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# Investigation of the physical properties of tomato powder prepared by spray drying technology

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**Abstract**
The aim of the present investigation was to study the various physical properties of the spray dried tomato powder. The spray drying process was operated at maltodextrin concentration (3%), air inlet temperature (152 $^0$C), feed flow rate (37 ml/min) and blower speed (1300rpm). Moisture content, bulk density, tapped density, flowability and water solubility index of the spray dried tomato powder were analyzed. Powder samples showed moisture activity of 4.40% and water activity of 0.47, which is good for powder stability. Powder samples showed excellent flowing properties with Hausner ratio of 1.18 and Carr index of 12.82%. The reconstitution property (water solubility index) was found to be 92.50%.

**Keywords:** Physical, tomato powder, spray drying technology

## 1. Introduction
Tomato (*Solanum lycopersicum* L.) is the most popular and commonly consumed vegetable fruit around the world. In India, around 20 million metric tonnes of tomatoes are produced annually (FAOSTAT, 2017) [6]. Tomatoes are a good source of various nutrients and health promoting bioactive compounds and thus, constitute essential part of people’s diet. However, tomatoes are highly perishable and around 15% losses are recorded every year at post-harvest stage. To overcome these losses, tomatoes are processed into various value added products which not only makes their availability round the year but also helps the farmers with better returns. However, the huge capital investment besides use of additives and their health concerns, overall change in mouthfeel and unappealing appearance limits the use of such products. Several researchers have standardized the process for development of various tomato based end products (Igile *et al*., 2016; Bashir, Bhat, Dar & Shah, 2014; Gaware, Sutar, & Thorat, 2010; Hayes, Smith, & Morrisetal., 2010) [15, 2, 10, 13]. However, limited study has been carried out in production of tomato powders. Tomato powder holds huge potential in processing industries. It can be used for preparation of sauces, ketchups and weaving foods. In addition, tomato powders reduce the bulk for storage, transport and packaging with extended storage life. Spray drying is the mostefficient technique used in various industries for the conversion of a wide range of products in powder form (Quek, Chok, & Swedlund, 2007) [20]. The versatility and flexibility of spray drying process especially low heat treatment have resulted in increased popularity of spray drying technique among food processors (Fu, &Chen, 2011) [9]. However, parameters like juice concentration, additives (maltodextrin, gum Arabic), feed flow rate and inlet/outlet temperatures are important that govern the quality of end product (powder) and their close maintenance is important for efficient spray drying process (Suhag,& Nanda, 2016) [23]. The present research was planned with an aim to investigate the various physical properties of spray dried tomato powder.

## 2. Materials and Methods
### 2.1 Raw materials
Well-matured, fully ripened tomato (*Solanum lycopersicum* L) fruit of Roma variety was procured from the fields of Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir. Maltodextrin (DE 20) manufactured by Himedia, India, was used as a carrier.

## 2.2 Spray Drying
Pilot plant spray dryer (SM Scienctech, Kolkata) with a concurrent air flow was used for spray drying. The feed mixture was fed to the dryer by means of peristaltic pump. The maltodextrin (3%), inlet air temperature (152 $^0$C), feed flow rate (37 ml/min), and blower speed (1300 rpm) were kept constant. After the completion of spray drying process, the powder was collected from the cyclone and the cylindrical parts of the dryer chamber by lightly sweeping the chamber wall as proposed by Bhandari, Senoussi, Dumoulin, and Lebert, (1993) [3]. The powders were then packed in polyethylene bags and stored in desiccator for further analysis.

## 2.3 Powder analysis
### 2.3.1 Moisture content
Moisture and water content are among the most important parameters measured in food as moisture content is inversely related to the dry matter of a food. More importantly, the moisture content in food also influences its storage stability and quality. Moisture content of the powders was estimated as per AOAC (2012) [1].

### 2.3.2 Water activity ($a_w$)
Water activity of samples was determined using a water activity meter (PRE AQUA LAB, Water Activity Analyser, SN (PRE 000197).

### 2.3.3 Bulk and tapped density
A known quantity of spray-dried tomato powder was loaded into a 10 mL graduated cylinder and the volume occupied was recorded and then used to calculate the bulk density (ρB) (weight per volume). The tapped density (ρT) was calculated by tapping the cylinder for 5 min (32 taps per minute). The final volume was then read and used to calculate the tapped density [13].

### 2.3.4 Flowability
In order to determine the flowability of the tomato powder, Hausner ratio and the Carr index were determined. Hausner ratio (HR) is correlated with the flowability of a powder or any granular material (Hausner, 1967). It was calculated by the formula:

$$\frac{\text{Tapped density } (\rho t)}{\text{Bulk density} (\rho b)}$$

Where, ρt =the tapped density,
ρb =the bulk density.
The range for HR in defining the flowability is as follows, as described by Tsai *et al*. 2007 [28].
1. 1.0<HR<1.1, free flowing powder;
2. 1.1<HR< 1.25, medium flowing powder;
3. 1.25<HR<1.4, difficult flowing powder;
4. HR>1.4, very difficult flowing powder.

### Carr index
Carr index represents the compressibility of a powder (Pereira *et al*, 2008). It was calculated by the following formula:

$$\text{Carr index} = 100 \times \frac{\rho t - \rho b}{\rho t}$$

where, ρt =the tapped density;
ρb=the bulk density.

### 2.3.5 Water solubility index
The WSI of the tomato powder was determined according to the method as described by Kha, Nguyen, and Roach (2010) [18]. 2.5g of spray-dried tomato juice powder was taken and placed in a 100ml centrifuge tube, 30ml of distilled water (30 mL) was added to the tube and was vigorously mixed, the mixture was then incubated at 37°C in a water bath for 30 min, and then centrifuged for 20 min at 11,410 g. The supernatant was carefully collected in a pre-weighed beaker and oven-dried at a temperature of 103 ± 2°C. The WSI (%) was calculated as percentage of dried supernatant with respect to the amount of sample taken.

## 3. Results and discussion
### 3.1 Moisture
Moisture content is an important property of powder, which is related to the drying efficiency. Moisture content of a product plays an important role in determining its flowability, stickiness and storage stability due to its effect on glass transition and crystallization behavior (Shretha et at., 2007) [22]. Moisture content of tomato powders was found to be 4.40% (Table 1), which is sufficient to make food powder microbiologically safe. The high temperature of spray drying process is responsible for the decreased moisture content, which is due to the greater temperature gradient between the atomized feed and the drying air, resulting in a greater driving force for water evaporation and thus produces powders with lower moisture content. The similar observation was obtained in the different fruit juice powders such as watermelon juice (Quek *et al*., 2007) [21], tomato juice (Goula and Adamopoulos, 2008) [12], acai juice (Tonon *et al*., 2008; Tonon *et al*., 2011) [24, 25] and pineapple juice (Jittanit *et al*., 2010) [17].

**Table 1:** Physical properties of spray dried tomato powder

| **Moisture content** | **4.40%** |
|---|---|
| Water activity | 0.47 |
| Bulk density | 0.34 g/ml |
| Tapped density | 0.39 g/ml |
| Flowability | |
| 1. Hausner ratio<br>2. Carr index | 1.18<br>12.82 % |
| Water solubility index | 92.56% |

### 3.2 Water activity
Water activity is the availability of free water in a food system responsible for any biochemical or microbiological reactions. High water activity indicates more free water available for biochemical or microbiological reactions and, hence, shorter shelf life [Quek *et al*., 2007] [20]. The powder samples showed water activity value of 0.47 (Table 1), which is good for powder stability. It was observed that higher inlet air temperature made the drying faster and reduced the moisture content of powder. Thus, the tomato powder can be considered biochemically or microbiologically quite stable. Similar water activity values were obtained by Quek *et al*., 2007 [21] and Tonon *et al*., 2009 [26] while studying the watermelon and acai powders, respectively.

### 3.3 Bulk density and tapped density
The bulk density of the tomato powder sample was found to be 0.34 g/mL (Table 1). Tonon *et al*., 2008 [24] found that the increased temperature caused the reduction in bulk density. An increase in the inlet air temperature often results in a rapid formation of dried layer on the droplet surface and particle

size and it causes the skinning over or casehardening on the droplets at the higher temperatures. This leads to the formation of vapor-impermeable films on the droplet surface, followed by the formation of vapor bubbles and, consequently the droplet expansion (Chegini and Ghobadian, 2005; Finney *et al*., 2002; Tonon *et al*., 2008; Tonon *et al*., 2011) [4, 8, 24, 25]. Walton (2000) reported, the increase of drying air temperature generally causes the decrease in bulk, particle density and provides the greater tendency to the particles to hollow. Ferrari *et al*. [Ferrari *et al*., 2012] [7] observed higher bulk density values for spray-dried blackberry powder when a blend of maltodextrin and gum arabic was employed as a carrier agent. The heavier the material, the more easily it is accommodated into the spaces between the particles, occupying less space and resulting in higher bulk density values. Chegini and Ghobadian (2005) [4] reported that spray dried powders with higher moisture contents tend to have a higher bulking weight because of the presence of water, which is considerably denser than the dry solid. The tapped density of the tomato powder was found to be 0.39 g/ml, which was in accordance with the results obtained by (Swaminathan, 2015).

### 3.4 Flowability
Flowability is an important property for dried particles and was expressed as the Hausner ratio (HR). The HR ratio of the tomato powder was found to 1.18 (Table 1), which indicates that the tomato powder obtained was to be a medium flowing powder (Tsai *et al*., 2007) [28]. According to the classification given by Geldart *et al*. (1984) [11], powders of HR below 1.25 were classified as lowly cohesive. The cohesiveness of powders determines their consistency and flow properties—the lower the cohesiveness, the better the flowability of powders (Domian *et al*., 2005) [5]. This is in accordance with their high Carr index (CI), which represents compressibility of the powder (Pereira *et al*, 2008). The CI was found to be 12.82%. According to Carr (Carr 1965) an excellent flowability can be expected if the CI is within 5-15%.

### 3.5 Water solubility index
WSI is the reconstitution property used to study the effect of process parameters. The water solubility index shown by the tomato powder sample was found to be 92.56% (Table 1). Our results clearly show that higher water solubility index was obtained at higher air inlet temperature. Powders produced at higher temperature resulted in powders with higher solubility due to their negative effect time on moisture content of the powder sample. A similar trend was reported by Phoungchandang and Sertwasana [2010] [19] for spray drying of ginger juice. The instant property of a powder is defined as the ability of a powder to dissolve in water. Hence, the ideal powder would wet quickly and thoroughly, sink rather than float and disperse/dissolve without lumps [Hogakemp *et al*., 2003] [14].

## 4. Conclusion
The present investigation concludes that maltodextrin (3%) air inlet temperature (152 $^0$C), feed flow rate (37 ml/min) and blower speed (1300rpm) offered the best results. The air inlet temperature have significant effect on the physicochemical properties. The results obtained during the present study indicate that good quality powder with optimum moisture content and water activity can be produced by spray drying, which demonstrate the great potential for the use of such powders in the food industry.

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