

Changes in physico-chemical parameters and organoleptic properties of differently dried apricot, plumcot and plum fruits

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Abstract. The preservation of seasonal fruits in the form of drying is an approach that has been applied for centuries. The present study presents the variation of important parameters such as colour, water activity, moisture content, pH and sensory parameters of air-, convectively and freeze-dried fruits of “Modesto” apricot, “Stanley” plum and their hybrid “Stendesto”. The obtained data showed similar results regarding air-drying and using a fruit dryer. Perceptible differences are reported with freeze-drying, not only in terms of colour but also in terms of consistency. Storage within six months showed changes in the sensory parameters (colour, consistency, aroma, appearance) for all three drying options. An advantage of convective drying (in a dryer) compared to air drying is the time-saving. In all three variants, the specific pleasant aroma of dried fruit is preserved for the entire storage period. The present study is a pilot for plum-apricot hybrids and their reference to the parent lines.

1 Introduction

Food preservation plays an important role not only by providing safer food but also by increasing its availability year round and lowering postharvest losses [1]. Drying is one of the most recognised traditional methods of food preservation [2]. Different types of drying exist like freeze-drying, convective drying, sun drying, air drying, among others. Dried products are characterised by a decreased water activity and moisture content. These ensure their controlled microorganism and antimicrobial compounds resulting in a product that is safe for consumption [3].

Each type of drying requires different resources making some more sustainable than others. For example, sun drying does not utilize electricity or other resources while freeze-drying or even convective drying are energy consuming. When time is being evaluated the latter are more favourable compared to sun or air drying. A recent paper describes the need for preserving the quality of agricultural products by designing appropriate drying conditions [4]. A number of dried products are highly cherished as part of the human diet. Dried fruits are often regarded as snacks while dehydrated vegetables are part of the preparation of different dishes. For example, the drying methods of tomatoes have been discussed and results revealed that not only the thickness and form of slices is important but also their treatment with different agents, i.e. citric acid [5]. Another rather popular example of dried fruit are raisins. Their health benefits have been reported throughout the years [6], but only few papers focus on their production [7]. Just recently an important topic from the production of dried grapes has been discussed namely the prospective and

green use of the biomass derived from various stages of the grape drying process [8]. Novel drying conditions like indirect solar drying have been applied on banana slices [9]. Some papers suggest the production of energy dense snacks by coating the product of drying with probiotic bacteria and using freeze-drying afterwards [10]. Regardless of the object being dried and the conditions used, important quality parameters of the finished product are colour, shape, moisture content and some sensory indications like crispness [11].

The objective of this research was to evaluate different methods of drying apricot, plum, and plum-apricot fruits, and to follow the changes of their moisture content, water activity, titratable acidity, pH, colour, and sensory parameters during a period of six months' storage.

2 Materials and methods

2.1 Materials

Fruits from the “Modesto” (apricot), “Stanley” (plum), and “Stendesto” (plum-apricot) varieties were gathered in the year 2023 following ripening periods. A total of sixty fruits per variety were harvested from the experimental fields of the Fruit Growing Institute (Plovdiv, Bulgaria) and transported in an air-conditioned vehicle to the University of Food Technologies, where the fruits (incl. the peel) were further processed. Twenty extra fruits per variety were

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harvested in case there was decay or damage during/after the harvest.

2.2 Drying procedures

2.2.1 Air drying

Each fruit variety was washed, de-stoned and sliced with a ceramic knife at a thickness of 3 ± 2 mm. After that, the slices were placed on flat trays with holes to assure natural ventilation. Each fruit variety was air dried for 168 hours, at a temperature of $24\pm 1^\circ\text{C}$. The dried slices were then placed in labelled plastic containers with seals where they were stored for six months according to their specific drying date.

2.2.2 Conventional drying

Each fruit variety was washed, de-stoned and sliced with a ceramic knife at a thickness of 3 ± 2 mm. After that, the slices were placed on flat trays with holes in the fruit dryer (Sencor SFD 6600BK, Japan). The slices were dried at 35°C for 24 h. The dried slices were then placed in labelled plastic containers with seals where they were stored for six months according to their specific drying date.

2.2.3 Freeze drying

Each fruit variety was washed, de-stoned and sliced with a ceramic knife at a thickness of 3 ± 2 mm. The slices were then frozen in a freezer for 24h. They were consequently freeze-dried with a vacuum freeze dryer (BK-FD12S, Biobase, Shandong, China) at 3.5 MPa and -55°C . The dried slices were then placed in labelled plastic containers with seals where they were stored for six months according to their specific drying date.

2.3 Moisture content

The moisture content of studied samples was measured using an infrared moisture analyser PMB 53 (Adam Equipment Inc., Oxford, UK).

2.4 Water activity

The water activity (a_w) was measured using a LabSwift-aw, Novasina AG, Lachen, Bassersdorf, Switzerland.

2.5 Titratable acidity and pH

The titratable acidity (TA) was measured by titration with 0.1N NaOH. Results are expressed as citric acid equivalents.

The pH was determined using a Jenway 550 Benchtop handheld pH meter (Cambridgeshire, UK) with the electrode standardized to pH 4.0; 7.0 and 10.00 buffers (Sigma-Aldrich, Darmstadt, Germany).

2.6 Colour measurement

A PCE-CSM 2 (PCE-CSM instruments, Meschede, Deutschland) with a measuring aperture of 8 mm was used to analyse the colour parameters (L^* , a , b , c , h) of

the dried slices of each fruit variety. Colour difference is expressed as ΔE .

2.7 Sensory evaluation

The design and execution of the sensory evaluation followed ISO 8586:2023 [12] and ISO 8587:2006/Amd. 1:2013 [13]. The performed sensory evaluation covered overall appearance, aroma, colour, consistency. Appearance and aroma were evaluated by a structured scale, where unpleasant, unappealing and pleasant, appealing were being opposed for appearance; unpleasant, and pleasant, fruit-like were for aroma. Colour was evaluated by a scale from yellow to brown according to panellists' perception. Consistency was marked either sticky – non sticky, brittle - plastic, hard or respectively soft.

2.8 Statistical analysis

MS Excel software was used for data analysis. All assays were performed in at least triplicates. Results are presented as mean \pm SD (standard deviation). Additional statistical analyses of the data were presented using one-way ANOVA and a Tukey–Kramer post hoc test ($\alpha = 0.05$), as described by Assaad et al. [14].

3 Results and discussion

Moisture content, water activity, titratable acidity, pH, and colour change were the monitored parameters. Colour is always one of the first indicators leading to consumer decision-making about food products. Titratable acidity and pH are two interrelated concepts in food analysis that deal with acidity. Titratable acidity and pH are indicators of the amount of organic acids and their salts contained in the fruit. For example, while pH is important for assessing the potential for microbial growth in a particular food, titratable acidity is a better predictor than pH of how organic acids in food affect flavour. Unlike strong acids, which are completely dissociated, dietary acids are only partially ionized [15]. The tart taste sensation caused by organic acids is greatly influenced by the presence of sugars. Titratable acidity measurements deal with the total acid concentration of a food (also called total acidity), pH measures acidity in terms of H^+ ions present in the sample (also called active acidity). Acidity measurement is the main criterion for indicating the freshness and composition of raw and perishable foods [16].

Water activity is an important indicator for predicting and controlling the shelf life of food products. Microorganisms are predominantly neutrophilic and cannot grow at less than 4.5 pH and 0.8 water activity. Lower water activity, in general, helps prevent the proliferation of microorganisms [17]. “Modesto” apricot Table 1 summarizes data on dried “Modesto” apricot fruits and their changes during storage.

Table 1 Physico-chemical parameters of dried apricot fruits during storage (six months, I-VI) (n=3). Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to ANOVA and the Tukey test.

Measurement/ parameter	I	II	III	IV	V	VI
Air drying						
Moisture content, %	4.54±0.28 ^b	5.00±0.42 ^{ab}	6.35±0.58 ^a	5.89±0.45 ^{ab}	6.43±0.96 ^a	6.25±0.81 ^{ab}
a_w	0.595±0.02 ^c	0.595±0.007 ^c	0.525±0.007 ^d	0.665±0.007 ^b	0.548±0.01 ^d	0.951±0.00 ^a
pH	3.55	3.56	3.52	3.7	3.66	3.53
TA	1.12	0.94	0.31	2.2	0.19	4.13
Colour						
L^*	43.43±0.77 ^a	45.17±5.38 ^a	42.46±9.19 ^a	32.29±5.78 ^a	30.9±5.69 ^a	32.74±6.98 ^a
a	18.56±1.15 ^a	18.45±1.67 ^a	17.32±0.82 ^a	14.93±2.65 ^a	13.84±2.68 ^a	14.55±1.38 ^a
b	36.60±0.99 ^a	35.58±6.25 ^a	31.71±6.70 ^{ab}	22.17±7.49 ^{ab}	18.88±7.53 ^b	20.26±4.79 ^{ab}
c	41.05±1.38 ^a	40.12±6.17 ^a	36.20±6.22 ^{ab}	26.79±7.71 ^{ab}	23.54±7.48 ^b	24.99±4.67 ^{ab}
h	60.62±4.27 ^a	62.24±3.11 ^a	60.85±4.02 ^a	54.94±4.91 ^a	52.22±6.84 ^a	53.73±4.24 ^a
Conventional drying						
Moisture content, %	7.03±0.19 ^b	12.31±3.03 ^a	12.06±2.21 ^a	7.03±0.4 ^b	4.36±0.61 ^b	6.2±0.36 ^b
a_w	0.595±0.07 ^c	0.68±0.01 ^{ac}	0.735±0.03 ^a	0.63±0.00 ^{bc}	0.685±0.007 ^{ab}	0.612±0.002 ^{bc}
pH	3.63	3.66	3.39	3.25	3.81	3.75
TA	1.29	0.72	0.71	2.59	1.57	2.79
Colour						
L^*	42.24±6.35 ^a	38.76±5.19 ^{ab}	32.14±3.93 ^{ab}	28.34±3.22 ^b	32.95±8.84 ^{ab}	31.90±7.33 ^{ab}
a	21.72±3.13 ^a	17.05±0.86 ^b	15.14±1.08 ^{bc}	11.94±1.64 ^c	12.08±2.64 ^c	15.38±1.77 ^{bc}
b	45.74±6.63 ^a	30.52±5.06 ^b	21.58±1.68 ^{bc}	14.65±2.09 ^c	18.22±6.77 ^c	20.45±2.93 ^{bc}
c	50.73±6.46 ^a	35.03±4.53 ^b	26.40±1.20 ^{bc}	18.76±2.63 ^c	21.91±7.10 ^c	25.64±2.98 ^{bc}
h	64.45±4.02 ^a	60.45±3.97 ^{ab}	54.87±3.55 ^{bc}	50.44±1.38 ^c	55.48±4.04 ^{bc}	52.67±4.07 ^{bc}
Freeze drying						
Moisture, %	5.41±1.64	7.36±0.02	8.62±2.29	9.17±0.96	10.01±1.09	11.02±2.43
a_w	0.256±0.002	0.375±0.002	0.455±0.01	0.447±0.007	0.489±0.0	0.534±0.0
pH	6.15	6.15	5.5	5.43	5.71	5.75
TA	8.59	6.19	2.35	2.67	2.86	2.22
Colour						
L^*	66.78±0.95	67.71±3.69	68.63±4.74	71.46±12.20	70.87±8.08	72.08±5.62
a	18.32±1.84	12.37±1.77	13.23±2.63	10.06±0.91	12.25±1.17	13.58±0.91
b	46.76±0.75	38.14±3.07	39.65±2.92	35.26±1.16	38.09±2.94	38.26±3.76
c	50.24±1.02	38.21±3.41	41.83±3.37	36.68±0.92	40.01±3.02	40.61±3.81
h	68.62±1.95	71.17±1.44	71.64±2.76	74.04±1.82	72.15±1.37	70.41±0.97

A gradually increasing moisture during storage is visible for the freeze-dried fruit. A 90-day storage of sun-dried apricots showed an average moisture content of 19.00 % [18]. These results are three times greater than the currently recorded. Other authors reported a moisture content of 14% for apricot pestil samples [19]. Moisture content increased in the air dried samples, while in the conventionally dried the moisture content began to increase and then decrease after the fourth month of storage. The same trend was observed for the water activity parameter, where the results did not exceed 0.6 for freeze-dried and 0.8 for conventionally dried. A significant increase of the water activity was established in the sixth month of storage for the air dried samples. This indicates that based on the type of drying the storage period should be different. The pH and TA did not show a specific trend in their six month storage. The air- and conventional drying resulted in lower pH values compared to fresh fruit [20], while freeze-drying produced samples with a higher pH. Colour remained relatively similar between measurements. Figure 1

shows photographs taken during each of the measurements of the differently dried slices of the “Modesto” apricot variety.

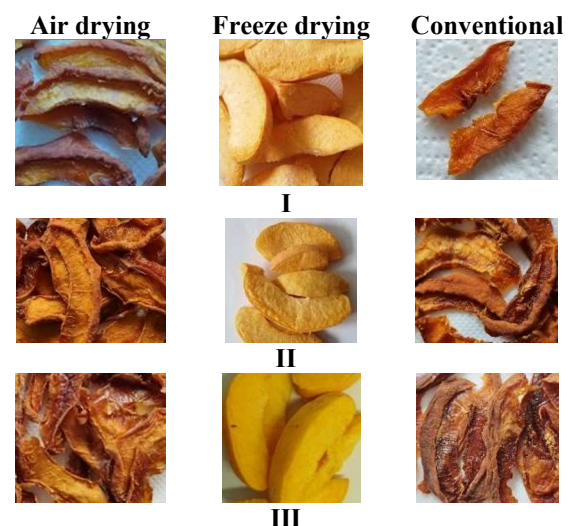




Fig. 1. Storage changes of differently dried apricot fruits (six months, I-VI)

The obtained data show similar results regarding drying in air and in a fruit dryer. Perceptible differences are reported with freeze-drying, not only in terms of colour but also in terms of consistency. Storage within six months showed changes in sensory parameters for all three drying options. The sensory evaluation revealed that the dried slices have kept their distinguishable pleasant fruit-like aroma during each of the six measurements. This applied for all three types of drying i.e. air, conventional, freeze. The consistency of the air- and conventional dried fruits was similar: plastic and

non-sticky at the beginning of storage and soft and little sticky at the final two measurements. The freeze-dried slices were the only ones with a brittle consistency that became softer with storage. After the third month, the hard, brittle consistency characteristic of freeze-dried fruits is replaced by a soft, non-sticky one. The freeze-dried slices managed to keep to original colour of the fruit resulting in vivid orange-yellow slices. On the other hand the conventional and air dried fruit produced light orange-brown to dark brown slices with storage. The overall appearance was marked as excellent for the freeze-dried slices and very good, acceptable for the conventional and air-dried fruits.

An advantage of convective drying (in a dryer) compared to air drying is time-saving. In all three variants, the specific pleasant smell of dried fruit is preserved for the entire storage period. In the widely available literature, some articles can be found regarding convectively dried apricots [21], but there the temperature regime is significantly higher (80 °C) than applied here (35 °C) and a comparison is not suitable to be made.

3.1 “Stendesto” plum-apricot

Table 2 summarizes the data on dried plum-apricot “Stendesto” fruits and their changes during storage.

Table 2 Physico-chemical parameters of dried hybrid fruits during storage (six months, I-VI) (n=3). Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to ANOVA and the Tukey test.

Measurement/ parameter	I	II	III	IV	V	VI
Air drying						
Moisture content, %	6.01±0.53 ^a	7.01±1.32 ^a	6.71±0.33 ^a	4.98±2.31 ^a	7.36±1.66 ^a	7.32±2.90 ^a
a _w	0.595±0.02 ^{ab}	0.61±0.00 ^a	0.58±0.01 ^{ab}	0.603±0.00 ^{ab}	0.597±0.002 ^{ab}	0.563±0.00 ^b
pH	3.7	4.34	4.23	4.82	3.63	3.53
TA	0.79	1.24	0.89	1.13	1.5	1.79
Colour						
L*	36.94±5.19 ^a	28.69±7.81 ^a	27.66±5.99 ^a	27.95±2.06 ^a	35.62±1.81 ^a	35.42±14.53 ^a
a	15.11±1.23 ^a	7.81±4.60 ^a	9.46±3.78 ^a	5.55±2.90 ^a	13.98±1.31 ^a	13.17±3.71 ^a
b	24.79±4.90 ^a	9.15±7.89 ^a	9.81±5.70 ^a	5.48±4.67 ^a	18.05±4.73 ^a	18.08±9.89 ^a
c	29.07±4.70 ^a	12.18±8.89 ^a	13.90±6.12 ^a	7.87±5.36 ^a	22.90±4.42 ^a	22.55±10.04 ^a
h	58.18±3.80 ^a	42.76±12.94 ^a	40.61±20.17 ^a	40.17±8.80 ^a	51.48±5.23 ^a	51.08±8.95 ^a
Conventional drying						
Moisture content, %	9.14±3.37 ^a	8.12±0.02 ^a	9.65±0.98 ^a	8.44±1.13 ^a	6.97±0.27 ^a	7.47±0.53 ^a
a _w	0.55±0.00 ^c	0.645±0.007 ^a	0.605±0.02 ^b	0.603±0.01 ^b	0.561±0.002 ^c	0.616±0.007 ^b
pH	3.54	3.47	4.00	4.15	3.78	3.61
TA	3.2	0.15	0.75	0.13	3.25	1.8
Colour						
L*	46.05±8.66 ^a	43.76±7.62 ^a	42.67±7.61 ^a	36.70±10.78 ^a	46.31±4.10 ^a	47.42±10.18 ^a
a	14.65±4.47 ^a	14.43±1.74 ^a	16.09±2.11 ^a	11.86±3.09 ^a	15.49±1.48 ^a	15.75±1.17 ^a
b	36.83±4.44 ^a	27.28±4.14 ^{ab}	24.03±4.07 ^{ab}	17.22±8.78 ^b	25.07±2.73 ^{ab}	26.29±4.50 ^{ab}
c	39.71±5.65 ^a	30.95±3.57 ^{ab}	28.97±4.16 ^{ab}	21.07±8.84 ^b	29.47±3.09 ^{ab}	30.71±4.04 ^{ab}
h	68.74±4.18 ^a	61.84±5.07 ^{ab}	55.92±3.95 ^b	52.77±9.29 ^b	58.26±0.36 ^{ab}	58.65±4.43 ^{ab}
Freeze-drying						
Moisture content, %	3.08±0.04 ^c	4.73±0.79 ^b	4.41±0.11 ^{bc}	5.19±0.44 ^b	6.72±0.37 ^a	7.43±0.90 ^a
a _w	0.196±0.002 ^c	0.278±0.007 ^d	0.306±0.004 ^c	0.35±0.02 ^b	0.353±0.005 ^b	0.391±0.00 ^a

pH	6.55	6.42	6.25	5.9	6.68	5.4
TA	3.67	3.93	4.8	3.39	2.16	3.22
Colour						
L*	55.54±9.73 ^b	67.96±5.81 ^{ab}	66.58±3.23 ^{ab}	61.60±9.19 ^{ab}	64.93±5.46 ^{ab}	77.36±6.60 ^a
a	17.28±4.88 ^a	14.70±4.04 ^a	17.17±1.73 ^a	16.44±1.72 ^a	12.46±3.54 ^a	14.08±3.66 ^a
b	33.08±3.02 ^a	33.69±3.30 ^a	36.93±3.31 ^a	35.08±1.61 ^a	32.61±0.29 ^a	35.90±5.97 ^a
c	37.61±1.98 ^a	36.91±3.41 ^a	40.77±2.82 ^a	38.53±1.82 ^a	35.03±1.28 ^a	38.62±6.51 ^a
h	62.38±8.09 ^a	66.45±6.01 ^a	64.95±3.51 ^a	64.77±1.76 ^a	69.23±5.47 ^a	68.67±3.79 ^a

The results about the plum-apricot hybrid correspond well to the trends of the dried apricot fruit. Considering the moisture content, a steady increase is registered for the freeze-dried samples, and very small fluctuations for the air- and conventionally dried samples. An increase in the a_w data was also present. The a_w remained low enough to ensure an inability of microorganism growth during the storage period. The “Stendesto” freeze-dried samples provided the lowest amount of capillary (free) water among all three studied fruit. Research explains that the distribution of different types of water (free, bound, and strongly bound) in plant-based matrices is very important to the shrinkage experienced during the process of drying [22]. The TA and pH did not follow any specific curve change as it was stated for the apricot samples. The pH values in all three dried fruit were higher than the fresh one [20]. Colour remained the same according to data. Figure 2 shows photographs taken during storage of each of the measurements of the dried plum-apricot variety “Stendesto” samples.

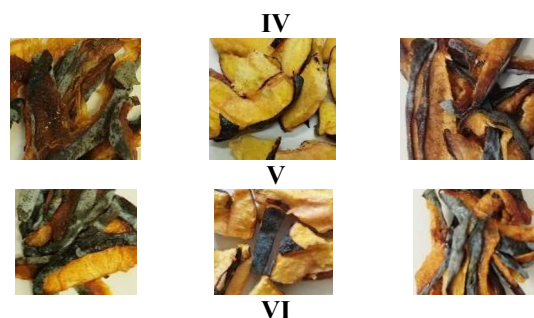


Fig. 2. Storage changes of differently dried plum-apricot fruits (six months, I-VI)

The sensory assessment within the six measurements, included overall appearance, colour, consistency and aroma. The data obtained from the sensory evaluation show similar results regarding air and conventional drying. Perceptible differences are reported for freeze-drying, not only in terms of colour but also in terms of consistency. After the third month, the hard, brittle consistency characteristic of freeze-dried fruits is replaced by a soft, non-sticky one. The results are consistent with the described changes in dried apricots of the “Modesto” variety. Storage within six months showed changes in sensory parameters for all three drying options. In all three variants, the specific pleasant smell of dried fruit is preserved for the entire storage period. The consistency of the air and conventionally dried fruit changed from plastic and non-sticky to plastic but sticky. Panellists described the overall appearance as excellent to very good at the end of the storage period (month six).

Generally, the plum-apricot dried samples revealed more similarity to the “Stanley” plum in their drying behaviour regardless the drying method.

3.2 “Stanley” plum

Table 3 summarizes data on the dried “Stanley” plum fruits and their changes during storage.

Table 3 Physico-chemical parameters of dried plum fruits during storage (six months, I-VI) (n=3). Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to ANOVA and the Tukey test.

Measurement/parameter	I	II	III	IV	V	VI
Air drying						
Moisture content, %	7.35±1.34 ^a	8.3±0.36 ^a	7.66±0.22 ^a	7.54±1.61 ^a	6.00±0.38 ^a	7.73±0.53 ^a
a_w	0.54±0.00 ^c	0.563±0.01 ^{ab}	0.572±0.00 ^a	0.576±0.003 ^a	0.552±0.007 ^{bc}	0.525±0.002 ^d
pH	3.95	4.42	4.13	4.12	3.66	6.51
TA	1.85	1.63	2.24	2.00	1.32	4.5
Colour						

L*	46.2±1.86 ^a	26.76±2.52 ^{bc}	34.27±3.35 ^b	32.53±4.47 ^b	23.54±1.92 ^c	34.14±6.24 ^b
a	11.34±2.35 ^a	10.64±1.00 ^a	10.06±1.26 ^a	11.71±1.43 ^a	11.37±3.10 ^a	14.36±1.36 ^a
b	27.19±5.44 ^a	13.86±2.92 ^{bc}	15.75±3.44 ^{bc}	15.37±4.69 ^{bc}	11.60±3.66 ^c	21.01±4.10 ^{ab}
c	29.49±5.78 ^a	17.49±2.94 ^b	18.87±3.52 ^b	19.39±4.54 ^b	16.25±4.78 ^b	25.48±4.05 ^{ab}
h	67.25±2.76 ^a	52.12±2.99 ^{bc}	57.06±3.28 ^b	51.71±5.83 ^{bc}	45.25±1.82 ^c	55.28±3.48 ^b
Conventional drying						
Moisture content, %	6.3±0.6 ^a	5.81±0.66 ^a	6.98±1.30 ^a	7.16±1.44 ^a	5.78±2.83 ^a	5.94±0.79 ^a
a_w	0.585±0.007 ^a	0.525±0.007 ^c	0.428±0.004 ^c	0.53±0.01 ^c	0.555±0.008 ^b	0.494±0.01 ^d
pH	3.8	4.15	3.96	4.17	4.11	6.59
TA	1.2	1.76	1.14	1.74	1.72	1.75
Colour						
L*	40.34±4.36 ^a	43.95±1.27 ^a	38.79±2.99 ^a	42.77±5.07 ^a	48.64±12.61 ^a	47.87±1.79 ^a
a	8.96±2.26 ^a	13.04±3.32 ^a	10.62±0.94 ^a	13.19±2.63 ^a	11.97±1.77 ^a	11.58±2.49 ^a
b	30.32±1.21 ^a	28.93±7.41 ^a	24.69±3.21 ^a	25.06±6.27 ^a	30.58±4.28 ^a	23.36±2.61 ^a
c	31.67±1.79 ^a	31.73±8.11 ^a	26.88±3.31 ^a	28.33±6.72 ^a	32.86±4.49 ^a	26.08±2.59 ^a
h	73.67±3.58 ^a	65.73±0.51 ^{bc}	66.64±1.05 ^{bc}	61.89±2.23 ^c	68.59±2.09 ^d	63.52±2.12 ^c
Freeze drying						
Moisture content, %	2.90±0.23 ^a	3.78±1.78 ^a	4.39±0.42 ^a	4.66±0.89 ^a	4.81±0.93 ^a	5.48±1.20 ^a
a_w	0.229±0.005 ^d	0.290±0.003 ^c	0.331±0.04 ^{bc}	0.365±0.005 ^{ab}	0.362±0.002 ^{ab}	0.382±0.005 ^a
pH	6.94	6.97	7.08	6.67	6.97	6.63
TA	3.26	6.39	2.28	2.71	3.31	4.09
Colour						
L*	59.62±6.52 ^a	58.17±9.75 ^a	67.68±1.16 ^a	60.71±8.92 ^a	52.87±3.39 ^a	66.28±5.39 ^a
a	12.89±2.49 ^a	13.24±1.43 ^a	14.39±2.85 ^a	14.61±2.93 ^a	16.20±1.94 ^a	17.88±3.65 ^a
b	36.47±3.14 ^a	35.56±2.28 ^a	39.22±4.14 ^a	39.14±6.79 ^a	32.77±1.62 ^a	39.71±1.52 ^a
c	38.79±2.11 ^a	37.98±2.15 ^a	41.83±4.45 ^a	41.81±7.23 ^a	36.62±0.75 ^a	43.65±2.16 ^a
h	70.32±5.07 ^a	69.53±2.46 ^a	69.88±3.19 ^a	69.55±2.15 ^a	63.65±3.76 ^a	65.87±4.44 ^a

The lowest moisture content belonged to the freeze-dried samples while the air dried and the conventionally dried has rather similar values ranging from 6.3 to 7.73 %. Miletić et al. [23] have studied the chemistry of dried plums and they have documented comparable data even though a higher drying temperature has been used in the study. The measured water activity showed that the values were low enough to ensure microbial growth inhibition. The pH values of the air- and conventionally dried samples were comparable to the fresh fruit [20] at the beginning of storage and were higher afterwards. The pH of the freeze-dried samples was 1.8 higher than the pH of the fresh “Stanley” plum. The calculated ΔE between the air dried and conventionally dried samples is 7.06 which means that the human eye should be able to perceive a difference without difficulty. Figure 3 presents photographs taken at each of the measurements during storage of dried plum fruits from the “Stanley” variety.

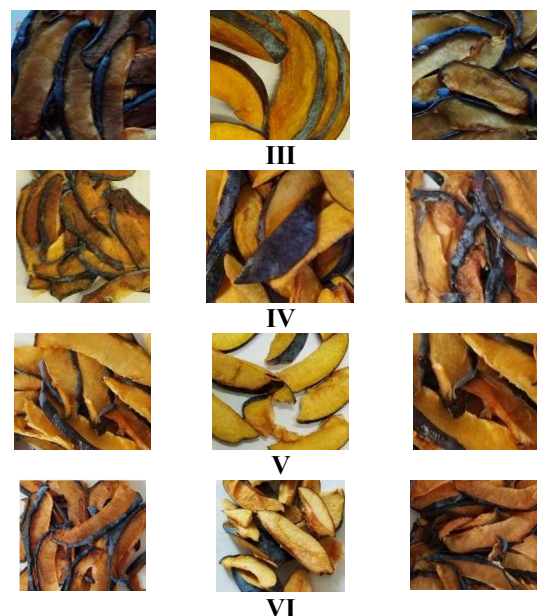
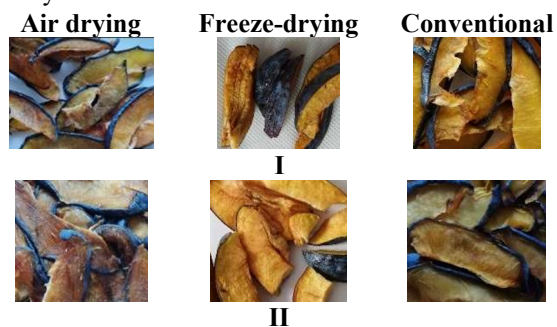


Fig. 3. Storage changes of differently dried plum fruits (six months, I-VI)

The sensory evaluation confirmed the finding about the apricot and the hybrid dried samples. The colour has not changed significantly during storage, which is further supported by the CIE lab results reported in Table 3. The lyophilized fruit has a colour that is most similar to the fresh fruit. The consistency follows the same changes as described for the plum-apricot and the apricot. The overall appearance is marked as excellent to very good during the storage period of six months.

4 Conclusion

This study follows changes in the moisture content, a_w , pH, TA, colour and sensory perception of air-, freeze- and conventionally dried apricot, plum-apricot, and plum fruits. The study design is a first evaluating more than one fruit and incorporating the types of drying procedures. The presented data are considered pilot especially on the topic of hybrid fruit evaluation. Generally, the plum-apricot dried samples revealed more similarity to the “Stanley” plum in their drying behaviour regardless the drying method. All three types of drying revealed both advantages and disadvantages i.e. energy consumption, time, storage changes.

The air-dried and conventionally dried samples showed similarities. However, the freeze-drying method resulted in the best colour retention, and the most brittle consistency. This can provide sources for the freeze-dried fruit's inclusion in culinary and confectionary products in the type of powder as well as be consumed in cereals, granola, among others.

Further studies could reveal the potential change in the chemical content and biological activity of the three dried fruits during storage. Additionally, different types of solvents can be applied to alter the dried slices in terms of their appearance (colour, consistency) and make them more appealing.

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The data presented in this study are available on request from the corresponding author.

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