

## **DEVELOPMENT OF A SOLAR DRYING TECHNOLOGY FOR THE DEHYDRATION OF VEGETABLES IN ZAMBIA**

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### **ABSTRACT**

A survey of traditional methods of drying vegetables indicated a need for improved drying facilities in rural areas. Laboratory tests identified the optimum pretreatments for cowpea, pumpkin and delege leaves, when using an indirect solar dryer. A model for improving the procedures for drying these vegetables, with recommendations for organising the drying facilities is presented.

### **INTRODUCTION**

The practice of direct solar drying of vegetables and the utilisation of dried vegetable products is well established in Zambia.

A preliminary survey was carried out to identify traditional drying technologies, the specific vegetable crops to which these technologies are applied and the uses of dried products. The pilot plant survey was confined to limited locations within the Southern, Eastern, Central and Lusaka provinces.

The results of the survey indicated that:

1. Drying was carried out towards the end of the rainy season and to overcome the anticipated seasonal shortages in the dry season.
2. Dried products were stored over 2-3 months for use in the late dry season.
3. All products were subjected to pretreatments such as blanching.
4. The most common vegetables for solar drying (SD) are pumpkin, cowpea and delege leaves.
5. Occasionally collective drying was carried out using common drying sites (flat stone surfaces) but generally drying capacity was limited by lack of an adequate and organised technology.

The survey suggested two areas that required further investigation with a view to improving the processes for preserving vegetables. These were optimisation of pretreatment procedures to ensure the minimum loss of nutrient value, and, second, an improved system for drying material based on a solar heat collector. Since pumpkin, cowpea and delege leaves were the most common crops preserved in this way these were selected for further investigation.

### **OPTIMISING PRETREATMENT PROCEDURES**

The traditional pretreatments, including hot water or steam blanching, mincing and crushing, and pressing to remove excess moisture, were evaluated. The effect of such pretreatments on the quality of the dried product was measured under laboratory conditions.

Blanching time was determined and optimised using the residual polyphenol oxidase and peroxidase tests. The carotene and ascorbic acid content of the dried products were evaluated as parameters of nutritional quality. The effects of two levels (high and low) of:

1. Water: Vegetable (W/V) ratio
2. Blanching time
3. Drying temperature

on carotene and ascorbic acid content of the dried product were investigated using a full factorial experimental design.

The results are shown in Tables 1 and 2. Analysis of variance showed that for pumpkin leaves, the effect of W/V, blanching time and drying temperature (at the two levels tested) had no significant effect on the ascorbic acid and carotene levels in the dried product. In cowpea the effects of blanching time and drying temperature were significant ( $p > 0.05$ ) in the case of ascorbic acid.

Since the effect of W/V on ascorbic acid and carotene retention was not significant, water blanching could be recommended, though water blanching is known to result in heavier losses of water soluble nutrients such as ascorbic acid, than steam blanching.

Based on enzyme inactivation studies, six minutes was selected as the optimum blanching time for both steam and water blanching of the leaf vegetables under study. The effect of drying temperature, particularly on ascorbic acid content was dependent on the level of blanching time, a low blanching time in combination with low drying temperature being the most ideal.

#### **DEVELOPMENT OF A SOLAR DRYER**

Preliminary testing of a tent-type solar dryer resulted in heavy losses of ascorbic acid and poor colour retention. An indirect solar dryer was constructed, consisting of a separate solar collector attached to a drying chamber. The collector was constructed of corrugated iron sheets painted black and covered with a single layer clear polythene sheet. The collector chamber was insulated with dried grass. The drying chamber was constructed from wooden planks and included four shelves, each capable of taking three trays, 96cm x 51cm x 5cm. The drying chamber was provided with a chimney for improved convective air flow.

Drying tests were conducted using cowpea, pumpkin and delele leaves. Delele leaves are traditionally not blanched due to their mucilaginous nature and high water uptake in blanching. In these tests unbleached and steam blanched samples of delele leaves and both water and steam bleached samples of cowpea and pumpkin were used.

Table 3 summarises the drying time and temperature drying parameters for the three types of leaf material with a maximum tray loading of 1.0 to 1.5 kg of raw vegetable. A maximum drying temperature of 40-42°C was obtained in the drying chamber on clear sunny days resulting in an 18-20°C temperature rise above ambient temperature and a drying time of 28-50 hr.

Under cloudy conditions, maximum chamber temperatures were in the range of 24-34°C (10-14°C above ambient temperature) resulting in an extended drying time of 50-60 hrs.

Pretreatment also affected the drying time. Steam blanched and unblanched material dried faster than water blanched material under the same drying conditions.

The dried products had good colour retention and rehydration properties, with steam blanching resulting in better rehydration than water blanching (Table 4). The carotene content of the dried products was consistently high though ascorbic acid losses appeared to be higher than in traditionally dried products due possibly to a slower drying rate (Table 5).

Table 6 suggests that the recommended daily allowance of carotene (7500 IU of provitamin A or carotene) is provided in less than half of the quantity of solar dried material (pumpkin leaf) than that required of traditionally sun dried leaves.

### **CONCLUSION**

From the survey of traditional methods of drying vegetables, it is clear that there is a need for improvements in the drying facilities in the rural areas in order to increase the output and improve the quality of the dried product from both the nutritional and aesthetic points of view.

Though it was not possible to optimise the drying process through computation of mathematical models, some appropriate input variables have been defined for constructing a drying model suitable for use in rural communities.

### **The proposed model**

In designing the drying model two main inputs are considered: blanching and drying.

- a. **Blanching:** Both steam and water will be used but the selection of either option will depend on the conditions prevailing on a particular day. For example, steam is proposed for blanching on cold, cloudy days when there is little sunshine available. Only steam is proposed for blanching delele leaves which are not traditionally blanched owing to their mucilaginous nature. The use of steam will be favoured where there is scarcity of water. Water will be used on clear, sunny days for blanching vegetables other than delele leaves, and for economy the minimum necessary to completely immerse the vegetables will be used. A maximum of 6 minutes and a minimum of 5 minutes blanching time is proposed for all vegetables. Air cooling rather than water cooling is to be applied after the blanching, especially on a cloudy day.
- b. **Drying:** An indirect solar dryer is to be used and a temperature of 30-50°C is expected in the drying chamber depending on weather conditions on a particular day. A tray-load of 1.0-1.5kg of raw materials will be employed to effect satisfactory drying.

The model is expected to be a simple and low cost process for drying. To this effect as much as possible of the basic requirements will be procured from the locality. If possible the drying facilities will be established near to a stream or a river to facilitate ready access to a water supply. Containers for blanching will be made from epoxy painted drums or other cheap large cooking pots. Steam will be generated by boiling water in the drum. Fuel, eg wood, for boiling water will be obtained locally. The dryer itself will be constructed from materials available in the locality. The drying chamber to be brick or mud.

There exists a tradition of group or community drying on flat stone surfaces. This tradition will be exploited and built upon by encouraging vegetable drying on a cooperative basis. Presently only one such cooperative venture exists in the country - the Chikuni vegetable and fruit growers and processors cooperative in the Southern Province.

Some aspects of the proposed model have been tested in the laboratory and the results are quite encouraging. Higher drying temperatures have been obtained than in traditional sun drying. There is better nutrient retention and vegetables are dried under more hygienic conditions. The material being dried could also be left overnight in the dryer without risk from rain, contamination by birds, insects, dust and others.

TABLE 1: Total carotene in dried pumpkin leaves (mg/100g solids)

Treatment		Repeats			Treatment total	Total for 2 temp	Treatment mean
Blanching water (l)	Blanching time (min)	Drying temp (°C)	1	2			
30	4	50	55.3	63.8	77.7	196.8	65.60
		80	53.2	62.8	48.1	164.1	360.9
80	4	50	68.2	61.1	55.3	184.6	61.53
		80	60.4	55.5	54.9	170.8	355.5
80	8	50	62.4	63.0	69.0	194.4	64.80
		80	51.0	70.4	55.7	177.1	371.5
80	8	50	51.1	68.0	51.4	170.5	56.83
		80	59.3	60.8	61.0	181.1	351.6
			<b>460.9</b>	<b>505.4</b>	<b>473.1</b>	<b>1439.4</b>	

TABLE 2: Ascorbic acid in dried cowpea leaves (mg/100g solids)

Treatment		Repeats			Treatment total	Total for 2 temp	Treatment mean
Blanching water (l)	Blanching time (min)	Drying temp (°C)	1	2			
30	4	50	46.3	24.8	37.0	108.1	36.03
		80	23.1	16.4	18.2	57.7	165.8
80	4	50	13.6	19.1	20.9	53.6	17.86
		80	24.3	16.2	16.8	57.3	110.9
80	8	50	36.7	23.8	38.2	98.7	32.90
		80	23.2	22.9	19.2	65.3	164.0
80	8	50	14.8	18.2	14.1	47.1	15.70
		80	18.7	17.4	13.3	49.4	96.5
			<b>200.7</b>	<b>158.8</b>	<b>177.7</b>	<b>537.2</b>	

**TABLE 3: Summary of the drying experiment**

Vegetables	Treatment	Amount of material (kg)		Drying period (hrs)	Ambient temp °C (AV)	Drying temp °C (max)	Temp rise above ambient (°C)
		Tray load	In Out				
Pumpkin	Water blanched:	1.0	3.0 0.383	51	20	34	14
		1.3	1.3 -	50	24	42	18
Cowpea	Water blanched:	0.453	0.453 0.084	27	20	34	14
		1.0	2.0 0.179	60	22	32	10
Delele	Unblanched:	0.595	0.595 0.070	29	22	32	10
		0.507	0.507 0.15	27	24	42	18
	Steam blanched	0.291	0.291 0.054	28	24	42	18

**TABLE 4: Mean moisture, total carotene and ascorbic acid content: dehydration ratio and rehydration ratio of solar dried pumpkin, cowpea and delele leaves**

<b>Vegetable</b>	<b>Treatment</b>	<b>Moisture %</b>	<b>Dehydration ratio</b>	<b>Rehydration ratio</b>	<b>Total carotene mg/100g solids</b>	<b>Ascorbic acid mg/100g solids</b>
Pumpkin	Water blanched:	10.4	8:1	6:1	39.1 (69.1% Rtn)	14.8 (2.3% Rtn)
	Steam blanched:	6.7	5.4:1	7:1	41.7	21.4
Cowpea	Water blanched:	7.9	11.2:1	4:1	43.3 (83.1% Rtn)	16.3 (2.0% Rtn)
	Steam blanched:	6.8	8.5:1	6:1	59.5	246.8
Delele	Unblanched:	6.5	3.4:1	5:1	35.5 (91.3% Rtn)	151.6 (25.6% Rtn)
	Steam blanched:	7.0	5.4:1	6:1	41.8	199.2

**TABLE 5: Carotene and ascorbic acid content in traditionally dried pumpkin leaf and cowpea leaf from the Northern Province**

<b>Vegetable</b>	<b>Carotene mg/100g solids</b>	<b>Ascorbic acid mg/100g solids</b>
<b>Pumpkin</b>		
Unblanched:	16.2	47.6
Blanched:	18.5 (32.7% Rtn)	34.9 (5.5% Rtn)
<b>Cowpea</b>		
Unblanched:	35.6 (68.3% Rtn)	55.9 (7.0% Rtn)

**TABLE 6: Amount of fresh and dried\* vegetable necessary to provide the equivalent of 7500 i.u. of carotene**

<b>Vegetable</b>	<b>Fresh (gm)</b>	<b>Traditionally sun dried (gm)</b>	<b>Solar dried (gm)</b>
<b>Pumpkin</b>			
Unblanched:	52.9	30.2	-
Water blanched:		26.5	12.5
Steam blanched:		-	11.7
<b>Cowpea</b>			
Water blanched:	57.7	13.7	11.3
Steam blanched:		-	8.2
<b>Delele</b>			
Unblanched:	46.4	-	13.8
Steam blanched:		-	11.7

Assuming dried vegetables with 8% moisture content.