

# Effect of Hybrid Solar Drying Method on the Functional and Sensory Properties of Tomato

J. B. Hussein<sup>1</sup>, M. A. Usman<sup>1</sup>, K. B. Filli<sup>1,2,\*</sup>

<sup>1</sup>Department of Food Science and Technology, Modibbo Adama University of Technology Yola, P. M. B. 2076 Yola, Nigeria

<sup>2</sup>SP Food and Bioscience Box 5401, 402 29 Gothenburg, Sweden

\*Corresponding author: kbfilli@yahoo.com

**Abstract** A hybrid solar dryer, direct solar energy dryer and open sun drying under the climatic conditions of Yola, Nigeria was used to dry tomato slices. The effect of these drying methods on the functional and sensory quality of the dried tomatoes was examined. The functional properties of the dried tomatoes slices were significantly different ( $p < 0.05$ ). In open sun dried tomatoes, the bulk density ranged from 0.56 – 0.62 g/ml, water absorption index (WAI) 436.33 – 475.67 gH<sub>2</sub>O/sample, water solubility index (WSI) 6.00 – 14.00, specific volume 1.61 – 1.78 ml/g and wettability 10.33 – 13.33 s for 4 – 8 mm thick tomato samples. For solar dried tomatoes, the bulk density ranged from 0.52 – 0.57 g/ml, the WAI ranged from 412.00 – 454.00 gH<sub>2</sub>O/sample, the water solubility index (WSI) range was 12.33 – 16.67, specific volume range was 1.73 – 1.90 ml/g and wettability ranged from 5.85 – 10.63 s for 4 – 8 mm thick tomato samples. For the hybrid dried tomatoes, the bulk density ranged from 0.50 – 0.54 g/ml, the WAI values ranged from 386.00 – 436.00 gH<sub>2</sub>O/sample, the WSI 14.67 – 18.00, specific volume range was 1.84 – 1.99 ml/g and wettability 5.80 – 8.44 s for 4 – 8 mm thick tomato sample. The organoleptic properties showed that the tomatoes dried by hybrid drying method was superior in terms of acceptability test than those dried using direct solar energy and a photovoltaic (PV) solar panel tomato products. Conclusively, good quality shelf stable dried tomato slices could be produced using hybrid drying method.

**Keywords:** tomato, bulk density, water absorption index, organoleptic properties

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## 1. Introduction

A tomato (*Lycopersicon esculentum* Mill.) is one the most important vegetable grown crops all over the world including the tropical countries. It is a highly seasonal, perishable and available in large quantities at a particular season of the year. Tomato is an important vegetable for human use because of its vitamins and minerals content that provide the basic human nutritional requirements [26]. According to Splittstoesser [38], tomato is ranked 14 among sixteen common vegetables (spinach, lima beans, peas, sweet potato, carrots, cabbage, lettuce, onion, etc) based on their total nutritional concentration but ranked first based on the contribution of nutrients to the diet. Tomato is one of the most popular produced and extensively consumed vegetable crop in the world [18]. It can be eaten raw in salads or as an ingredient in many dishes, drinks and consumed as tomato based products [3].

Tomatoes and tomato-based foods provide a wide variety of nutrients and many health-related benefits to the body. In regions where it is being cultivated and consumed, it constitutes a very essential part of people's diet. Tomato production accounts for about 4.8 million hectares of harvested land area globally with an estimated production of 162 million tonnes [13]. China leads world

tomato production with about 50 million tonnes followed by India with 17.5 million tonnes [13]. Tomato production can serve as a source of income for most rural and peri-urban producers in most developing countries. Despite all the numerous benefits from the crop, many challenges are making its production unprofitable in most developing countries especially those in Africa.

Due to market glut during peak season large quantity of tomato gets spoiled. Processing, preservation and storage of tomatoes during peak season can prevent the huge post-harvest losses in tomato and make them available in the off season at comparatively lesser cost. Tomatoes, as other vegetables, can be dried using various techniques. In any tomato drying technique the required time for drying the product depends on many parameters such as tomato variety, the soluble solids content (° brix) of the fresh product, the air humidity, the size of the tomato segments, the air temperature and velocity and the efficiency of the drying system. The rate of drying affects the end quality of the dried product [5].

Tomato contains higher amounts of lycopene, a type of carotenoid with anti-oxidant properties [6] which is beneficial in reducing the incidence of some chronic diseases [10] like cancer and many other cardiovascular disorders [16]. This anti-oxidant property and its health benefit have raised the interest in tomato research and its consumption as a crop with medicinal properties (Di

Mascio *et al.*, 1989). Lycopene is believed to be the main contributing compound in tomatoes responsible for lower risk of prostate cancer [31]. Other studies have also shown that consumption of tomatoes and tomato-base foods can be linked to reduced incidence of a variety of cancers in general, including pancreatic, lung, stomach, colorectal, oral, bladder, breast and cervical cancers [17]. Lycopene in tomatoes enhance fertility by improving the quality and swimming speed of sperm whilst reducing the number of abnormal sperm in men [21]. Arah *et al.* [7] reported that tomatoes and tomato-based foods provide a wide variety of nutrients and many health-related benefits to the body.

The tomato industry has the ability to increase the export earnings of African countries whilst improving the living standards of the individuals producing it. Postharvest losses and other challenges however, pose a great threat in the quest to attain all these benefits. Postharvest challenges, both on-farm and off-farm are gradually collapsing the tomato industry in most African countries. Continuous drying can prevent microbial growth during drying [20]. Hybrid dryers have been developed to control the drying air conditions throughout the drying time independent of sun-shine especially at night or poor weather when it is not possible to use the solar energy, using alternative heating sources such as sawdust burner [9]; kerosene stove [8] or by using a biomass stove [4,32]; electric heater [12,34]. In a hybrid solar dryer, drying is continued during off sunshine hours by back-up heat energy or storage heat energy.

Drying is the cheapest mode of preservation of fruits and vegetables. Dehydrated Tomato powder holds a promising and potential market for processing industries for preparation of products like sauce, ketchup, chutneys, soups and baby foods. The fuel or electricity to power the machine may not be available or affordable, in addition to leading to environmental problems associated with greenhouse gas emissions [11]. Tomato powders are ready to use in vegetable and curry mix, reduce the bulk for storage, transport and packaging with extended storage life. Tomato and tomato products are the major sources of lycopene and are considered to be important contributors of carotenoids in human diet [19,40]. Traditional solar fruit drying is often a slow process impeded by the high humidity, haze, and intermittent clouds experienced in tropical regions. In sunny, arid places, solar crop drying is a relatively simple process, and can often be accomplished without the need for a solar dryer [35].

Canning of tomato paste have helped to curb the wastage, but the capital intensive nature of the industry, the alteration in the taste of the product canned (as additives are added to aid in preservation) and the bulky nature of the paste product as well as poor durability have all contributed to limiting the establishment of canning industries. As a result only a small percentage of the produce is absorbed by this industry [1]. The warm, dry air's high capacity to take on moisture quickly removes moisture from fruits. Although simply exposing fruits to direct sunlight will often be sufficient for drying, crop dryers are often utilized to protect fruits from dirt, insects, and contamination. In humid, tropical climates, however, drying can be impeded [15]. With the humid air's reduced capacity to absorb moisture from the drying fruits, using a solar crop dryer coupled with a solar concentrator helps to improve the drying rate by increasing internal dryer

temperature and radiation. Today, large-scale mechanized dryers are often used to dry fruits in industrialized countries. These machines force air heated by boilers across the fruits to quickly dry them. This improved process, however, is often not viable in many developing countries. The large amount of capital needed for machinery is often prohibitively expensive for small-scale farmers in rural areas [35].

The interest in the production of dried tomatoes is increasing because of the possibility of using them in different purposes and drying efficiencies alone may not be adequate in qualifying this dryer for acceptance, except when the quality of the dried product is comparable to other alternatives in terms of functional and organoleptic properties. Thus, this study is aimed towards carrying out quality assessment of hybrid dried tomato compared to solar and open sun dried tomato by determining its functional properties and wholesomeness.

## 2. Materials and Methods

### 2.1. Sample Preparation

The tomatoes used for this study were obtained from the Jimeta Modern Market Yola, Adamawa State. Samples of tomatoes were selected from the lot based on firmness, colour and size uniformity. They were washed thoroughly with tap water, rinsed with distilled water and then wiped with an absorbent paper [29]. Thirty-six (36) kilograms of tomatoes were washed, sorted, blanched (in boiling water 100°C for 2 minutes) and divided into three equal portions of 12kg each. Then, each portion was sliced with Tomato Slicer to a thickness of 4, 6 and 8 mm respectively. Each portion of the sliced tomatoes was further divided into three equal portions of 4 kg each. Drying was performed using three types of drying methods i.e. sun drying, Hybrid-photovoltaic solar drying and solar drying methods. The initial moisture content of the tomato samples was determined in an oven at a temperature of 105°C for 24 h. The initial moisture content was 94.22% (wet basis) for tomatoes.

### 2.2. Drying Procedures

#### 2.2.1. Open Sun Drying Method

The first portion of the sliced tomatoes was spread in a single layer on a four different wire meshes made in Nigeria (1kg on each wire mesh) and sun dried until equilibrium moisture content was achieved.

#### 2.2.2. Hybrid-photovoltaic Solar Dryer

The second portion was dried in a constructed hybrid dryer from local materials obtained in Nigeria (1kg on each tray) but by using both heating source together. The schematic diagram of the experimental system is shown in Figure 1.

The dryer consists of a DC extractor fan, drying chamber (500 × 500 × 1100 mm<sup>3</sup>), drying trays, collector (which is an absorber plate made of aluminum sheet painted black and a transparent glass of 5mm tick which permit in only sun radiation.), air channel (air vent which is provided on the lower front side of the collector for easy passage of air into the dryer), DC blower fan and 500 W

power heater located at the bottom of the drying chamber, two solar panel rated 180W power each, solar battery rated 200Ah and a temperature sensor which was located at the center of the chamber to sense the chamber temperature. The two sources heat were working i.e. the heater was working and the solar collector was also working. The solar energy from the panel was charging the battery, so as it charges the battery, the energy is been used. This method has the advantage of constant heat

supply thus, if heat from solar collector drops/lowers down due to change in intensity of the sun, the solar regulator (fixed in the control box) will regulate the charge supply from the battery and the heater will supply a stable heat. The sliced tomato were spread in a single layer on a four different wire meshes (1kg on each wire mesh) and then dried until equilibrium moisture content was achieved. This procedure was repeated for 6 and 8mm tomato slices respectively.

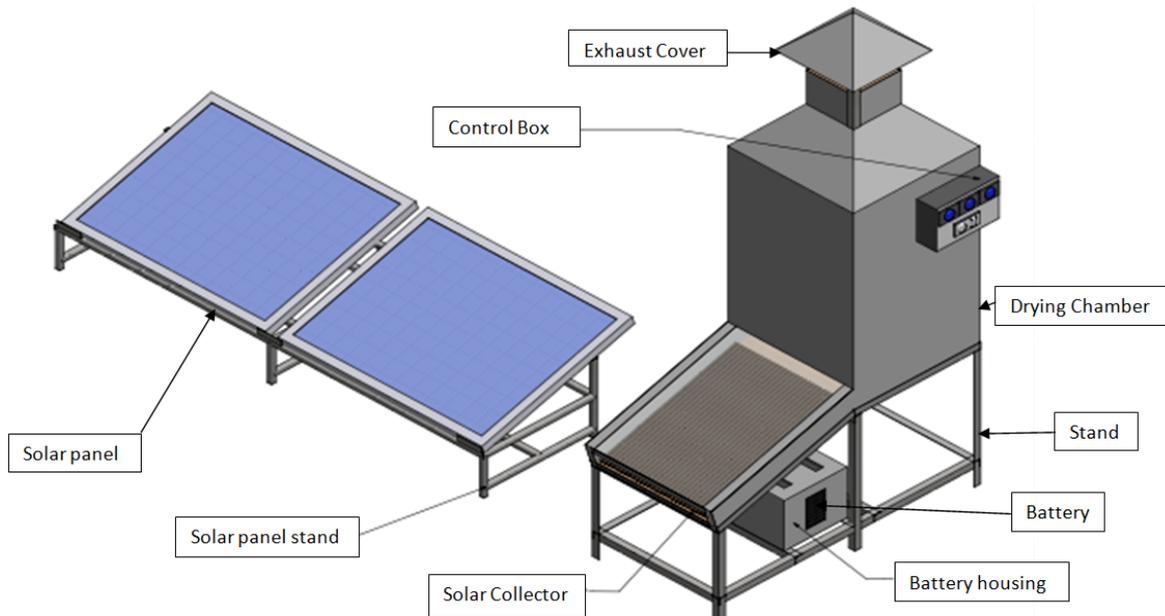


Figure 1. Isometric view of the Hybrid Dryer

### 2.2.3. Design Consideration and Specifications

The following determinant factors and assumptions were taken into consideration when constructing the hybrid dryer based on the procedures described by Adelaja and Ojolo, (2010); Gutti *et al.*, (2012);

- i. Geographical and Meteorological data of Location.
- ii. The solar radiation of the location (Adamawa State) as a case study was used as starting points in solar equipment design.
- iii. Sanitary design factors: the construction materials must be noncorrosive and nontoxic.
- iv. Ease of assembly and disassembly: the hybrid dryer was constructed in such a way that all the surfaces contacting the drying samples can be exposed, clean and inspect. Easy to adjust, dismantle and couple.
- v. Time constraint.
- vi. The initial and expected final moisture content of the vegetables and fruits to be processed.
- vii. The ambient temperature and operating in-chamber temperature.

Having considered and analysed the above listed factors with specific reference to the case study location (Adamawa State), the following design specifications were arrived at;

- i. Use tomatoes as a case study vegetable so as to cover a large range of fruits and vegetables. Also, tomatoes are vegetables of high interest in the study are being widely grown and having a very high percentage of post-harvest loss due to

inadequate post-harvest processing in the study area.

- ii. The required thermal performance was identified to be.
- iii. Based on the expected capacity of the dryer, economic considerations and engineering and ergonomic factors considerations, the shape and size of the dryer and its components were analyzed and a cabinet-type dryer was chosen as the most optional.
- iv. Initial moisture content: 95% wet basis.
- v. Expected moisture content: 10 % wet basis.
- vi. Operating temperatures; ambient is 30°C and in-chamber is 60°C.
- vii. Residency period per batch: 8 Hours.
- viii. Heat loss from drying chamber  $\leq 5\%$

### 2.2.4. For Solar Drying Method

The third portion was dried in the constructed hybrid dryer (1kg on each tray) by using solar collector as the heating source alone. This is the solar drying method; here the heating source is from solar collector alone. The heater was not working in this case but the solar energy from the panel was charging the battery. So if the weather changes with poor sun intensity especially when drying through the night, the stored energy in the battery will power the heater to generate heat to facilitate drying process. The sliced tomato were spread in a single layer on a four different wire meshes (1kg on each wire mesh) and then dried until equilibrium moisture content was achieved. This procedure was repeated for 6 and 8mm respectively.

## 2.3. Determination of Functional Properties of Dried Tomatoes

### 2.3.1. Determination of Bulk Density

Dried tomatoes were pulverized in a Kenwood blender (Philips HR 2001, China). The bulk density was expressed in grams/ml as described by Jinapong *et al.* [24]. Twenty grams sample of the tomato powder were weighed and then transferred to a graduate 100 ml measuring cylinder and taped with a finger ten times. The bulk density was obtained by measuring the volume occupied in the cylinder. The samples were randomly selected and replicated 10 times and the average value taken.

### 2.3.2. Determination of Water Absorption Index (WAI) and Water Solubility Index (WSI)

The WAI and WSI were determined using the equations as described by Qing - Bo *et al.* [33] and Filli *et al.* [14]. The ground tomato was suspended in water at temperature 30°C for 30 minutes; it was stirred gently during this period and centrifuged at 3000 x g for 15 minutes. The supernatant was decanted into an evaporating dish of known weight. The WSI was considered as the weight of dry solids in the supernatant expressed as a percentage of the original weight of sample. The WAI was considered as the weight of gel obtained after removal of the supernatant through a strainer (pore size = 500µm) per unit weight of original dry solids (gH<sub>2</sub>O/1g sample). Determinations were made in triplicate and the average taken.

$$WAI = \frac{\text{Weight of sediment}}{\text{weight of dry solid}} \times 100 \quad (1)$$

$$WSI = \left( \frac{\text{Weight of dissolved solid in the supernatant}}{\text{weight of dry solid}} \right) \times 100. \quad (2)$$

### 2.3.3. Determination of Specific Volume

The inverse operation relates specific volume and bulk density. Specific volume is the ratio of the volume of the substance to the volume of an equal weight of another substance taken as standard. Thus specific volume is equal to inverse of bulk density.

### 2.3.4. Determination of Wettability

The wettability of the dried tomatoes samples was determined as described by Onwnka [28]. Into a 25ml graduated cylinder with a diameter of 1cm, 1g of sample was added. A finger was placed over the open end of the cylinder which was invested and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The finger was removed and the rest material allowed to be dumped. The wettability is the time required for the sample to become completely wet

## 2.4. Sensory Evaluation of the Dried Tomatoes

Sensory evaluation was carried out on each coded products. Assessed qualities include: colour, taste, flavour and overall acceptability. Twenty (20) untrained panelists were selected at random from Department of Food Science and Technology, Modibbo Adama University of

Technology, Yola. A standardized cooking procedure was employed. Twenty (20g) of each dried tomatoes sample plus 2g of dried pepper was weighed into 200ml pure water. The solution was stirred gently to allow it to rehydrate. Fifty (50ml) of vegetable oil, 1 cube of maggi (Monosodium glutamate) and 0.25g of table salt was used to cooked each sample for 10 minutes. Dried tomato sample was obtained from Jimeta Modern Market Yola, Adamawa State and used as a control. Evaluation was based on the above named quality parameters and were assessed accordingly. A nine (9) point Hedonic scale described by Iwe, [23] was used (1 and 9 for extremely like and extremely dislike, respectively).

## 2.5. Statistical Analysis

Data obtained from the study were analyzed by analysis of variance (ANOVA) and the Duncan multiple range test was used to compare differences among means of data at 0.05 level ( $p \leq 0.05$ ) of significant. SPSS version 20 statistical software was used for this analysis.

## 3. Results and Discussion

### 3.1. Effect of Different Drying Method on the Functional Properties of Dried Tomatoes

The functional properties of food materials always play an important role in assessing their quality and palatability as well as the consumer acceptability. Table 1 shows the results obtained from the analyses of functional properties of the dried tomato samples in this study. The means obtained were calculated from triplicate measurements from data obtained. Means with the same superscripts are not significantly different ( $p > 0.05$ ). The result of bulk density of sun dried tomato ranged from 0.56 – 0.62 g/ml for 4 – 8mm thick samples, the solar dried samples ranged from 0.52 – 0.57g/ml for 4 – 8mm thick tomato samples and the hybrid dried tomato samples ranged from 0.50 – 0.54g/ml for 4 – 8mm thick tomato samples. The bulk density (BD) is an important property that has a direct impact on the packaging and storage space requirement of powders or dried products, which is equally important in transportation requirement for products generally. It also provides indication of physical properties like cohesion and porosity and may affect flow behavior and storage stability of powder materials [39]. The results of bulk density shows that as the thickness of the tomato slices increased the bulk density also increased. This may be due to slower migration of moisture from the interior part of the test sample during drying resulting in more shrinkage i.e. reduced volume and consequently leading to increased bulk density.

The increased inlet temperature can also cause a decrease in bulk density, as evaporation rates are faster at such conditions and samples dried under this condition appears to have more porous or fragmented structure, and therefore has a greater tendency for the particles to have hollows and more void spaces. With regard to the influence of drying time on the functional property, the bulk density of dried tomato powder samples increased with increasing drying time which is expected. The effect of drying method on the dried tomato powder was depended on its moisture content, due to the sticky nature

of the product. With the dried tomato powder having high moisture content and more particles tends to stick together due to more interspaces between them and consequently resulting in a larger bulk volume [2]. The bulk density of tomato powder was slightly increased as the drying time increased with decreasing temperature of drying. This may be due to the increasing of drying air temperature or drying temperature which causes a reduction in bulk density, because as evaporation rates are faster the products dry to a more porous or fragmented structure [2].

The bulk density can also depend on the attractive inter-particle forces, particle size and number of contact positions [30]. Singh *et al.* [36] reported that the bulk density of the powder is primarily dependent on particle size, particle size distribution and individual particle geometry. This might be the reason for the differences in the bulk density of the tomato samples. It is important to note that the total volume of inter-particle voids can change with drying and packing processes.

**Table 1. Functional properties of dried tomato samples**

Samples		Bulk density (g/ml)	WAI (gH <sub>2</sub> O/g sample)	WSI	Specific Volume (ml/g)	Wettability (s)
Sun Dried	4	0.56 ± 0.01 <sup>cd</sup>	436.33 ± 3.48 <sup>bc</sup>	14.00 ± 1.16 <sup>bc</sup>	1.78 ± 0.01 <sup>de</sup>	10.23 ± 0.56 <sup>c</sup>
	6	0.58 ± 0.01 <sup>b</sup>	449.67 ± 12.67 <sup>b</sup>	9.33 ± 0.67 <sup>d</sup>	1.70 ± 0.02 <sup>f</sup>	11.62 ± 0.54 <sup>b</sup>
	8	0.62 ± 0.01 <sup>a</sup>	475.67 ± 13.25 <sup>a</sup>	6.00 ± 1.00 <sup>e</sup>	1.61 ± 0.02 <sup>se</sup>	13.33 ± 0.67 <sup>a</sup>
Solar Dried	4	0.52 ± 0.01 <sup>f</sup>	412.00 ± 6.00 <sup>c</sup>	16.67 ± 0.88 <sup>a</sup>	1.90 ± 0.01 <sup>b</sup>	5.85 ± 0.18 <sup>e</sup>
	6	0.55 ± 0.01 <sup>de</sup>	430.00 ± 6.56 <sup>bc</sup>	17.00 ± 1.00 <sup>a</sup>	1.81 ± 0.02 <sup>cd</sup>	6.21 ± 0.32 <sup>e</sup>
	8	0.57 ± 0.01 <sup>bc</sup>	454.00 ± 8.62 <sup>ab</sup>	12.33 ± 0.67 <sup>c</sup>	1.73 ± 0.01 <sup>ef</sup>	10.63 ± 0.56 <sup>bc</sup>
Hybrid Dried	4	0.50 ± 0.01 <sup>e</sup>	386.00 ± 6.00 <sup>d</sup>	18.00 ± 0.58 <sup>a</sup>	1.99 ± 0.01 <sup>a</sup>	5.80 ± 0.12 <sup>e</sup>
	6	0.53 ± 0.01 <sup>f</sup>	412.67 ± 5.70 <sup>c</sup>	16.00 ± 0.58 <sup>ab</sup>	1.90 ± 0.01 <sup>b</sup>	6.22 ± 0.19 <sup>e</sup>
	8	0.54 ± 0.01 <sup>e</sup>	436.00 ± 6.66 <sup>bc</sup>	14.67 ± 0.67 <sup>bc</sup>	1.84 ± 0.03 <sup>c</sup>	8.44 ± 0.42 <sup>d</sup>

a-g: Means in the same column bearing different superscript are significantly different at p<0.05

Key:

WAI = Water absorption index

WSI = Water solubility index

4, 6 and 8mm are the thickness.

The water absorption index (WAI) for a dried food may be related to the amount of water absorbed by materials after swelling in excess water and which can be considered as an index of how the components can take up moisture freely. The WAI of materials relates to the amount of hydration to the internal porosity. It could be used as an index of the potential 'juiciness' of a material. The WAI of the sun dried tomatoes ranged from 436.33 – 475.67 gH<sub>2</sub>O/sample for 4 – 8mm thick tomato samples, for the solar dried tomato samples it ranged from 412.00 – 454.00 gH<sub>2</sub>O/sample for 4 – 8mm thick tomato samples and the hybrid dried samples ranged from 386.00 – 436.00 gH<sub>2</sub>O/sample for 4 – 8mm thick tomato samples. This result shows that as the thickness of tomato samples was increased the WAI of the dried samples also increased. This result could be related to the result of bulk density earlier stated that higher thickness resulted in higher bulk density. This suggests that more shrank product will have higher bulk density and it is expected to absorb more moisture, this will have significance during cooking as it is expected to increase the yield of the mixture.

Solubility is the most reliable criterion to evaluate the behavior of powder in aqueous solution systems. This parameter is attained after the powder undergoes dissolution steps of sinkability, dispersability and wettability. The result of water solubility index (WSI) in this study was on the contrary in inverse relation with respect to the thickness of the samples. Water solubility index is related to the amount of low molecular weight products of material degradation which are easily soluble because of reduced entanglement. It can therefore be said that, an increase in WSI was a sign of increased solubilisation of components in a system. The lower

values of WSI with increase in thickness may be attributed to the greater effect of heat on degradable products in thinner samples, because there is a faster rate of heat transfer through thinner samples when compared with thicker samples whose effect was less because of resistance to transfer of heat to the interior of such samples. The solubility index showed an increase with an increase in inlet air temperature. The increase in solubility with drying temperature may be due to increased dissociation of the organic acids and other components with temperature.

In addition, increasing the drying air temperature generally produces an increase in particle size resulting in a decrease in the time required for the powder to dissolve. The larger particles may sink, whereas smaller ones are dustier and generally float on water making for uneven wetting and reconstitutions. The increase of water solubility index of the sun dried samples compared to solar and hybrid dried may be due to higher drying temperature and shorter drying time for the solar and hybrid dried samples which might have resulted in the increase of the particle size and consequently a decrease in the time required for the powder to dissolve. It is also important to note that Maillard reaction may occur in tomato dried by hybrid and sun drying methods which can cause binding of reducing sugars to amino acids and eventually leading to brown-pigmented reaction products, resulting to less tomato powder solubility [25].

The specific volume which is the measure of inverse of bulk density was decreased as the bulk density and increased as the thickness of tomato slices decreased. This may be attributed to the fact that as the thickness of slice increases, there will be slower migration of moisture from

the interior part of the test sample during drying resulting in more shrinkage i.e. reduced volume and consequently leading to increased bulk density. The wettability of sun dried tomato samples ranged from 10.33 – 13.33s for 4 – 8mm thick tomato samples, the solar dried samples ranged from 5.85 – 10.63s, for the 4 – 8mm thick samples and the hybrid dried samples ranged from 5.80 – 8.44s for 4 – 8mm thick tomato samples.

The wettability of hybrid dried tomato was significantly different from both solar and sun dried tomato; the result shows that the solar dried tomato was also significantly different from sun dried tomato samples. This may be due to the lower moisture contents of hybrid dried samples than the others. The respective moisture contents of products were as follows: sun dried tomato was 9.83 %, solar dried was 9.56 % and hybrid dried was 7.63 %. Thus, the lower the powder moisture content, the higher the solubility of the powder. Singhanat and Anong [37] reported that the instant properties of a powder involve the ability of a powder to dissolve in water. Most powdered foods are intended for rehydration. Hence the ideal powder would wet quickly and thoroughly, sink rather than float and disperse/dissolve without lumps. The ability of the hybrid dried tomato samples to wet quickly and thoroughly than the other methods suggests that it is a good product in terms of rehydration meaning less time

and energy required during preparation. The isometric view of the hybrid dryer is shown in Figure 1.

### 3.2. Effect of Different Drying Method on the Sensory Qualities of Dried Tomatoes

The results of sensory evaluation of dried tomatoes samples obtained from 20 member panelists were graphically presented in Figure 2. The results was statistically significant at 95% probability level ( $p < 0.05$ ). This implies that there was high variation in test samples. In terms of colour, hybrid dried tomatoes was rated as the highest with a score of 8.30; this was followed by solar dried tomato samples 7.75 and sun dried tomatoes 5.65. The dried tomatoes obtained from the market that is usually sun dried without proper cleaning process that was used as control was rated the lowest with a score of 3.20. From the result of sensory evaluation it shows that the colour of hybrid dried tomatoes was more preferable than that of solar dried tomatoes with solar dried tomatoes more preferable than sun dried tomatoes. The sun dried tomatoes in the research location was more preferable than control, which was the sun dried tomato obtained from the local market. The hybrid dried tomatoes was ranked the best in terms of the colour, having a brightest colour when compared with the other two samples. This was followed by tomatoes dried by solar energy dryer and the open sun dried samples respectively.

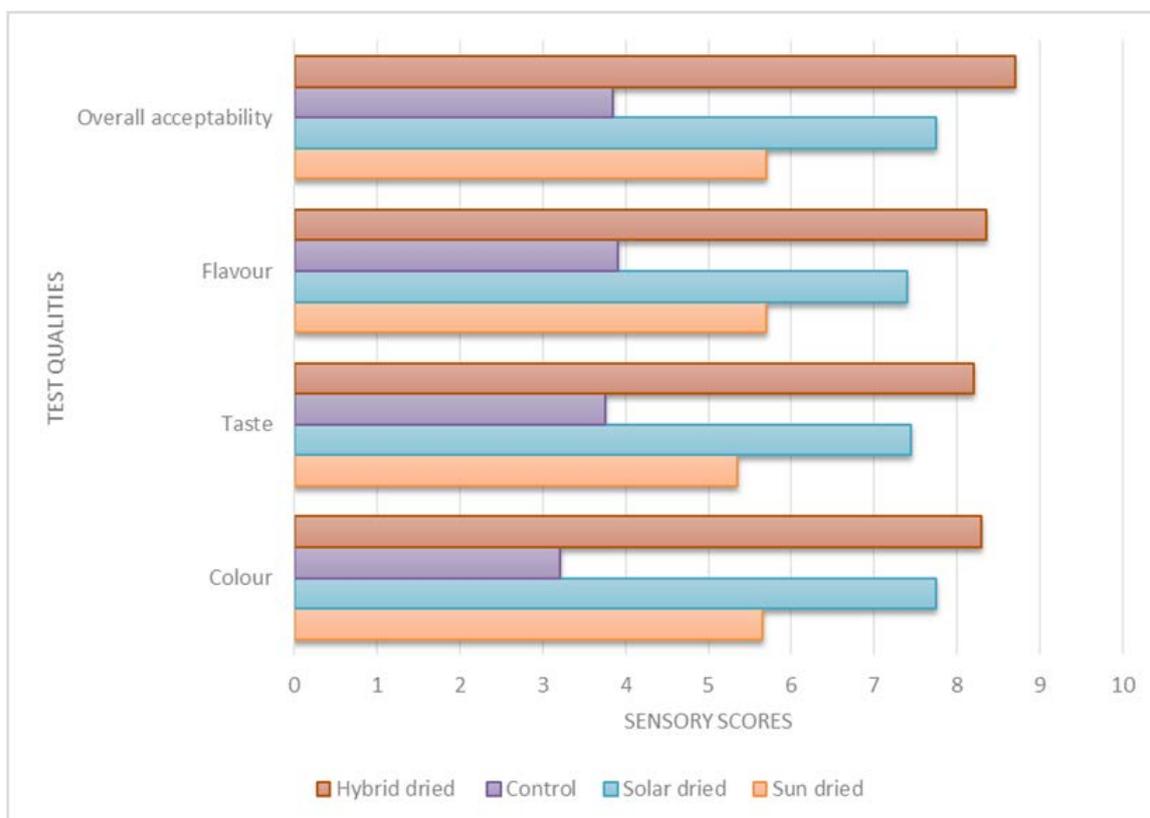


Figure 2. Graphical Representative of Sensory Evaluation

The least in colour preference was the control sample sun dried tomato outside our research location which had dull appearance. In term of taste, the hybrid dried tomatoes was still rated the highest with a score of 8.20, which was followed by solar dried tomatoes 7.45 and sun dried tomatoes was rated 5.35 on the average. The dried

tomatoes obtained from the local market, the control sample was rated the lowest with a score of 3.75. From the result of acceptability test it shows that the hybrid dried tomatoes was more preferable than the other samples of dried tomatoes. The tomato samples can be rated in the following order hybrid dried tomatoes > solar dried

tomatoes > open sun dried > control. In essence, the taste of the tomatoes dried by hybrid dryer was superior to the other tomatoes products examined. This result is in agreement with the findings of Isiaka, [22] who reported that solar energy dried tomatoes was superior to open sun dried tomatoes. The same trend was obtained for flavour and overall acceptability from that study. Isiaka [22] reported that to determine the wholesomeness of dried tomatoes, the organoleptic properties in terms of colour (appearance) and taste (flavour) were the two major quality attributes which play important roles in tomato acceptability.

#### 4. Conclusion

The study was conducted to study the quality assessment of hybrid dried tomato compared to solar and open sun dried tomato by determining their functional properties and sensory evaluation. From the result of functional properties it showed that the dried tomato samples produced were influenced by the drying methods as expected and these also influenced the palatability and consumer acceptability. The results of bulk density shows that as the thickness of the tomato slices increased the bulk density also increased. This result shows that as the thickness of tomato samples was increased the WAI of the dried samples also increased. This result could be related to the result of bulk density earlier stated that higher thickness resulted in higher bulk density. This suggests that more shranked product will have higher bulk density and it is expected to absorb more moisture, this will have significance during cooking as it is expected to increase the yield of the mixture. The wettability of hybrid dried tomato was significantly different from both solar and sun dried tomato; the result shows that the solar dried tomato was also significantly different from sun dried tomato samples.

The results for organoleptic properties showed that the dried tomatoes produced by hybrid drying method was superior than those of both solar and open sun dried tomato slices at 95 percent probability level. Thus, from the results it can be concluded that the quality of the dried tomatoes produced from hybrid drying method was superior to other dried tomatoes produced in terms of overall acceptability. The study has therefore provided useful information for the design of drying process for tomatoes. This method of drying can be up scaled and adopted to assist in reducing post-harvest losses of commodities like tomatoes which is very common with agricultural commodities in developing countries like Nigeria. The result showed that efficiency of agricultural dryers could be increased through the use of a combination of solar and heating element coil powered by photovoltaic (PV) solar panel, compared to conventional dryers with only solar or only biomass heating sources.

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