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Impact of Irrigation Regimes on Some Selected Food Properties of Tomato Fruits

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ABSTRACT

The demand for tomato (*Lycopersicon esculentum*) as a vegetable and as an industrial raw material is increasing globally. To maximize tomato production and quality, there is need for good water management. This research studied the effect of three irrigation frequencies (F_1=7 days; F_2= 5 days; and F_3= 3 days) and three depths of water applications (D_1= 100%ETc; D_2 =75%ETc; D_3=50%ETc) on some selected food properties of the tomato. The fruits were harvested when observed ripe and the selected food properties were measured. The results from the experiment showed that the moisture content was in the range of 91.44 to 93.53%; crude fibre, 0.64 to 0.69; crude protein, 0.71 to 0.96 %; crude fat, 0.28 to 0.31%; ash content, 0.19 to 0.22%; sodium, 8.62 to 9.02 mg/100g; potassium, 216.33 to 220 mg/100g; calcium, 4.1 to 4.83 mg/100g; phosphorus, 21.12 to 22.73 mg/100g; vitamin C, 20.38 to 22.07mg/100g; and lycopene, 29.73 to 37.08 mg/100g. The statistical analysis of the result showed that the factors examined were not very significant ($p<0.05$). Thus, the results of the experiment will be useful for engineers who design irrigation water management for the tomato growers for maximizing tomato production through water management.

Keywords: Tomato, irrigation regime, irrigation frequency, food qualities, vitamin, water management

INTRODUCTION

It has been reported that more than 800 million people are undernourished globally [1]. Tomato fruit is one of the plant derived nanovesicles plants due to its anti-inflammatory, anticancer and ant oxidative properties as a result of its ease of absorption and digestibility by the human system [2]. The production of the crop in 2017 was reported to be 182,301,395 metric tonnes which was an increase of about 1.6% from the 2016 production. China is the largest producer with about 33% of the world production [3]. Globally, the crop is demanded round the year but production is seasonal without irrigation. To have the crop round the year and also provide for industrial raw materials, supplemental irrigation is required. The crop performance is sensitive to irrigation practices [4]**.** The management of water is one of the factors affecting crop growth and productivity [5-6]**.** Indeed, crop yield and quality are very sensitive to appropriate water and nutrient contents in the root zone of plants, which can improve the absorbing area and capacity of roots [6]. This work, therefore, evaluates the effect of irrigation regime on some selected food quality factors of tomatoes.

MATERIALS & METHODS

2.0 Materials and Methods

The materials and the methods used for the research is as discoused below

2.1 Study Area

The study was carried out on the experimental farm of the Department of Agricultural Engineering, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria (8°10'06" N and 4°16'12" E). The area has an average daily maximum temperature of 33°C and an

average daily minimum temperature of 28 °C.

2.2 Experimental Design

To investigate the effect of irrigation regime on some selected food properties of tomatoes, a 2 by 3 by 3 factorial designs was done. The factors used with their levels are irrigation frequency (7 days, 5 days and 3 days) and irrigation depth (100%, 75% and 50% ETc). The water requirement for tomatoes was calculated using Equation 1 [7].

$$ET_c = \frac{(I - Q - \Delta S + R_0)}{A} \qquad (1)$$

where:

ET_c is evapotranspiration or crop water use (mm);

I is irrigation water added, (cm^3);

Q is deep percolation (cm^3), measured from the base of the buckets;

ΔS is soil water storage change (cm^3), (the difference between bucket weights every 24 h);

R_o is runoff (cm^3), (R_o=0 in this study because there was no runoff from the buckets); and

A is cross-sectional area of the bucket (cm^2); 10 is a conversion factor from cm/d to mm/d.

2.3 Irrigation Scheduling

The volume of application for the desired depth was determined by multiplying the depth by the crop area as presented in Equation 2.

$$a_v = d_i \times a_c \qquad (2)$$

where:

$a_v$is the volume of application (m^3 or L),

d_i is the irrigation depth (m) and

a_c is the crop area (m^2)

The drippers were calibrated to have a discharge 4L/h. The time required for applying the desired volume was calculated using Equation 3.

$$t = \frac{a_v}{d} \qquad (3)$$

where:

t is the time required (hr),

d is the discharge (L/hr)

2.4 Analysis of nutritional compositions

The tomato fruit was harvested when ripe and the selected nutritional compositions (moisture, ash, protein, fat, fibre, calcium, sodium, potassium, phosphorus, vitamin C and lycopene) were analyzed using standard methods as described by [9].

RESULT

3.0 RESULTS AND DISCUSSION

The results of the experiments is as reported and discussed below

3.1.1 Effect of irrigation scheduling on moisture of the tomato fruit

The moisture content of any food has been reported to be an index of its water activity and it is used to define its stability and susceptibility to microbial contamination [10]. The highest moisture content of the tomato fruits (93.53%) was recorded when the water frequency was at 100% depth of crop water application at 3 days irrigation frequency (Table 1).

Table 1: Effect of irrigation scheduling on moisture of the tomato fruit

	D_1	D_2	D_3
F_1	91.89±1.21	91.57±1.17	91.44±0.69
F_2	92.44±0.61	91.86±0.52	91.82±1.36
F_3	93.53±0.59	92.77±0.53	92.57±0.77
F-value	1.844ns	11.487*	1.371ns

Note: F_1= 7days irrigation interval; F_2=5days irrigation interval; F_3= 3days irrigation interval; D_1= 100% depth of crop water requirement; D_3= 50% depth of crop water requirement; F-value= frequency value; ns= not significant; *= significant.

It was also observed that the least moisture content (91.89%) was also recorded when the water frequency was at 50% depth of crop water application and irrigation frequency of 7 days. This result was in the range reported by [11-13] who reported between 87.58 and 91% for the variety of tomato studied and [14] who reported 91.18% for the tomato they studied. This result was subjected to statistical evaluation and it was observed that the frequency of irrigation has no significant ($p<0.05$) effect on the moisture content but depth of water application is significant.

3.1.2 Effect of irrigation scheduling on crude fibre of the tomato fruit

Fibre is the portion of food that is not digested by digestive enzymes. However, it is very important in human nutrition because it helps improve the digestibility of food and thereby preventing constipation and colon cancer. The presence of dietary fibres in the human body lowers the body cholesterol, which in turn reduces the risk of cardiovascular diseases. The result of the effect of irrigation regime on the crude fibre of tomato is presented in Table 2.

Table2: Effect of irrigation scheduling on Crude fibre of the tomato fruits

	D_1	D_2	D_3
F_1	0.67±0.03	0.68±0.06	0.71±0.02
F_2	0.65±0.02	0.67±0.05	0.69±0.05
F_3	0.64±0.03	0.67±0.03	0.69±0.11
F-value	8.667*	0.029 ns	0.618 ns

The fibre contents of the tomato for the different water applications ranged between 0.64 and 0.71% with treatment F_1D_3 recording the highest. The range of fibre content obtained in the present study fell within the 0.5 and 0.7% reported by [15]; 0.42 and 2.8% reported for tomato by [11] and 0.5 and 0.7% range reported by [16] but less than 11.4% reported by [13]. This result was subjected to statistical evaluation and it was observed that the two factors were not significant at ($p<0.05$) on the selected food values.

3.1.3 Effect of irrigation scheduling on crude protein of the tomato fruits

The result of the effect of irrigation scheduling on crude protein of the tomato fruits is given in Table 3.

Table 3: Effect of irrigation scheduling on Crude protein of the tomato fruits

	D_1	D_2	D_3
F_1	0.82±0.09	0..76±0.044	0.71±0.04
F_2	0.86±0.09	0.86±0.035	0.79±0.09
F_3	0.96±0.09	0.94±0.101	0. 79±0.13
F-value	0.461ns	1.063ns	1.049ns

The highest protein was observed at D_1F_3. The protein content recorded in this work was between 0.96 and 0.71%. which is lower than the one reported by [11] who reported 1.8% and [14] who reported 17.7% but higher than 0.22% reported by [17] for the tomatoes investigated. This may be due to variations in varieties and other environmental conditions during production.

3.1.4 Effect of irrigation scheduling on crude fat of the tomato fruits

The result of the effect of the irrigation regime on crude fat is as present in Table 4.

Table 4: Effect of irrigation scheduling on Crude fat of the tomato fruits

	D_1	D_2	D_3
F_1	0.28±0.06	0.29±0.04	0.29±0.05
F_2	0.29±0.05	0.29±0.04	0.29±0.05
F_3	0.29±0.03	0.29±0.03	0.31±0.04
F-value	0.320ns	0.167ns	0.242ns

The highest crude fat (0.31%) of the tomato fruits was recorded at D_3F_3. The fat content observed in this study was higher than between 0.09 and 0.15% reported by [10]**.** This may be due to difference in variety. This result was subjected to statistical evaluation and it was observed that the effect of irrigation regime has no significant ($p<0.05$) effect on the crude fat of the tomato fruits harvested.

3.1.5 Effect of irrigation scheduling on ash of the tomato fruits

The effect of irrigation regime on ash content of the tomato fruits is presented in Table 5.

	D_1	D_2	D_3
F_1	0.19±0.013	0.19±0.03	0.19±0.03
F_2	0.19±0.004	0.19±0.06	0.22±0.04
F_3	0.21±0.03	0.19±0.03	0.22±0.02
F-value	1.631ns	0.95ns	2.355ns

The highest ash (0.22%) of the tomato fruits was observed at D3F3. This ash content is lower than 8.75% reported by [14]. The difference may be due to variety and the planting condition. It was observed that the ash content of the tomato fruits for all the treatments did not change appreciably. Analysis of variance indicated that there was no significant difference ($p>0.05$) in the ash content of the fruit.

3.2.0 Effect of Irrigation Scheduling and Depth of Water Application on Some Selected Mineral Content of Tomato

Mineral content are naturally occurring inorganic solid substances. They are very essential for a variety of body functions including the regulation of metallic pathways, formation of vital organs, maintenance of body physiological functions etc. The selected mineral for this work are sodium, calcium, phosphorus, and potassium

3.2.1 Sodium

The results of the effect of irrigation regime on sodium of the tomato fruits is presented in Table 6.

Table 6: Effect of irrigation scheduling on Sodium of the tomato fruits

	D_1	D_2	D_3
F_1	8.62±0.15	8.77±0.22	8.89±0.48
F_2	8.77±0.39	8.85±0.29	8.89±0.25
F_3	8.91±0.27	8.92±0.11	9.02±0.15
F-value	0.394ns	1.985ns	2.205ns

The highest sodium content (9.02 mg/100g) was recorded at D_3F_3. The observed sodium in this report is lower than 26 mg/100g reported for tomato by [11] and 56.90 to 80.65 mg/100g reported by [14]. The increase in sodium with the increase in the irrigation frequency was in agreement with [11] that reported a reduction in tomato sodium with water stress. This result was subjected to statistical evaluation and it was observed that the frequency ($p<0.05$) of irrigation has no significant effect on the sodium of the tomato fruits.

3.2.2 Potassium

The results of the effect of irrigation regime on potassium of the tomato fruits is presented in Table 7.

Table 7: Effect of irrigation scheduling on Potassium of the tomato fruits

	D_1	D_2	D_3
F_1	216.42±3.94	216.78±5.40	217.94±4.99
F_2	218.91±5.18	219.74±3.86	219.52±2.87
F_3	220.97±4.14	219.08±5.18	219.31±3.53
F-value	1.575ns	0.561ns	0.185ns

The highest potassium (220.97mg/100g) of the tomato fruits was recorded at D_1F_3 while the least (216.42mg/100g) was recorded at D_1F_1. The observed potassium was higher than the 16.63 to 10.97 mg/100g reported by [14]. The increase in potassium of tomato with increase in the rate of water application was in agreement with [18] who reported that regulated deficit irrigated fruits contain less potassium than control fruits.

3.2.3 Calcium

The results of the effect of irrigation regime on calcium of the tomato fruits is presented in Table 8.

Table 8: Effect of irrigation scheduling on Calcium of the tomato fruits

	D_1	D_2	D_3
F_1	4.10±0.59	4.19±0.54	4.34±0.54
F_2	4.47±0.58	4.48±0.67	4.57±0.67
F_3	4.75±0.74	4.78±0.72	4.83±0.79
F-value	1.567ns	1.251ns	0.795ns

The highest calcium (4.83mg/100g) of the tomato fruits was attained at D_3F_3. This result was subjected to statistical evaluation and it was observed that the irrigation regime was not statistically significant at ($p<0.05$) on the calcium of the tomato fruits.

3.2.4 Phosphorus

The results of the effect of irrigation regime on phosphorus of the tomato fruits is presented in Table 9.

Table 9: Effect of irrigation scheduling on Phosphorus of the tomato fruits

	D_1	D_2	D_3
F_1	21.12±2.28	21.44±2.32	21.65±2.54
F_2	21.54±2.29	21.86±2.09	21.95±5.49
F_3	21.60±2.36	22.01±2.59	22.78±1.85
F-value	0.071ns	0.095ns	0.638ns

The highest phosphorus (22.78 mg/100g) of the tomato fruits was attained at D_3F_3. The phosphorus content of the tomato increases with increase in the rate of water application. This result was subjected to statistical evaluation and it was observed that the irrigation regime was not statistically significant at ($p<0.05$) on phosphorus of the tomato fruit.

3.2.5 Vitamin C

The results of the effect of irrigation regime on vitamin C of the tomato fruits is presented in Table 10.

Table 10: Effect of irrigation scheduling on Vitamin C of the tomato fruits

	D_1	D_2	D_3
F_1	21.42±1.87	21.74±1.39	22.07±1.19
F_2	21.14±1.68	21.21±1.75	21.21±1.44
F_3	20.20±2.28	20.38±1.87	20.56±2.07
F-value	0.453ns	1.31ns	1.317ns

The highest vitamin C (22.07 mg/100g) of the tomato fruits was attained at D_3F_1. The increase in Vitamin C was in agreement with the report from literature by [19 - 20], and [21 - 22], who reported an increase in Vitamin C with reduction in irrigation. This result was subjected to statistical evaluation and it was observed that the irrigation regime was not significant at ($p<0.05$) on vitamin C of the tomato fruits.

3.6 Lycopene

The results of the effect of irrigation regime on lycopene of the tomato fruits is presented in Table 11.

Table 11: Effect of irrigation scheduling on Lycopene of the tomato fruits

	D_1	D_2	D_3
F_1	29.73±6.49	31.16±4.39	31.55±4.22
F_2	29.79±6.96	33.16±7.19	33.82±5.19
F_3	36.01±4.28	36.21±4.28	37.08±4.53
F-value	2.164ns	1.287ns	2.135ns

The highest lycopene (37.08 mg/100g) of the tomato fruits was observed at D_3F_3. This result was subjected to statistical evaluation and it was observed that the effect of irrigation regime was not significant at ($p<0.05$) on the lycopene of the tomato fruits.

CONCLUSION

The statistical analysis of the result showed that the factors examined were not significant in the food composition except moisture content. Thus, the results of the experiment will be useful to tomato growers who are searching for good water management practices to maximize tomato production through water management.

AUTHORS' CONTRIBUTIONS

Dr Idowu, D.O. designed the study and wrote the first draft of the manuscript. Engr. Adebayo, T.B and Mr Onofua, O.E managed the analyses of the study and literature searches while Engr. Dr. Oloyede, C.T. manages the experimental design and procedure for the experiment. All authors read and approved the final manuscript.

Declaration by Authors

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