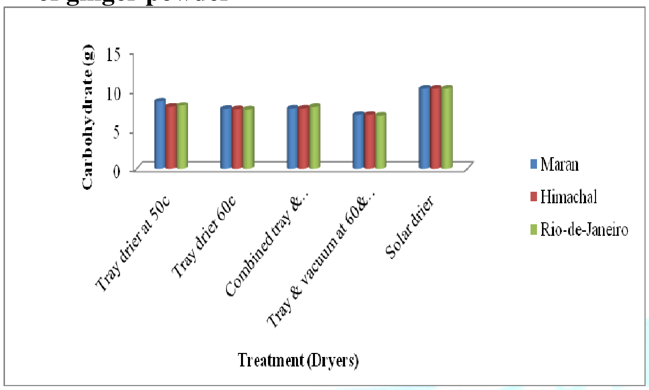
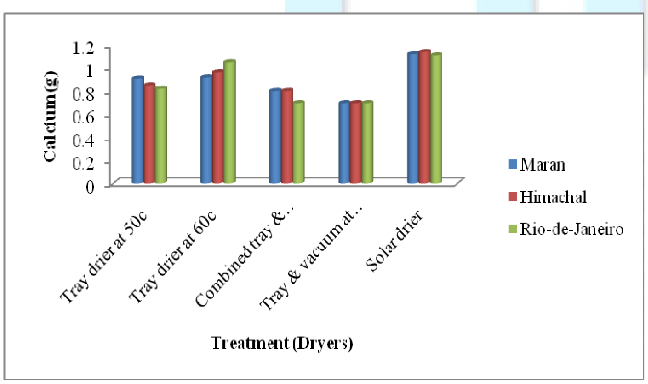
Effect of drying methods on the carbohydrate contents of ginger powder



3.1.3 Calcium (g)

Samples	Tray drier at 50⁰C	Tray drier at 60⁰C	Combined tray & vacuum at 50⁰& 60⁰C	Combined tray & vacuum at 60⁰& 50⁰C	Natural circulation solar drier
Maran	0.91	0.92	0.8	0.7	1.12
Himachal	0.85	0.96	0.8	0.7	1.14
Rio-de-Janeiro	0.82	1.05	0.7	0.7	1.11
	Result	S. Ed. (±)	C.D. at 5%		
Due to samples	**S**	0.031	0.066		
Due to tray	**NS**	0.040	0.086		

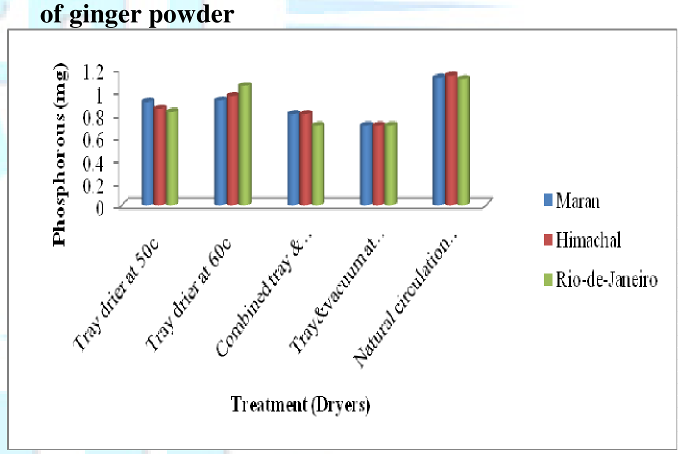
Effect of drying methods on the calcium contents of ginger powder



3.1.4 Phosphorous (mg)

Samples	Tray drier at 50⁰C	Tray drier at 60⁰C	Combined tray & vacuum at 50⁰& 60⁰C	Combined tray & vacuum at 60⁰& 50⁰C	Natural circulation solar drier
Maran	0.91	0.92	0.8	0.7	1.12
Himachal	0.85	0.96	0.8	0.7	1.14
Rio-de-Janeiro	0.82	1.05	0.7	0.7	1.11
	Result	S. Ed. (±)	C.D. at 5%		
Due to samples	**S**	0.031	0.066		
Due to tray	**NS**	0.040	0.086		

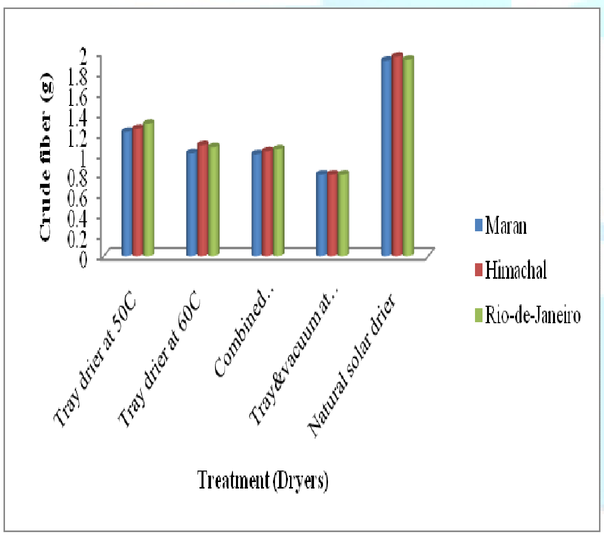
Effect of drying methods on the phosphorous contents of ginger powder



3.1.5 Crude fiber (g)

Samples	**Tray drier at 50^0C**	**Tray drier at 60^0C**	**Combined tray & vacuum at 50^0& 60^0C**	**Combined tray & vacuum at 60^0& 50^0C**	**Natural circulation solar drier**
Maran	1.22	1.01	1.0	0.8	1.92
Himachal	1.25	1.09	1.03	0.8	1.96
Rio-de-Janeiro	1.3	1.07	1.05	0.8	1.93
	Result	S. Ed. (±)	C.D. at 5%		
Due to samples	**S**	0.014	0.030		
Due to tray	**S**	0.018	0.039		

Effect of drying methods on the crude fiber contents of ginger powder



3.2 Sensory analysis

ORGANOLEPTIC SCORE								
sample	**Ginger Varieties**	**Color**	**Taste**	**Aroma**	**Flavor**	**Texture**	**Appearance**	**Overall Acceptability**
T_1	Rio-de-Janeiro	7	8	7	7	7	7	7
T_2	Himachal	7	7	7	7	7	7	7
T_3	Maran	7	7	7	6	7	6	7
T_4	Rio-de-Janeiro	8	7	8	8	8	7	8
T_5	Himachal	7	7	8	8	7	7	7
T_6	Maran	7	7	7	7	8	7	7
T_7	Rio-de-Janeiro	8	7	8	7	8	8	8
T_8	Himachal	7	7	7	7	8	7	7
T_9	Maran	7	7	7	8	7	7	7
F-test		S	S	S	S	S	S	S
S. Ed. (±)		0.259	0.296	0.333	0.314	0.294	0.212	0.305
C. D. (P = 0.05)		0.552	0.631	0.709	0.669	0.626	0.452	0.650

Table [b] Bulk density, Angle of repose and Slide of the ginger particles of different size

Ginger particle (μm)	Bulk density (g/ml)	Angle of repose (°)	Angle of slide (°)
300	0.3069 ± 0.002a	51.50 ± 0.33d	45.80 ± 0.25d
149	0.3183 ± 0.001a	50.67 ± 0.29c	44.05 ± 0.31c
74	0.3277 ± 0.002b	49.37 ± 0.25b	41.88 ± 0.29b
37	0.3347 ± 0.002b	47.70 ± 0.26a	40.61 ± 0.40a
8.34	0.3426 ± 0.002c	46.33 ± 0.37a	39 .50 ± 0.20a

4.7.3 The water holding capacity (WHC) and water solubility index (WSI)

The different particle sized powders had different water holding capacity (Fig.4.19). The water holding capacity increased with decreasing the size of ginger particles. The values of water holding capacity of ginger with particle sizes of 300 – 8.32 μm ranged from 0.26 to 0.29 g/g, 0.28 to 0.33 g/g, 0.31 to 0.41 g/g, 0.32 to 0.46 g/g, 0.32 to 0.49 g/g and 0.33 to 0.52 g/g for 10, 20, 30, 40, 50 and 60 min, respectively. At the same time, the WSI was investigated. As shown in Fig. 2, the WSI also increased with decreasing the size of ginger particles. The WSI values of ginger with particle sizes of 300–8.34 μm ranged from 27.81% to 30.07%, 28.06% to 30.68%, 28.53% to 31.82%, 28.91% to 31.93%, 29.35% to 32.60% and 29.86 to 33.70% for 10, 20, 30, 40, 50 and 60 min, respectively.

4.7.4 The solubility of protein

The superfine milling could lead to marked differences in chemical composition separation of the granulometric fractions **(Maarou et al., 2000).** The crude protein content of ginger was 12.57%. The solubility of protein with different sized ginger particles was studied as shown in Fig. 3. The smaller the size, the higher the content of protein (ginger with particle sizes of 300–8.32 μm from 31.10% to 76.58%, 31.25% to 79.12%, 31.58% to 83.08%, 31.91% to 84.93% and 31.96% to 85.24% for 10, 20, 30, 40, 50 and 60 min, respectively). This evolution was regular. In particular, a step in the content evolution appeared for the finer fractions under 74 µm, with amarked an increase of the protein content. The superfine particle size of 8.34 μm had the highest solubility, the solubility rate of the protein reached 83.08% after 20 min. The ginger particle with a particle size of 300 μm attained the same solubility rate after 30 min, but at this time the particle size of 8.34 μm had achieved 85.24%. The results indicated that the superfine ground gingercould increase protein solubility. Therefore, the main factor to affect the solubility of protein was shown to be the particle size and the area of the powder.

Conclusion

From the investigated study, it can be concluded that the ginger flakes obtained by the drying techniques can be grinded into superfine ginger powder. The superfine grinding could produce a narrow and uniform particle size distribution in dry ginger. The physico-chemical properties of five types of ginger powders with particles size of 300, 149, 74, 37 and 8.34 µm were investigated. The values of water absorption index (WAI), water solubility index (WSI) and protein content significantly increased with the decreasing size of ginger particles ($p < 0.05$). It was also observed that Ginger variety of Rheodijanerio when dried in solar drier was having least moisture content and suited best for the superfine grinding with minimum particle size. The keeping quality and nutritional quality of the Rheodijanerio is superior as compared to other varieties.

Appendix

Protein (g)

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Due to samples	4	2.260	0.565	235.04577	3.84	**S**
Due to tray	2	0.002	0.001	0.4105409	4.46	**NS**
Error	8	0.019	0.002	-	-	-
TOTAL	14		-	-	-	-

Carbohydrates (g)

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Due to samples	4	20.088	5.022	138.76734	3.84	**S**
Due to tray	2	0.069	0.034	0.950723	4.46	**NS**
Error	8	0.290	0.036	-	-	-
TOTAL	14		-	-	-	-

Calcium (g)

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Due to samples	4	0.342	0.086	35.010914	3.84	**S**
Due to tray	2	0.001	0.000	0.1336971	4.46	**NS**
Error	8	0.020	0.002	-	-	-
TOTAL	14		-	-	-	-

Phosphorous (mg)

ANOVA						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Due to samples	4	857.909	#####	136.79855	3.84	**S**
Due to tray	2	2.097	1.049	0.6688636	4.46	**NS**
Error	8	12.543	1.568	-	-	-
TOTAL	14		-	-	-	-

Crude fiber (g)

ANOVA						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Due to samples	4	2.266	0.566	1129.1894	3.84	**S**
Due to tray	2	0.005	0.002	4.8372093	4.46	**S**
Error	8	0.004	0.001	-	-	-
TOTAL	14		-	-	-	-

Color

ANOVA						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	4.667	0.5833	5.785761516	2.51	**S**
Error	18	1.815	0.1008	-	-	-
TOTAL	26		-	-	-	-

Taste

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	2.667	0.3333	2.531859229	2.51	**S**
Error	18	2.370	0.1317	-	-	-
TOTAL	26		-	-	-	-

Aroma

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	6.000	0.7500	4.50931926	2.51	**S**
Error	18	2.994	0.1663	-	-	-
TOTAL	26		-	-	-	-

Flavor

ANOVA						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	10.667	1.3333	9.01645503	2.51	**S**
Error	18	2.662	0.1479	-	-	-
TOTAL	26		-	-	-	-

Texture

ANOVA						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	6.667	0.8333	6.43776824	2.51	**S**
Error	18	2.330	0.1294	-	-	-
TOTAL	26		-	-	-	-

Appearance

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	6.000	0.7500	11.1129404	2.51	**S**
Error	18	1.215	0.0675	-	-	-
TOTAL	26		-	-	-	-

Overall Acceptability

ANOVA :						
Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**
Treatment	8	4.667	0.5833	4.181934045	2.51	**S**
Error	18	2.511	0.1395	-	-	-
TOTAL	26		-	-	-	-

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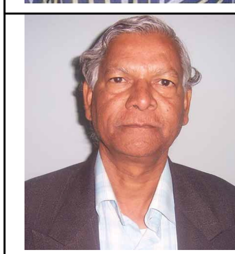

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