Application Note
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Lyophilisation of fresh banana slices

Lyovapor™ L-200 Pro

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1. Introduction

Freeze drying is a gentle form of drying and may be used to preserve foods without changing their appearance or taste.
The freeze drying process includes the freezing of the food sample and subsequent applying a fine vacuum to the frozen sample. Under these conditions, the water in the food will sublimate, hence, the sample dries.
In food applications, freeze drying is commonly used to make instant coffee and to dry and conserve fruits, vegetables or herbs [1 – 4].

2. Equipment

- BUCHI Lyovapor™ L-200 Pro
- BUCHI Lyovapor™ Software
- Deep Freezer -40°C, tritec HANNOVER
- Stainless steel tray
- Mettler Toledo HR73 Halogen Moisture Analyser

3. Chemicals and Materials

- Banana, purchased from a local supermarket.

4. Experimental

4.1. Sample preparation

The banana was cut into slices of approximately 5 mm width. Eleven banana slices were placed on the stainless steel shelf (Figure 1) and then, frozen overnight in a deep freezer at -40°C. Alternatively, a -20 °C freezer can be used.

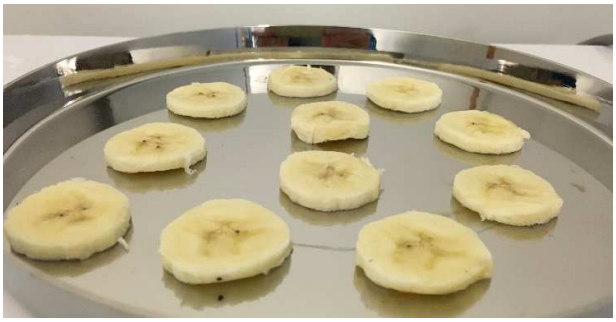

Figure 1: Tray with fresh cut banana slices.

4.2. Lyovapor™ L-200 settings

After 24 hours of deep freezing, the banana slices were transferred with the tray into the Lyovapor™ L-200 for freeze drying. The general settings are listed in Table 1.

Table 1: General settings for drying of banana slices in Lyovapor™ L-200.

Drying chamber type	Standard	Safety temperature below collapse [°C]	Inactivated
Sample collapse temperature [C°]	Inactivated	Gas type	Ambient air

The shelf temperature itself was chosen such that it does not exceed 25 °C at the end of the primary and secondary drying (temperature set point). The steps of the primary and secondary drying process were programmed using the Lyovapor™ Software as listed in Table 2.
During the primary drying phase, the bulk solvent, in this case water, is removed from the sample by sublimation. In the secondary drying phase the sample is dried by removing adsorbed solvent.

Table 2: Parameters of the primary and secondary drying steps, set on the Lyovapor™ Software.

Step		1	2
Phase		Primary Drying	Secondary Drying
Time	hh:mm	12:00	03:00
Temperature set point	°C	25.0	25.0
Temperature gradient	°C/min	0.07	0.00
Pressure type		Regulated	Regulated
Pressure set point	mbar	0.370	0.100
Safety pressure	mbar	1.500	1.500
Safety pressure duration	sec	10	10

4.3. Halogen Moisture Analysis

After drying of the banana (see Figure 2), the residual moisture content of three banana slices were analyzed to assess the drying efficiency. Therefore, the samples were ground in a mortar and transferred to the moisture analyzer within 30 seconds. For moisture analysis, a halogen moisture balance using parameters listed in Table 3 was applied. The switch-off criterion 5 refers to a change of no more than 1 mg / 140 s.

Table 3: Moisture analyser settings

switch-off criterion	5
Drying temperature [C°]	110

Figure 2: Tray with banana slices after freeze drying.

5. Results and Discussion

5.1. Visual evaluation of the freeze dried banana Slices

Figure 1 and 2 show the tray plate with the banana slices before and after freeze drying process, respectively. All eleven banana slices showed a homogenous freeze dried structure and appearance. No change of their size and morphology could be observed during the drying.

5.2. Moisture analysis of the freeze dried banana pieces

To determine the drying efficiency of the Lyovapor™ L-200, the residual moisture content of three banana slices, were analyzed using a halogen moisture analyzer. The results of the measured moisture contents and drying efficiencies are shown in Table 4.

Table 4: Results of the moisture analysis after freeze drying with Lyovapor™ L-200.

Banana slice	Weight of freeze dried sample [g]	Weight of halogen dried sample [g]	Moisture content [%]
1	0.606	0.587	**3.14**
2	0.843	0.818	**2.97**
3	0.794	0.770	**3.02**

All analyzed samples contained ≤ 3.14 % moisture after freeze drying process. The initial water content of the banana was 76.97 ± 1.24 % (n=3). Hence, applying the described freeze drying method on the Lyovapor™ L-200 lead to a water removal of ≥ 95.92 %.
In general, applying the freeze drying process to foods such as banana slices, has the following advantages and disadvantages [5]:

Advantages

- The process at low temperature and low pressure makes freeze drying an effective way to keep color, smell, flavor and heat-sensitive nutrients of food.
- Eliminates the surface hardening of the food.
- Freeze dried food is porous and easy to rehydrate and/or dissolve. It can be consumed directly or after rehydration.
- Since freeze dried food contains very low moisture, it has relatively small density and is easy to be transported. The freeze dried food can be preserved at room temperature for a long time, while the cost of transportation is much lower than that of frozen food.
- No additives are added into the food during freeze drying process.

Disadvantage

- If exposed directly to air, freeze dried food will be rehydrated quickly, resulting in deterioration of food.
- The freeze dried products have to be vacuum- or vacuum-nitrogen packed and the packaging material must not be permeable to water vapor.
- During transportation and sale process, freeze dried food is easy to be powdered or cracked for its loose porous structure.
- Freeze drying is a time- and energy-consuming process, which leads to higher production costs.

6. Conclusion

With the Lyovapor™ L-200, a high drying efficiency was achieved for the water removal of a banana. In summary, the Lyovapor™ L-200 allows freeze drying of fruits such as banana slices.

7. References

[1] G. W. Oetjen; Freeze drying; Ullmann's Encyclopedia of Industrial Chemistry (2004).
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[5] H. Tse-Chao Hua, L. Bao-Lin, Z. Hua; Freeze drying of Pharmaceutical and Food Products, Woodhead Publishing Series in Food Science, Technology and Nutrition, pages 141–169 (2010).