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EFFECTS OF SIZE REDUCTION AND DRYING METHODS ON DRIED GINGER QUALITY AND OIL/OLEORESIN YIELD

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ABSTRACT

A survey was carried out to appraise the existing handling and primary processing of ginger in Southern Kaduna Area of Kaduna. Alongside a set of experiments were carried out to examine the effects of these traditional size-reduction treatments and different drying methods on dried ginger quality and oil/oleoresin yield. Different samples of freshly harvested ginger in whole-unpeeled (WU), split-unpeeled (SU), whole-peeled (WP) and split-peeled (SP) forms were dried under sun drying (D1), solar drying (D2), natural air drying (D3) and fire-heated drying (D4) methods. The result show that splitting ginger rhizomes into halves and spreading them on hard compact platform under the sun to dry is the popular primary processing technology in the study area. Split-dried ginger form was found to be the most accepted form in both the local and international ginger trade. The result in Table2a represents the summary of the data obtained on dried ginger oil/oleoresin content. The analysis indicates that the combined effect of size-reduction treatment (P) and drying methods (D) on essential oil/oleoresin content of dried ginger was highly significant (0.05). Comparing the interaction means of the physical processing treatment (P) and the drying methods (D), the Whole-unpeeled samples dried under fire-heated drying method (WUD4), split-unpeeled samples dried under fire-heated drying method (SUD4), split-unpeeled samples dried under solar drying method (SUD2) and split-unpeeled samples dried under open-sun drying method (SUD1) recorded significant yields of ginger oil/oleoresin, while samples of whole-peeled (WP) and split-peeled (SP) dried under the different drying methods recorded very insignificant yields of oil/oleoresin. The study suggests that for industrial production of ginger oil/oleoresin, farmers should adopt drying ginger whole-unpeeled under fire-heated drying method.

Keywords: *Primary Processing; Size-reduction Treatments; Drying Methods; Dried ginger; oil/oleoresin*

INTRODUCTION

Ginger (Zingiber officinale Roscoe), a herbaceous perennial plant which belongs to the order Scitamineae and the family Zingiberaceae, is grown largely in southern Kaduna area of Kaduna Sate, the traditional home of ginger in Nigeria (Ayodele and Sambo, 2014). Ginger (Zingiber officinale) is an important root crop and a typical herb extensively grown across the world for its pungent aromatic under-ground stem or rhizome which makes it a valuable export commodity in world trade (NEPC,1999; Fumen, 2003). It is an important export The exact origin of ginger is quite uncertain, but it is widely believed to be a native of south-eastern Asia, where it was first cultivated (Musa, 1991). In Nigeria, ginger cultivation has been traced back to 1921, but the promotion and introduction of its production began in Southern Kaduna area of Kaduna state in 1927 (Musa, 1991; Fumen, 2003) The promotion and introduction of ginger production in the area was intended to generate internal trade and income to enable the people of the area pay taxes to the colonial government (Musa, 1991; Fumen, 2003). Early cultivation of ginger in Nigeria was predominant among Ham and Koro communities in Kagarko, Kachia, Jaba and Jema'a Local Government Areas, with crop valued for its powder, oil and oleoresin (Njoku *et al.*, 1995). The spicy underground rhizome is used as spice in culinary, beverage, confectionary, pharmaceutical and perfumery industries (Njoku, *et al.,*1995). Ginger is traded in either of the three basic forms namely fresh rhizome, preserved or dried ground ginger (Onu and Simonya, 2017). Dried ginger contains 7-12% moisture, 1-3% essential oil, 5-10% oleoresin and 50- 55% starch, with protein, fibre, fat and ash as its other proximate constituents (Ebewele and Jimoh, 1981, Fumen and Ajisegiri, 2006).

Ham land as the major producing spot in Southern Kaduna area to date, with over 95% of the country's total annual production, which places the country among the leading ginger producing and exporting countries in the world (Agubas, 1998; NEPC, 1999). Nigeria's ginger has been reported to be highly valued in the international market for its aroma, pungency, high oil and oleoresin contents (Njoku *et al*., 1995; Eze and Agbo, 2011). The two popular cultivars of ginger initially produced in the country were the 'Tafin-Giwa', a yellowish cultivar with plump rhizomes and 'Yatsun-Biri, a black or dark cultivar with small compact rhizomes, but today the yellow cultivar, due to its superior yield, is more popular

than the dark cultivar (Musa, 1991; Fumen, 2003).

The bulk of Nigeria's ginger is traded internationally in split-dried form, where the importing countries further process it into its industrial products mainly ginger powder, essential oils, oleoresin and ginger ale concentrates (Olaoye *et al*., 2014: Onu and Simonya, 2017). The amount of foreign exchange earned by exporting dried ginger is however very low compared to the amount spent on importing processed ginger products thereby substantiating the need for industrial processing of the Nigeria's ginger (Meadows, 1988). Primary processing of freshly harvested ginger entails sorting, washing, soaking, splitting or peeling and drying it to a storage moisture content of 7-12% (Ebewele and Jimoh, 1981; Fumen, 2003). The quality of freshly harvested Nigeria's ginger has been ranked the best in the world, but due to low level of mechanization of ginger processing, the quality of dried ginger is low (Onu and Okafor, 2003). The processing of the Nigeria's ginger has not been standardized; hence the microbiological, sensory and chemical properties of the products often fall below importers' specifications (Ebewele and Jimoh, 1981; Fumen, 2003). Nigeria's ginger therefore receives low rating in international markets and continues to lose foreign exchange earnings (Ekundayo *et. al*., 1988; Agubas, 1998). The traditional drying methods used by farmers are varied, haphazard and risky, and often result in mould growth, loss of some volatile oil by evaporation and destruction of some heat-sensitive pungent properties (Ebewele and Jimoh, 1981).

Ginger farmers continually process their ginger stocks into split-dried form as splitting and sun drying remain the most widely accepted processing treatment and drying method for ginger in Nigeria (Fumen *et al*., 2003; Maigida and Kudi, 2000). The preference of split-dried ginger to peeled-dried could be attributed to the fact that the flavour components of ginger are concentrated just below the peel; hence peeling the cork skin leads to loss of these components (Akomas and Oti, 1988). The split-dry process has been reported to conserve about 15-20% ginger flavour components, which are lost in the peel - dry process (Adeyemi and Onu,1997). Besides conservation of volatile oil components, the split - dry process also facilitates fast and thorough drying of ginger; hence split-dried ginger is most suitable for

industrial distillation and extraction of volatile oil and oleoresin (Meadows, 1988; Akomas and Oti, 1988; Fumen and Ajisegiri, 2006).

In view of the quest to produce high quality dried ginger that meets international market standard, this paper attempts to examine the existing traditional size-reduction treatments and drying methods, and their effects on dried ginger oil/oleoresin yield.

MATERIALS AND METHODS

The study was carried out in two phases. Phase one involved an examination of the existing traditional size-reduction treatments, drying methods, processed products and uses of ginger in the study area. A structured questionnaire was administered to some farmers in randomly selected locations of the area. The questionnaire was structured into four parts with the following sub headings: (A) Pre-processing handling (cleaning, sorting and grading), (B) Processing methods, tools and materials, (C) Processed forms of ginger, and (D) use of ginger. Under each sub heading were listed items to enable the respondents make appropriate choices. Data drawn from the responses of the farmers was recorded in a tabular form.

The second phase of the study involved a set of experiments to examine the effects of the primary processing treatments and drying methods on some proximate and chemical properties of dried ginger. To evaluate the effects of peeling, splitting and identified drying methods on ginger oil and ginger oleoresin yields of dried ginger, several analyses were conducted following methods adopted by the association of official analytical chemists (AOAC, 1980). A bulk sample of 36kg weight of freshly harvested ginger (*Tafin-Giwa*) was obtained from Fai District, a prominent ginger producing spot in the Southern Kaduna Area of Kaduna state. The bulk ginger sample was divided into four main parts of 9kg, each. The four main parts of the bulk sample represented the four different primary processing treatments being investigated. These include whole-unpeeled (WU), whole-peeled (WP), split-peeled (SP), and split-unpeeled (SU). The four main parts were further sub divided into three equal parts of 3kg, each. The three sub samples were subjected to different chemical processing treatments namely non-soaking, soaking and bleaching (Akomas and Oti, 1988; Musa, 1991). Each of the sub-sample was further divided into four sub-sub-samples

and each sub-sub-sample was subjected to different drying methods namely, open-sun, solar, natural air and open-fire-heated drying. Thus, a 4 x 3 x 4 factorial experiment in split-split-plot design was adopted, and each experiment replicated three times as adopted by Steel and Torrie (1980).

To evaluate the effects of peeling, splitting and drying on ginger oil and ginger oleoresin yields, proximate analysis of dried ginger samples was carried out.

RESULTS AND DISCUSSION

The results, based on the two phases of the study are presented in Tables 1 and 2. Table1a presents the result of the survey of ginger handling on pre-processing handling and processing methods, tools and materials, while Table1b presents finding on the processed ginger products and their uses. Tables 2a, 2b and 2c present results of effects of splitting and peeling treatments and drying methods on ginger oil and ginger oleoresin yields of dried ginger

Survey of Ginger Handling, Primary Processing, Processed Products and Use

Result in Table1a shows the pre-processing handling activities being undertaken to facilitate the quality of dried ginger. About 68% of the respondents reported that after harvest, the roots, soil lumps, stones and plant materials are removed to keep the spicy rhizomes clean. To produce dried ginger with uniform sizes, 18% of the respondents reported that the rhizomes are often graded to small, medium and large sizes. Thirty-five percent (35%) of the respondents claimed that for farmers to produce clean and quality dried ginger, the fresh rhizomes are properly washed to remove dirt before splitting. This result agrees with the steps taken in primary processing of freshly harvested ginger (Akomas and Oti, 1988; Fumen and Ajisegiri, 2004).

Concerning the processing methods, tools and materials, the result shows that about 82% of the respondents upheld that splitting the rhizomes into halves is the most popular size-reduction treatment in the study area and about 85% upheld drying as the means of moisture removal while 88% of the respondents agreed with open sun as the major energy source (Musa, 1991). Most (75%) of the respondents acknowledged the use of splitting knives to split the rhizomes into halves, while 72% of the respondents acknowledged the use of compact ground floors as the most popular platforms for drying ginger. Drying the split halves of ginger rhizomes under open-sun is the most widely

accepted practices adopted by farmers in the study area, agreeing with Okafor (2002). The practice of peeling ginger rhizomes is unpopular, and is practiced only with small quantities of ginger meant for culinary purposes (Fumen, 2003). Some of the factors that militate against the practice of peeling ginger in the area include time consumption, tediousness and based on value, the peeled-dried ginger does not attract any significant price difference over the split-dried ginger. Hence, most farmers in the study area prefer to process their stocks into split-dried form (KSADPPMEU, 1984; Fumen and Ajisegiri, 2004). It has been further stressed that the preference of split-dried ginger over peeled-dried ginger in the area is because the split-dried ginger is the most demanded form by the local and export market (Maigida and Kudi, 2000; Fumen *et al*., 2003; Yiljep *et al*., 2005). Other factors for the wider acceptability of split-dried ginger over peeled-dried ginger, as earlier stated may be attributed to the loss of flavour components of ginger in peel-dry process (Akomas and Oti, 1988). The split-dried ginger is most suitable for industrial distillation and extraction of volatile oil and oleoresin, respectively (Ebewele and Jimoh, 1981; Fumen, 2003).

The whole-unpeeled-dried form of ginger was not very common among farmers in the study area. The very small quantities observed were said to result from dehydration of the rhizomes during storage of 'seed ginger' or from fields left unharvested during the cold-windy harmatan period or when the dry season prolongs beyond expectation (Nnodu and Okwuowulu, 1988). The split-peeled-dried ginger was found in very insignificant quantities as most respondents were affirmative that the form of ginger is mainly prepared for culinary purposes. The removal of the peel (cork skin) and splitting are said to reduce the fibre content of the spicy rhizome, thereby minimizing roughage in food preparations, and also facilitates faster drying of the split halves. Ginger in this form is used for spicing local diets such as '*Kunu-tsamiya*', '*fatte*', *daffa-duka'* (jollof rice), '*gusgus*', '*fura de nono*', soups and pepper soup (Fumen, 2003). It is also used for preparing ginger powder, which is usually blended with some other spices as 'yaji'; a local curry powder for spicing various local diets (Nnodu and Okwuowulu, 1988).

Table1a: Survey findings on pre-processing handling, primary processing methods, tools and materials

S/No.	Processing activities, tools and materials	Responses	(%)
A	Pre-processing handling (cleaning, sorting and grading)		
i.	Removal of roots, soil lumps, stones and plant materials	41	68.3
ii.	Washing to remove all dirt particles	35	58.3
iii.	Grading for seed ginger and market	11	18.3
B	Processing methods, tools and materials		
i.	Splitting	49	81.7
ii.	Peeling	14	32.3
iii.	Drying	51	85.0
iv.	Whole – unpeeled	2	3.3
v.	Splitting knife	45	75.0
vi.	Peeling knife	3	5.0
vii.	Open – sun energy	53	88.3
viii.	Open-fire-heated platform	2	3.3
ix.	Compact ground floor	43	71.7
x.	Roof top	2	3.3
xi.	Road side	8	13.3
xi.	Jointed bacco sheets	8	13.3
xii.	Washing water	7	11.7
xiii.	Soaking water	20	33,3

Table1b: Survey findings on ginger processed products and uses

S/No.	Processed Products and Uses	Responses	(%)
A	Processed products		
i.	Split – dried	55	91.7
ii.	Peeled – dried	4	6.7
iii.	Whole - peeled – dried	2	3.3
iv.	Peeled - split- dried	1	1.7
v.	Peele - crushed- dried	6	10.0
B	Ginger product use		
i.	Local/export trade	55	91.7
ii.	Curry powder (*yaji*)	9	15.0
iii.	Local drink (*kunu zaki or kunu tsamiya*)	4	6.7
iv.	Pap (*akamu*)	2	3.3
v.	Soup	10	16.7
vi.	Suya mixes	5	8.3
vii.	Curried meat	3	5.0
viii.	Ginger mix juice	6	10.0

Analysis of Effects of Splitting, Peeling and Drying Methods on Ginger Oil/Oleoresin Yield of Dried Ginger

The result in Table2a represents the summary of the data obtained on dried ginger oil/oleoresin content. The analysis indicates that the combined effect of size-reduction treatment (P) and drying methods (D) on essential oil/oleoresin content of dried ginger was highly significant (0.05). Comparing the interaction means of the physical processing treatment (P) and the drying methods (D), the whole-unpeeled (WU) samples dried under fire-heated drying method (D4) or WUD4 samples recorded the highest mean per cent (2.0%) yield of ginger oil/oleoresin extracts. Following immediately was SUD4 or split-unpeeled (SU) samples dried under fire-heated drying method (D4) with a yield of 1.7% ginger oil extracts, SUD2 samples with 1.6% and SUD1 with 1.5%. All whole-peeled (WP) and split-peeled (SP) samples recorded very low mean per cent yields of oil/oleoresin.

Table2a: Summarized data on proximate analysis of dried ginger on ginger oil/oleoresin content

S/No.	Experimental factor			Code	Replication mean			Total mean
	P	C	D		RI	RII	RIII	
1	WU	U	D	WUUD	4.7	4.7	4.9	4.8
2	WU	S	D	WUSD	4.6	4.7	4.9	4.7
3	WU	**B**	D	WUBD	4.6	6.2	6.1	6.0
4	SU	S	D	SUSD	5.8	6.1	6.0	6.1
5	SU	S	D	SUSD	6.2	5.9	6.1	9.1
6	SU	B	D	SUBD	6.2	4.4	4.6	4.5
7	WP	U	D	WPUD	4.5	4.3	4.1	4.3
8	WP	S	D	WPSD	4.5	4.4	4.0	4.3
9	WP	B	D	WPBD	4.5	2.8	2.6	2.8
10	SP	U	D	SPUD	2.8	2.8	2.6	2.8
11	SP	S	D	SPSD	2.7	2.7	2.6	2.7
12	SP	B	D	SPBD	4.5	2.9	2.6	2.7
Total mean					4.5	4.4	4.5	4.5

The high ginger oil/oleoresin yield from the whole-unpeeled samples dried under fire-heated drying method (WUD4) could be attributed to the high flavour components below which was left undisturbed as the cork skin was not removed and the drying was effected within the shortest possible time. The fast and effective drying of the samples by the fire-heated drying was could also be attributed to the high temperature associated with the drying method (Agu *et al*., 2016).

The result agrees with available reports that drying ginger with fire-heated air up to 80°C enhances quick drying and has no adverse effect on ginger the volatile components of the spicy rhizome (Ebewele and Jimoh, 1981: Ukpabi, 1995; Agu *et al*., 2016).

The Ginger oil/oleoresin yields from SUD4, SUD2 and SUD1 samples show the conservative effect of the pungent cork skin in the split-dried ginger and the effect of relative high temperature drying methods of fire-heated drying, solar drying and the traditional open-sun drying (Akomas and Oti, 1988). However, the low yields of ginger oil/oleoresin from WUD1 WUD2 and WUD3 samples could be attributed to prolonged drying period which resulted in poor drying effect on the samples thus, affecting ginger oil/oleoresin yield. While the poor oil/oleoresin yield associated with the WP and SP samples could be attributed to the loss of flavour components due to complete removal of the cork skin.

Table2b: Analysis of variance of split-split-plot design of ginger oil/oleoresin content for dried ginger

Source of variation		Df	Ss	Ms	Computed F	5%	1%
Main plot:							
Replication		2	0.09	0.04	0.27	-	-
Physical	Treatment	3	205.22	68.41	456.07*	4.76	9.78
(P)							
Error (P)		6	0.90	0.15			
Sub-plot:							
Chemical	Treatment	2	0.11	0.05	0.71	-	-
(c)							
P. C.		6	0.25	0.04	0.57	-	-
Error (C)		16	1.11	0.07			
Sub-sub- plot:							
Drying treatment (D)	3	96.48	32.16	402.00*	2.74	4.08	
P.D.		9	73.09	8.12	101.50*	2.01	2.67
C.D.		6	0.32	0.05	0.62	-	-
P. C. D.		18	1.21	0.12	1.5ns	1.79	2.28
Error (D)		12	5.66	0.08			
Total		143	384.4	2.69			

			5				

a, CV(p) = 8.68%, CV (c) =5.9%, CV (d) = 6.3%; b, * = Significant at 5% level, ns = not significant

Table2c: Mean difference between size-reduction treatment (P) and drying method (D) interaction means on ginger oil/oleoresin content in dried ginger

S/No	Treatment interaction	Interaction mean (%)	Mean difference range		
			RI	RII	RIII
1	SUD1	1.5	0.5*	0.7*	0.8*
2	WPD1	1.0	0.2ns	0.3ns	
3	WUD1	0.8	0.1ns		
4	SPD1	0.7			
5	SUD2	1.6	0.2ns	0.5*	0.9*
6	WPD2	1.4	0.3ns	0.7*	
7	WUD2	1.1	0.4ns		
8	SPD2	0.7			
9	SUD3	1.2	0.4ns	0.4ns	0.6*
10	WPD3	0.8	0.0ns	0.2ns	
11	WUD3	0.8	0.2ns		
12	SPD3	0.6			
13	SUD4	2.0	0.3ns	0.9*	1.2*
14	WPD4	1.7	0.6*	0.9*	
15	WUD4	1.1	0.3ns		
16	SPD4	0.8			
17	WUD4	2.0	0.9*	1.2*	1.2*
18	WUD2	1.1	0.3ns	0.3ns	
19	WUD1	0.8	0.0ns		
20	WUD3	0.8			
21	SUD4	1.7	0.1ns	0.2ns	0.5*
22	SUD2	1.6	0.1ns	0.4ns	
23	SUD1	1.5	0.3ns		
24	SUD3	1.2			
25	WPD2	1.4	0.3ns	0.4ns	0.6*
26	WPD4	1.1	0.1ns	0.3ns	
27	WPD1	1.0	0.2ns		
28	WPD3	0.8			
29	SPD4	0.8	0.2ns	0.1ns	0.2ns
30	SPD2	0.7	0.0ns	0.1ns	
31	SPD1	0.7	0.1ns		
32	SPD3	0.6			

***=** significant at 5% level; ns = not significant

CONCLUSION

In this study, a survey was conducted to examine the existing traditional size-reduction treatments, drying methods, ginger processed products and their uses in the study area. A set of experiments were also conducted to examine the effects of the traditional size-reduction treatments and drying methods on dried ginger quality and oil/oleoresin yield. Different samples of freshly harvested ginger in whole-unpeeled (WU), split-unpeeled (SU), whole-peeled (WP) and split-peeled (SP) forms were dried under sun drying (D1), solar drying (D2), natural air drying (D3) and fire-heated drying (D4) methods. The result show that splitting ginger rhizomes into halves and spreading them on hard compact platform under the sun to dry is the popular primary processing technology in the study area. Split-dried ginger form was found to be the most accepted form in both the local and international ginger trade. The result in Table2a represents the summary of the data obtained on dried ginger oil/oleoresin content. The analysis indicates that the combined effect of size-reduction treatment (P) and drying methods (D) on essential oil/oleoresin content of dried ginger was highly significant (0.05). Comparing the interaction means of the physical processing treatment (P) and the drying methods (D), the Whole-unpeeled samples dried under fire-heated drying method (WUD4), split-unpeeled samples dried under fire-heated drying method (SUD4), split-unpeeled samples dried under solar drying method (SUD2) and split-unpeeled samples dried under open-sun drying method (SUD1) recorded significant yields of ginger oil/oleoresin, while samples of whole-peeled (WP) and split-peeled (SP) dried under the different drying methods recorded very insignificant yields of oil/oleoresin. The study suggests that for industrial production of ginger oil/oleoresin, farmers should adopt drying ginger whole-unpeeled under fire-heated drying method.

NOTATIONS

WUU -Whole-unpeeled unsoaked
WUS -Whole-unpeeled soaked
WUB -Whole-unpeeled bleached
SUU -Split-unpeeled unsoaked
SUS -Split-unpeeled soaked
SUB -Split-unpeeled bleached
WPU -Whole-peeled unsoaked
WPS -Whole-peeled soaked
WPB -Whole-peeled bleached
SPU -Split-peeled unsoaked
SPS -Split-peeled soake
SPB -Split-peeled bleached
D1 -Open-sun drying
D2 -Solar drying
D3 -Natural-air drying

D4 -Open-fire-heated drying

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