

CHAPTER IV

EXPERIMENTAL RESULTS

4.1 Spray-drying of lime juice without drying aid

4.1.1 From fresh lime juice

The powder resulting from drying condition of 140°C inlet air, with outlet air temperature of 80-85°C air pressure of atomizer at 40 psig by using fresh lime juice was very hygroscopic. After coming out of nozzle the powder tended to stick at spray-drier chamber. No lime powder was obtained in the receiving bottle.

4.1.2 From concentrated lime juice

Concentrated lime juice (30°Brix) dried at 180°C air pressure of atomizer at 40 psig and outlet air temperature 90°C also gave the same result as 4.1.1

4.2 Lime powder with drying aid

4.2.1 Effect of kinds of drying aid

The results are shown in Table 5 .

4.2.2 Effect of concentration of lime juice before drying

The results of the experiment are shown in Table 6

4.2.3 Effect of dextrin content

The results are shown in Table 8, 9, 10 and Fig.3 .

4.2.4 Effect of inlet air temperature

The experimental data are shown in Table 11, 12, 13 and Fig. 4 .

4.2.5 Experiment of 2³ factorial design

The results are shown in Table 14 and 15 .

4.3 Storage Test

Results of storage test on quality of powder i.e. moisture content, total acidity, ascorbic acid content and color under 3 packaging conditions viz, vacuum-packed in aluminium foil, air-packed in aluminium foil and air-packed in polyethylene bag are shown in Table 16 and Fig. 5 .

a

Table 5 Effect of kinds of drying aid on lime powder

Kinds of drying aid	Characteristics of powder	Days to develop caking
glucose (10%)	fine, yellow color	15
sucrose (10%)	fine, yellow color	18
dextrin (10%)	fine, pale	20

a : lime juice 8°Brix

inlet-air temperature 180°C

outlet-air temperature 100°C

pressure of atomizer 40 psig

powder was packed in polyethylene bag under atmospheric
condition

Table 6 Effect of concentration of lime juice before drying on characteristics of lime powder^a

Concentration of lime juice before drying (°Brix)	Characteristic of Powder
15	fine, tended to be sticky and caked after storing in Polyethylene for one day.
20	fine, but after running for 5 minutes the powder stuck to the drying chamber and was not obtainable in the receiving bottle.
30	fine, but after running for 3-4 min, the powder stuck to the drying chamber and was not obtainable in the receiving bottle.

a :	inlet-air temperature	140°C
	outlet-air temperature	70-80°C
	pressure of atomizer	40 psig
	lime juice concentrate prepared by freeze concentration	
	Dextrin added	30%

Table 7 Effect of dextrin content on drying of concentrated lime juice (30°Brix) ^a

Dextrin content ^b (%)	Characteristics of Powder
10	No powder was obtainable
20	No powder was obtainable
30	No powder was obtainable

a	inlet-air temperature	140°C
	outlet-air temperature	70-80°C
	air pressure of atomizer	40 psig
	lime juice concentrate prepared by freeze concentration	
b	in 30°Brix concentrated juice.	

Table 8 Physical and chemical properties of lime powder prepared from 10°Brix concentrated lime juice spray-dried with inlet air temperature at 200°C^a

dextrin content ^b (%)	Properties of lime powder				
	Acidity (mg citric/ 100 ml)	Ascorbic Acid mg/ 100 ml	pH	Optical density at 420 nm	moisture content (%)
20	515.72	1.36	2.6	42.5	4.65
25	514.72	2.04	2.6	40.0	3.47
30	514.01	3.4	2.6	29.5	3.29

a outlet-air temperature 70°C
 air pressure of atomizer 50 psig
 lime juice concentrate prepared by freeze concentration

b in 10°Brix concentrated juice

Table 9 Physical and chemical properties of lime powder prepared from 10^oBrix concentrated lime juice spray-dried^a with inlet air temperature at 250^o G

Properties of lime powder						
dextrin content ^b (%)	Acidity (mg citric/ 100 ml)	Ascorbic acid mg/ 100 ml	pH	Optical density at 420 nm	moisture content (%)	days to develop caking
20	515.4	2.7	2.6	43.5	4.0	150
25	514.5	2.7	2.6	43.2	3.4	182
30	514.3	4.8	2.6	38.5	3.1	270

a outlet-air temperature 80^oC
 air pressure of atomizer 50 psig
 lime juice concentrate prepared by freeze concentration
 powder was packed in polyethylene bag under atmospheric
 condition.

b in 10^oBrix concentrated juice

Table 10 Physical and chemical properties of lime powder prepared from 10°Brix concentrated lime juice spray-dried^a with inlet-air temperature at 300°C

Properties of Lime Powder					
Dextrin content ^b (%)	Acidity (mg citric/ 100 ml)	Ascorbic acid mg/100 ml	pH	Optical density at 420 nm	Moisture content
20	516.3	1.4	2.7	44.5	3.9
25	514.1	2.7	2.7	37.2	3.3
30	513.9	3.2	2.7	39.3	2.9

a outlet-air temperature 100°C
air pressure of atomizer 50 psig
lime juice concentrate prepared by freeze concentration

b in 10°Brix concentrated juice



Fig 3 Effect of dextrin content on the color of lime powder^a

a inlet air temperature 200°C
 outlet air temperature 70° to 80°C
 lime juice concentrate 10 Brix prepared by freeze
 concentration

Table 11 Organoleptic properties of reconstituted lime juice prepared from lime powder ^a with 30% dextrin ^b

Temperature (°C)	Color	Odor	Flavor
200	7.8	9	9
250	7.2	6	6
300	1	3	3

a	outlet-air temperature	70 to 80°C
	air pressure of atomizer	50 to 60 psig
b	in 10°Brix concentrated juice prepared by freeze concentration	

Table 12 Organoleptic properties of reconstituted lime juice prepared from lime powder spray-dried with 25% dextrin^a with 25% dextrin^b

temp. (°C)	Color	Odor	Flavor
200	8.4	8.3	8.4
250	6.6	5.5	6.6
300	2	3	2

a outlet-air temperature 70 to 80°C

air pressure of atomizer 50 to 60 psig

b in 10°Brix concentrated juice prepared by freeze concentration

Table 13 Organoleptic properties of reconstituted lime juice prepared from lime powder spray-dried with 20% dextrin^b

temp. (°C)	Color	odor	flavor
200	6.6	9	8.4
250	8.4	6	6.6
300	3.0	3.0	3.0

a outlet-air temperature 100°C
 air pressure of atomizer 50 to 60 psig

b in 10°Brix concentrated juice prepared by freeze concentration



Fig 4 effect of inlet air temperature on the color of lime powder^a

a dextrin content in 10 Brix concentrated juice prepared by freeze concentration was 20%

Table 14 Observation of 2³ factorial experiments

Run no.	Juice Concentration (°Brix)	Dextrin ^a content (%)	Inlet-air temp. (°C)	Moisture content ^b (%)	Acidity (citric acid mg/ 100 ml)	Ascorbic acid (mg/ 100 ml)	Optical ^c density at 420 nm	Organoleptic score	Storage Stability ^d (days to develop caking)	Percent recovery ^e (%)
1	8	8	150	12.00	516.3094	6.8	17	6.6	10	53.5
2	16	8	150	24.53	515.7718	8.16	24.5	4.6	1	10.1
3	8	16	150	4.5	516.2656	9.52	15	7.3	42	80.8
4	16	16	150	17.0	515.7188	9.52	27	5.3	12	61.72
5	8	8	250	6.75	515.7371	5.44	24.5	1.3	29	55.1
6	16	8	250	21.08	516.0378	6.75	28.5	2.3	1	10.75
7	8	16	250	4.18	514.7846	8.1	23.0	2.3	80	78.1
8	16	16	250	10.26	515.2175	9.45	26.1	5.6	30	5.6

a in 10°Brix concentrated juice

b outlet-air temperature 70 to 80°C
air pressure of atomizer at 50 psig

c of reconstituted juice filtrate at 7°Brix soluble solid

d powder packed in polyethylene bag under atmospheric condition

e percent-recovery = $\frac{\text{wt of powder (on dry basis)}}{\text{Total solid in juice}} \times 100$

Total solid in juice

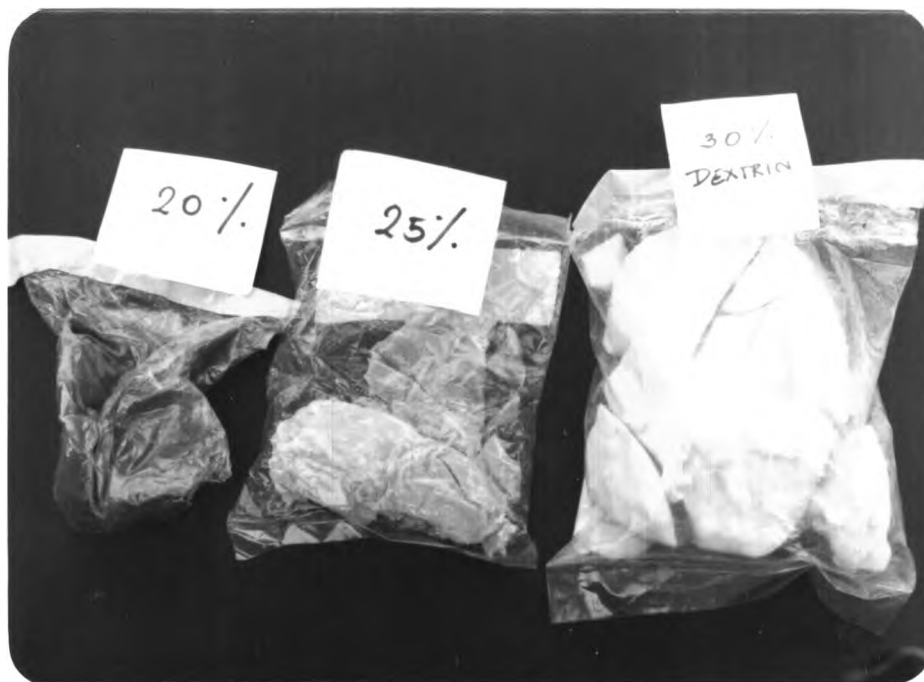
Table 15 Results of 2³ factorial experiments showing the effects of variables on physical and chemical properties of lime powder

Effects	Moisture Content (%)	Acidity (citric acid mg/100 ml)	Ascorbic Acid (mg/100 ml)	Optical Density at 420 nm	Organoleptic score
Juice Concentration	22.72	0.41	2.69	13.88	0.15
Drying aid (Dextrin)	-14.21	-0.83	6.75	- 2.83	2.85
Inlet-air temperature	-7.88	-0.52	-1.41	9.93	-6.15
Juice Concentration + Dextrin	-4.14	0.16	-1.34	2.13	1.15
Juice Concentration + Inlet-air Temperature	-2.31	0.20	1.34	-5.13	4.15
Dextrin + Inlet air temperature	0.82	-0.51	1.34	-2.83	1.45
Juice Concentration + Dextrin + Inlet air temperature	6.14	0.12	5.43	-0.13	0.5

Table 16 Storage test of lime powder

Properties of packed lime powder ^a												
Storage time (weeks)	Moisture content			Total acidity (citric acid mg/100 ml)			Ascorbic acid Content (mg/100 ml)			Optical density at 420 nm		
	1	2	3	1	2	3	1	2	3	1	2	3
0	3.47	3.47	3.47	514.53	514.53	514.53	2.72	2.72	2.72	37.4	37.4	37.4
2	4.19	4.25	5.82	516.59	516.24	513.67	2.04	2.04	2.04	37.8	37.4	37.5
4	4.42	4.48	6.23	516.61	516.26	5116.65	1.36	1.36	1.36	37.9	37.8	38.5
6	4.35	5.14	7.58	616.22	516.21	616.08	0	0	0	38.0	38.1	38.2
8	5.26	5.47	8.74	516.11	516.08	516.02	0	0	0	38.3	38.8	38.8
10	6.17	6.22	9.17	516.06	516.08	516.02	0	0	0	40.0	40.2	42.5

- a
- 1 = powder packed in aluminium foil with vacuum
 - 2 = powder packed in aluminium foil without vacuum
 - 3 = powder packed in polyethylene bag without vacuum



a

Fig 5 The color of lime powder packed in polyethylene bags stored for 9 months at room temperature

a	inlet air temperature	200 °C
	outlet air temperature	70° to 80° C
	air pressure of atomizer	50 psig
	10 Brix concentrated lime juice prepared by	
	freeze concentration	