

Best practice: Microwave drying of mealworms and BSF larvae

Overview

Short summary	Microwave (μ W) drying is a dielectrical drying technology to stabilise products for further applications and preservation. The application of microwave drying on mealworms and black soldier fly (BSF) larvae results in high quality and stable dried insect products. Microwave drying also has a slight decontaminating effect on microorganisms present in/on the insects. Compared to conventional drying technologies such as oven and freeze drying, microwave drying has a similar impact on nutritional and physicochemical quality, while requiring shorter drying times and consuming lower amounts of energy.
Related key barrier(s)	Specific insect processing technologies are required to produce a wide variety of intermediate and end products. Since many processing technologies have specific outcomes related to product quality and potential for further application, additional processing technologies specifically applied on insects are required in the insect sector. There is a need to investigate the effect of novel technologies such as microwave drying for insect matrices.
Relevant for insect species	Black Soldier Fly (<i>Hermetia illucens</i>) Yellow mealworm (<i>Tenebrio molitor</i>)
Relevant for which supply chain stage	Insect storage & processing Use of insects in feed Use of insects in food
Level of best practice	Company Insect sector as a whole (in a country) Insect sector as a whole (EU)
Other information	

Detailed description

Detailed description of best practice	<p>The aim of a drying technology is to reduce the water activity of a product to a value that reduces or impedes deterioration of the product quality by microbiological, chemical or enzymatic processes. As such, when drying insects using microwave drying, a stable water activity of 0.60 (corresponding with complete microbiological stability) was aimed for. To obtain this water activity value, processing parameters during drying have to be optimised depending on the insect species, volume to dry and μW installation. In order to reach the most optimal processing conditions for μW drying, a large scale continuous μW dryer (with a conveyor belt) is advised.</p> <p>Using a large-scale μW dryer comparable to the MEAM Dry S20 or MEAM Dry 32 (MEAM, Belgium, see Annex 1), following process parameters can be employed to obtain good quality dried mealworms and BSF larvae. Here, a mass of \pm 12 kg blanched insects was used as starting material.</p> <ul style="list-style-type: none"> • Use a power between 16 and 24 kW for the magnetrons. Since μW dryers are modular systems, this power can be adapted by including more or less 2kW μW generators and/or by switching them on and off. • Apply a layer thickness of 15 mm of insects • Set maximum temperature at 85 °C. Temperature can be monitored using IR sensors within the μW cavity. • Apply a drying time of 28 minutes for mealworms and 65 minutes for BSF larvae. Drying time may vary depending on the initial moisture content of
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the insects. An end moisture content of max. 8% should be aimed for to correspond with a stable water activity.

- Assist the μ W drying with a hot air flow, recovering μ W heat as generated by the magnetrons. This allows for an increased drying speed and a more energy-efficient drying process. By using a perforated conveyor belt, moisture can be removed via two sides, also improving the drying process.

Further, it is advised to include a decontamination step as pretreatment, e.g. blanching, in order to improve the initial microbiological quality of the insects. As demonstrated in the best practise sheet “Low electron energy beam of dried mealworms and black soldier fly larvae”, a decontamination step after drying is possible as well.

The application of μ W drying was compared to oven and freeze drying as benchmark technologies. It can be stated that, for a not yet completely optimised μ W process (i.e. in a research context), that the μ W drying did not result in losses in terms of nutritional quality (protein, fat, ash and chitin content and amino acid, fatty acid and mineral profile) compared to the other drying technologies. The only difference in nutritional quality was observed for vitamin B₁₂ content in dried BSF larvae, which was lower for μ W-dried insects compared to oven- and freeze-dried insects (see Annex 2). This is most probably related to the higher processing temperature (up to 85 °C) for μ W drying, compared to oven drying (60 °C) and freeze drying (- 55 °C). On the other hand, μ W drying had an additional decontaminating effect on mealworms in terms of microbiological quality compared to the benchmark drying methods (see Annex 3). Slight reductions in total viable counts and bacterial endospore counts were observed. In combination with a decontaminating pre-treatment, this may, in some cases, improve the microbiological safety of the product.

After drying, μ W-dried BSF larvae and mealworms were subjected to shelf life tests in order to monitor chemical (lipid oxidation) and microbiological stability. Since the water activity remained stable, no microbiological changes were observed, but lipid oxidation could continue (see Annex 4). Especially primary oxidation (peroxide value) was observed for the dried BSF larvae and according to international threshold limits (Ismail et al., 2016), μ W-dried BSF larvae can be given a shelf life of approximately 3 months. For μ W-dried mealworms, following the limited shelf life period that was tested, a shelf life of 3 months can be guaranteed as well.

Finally, two major advantages of the μ W technology are the short drying times (minutes) and the low relative energy consumption required to dry insects. Depending on the desired end quality or application, μ W drying may therefore be a valuable technology for insect stabilisation.

Targets for (intermediate) products and/or process outcomes	<p>A target water activity of 0.60 should be aimed for. This corresponds, in general, with a moisture content below 8%.</p> <p>When integrating a drying process in an insect production chain, it is advised to incorporate an efficient flow. For example, after rearing, insects should be killed, decontaminated, processed and stored or transported as quickly as possible. By aligning the different processing steps to avoid unnecessary storage and waiting times, process efficiency can be improved. For example, by applying a drying step immediately after blanching (as killing and decontamination step), no thermal energy is wasted.</p>
Risks involved	<p>Improper drying may result in a water activity that is too high after processing. This may allow microbiological spoilage or increased lipid oxidation during further storage of the product. During preservation of the dried insects, attention should be paid to the storage conditions (packaging, temperature, humidity), in order to retain</p>

the stable conditions and to prevent the products to take up water again, thus increasing the water activity.

Legislation involved (if any) As in all cases, end products should comply with national and EU legislation regarding food safety. Additionally, animal welfare should be taken into account, e.g. by not subjecting living larvae to μ W drying.

Further reading and sources

Further reading Deliverable 3.2, Deliverable 6.3, Milestone 3.2

[Future research needs (if any)] Further research on the impact of microwave drying on the quality and stability of insects (including other species) is advised. Of particular interest is the monitoring of a relevant large-scale industrial protocol implemented in a real insect processing facility. Furthermore, longer shelf life experiments, including additional preservation technologies should be investigated.

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Sources Ismail, A., Bannenberg, G., Rice, H. B., Schutt, E., MacKay, D. (2016). Oxidation in EPA- and DHA-rich oils: an overview. *Lipid Technology*, 28(3-4), 55-59.
<https://doi.org/10.1002/lite.201600013>

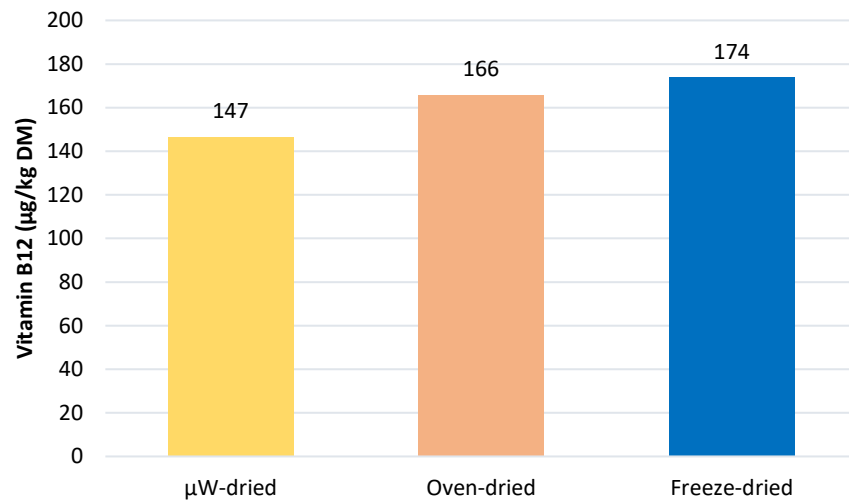
Technical annex

Annex 1 MEAM Dry S20 (top) and MEAM Dry 32 (bottom) microwave dryers (MEAM, Belgium) <https://meam-international.com/rentals/>



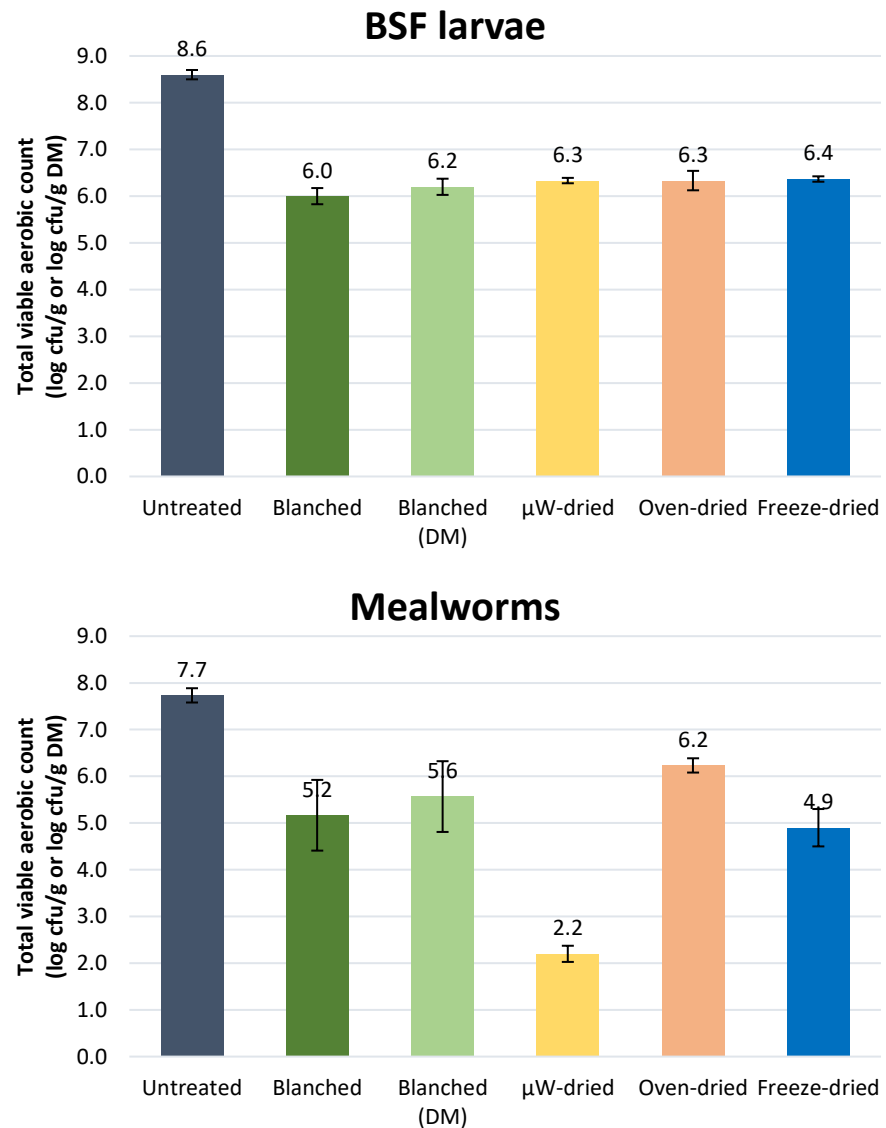


Annex 2 Vitamin B₁₂ content of dried BSF larvae. Results were obtained from one replicate (n=1).



Annex 3 Total viable aerobic counts (TVC) of BSF larvae and mealworms before and after drying with different drying technologies. Results are mean values (n=3) ± standard deviations and expressed as log cfu/g for untreated and blanched BSF larvae and as log cfu/g dry matter (DM) for dried larvae. Blanched (DM) represents a TVC of blanched BSF larvae expressed as log cfu/g DM for proper comparison with dried

larvae.



Annex 4

Lipid oxidation of μW-dried BSF larvae during 6 months of storage. Primary oxidation is shown as peroxide value (yellow graph), secondary oxidation as *p*-anisidine value (orange graph). Results are mean values (n=3) ± standard deviations.

