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Research article

An examination of the nutritional value of various fruits and vegetables dried using both conventional and contemporary techniques

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Abstract: Even though they contain vital vitamins, minerals, antioxidants, fibre, and carbs that enhance the quality of the diet, fruits and vegetables have higher nutritional benefits than other foods. Many fruits and vegetables are seasonal and highly biodegradable due to post-harvest losses, despite their nutritional and health benefits. Fruit and vegetable post-harvest losses in poor nations are reportedly between 30 and 40 percent. The primary causes of this loss are deficient post-harvest handling procedures, a lack of convenient processing technology and storage options, inadequate infrastructure, and weak marketing strategies. Using preservation techniques like canning, freezing, and drying can help reduce waste and improve the quality of food products. Fruit and vegetable drying is one of the earliest methods of food preservation that has ever been used by humans. It contributes significantly to product quality enhancement, marketability, and storage life extension. In the present case traditional and improved solar drying methods on the quality and nutritional composition of the dried fruits and vegetables are studied using different solar drying methods namely; open sun drying, a conventional solar dryer, and a newly improved solar dryer technology. Results showed that the solar drying methods were capable of retaining the quality and nutritional composition of dried vegetables.

Keywords: Fruits - Nutrient values - Vitamins - Minerals.

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INTRODUCTION

Due to their variety in colour, flavour, amount of nutrients, and health advantages, fruits and vegetables occupy a special position in the diet (Ssemwanga *et al.* 2020). They are excellent providers of dietary fibre, iron, zinc, folate, vitamin A, and vitamin C (Abrol *et al.* 2014*)*. The average amount of fruits consumed in India is substantially lower than the daily required allotment; as a result, many Indians experience deficiency disorders (An *et al.* 2016, Civille & Carr 2015).

Due to their high water activity, fruits and vegetables are quite perishable; consequently, treatments involving the removal of this moisture aid in their preservation. There is a severe nationwide scarcity of fruits throughout the dry months of the year, and the price rises beyond what a poor man can afford (George *et al.* 2015, Jodicke *et al.* 2019). Surplus fruits and vegetables must be stored for future use in order to meet the demands of the populace (Lamidi *et al.* 2019, Kumar *et al.* 2016). The goal of this study is to determine how various drying techniques affect the nutritional value of five fruits and five vegetables

MATERIALS AND METHODS

Materials

Fruits (apple, strawberries, banana, guava and pomegranate) and vegetables (cauliflower, capsicum, carrot, tomato and mint) were collected from local market and were washed with water.

Treatments

The fruits were dried using enhanced solar dryers, hot air ovens, microwaves, direct sun dryers, and solar

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dryers (Lamidi *et al.* 2019, Li *et al.* 2017).

Method

Fruits and vegetables were cut at a thickness of 2-3 mm after the exterior, inedible sections were removed (Orphanides *et al.* 2016, Prakash *et al.* 2016). Simultaneous replication drying cycles of three were carried out. The components were evenly dispersed among all of the fruits and vegetables. For assessments of nutrient absorption, the dried samples were ground and sieved using a 0.5 mm sieve to get uniform size granules, then packaged in airtight polythene bags (Owureku-Asare *et al.* 2017, Tunçkal *et al.* 2018, Wang *et al.* 2018).

RESULTS AND DISCUSSION

The tables are showing the nutrient analyses for fresh ripen and dried fruits as well as fresh and dried vegetables using different drying techniques (namely Hot air oven, Microwave, direct sun drying, solar drying and improved solar dryer). Table 1 is showing the nutrient analysis for fruits (apple, strawberry, banana, guava and pomegranate), whereas table 2 is showing the nutrient analysis for vegetables (cauliflower, capsicum, carrot, tomato and mint).

Table 1. Nutrient analysis for fresh and dried fruits (apple, strawberry, banana, guava and pomegranate).

S.N.	Parameters	Units	Ripen	Hot Air oven	Microwave	Direct sun drying	Solar drying	Improved solar dryer
1. APPLE								
1	Moisture	%				85.6		
2	Carbohydrates	g	13.8	13.1	13	14.4	14.9	15.3
3	Proteins	g	0.26	0.21	0.2	0.31	0.39	0.41
4	Vitamin - A	mg	0.06	0.02	0.02	0.11	0.12	0.13
5	Vitamin - B complex	mg	0.23	0.18	0.18	0.27	0.4	0.44
6	Vitamin - C	mg	4.6	3.2	4.1	4.9	5.1	5.4
7	Calcium	mg	6	2.7	3.7	7.1	7.1	7.2
8	Phosphorus	mg	11	5.8	6.1	10.4	11	10.8
9	Iron	mg	0.12	0.08	0.11	0.19	0.29	0.31
10	Potassium	mg	107	79	81	110	116	115
11	Manganese	mg	0.035	0.025	0.052	0.047	0.066	0.063
12	Zinc	mg	0.04	0.02	0.02	0.1	0.1	0.1
2. STRAWBERRIES								
1	Moisture	%				90.9		
2	Carbohydrates	g	7.7	6.7	6.8	8.4	9.8	10.1
3	Proteins	g	0.67	0.55	0.51	0.63	0.78	0.83
4	Vitamin - A	mg	--	--	--	--	--	--
5	Vitamin - B complex	mg	0.6	0.47	0.44	0.66	0.69	0.71
6	Vitamin - C	mg	58.8	50.4	52.3	59.5	69.5	64.3
7	Calcium	mg	16	17.7	16.2	18.4	21.1	21.2
8	Phosphorus	mg	24	20.6	22.4	23.8	26.1	28.6
9	Iron	mg	0.41	0.51	0.49	0.69	0.81	0.88
10	Potassium	mg	154	162	164	172	172	171
11	Manganese	mg	0.386	0.361	0.401	0.397	0.455	0.473
12	Zinc	mg	0.14	0.18	0.13	0.11	0.18	0.18
3. BANANA								
1	Moisture	%				74.9		
2	Carbohydrates	g	22.8	20.9	21.7	26	28.1	28.3
3	Proteins	g	1.1	0.94	0.97	1.14	1.29	1.31
4	Vitamin - A	mg	--	--	--	--	--	--
5	Vitamin - B complex	mg	1.58	1.41	1.37	1.52	1.77	1.82
6	Vitamin - C	mg	8.7	8.4	7.9	8.8	8.9	8.9
7	Calcium	mg	--	--	--	--	--	--
8	Phosphorus	mg	22	20	19	28	21	31
9	Iron	mg	0.26	0.34	0.47	0.39	0.49	0.48
10	Potassium	mg	358	418	435	400	487	472
11	Manganese	mg	0.27	0.21	0.24	0.31	0.43	0.39
12	Zinc	mg	0.15	0.19	0.25	0.21	0.21	0.23
4. GUAVA								
1	Moisture	%				68.7		
2	Carbohydrates	g	14.3	16.8	17.2	17.1	18.1	18.2

3	Proteins	g	2.55	2.08	2.44	2.63	2.88	2.86
4	Vitamin - A	mg	0.4	0.29	0.38	0.54	0.55	0.67
5	Vitamin - B complex	mg	1.75	1.88	2.04	1.92	2.1	2.13
6	Vitamin - C	mg	228.3	300.4	345.6	339.5	299.8	376.1
7	Calcium	mg	18	20.1	21.7	20.4	22.6	23
8	Phosphorus	mg	40	38	44	43.8	48.8	49
9	Iron	mg	0.26	0.27	0.3	0.29	0.29	0.32
10	Potassium	mg	417	438	409	410	495	488
11	Manganese	mg	0.1	0.14	0.13	0.17	0.19	0.17
12	Zinc	mg	0.23	0.41	0.32	0.37	0.42	0.4
	5. POMEGRANATE							
1	Moisture	%				78		
2	Carbohydrates	g	18.7	17.4	18.2	16	19.8	20.1
3	Proteins	g	1.67	1.52	1.55	0.63	1.77	1.98
4	Vitamin - A	mg	--	--	--	--	--	--
5	Vitamin - B complex	mg	0.865	1.058	0.996	0.917	1.101	1.113
6	Vitamin - C	mg	10.2	20.4	18.4	19.7	23.8	23.4
7	Calcium	mg	10	11.2	10	12.6	15.4	17
8	Phosphorus	mg	36	32.1	30.7	33.8	40	40
9	Iron	mg	0.3	0.33	0.39	0.41	0.58	0.53
10	Potassium	mg	236	267	240	272	292	287
11	Manganese	mg	0.119	0.108	0.102	0.12	0.12	0.121
12	Zinc	mg	0.35	0.31	0.38	0.3	0.41	0.44

Table 2. Nutrient analysis for fresh and dried vegetables (cauliflower, capsicum, carrot, tomato and mint).

	1. CAULIFLOWER							
S.N.	**Parameters**	**Units**	**Raw**	**Hot Air oven**	**Microwave**	**Direct sun drying**	**Solar drying**	**Improved solar dryer**
1	Moisture	%				92		
2	Carbohydrates	g	5	8.67	8.67	8.67	9.24	9.88
3	Proteins	g	1.9	2.77	2.81	2.54	2.98	3.1
4	Vitamin - A	mg	--	--	--	--	--	--
5	Vitamin - B complex	mg	1.47	2.44	2.59	2.47	2.55	2.71
6	Vitamin - C	mg	48.2	59.6	57.4	58.2	62.6	64.7
7	Calcium	mg	22	39	39	39	37	41
8	Phosphorus	mg	44	60	58	55	63	68
9	Iron	mg	0.42	0.62	0.67	0.72	0.68	0.73
10	Potassium	mg	299	411	379	329	418	423
11	Manganese	mg	0.155	0.308	0.296	0.285	0.312	0.334
12	Zinc	mg	0.27	0.42	0.49	0.48	0.51	0.57
	2. CAPSICUM							
1	Moisture	%				92		
2	Carbohydrates	g	4.64	6.86	7.02	6.64	7.29	7.43
3	Proteins	g	0.9	1.7	1.5	1.9	2	2.1
4	Vitamin - A	mg	1.78	2.11	2.07	2.53	2.66	2.78
5	Vitamin - B complex	mg	1.81	3.13	3.13	3.13	3.37	3.41
6	Vitamin - C	mg	142	222	222	222	220	227
7	Calcium	mg	6	10.7	10.7	10.7	11.1	11
8	Phosphorus	mg	27	39	39	39	40	43
9	Iron	mg	0.35	0.65	0.65	0.65	0.61	0.68
10	Potassium	mg	213	298	307	313	342	366
11	Manganese	mg	0.122	0.202	0.217	0.212	0.211	0.216
12	Zinc	mg	0.2	0.34	0.39	0.38	0.4	0.41
	3. CARROT							
1	Moisture	%				88		
2	Carbohydrates	g	9.6	15.1	16.8	17.1	17.5	17.6
3	Proteins	g	0.93	1.88	1.96	2.1	2	2.3
4	Vitamin - A	mg	9.38	16.4	17.7	17.8	18.1	18.4
5	Vitamin - B complex	mg	1.52	1.99	2.11	2.04	2.16	2.22
6	Vitamin - C	mg	5.9	9.4	8.9	9.8	10.2	10.6
7	Calcium	mg	33	41	48	46	51	57

8	Phosphorus	mg	35	49	56	51	54	59
9	Iron	mg	0.3	0.61	0.73	0.68	0.7	0.73
10	Potassium	mg	320	498	527	520	539	576
11	Manganese	mg	0.143	0.287	0.273	0.307	0.311	0.313
12	Zinc	mg	0.24	0.37	0.42	0.41	0.4	0.48
	4. TOMATO							
1	Moisture	%			94.5			
2	Carbohydrates	g	3.9	7.8	8.4	8.4	8.5	8.7
3	Proteins	g	0.9	1.3	1.3	1.3	1.62	1.6
4	Vitamin - A	mg	0.61	1.01	1.18	1.08	1.11	1.21
5	Vitamin - B complex	mg	0.799	1.49	1.44	1.38	1.51	1.55
6	Vitamin - C	mg	14	17.4	16.9	18.1	18.2	18.8
7	Calcium	mg	10	14.1	15.1	14.9	15.3	15.6
8	Phosphorus	mg	24	29	31	30	32	32
9	Iron	mg	0.27	0.31	0.33	0.36	0.35	0.39
10	Potassium	mg	237	327	313	337	326	341
11	Manganese	mg	0.14	0.29	0.31	0.34	0.33	0.31
12	Zinc	mg	0.17	0.22	0.21	0.23	0.22	0.27
	5. MINT							
1	Moisture	%			85.5			
2	Carbohydrates	g	8.4	10.2	10.6	10.6	11.4	11.9
3	Proteins	g	3.3	4.8	5.1	5.3	5.5	5.8
4	Vitamin - A	mg	4.2	6.1	5.9	6.2	6.3	6.5
5	Vitamin - B complex	mg	1.6	2.9	3.1	3.6	3.3	3.7
6	Vitamin - C	mg	13.3	17.1	17.8	17.3	18.1	18.5
7	Calcium	mg	199	273	244	237	230	288
8	Phosphorus	mg	60	76	72	68	71	73
9	Iron	mg	11.9	14.9	15.7	15.1	14.6	15.4
10	Potassium	mg	458	523	518	538	559	584
11	Manganese	mg	1.118	2.02	2.22	2.12	2.18	2.24
12	Zinc	mg	1.09	1.56	1.76	1.66	1.7	1.74

Moisture

Fruits and vegetables generally contain varying amounts of moisture, which contributes to their juiciness and overall texture. The moisture content of fruits can differ depending on the type of fruit, its ripeness, and growing conditions. The moisture content present in the selected fruits range from 68.7–90.9 %. The minimum moisture is reported for Guava and maximum moisture content is shown for strawberry. The average moisture present is all the fruits is around 81%. In the selected vegetables mint shows minimum moisture content as 85.5% while maximum moisture content is shown by tomato as 94.5%.

Carbohydrates

Fruits are a natural source of carbohydrates, which are essential for providing energy to the body. The carbohydrate content in fruits can vary depending on the specific type of fruit and its ripeness. It's important to note that carbohydrates in fruits primarily consist of natural sugars, such as fructose. These sugars are accompanied by dietary fiber, vitamins, minerals, and other beneficial compounds that contribute to the overall nutritional value of fruits. While fruits do contain carbohydrates, they are generally considered a healthy food choice due to their nutrient content and the fact that they often have a low glycemic index, meaning they have a minimal impact on blood sugar levels when consumed in moderation. In the present study the carbohydrate content present in the fruits is found to be between 10.1–28.3 gm per 100gm. The minimum value is shown by Strawberry while maximum value is obtained for banana fruit.

The carbohydrates in the selected vegetables vary in the range 3.9 to 72 g / 100 gm. The minimum value is shown by tomato and the maximum value is shown by Fenugreek vegetable.

Proteins

In the present study the protein content in the selected fruits ranges from 0.20 gm to 2.88 gm per 100 gm. The minimum protein is found in apple while maximum protein content is present in Guava. Similarly the protein content in the selected fruits ranges from 0.9 gm to 29.4 gm per 100 gm. The minimum protein is found in capsicum and tomato while maximum protein content is present in Fenugreek.

Vitamin A

Vitamin A is a necessary ingredient that is required for sustaining cell growth and development, immunological function, and keeping good vision. While fruits are not typically high in vitamin A compared to vegetables and animal-based foods, some fruits do contain this important vitamin. In the selected fruits the vitamin A ranges from 0.02–11.6 mg / 100 gm. The minimum value is found in apple white the highest value is for pineapple fruit. In the selected seven vegetables the vitamin A ranges from 0.04–18.4 mg / 100 gm. The minimum value is found in cauliflower white the highest value is for carrot.

Vitamin B complex

The vitamin B complex consists of a group of water-soluble vitamins that play essential roles in various bodily functions, including energy production, metabolism, and nervous system health. While fruits are not the primary source of vitamin B complex, some fruits do contain certain B vitamins in varying amounts. The values for Vitamin B complex varies from 0.18 to 2.13 mg / 100 gm. The minimum is shown by apple and the highest value is obtained for guava fruit. The values for Vitamin B complex varies from 0.56 to 3.7 mg / 100 gm. The minimum is shown by bitter gourd and the highest value is obtained for Fenugreek and Mint.

Vitamin C

Vitamin C, also known as ascorbic acid, is a water-soluble vitamin that is well-known for its role in supporting the immune system, promoting collagen synthesis, and acting as an antioxidant in the body. Fruits are excellent sources of vitamin C, and many of them contain significant amounts of this important nutrient. The analysis results for Vitamin C ranges from 5.4 mg for apple to 376.1 mg / 100gm for Guava fruit. The analysis results for Vitamin C ranges from 3 mg for Fenugreek to 227 mg / 100gm for Capsicum fruit.

Calcium

Fruits are generally not significant sources of calcium compared to other food groups like dairy products or fortified plant-based milks. Calcium is primarily found in foods such as dairy products, leafy green vegetables, and fortified products. However, there are a few fruits that contain small amounts of calcium. The minimum value for calcium is obtained for apple *i.e.* 0.31 mg / 100 gm and the highest value of 17 mg / 100gm is obtained for pomegranate.

Phosphorus

Fruits are generally not significant sources of phosphorus compared to other food groups like meats, dairy products, legumes, and whole grains. Phosphorus is a mineral that is found in higher quantities in animal-based foods and plant-based foods like legumes and whole grains. However, there are a few fruits that contain small amounts of phosphorus. The analysis result shows the phosphorus values in the range 6.1–49 mg / 100 gm. The minimum value is shown by apple while maximum value is shown by guava. The analysis result shows the phosphorus values in the range 32–423 mg / 100 gm. The minimum value is shown by Tomato while maximum value is shown by Fenugreek.

Iron

Iron is an essential mineral that plays a crucial role in carrying oxygen throughout the body and supporting various physiological processes. While fruits are not typically considered significant sources of iron compared to foods like meat, legumes, and leafy green vegetables, some fruits do contain small amounts of this mineral. The value for iron in fruits ranges from 0.31–0.88 mg / 100 gm. The lowest value is shown by apple and highest value is shown by strawberries. The value for iron in fruits ranges from 0.3–15.4 mg / 100 gm. The lowest value is shown by tomato and highest value is shown by Mint.

Potassium

Fruits are excellent sources of potassium, an essential mineral that plays a vital role in maintaining proper fluid balance, supporting heart health, and promoting proper muscle and nerve function. Many fruits are rich in potassium. The analysis result for potassium ranges from 115 mg / 100 gm for pineapple fruit and 488 mg / 100 gm is obtained for guava fruit. The analysis result for potassium ranges from 213 mg / 100gm for capsicum and 488 mg / 100 gm is obtained for Fenugreek.

Manganese

Manganese is an essential trace mineral that is involved in various physiological processes, including metabolism, bone development, and antioxidant activity. While fruits are not typically considered significant sources of manganese, some fruits do contain small amounts of this mineral. The values for manganese ranges

between 0.025–1.632 mg / 100 gm. The minimum value is for apple and maximum value is obtained for pineapple. The values for manganese ranges between 0.1–2.24 mg / 100 gm. The minimum value is for Bitter Gourd and maximum value is obtained for Mint.

Zinc

Zinc is a necessary mineral that is important for many body processes, including protein synthesis, cell division, wound healing, and immunological function. While fruits are not typically considered significant sources of zinc, some fruits do contain small amounts of this mineral. The lowest value for zinc *i.e.* 0.1 mg is for apple while the highest value of 0.44 mg / 100 gm is obtained for pomegranate fruit. The lowest value for zinc *i.e.* 0.17 mg is for tomato while the highest value of 0.44 mg / 100 gm is obtained for Fenugreek.

From the above tables 1 and 2 it is clearly seen that the dried fruits and vegetables can retain the good number of nutrient values. Also, it is very clear from the tables that the improved solar drying technique shows the highest nutrient values for all the fruits and vegetables as compared to the other drying technology.

CONCLUSION

The quantity of nutrients maintained may be useful, especially in populations with few other sources of these micronutrients, despite the examination of the results showing significant losses in minerals as a result of drying. Fruit drying should be promoted as a means to guarantee a year-round supply of micronutrients to communities at risk. When in season, fruits can be preserved and fed to children. Fruit drying should be encouraged using sun dryers. Since solar dryers are an expensive facility, women, for instance, should be encouraged to organise into groups through which soft loans can be provided by microfinance organisations for the purchase of solar dryers. Fruit drying using the sun is another suggested low-tech method for preserving food.

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