Journal of Microbiology, Biotechnology and Food Sciences

Akinyele et al. 2012 : 2 (2) 701-712

REGULAR ARTICLE

EFFECT OF ELECTROMAGNETIC FIELD ON THE SPOILAGE FUNGI OF SOME SELECTED EDIBLE FRUITS IN SOUTHWESTERN, NIGERIA

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ABSTRACT

The influence of electromagnetic field wave on the survival of spoilage fungi associated with some edible fruits consumed in southwestern, Nigeria was studied using cashew (*Anacardium occidentale* L.), pineapple (*Ananas comosus*), carrot (*Daucus carota*), cucumber (*Cucumis sativus*), apple (*Malus domestica*) and African star apple (*Chrysophyllum africanum*). The spoilage fungi used include the genera of *Aspergillus, Penicillium, Articulospora, Mucor, Staphylotrichum, Bisbyopeltis, Fusarium, Rhizopus* and a yeast, *Saccharomyces cerevisiae*. There was a general decrease in fungal growth as shown in the number of spores produced with increase in exposure time of isolates to electromagnetic field except in *Articulospora inflata, Penicillium italicum* and *Mucor mucedo* where there was stimulatory effect as there was increase in the fungal spores compared to the control. A decrease was also observed in growth of the fungal isolates with increase in the intensity of the electromagnetic field at voltage of 7 V to 10 V and from 10 V to 13 V. The highest percentage reduction was recorded by *Bisbyopeltis phoebesii* at intensity of voltage 13V after 60 minutes of exposure. Exposure of the fruits to electromagnetic field wave did not alter the nutrient components of the fruits as observed in the proximate and mineral contents of the treated and untreated fruits. The result of the study revealed that electromagnetic field wave has great potential for use in the control of fruits spoilage and food preservation.

Keywords: Berry, electromagnetic field, spoilage, fungi, control

INTRODUCTION

One of the limiting factors that influence the fruits economic value is the relatively short shelf-life period caused by spoilage organisms and pathogens' attack **(Rashad *et al*., 2011)**. It is estimated that about 20-25% of harvested fruits are lost during post-harvest handling even in the developed countries **(Droby, 2006; Zhu, 2006)**. In developing countries, however, post-harvest losses are often more severe due to inadequate storage and transportation facilities **(Rashad *et al*., 2011)**. Fungal infections of fruits may occur during the growing season, harvesting, handling, transport and post-harvest storage and marketing conditions, or after purchase by consumers. Fruits contain high level of sugar and nutritional elements. Their low pH values make them particularly desirable to fungal decay **(Singh and Sharma, 2007)**.

The traditional methods of food preservation though guarantees its safety, sometimes cause loss of sensitive nutrients, denaturation of proteins as well as changes of structure, colour and taste. Also, there may be the formation of new undesirable substances **(Lipiec *et al*., 2004)** thereby emphasizing the importance of non-thermal methods of food preservation. These methods preserve the nutritious value of food and at the same time, reduce threat by spoilage organisms. The antimicrobial effect of exposure to electromagnetic field is not due to the temperature effect, but rather its ability to cause damage to the cell structure and composition. Results of previous studies have confirmed the inhibition of microorganisms when placed in electromagnetic fields and inhibitory effect on microbial population **(Lipiec *et al*., 2004)**. The aim of this study, therefore, was to analyze the antimicrobial effect of varying electromagnetic field wave at various periods on the spoilage fungi of some common edible fruits in southwestern, Nigeria.

MATERIAL AND METHODS

Source of Isolates

Fungi associated with the spoilage of the selected edible fruits were obtained from a previous study and confirmed by subculturing them on freshly prepared Potato Dextrose Agar

(PDA) plates. Isolates were identified using the methods of **Olutiola *et al.* (2000)** and **Barnett and Hunter (1998).**

Treatment of Isolates with Electromagnetic Field Wave

An electric circuit that generated the Electromagnetic field wave used for this research work was designed and constructed at the Department of Physics, Federal University of Technology, Akure, Nigeria. The Electromagnetic field wave was generated from solenoid coil of hundreds of turns of copper wire. The coil was connected across a voltage source of about 15 V which induced magnetic field around the coil. The intensity of the field was varied through the variable resistor of 10kΩ and the timing circuit was wired with 555 timer integrated circuit (IC) as an Astable multivibrator. A Triac, a high current switching device was employed to control the flow of current through the coil. The whole circuitry was cased in a locally fabricated Perspex case which served as a guide for the wave. A hole was created through which the wave was focused on the sample.

Isolates from the stock culture were transferred unto freshly prepared plates and afterwards multiplied in liquid nutrient medium (broth). From every breed, 1 ml inoculum was taken and introduced into 9 ml freshly prepared broth in test tubes. Then, the test tubes were treated with electromagnetic field wave generated by 7, 10 and 13 V for 0, 15, 30, 45 and 60 minutes respectively. Non-treated isolates were taken as control material.

After the treatment of isolates with electromagnetic field wave, the isolates were inoculated on petri dishes containing selected medium and incubated at 25℃ for 3 – 5 days. The same process as above was repeated for the control. All these were made in three replicates. After the incubation period, the fungal spores were counted to determine the effect of electromagnetic field wave on the number of spores using New Improved Neuber Haemacytometer.

Proximate and Mineral Analysis of Fruits

Proximate analysis was carried out on treated and untreated fruits according to **AOAC (2005)**.

Statistical Analysis of Data

Data obtained were analyzed using the Analysis of Variance (ANOVA) and the means separated using Duncan's New Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The electromagnetic field significantly reduced the growth of the fungi compared to the control except in *Articulospora inflata, Penicillium italicum* and *Mucor mucedo* where treatment with electromagnetic field wave had a stimulatory effect with an increase in the number of fungal spores compared to the control. It was observed that increase in the intensity of the electromagnetic field further reduced the number of the fungal spores. Zhang *et al*. (1994) observed that various inactivation levels of S. *cerevisiae* have been achieved in food models and foods using a variety of PEF chambers and experimental conditions.

The effects of electromagnetic field wave at different intensities and periods of exposure on spoilage fungi isolated from cashew, pineapple, apple, cucumber, carrot and African star apple are as shown in figures 1, 2, 3and 4 respectively .Growth reduction in percentages of fungi treated with electromagnetic field wave at different intensities for different periods of exposure are shown in Table 1 while percentage increase in the spores of fungi on which electromagnetic field showed stimulatory effect are reported in Table 2.

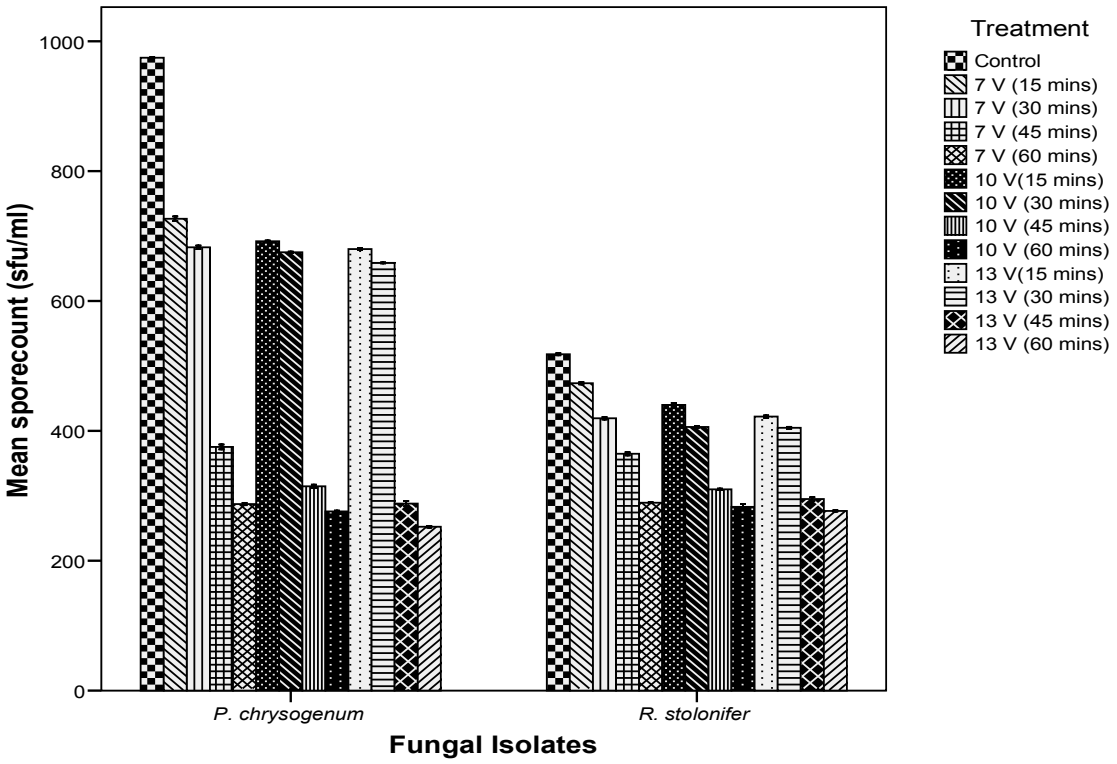

Figure1 Effect of EMF wave on Fungi Isolated from Cashew

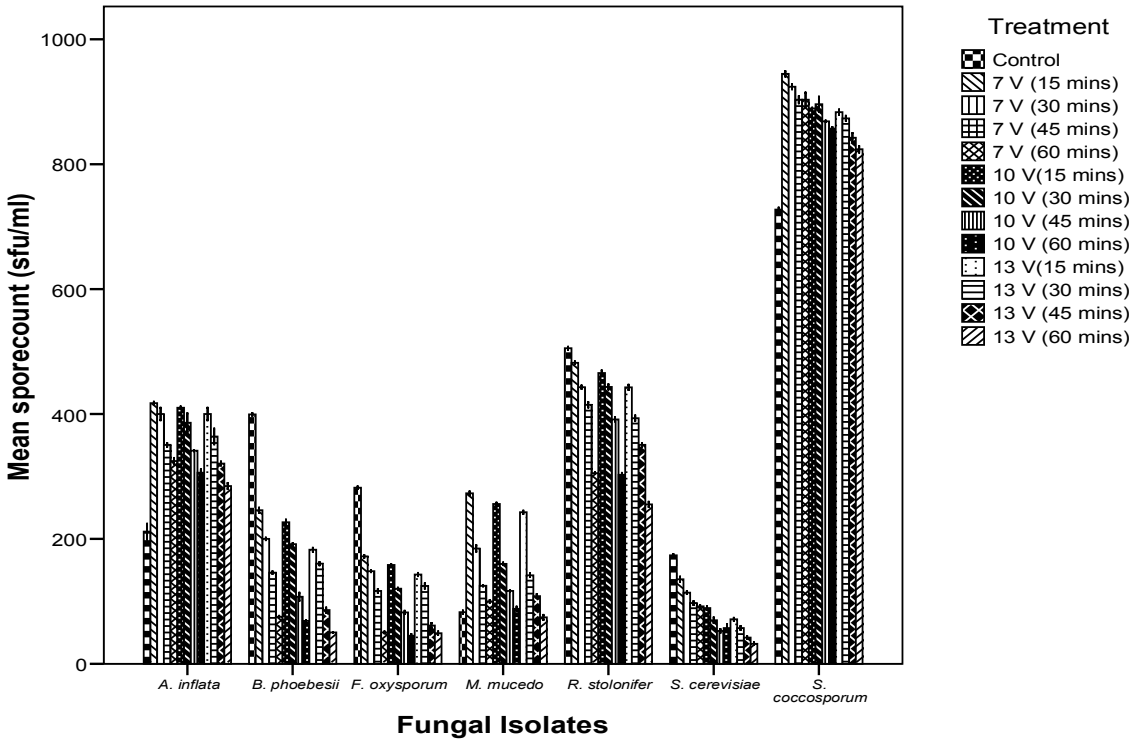

Figure 2 Effect of EMF wave on Fungi Isolated from Pineapple

Increased duration of exposure to electromagnetic field resulted in decrease of most of the fungal isolates by at least 50% when compared with the control showing the maximum percentage reduction at 60 minutes exposure period. Consumption of fruit and vegetable products has dramatically increased by more than 30% during the past few decades. It is also estimated that about 20% of all fruits and vegetables produced is lost annually to spoilage **(Akinmusire, 2011)**. However, the growing interest in what is commonly known as healthy and safe food, that is food with a high nutritive value, can be observed world-wide **(Lipiec *et. al*., 2004).**

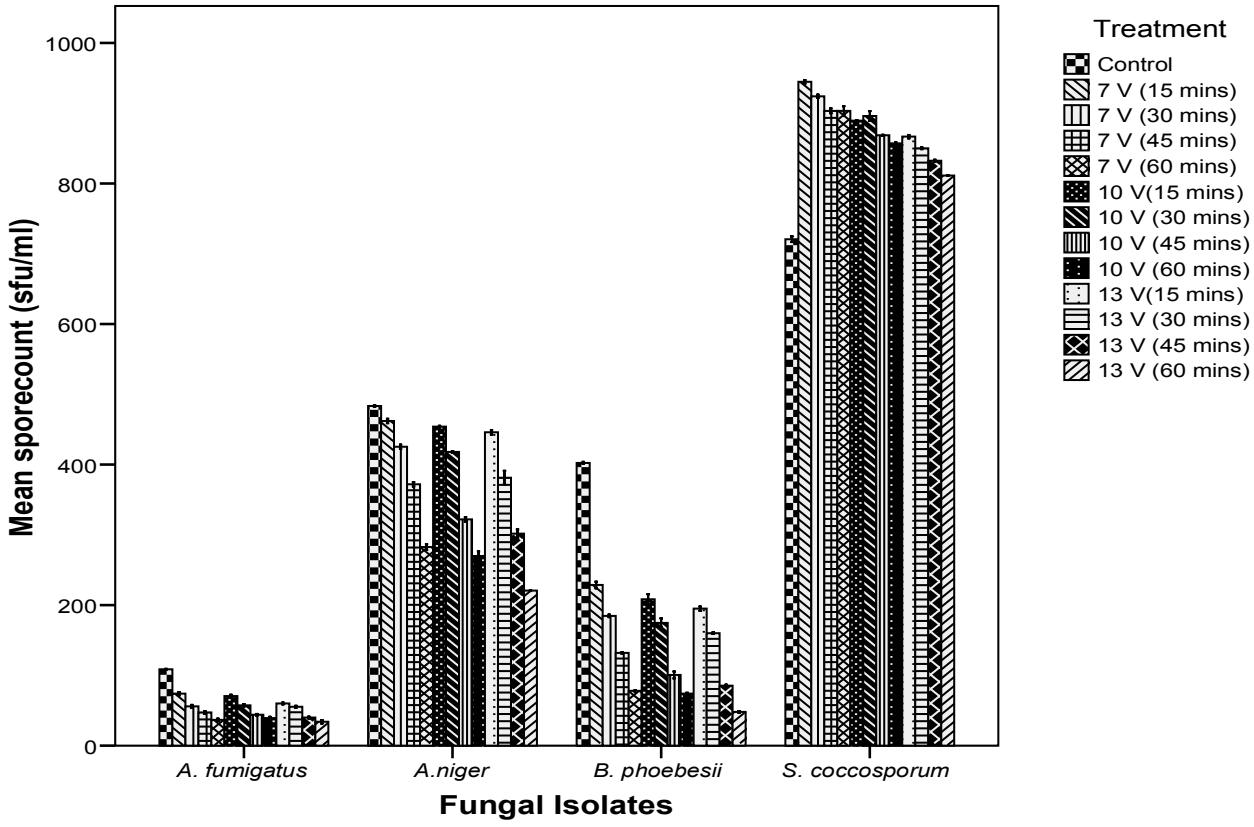

Figure 3 Effect of EMF wave on Fungi Isolated from Apple

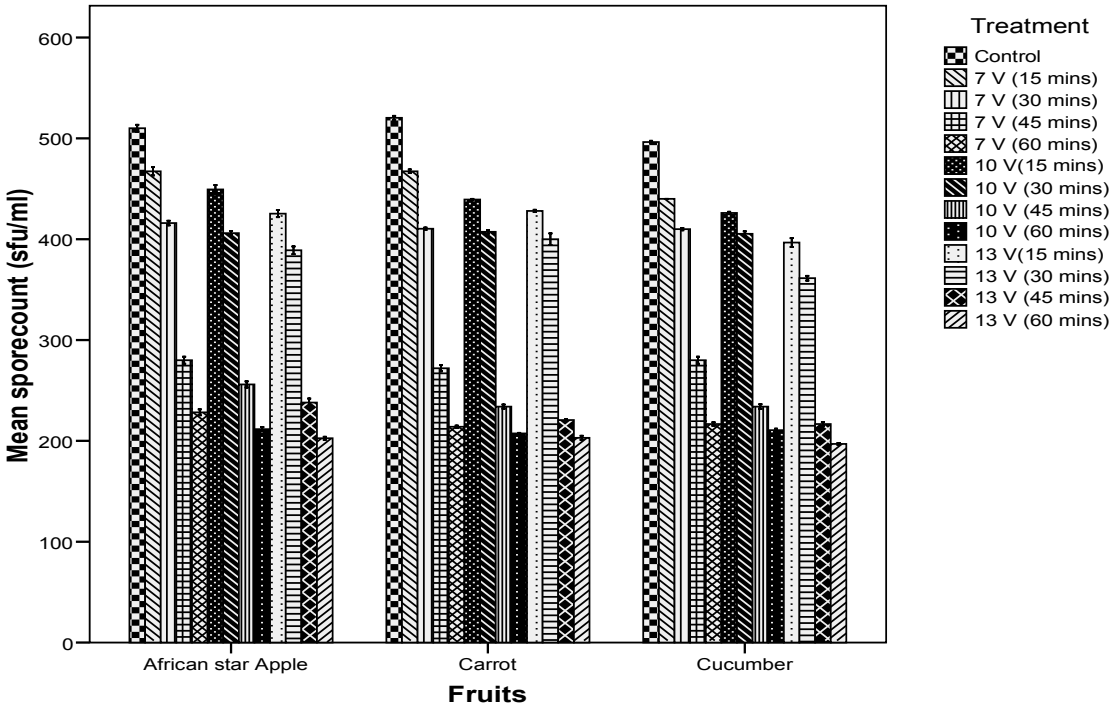

Figure 4 Effect of EMF wave on *Rhizopus stolonifer* Isolated from African Star Apple, Carrot and Cucumber

Table 1 Percentage Decrease of Isolated Fungi from Selected Edible Fruits

Isolates	Pineapple (*Ananas comosus*)				Cashew (*Anacardium occidentale)*		Apple (*Malus domestica*)			Cucumber (*Cucumis sativus*)	Carrot (*Daucus carota*)
	B. phoebesii	*F. oxysporum*	*R. stolonifer*	*S. cerevisiae*	*P. chrysogenun*	*R. stolonifer*	*A. fumigatus*	*A. niger*	*B. phoebesii*	*R. stolonifer*	*R. stolonifer*
15m(7V)	38.4± .32^{c}	39.0±0.62^{c}	4.6 ± 0.80^{a}	22.1±1.46^{b}	25.5 ± 0.62	8.6 ± 0.88	31.9± 4.31^{b}	4.4±1.14^{a}	43.2 ±2.31^{c}	11.4 ± 0.37	10.2 ± 0.54
30m(7V)	49.9± .76^{d}	47.4±0.19^{c}	12.3±0.92^{a}	34.3±1.79^{b}	30.0 ± 0.52	19.1±0.84	48.5± 2.62^{b}	11.9±1.26^{a}	54.1 ±0.75^{c}	17.4 ± 0.59	21.1 ± 0.72
45m(7V)	63.4± .58^{d}	58.6±0.92^{c}	17.9±0.63^{a}	43.9±2.42^{b}	61.5 ± 0.65	29.6±0.50	56.4± 3.24^{b}	23.0±1.26^{a}	67.2 ±0.61^{c}	43.6 ± 1.44	45.0 ± 2.64
60m(7V)	81.1±0.35^{c}	82.2±0.52^{c}	39.6±0.45^{a}	47.0±0.82^{b}	70.5 ± 0.31	44.1±0.46	63.8± 2.78^{b}	41.5±1.33^{a}	80.6 ±0.44^{c}	56.3 ± 0.80	58.9 ± 0.32
15m(10V)	43.2±1.22^{b}	43.9±0.41^{b}	7.9 ± 0.96^{a}	48.6±1.25^{c}	29.0 ± 0.28	15.1±1.33	34.9± 3.03^{b}	6.1± 0.31^{a}	48.2 ±2.82^{c}	14.2 ± 0.60	15.6 ± 0.78
30m(10V)	52.0±0.22^{b}	57.3±0.53^{c}	12.3±1.01^{a}	59.9±3.06^{c}	30.8 ± 0.10	21.6±0.50	47.2± 3 33^{b}	13.5±0.31^{a}	56.6 ±3.09^{c}	18.3 ± 0.73	21.7 ± 0.89
45m(10V)	73.1±1.47^{c}	70.8±1.10^{b,c}	22.6±0.83^{a}	69.7±1.98^{b}	67.7 ± 0.42	40.2±0.54	59.5± 2.22^{b}	33.4±0.92^{a}	74.9 ±2.06^{c}	52.9 ± 0.78	55.0 ± 0.41
60m(10V)	82.8±0.31^{c}	84.1± 0.83^{c}	40.1±0.83^{a}	67.0±3.69^{b}	71.7 ± 0.18	45.4±1.24	66.2± 3.09^{b}	44.1±2.44^{a}	81.6 ±0.44^{c}	57.6 ± 0.33	60.2 ± 0.15
15m(13V)	54.3±0.66^{c}	49.3± 1.07^{b}	12.4±0.81^{a}	58.9±1.54^{d}	30.2 ± 0.14	18.5±0.94	44.8± 2.36^{b}	7.7 ± 0.86^{a}	51.5± 1.54^{c}	20.1 ± 1.20	17.7 ± 0.18
30m(13V)	59.9±0.69^{c}	55.8± 1.71^{b}	22.2±1.10^{a}	67.0±1.84^{d}	32.4 ± 0.04	21.9±0.72	49.1± 2.44^{b}	21.1±3.73^{a}	60.2 ±0.46^{c}	7.2 ± 0.97	23.1 ± 1.41
45m(13V)	78.5±1.11^{c}	78.3± 1.33^{c}	30.6±0.74^{a}	75.8± .26^{b}	70.5 ± 0.72	43.1±0.70	63.2 ± 19^{b}	37.6 ± 2.0^{a}	78.8 ±0.76^{c}	56.4 ± 0.78	64.6±11.94
60m(13V)	87.4±0.14^{c}	82.6± 0.97^{b}	49.5±0.60^{a}	81.6±1.13^{b}	74.1 ± 0.20	46.6±0.05	68.7 ± 3.96^{b}	54.4±0.11^{a}	88.0 ±0.57^{c}	60.3 ± 0.48	61.0 ± 0.89
Control	100	100	100	100	100	100	100	100	100	100	100

Legend: Values are mean ± Standard Deviation (SD) of replicates (n = 3), Values with the same alphabet in a column for each fruit are not significantly at P 0.05

Table 2 Percentage Increase of Fungal Isolates showing Stimulatory Reactions towards Treatment with Electromagnetic Field

Fruits	**Pineapple (*Ananas comosus*)**			**Apple (*Malus domestica*)**
Fungal Isolates	*A. inflata*	*M. mucedo*	*S. coccosporum*	*S. coccosporum*
7V (15 mins)	49.27 ± 3.24	69.71 ± 1.25	23.01 ± 0.03	23.71 ± 0.58
7V (30 mins)	47.02 ± 4.13	55.24 ± 0.33	21.28 ± 0.55	22.01 ± 0.63
7 V(45 mins)	39.65 ± 3.21	33.85 ± 2.54	19.48 ± 0.56	20.22 ± 0.39
7V (60 mins)	34.76 ± 4.87	17.33 ± 2.02	19.47 ± 1.35	20.21 ± 1.61
10V (15 mins)	48.37 ± 3.24	67.71 ± 1.11	18.22 ± 0.38	18.97 ± 0.89
10V (30 mins)	45.05 ± 5.10	48.32 ± 2.21	18.81 ± 1.43	19.55 ± 1.76
10V (45 mins)	37.99 ± 3.52	29.14 ± 2.20	16.27 ± 0.35	17.04 ± 0.71
10V (60 mins)	30.81 ± 4.33	6.03 ± 1.56	15.12 ± 0.62	15.91 ± 1.02
13V (15 mins)	47.01 ± 4.48	65.94 ± 0.84	17.66 ± 0.53	16.85 ± 0.62
13V (30 mins)	41.78 ± 4.62	41.61 ±2.88	16.72 ± 0.71	15.23 ± 0.76
13V (45 mins)	33.98 ± 4.26	23.69 ± 1.11	13.65 ± 0.42	13.42 ± 1.01
13V (60 mins)	25.66 ± 3.63	-	11.73 ± 0.93	11.17 ± 0.98

Legend: Values are mean ± Standard Deviation (SD) of replicates (n = 3).

The result of the proximate analysis of the treated and untreated fruits showed that the electromagnetic field has no side effects on the nutrient components of the fruits (Table 3). This finding is in agreement with **Simpson *et al.* (1995)**. They reported that there were no physical or chemical changes in the nutritional contents of PEF-treated apple juice and also sensory evaluation gave no significant difference in untreated and treated juices.

Table 3 Proximate and Mineral Composition of Untreated and Treated Selected EdibleFruits.

Fruits	Moisture (%)	Dietary fibre (g)	Fat (g)	Protein (g)	Ash (g)	Carbohydrate (g)	Mg (mg)	Ca (mg)	K (mg)	Vitamin C (mg)
Untreated Fruits										
Cashew	72.97 ± 0.45	3.07 ± 0.31	43.10 ±0.96	18.07 ± 0.11	0.64 ± 0.02	29.5 ± 0.50	288.00 ± 4.00	35.33 ± 5.03	648.00 ± 8.00	0.49 ± 0.01
Pineapple	82.67 ± 2.31	1.20 ± 0.20	0.11 ± 0.24	0.52 ± 0 02	0.81 ± 0.01	12.19 ± 0.01	12.27 ± 2.41	13.00 ± 0.20	111.33 ± 1.16	35.33 ± 1.16
Apple	79.60 ± 0.53	2.53 ± 0.23	0.15 ±0.01	0.19 ± 0.01	0.20 ± 0.01	13.43 ± 3.50	4.98 ± 0.02	6.00 ± 0.20	103.73 ± 0.64	4.71 ± 0.25
Cucumber	78.33 ± 2.40	0.41 ± 0.01	0.11 ± 0.01	0.61 ± 0.01	0.21 ± 0.01	3.67 ± 0.12	10.93 ± 0.90	15.08 ± 0.33	145.67 ± 6.02	2.93 ± 0.12
Star Apple	69.63 ± 1.48	2.99 ± 0.48	6.60 ± 0.53	2.42 ± 0.04	2.70 ± 0.00	14.13 ± 2.01	74.33 ± 4.04	91.67 ± 7.64	966.67 ± 12.58	47.67 ± 2.52
Carrot	62.8 ± 2.43	2.60 ± 0.53	0.21 ± 0.01	0.93 ± 0.02	0.36 ± 0.05	18.00 ± 1.00	16.61 ± 0.54	29.33 ± 1.16	241.00 ± 1.00	7.02 ± 0.17
Treated Fruits										
Cashew	71.67 ± 1.53	2.87 ± 0.12	42.00 ± 1.73	18.47 ± 0.50	0.65 ± 0.01	30.33 ± 5.51	282.67 ± 3.06	34.93 ± 1.62	643.33 ± 5.77	0.47 ± 0.01
Pineapple	81.33 ± 2.31	1.27 ± 0.03	0.11 ± 0.01	0.50 ± 0.00	0.79 ± 0.01	12.00 ± 2.00	11.67 ± 0.57	12.80 ± 0.35	112.00 ± 1.73	33.80 ± 1.71
Apple	80.0 ± 0.00	2.50 ± 0.50	0.15 ± 0.01	0.19 ± 0.02	0.18 ± 0.03	12.73 ± 0.83	4.58 ± 0.50	5.86 ± 0.10	102.35 ± 0.32	4.52 ± 0.46
Cucumber	77.60 ± 1.44	0.44 ± 0.02	0.11 ± 0.01	0.61 ± 0.05	0.24 ± 0.00	3.61 ± 0.18	10.87 ± 0.11	14.00 ± 1.00	144.27 ± 2.06	2.79 ± 0.19
Star Apple	69.33 ± 1.16	2.79 ± 0.26	6.87 ± 0.12	2.49 ± 0.02	2.70 ± 0.06	17.33 ± 0.58	70.33 ± 4.00	88.27 ± 6.24	950.67 ± 12.28	47.67 ± 2.52
Carrot	62.93 ± 0.06	2.73 ± 0.31	0.19 ± 0.01	0.91 ± 0.06	0.39 ± 0.01	8.67 ± 0.58	15.55 ± 1.39	28.50 ± 3.04	239.43 ± 1.25	6.75 ± 0.22

Legend: Mg = Magnesium, Ca = Calcium, K = Potassium

CONCLUSION

This study revealed that electromagnetic field wave has the potential of reducing post-harvest spoilage fungi of some fruits and can be used as a means of controlling spoilage fungi with a resultant increase in their shelf life.

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