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OVERVIEW OF THE CONSTRUCTION DEVICES FOR HONEY DEHYDRATION®

Przegląd konstrukcji urządzeń przeznaczonych do odwadniania miodu®

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Key words: honey, dehydration, compaction devices.

The aim of the work presented in the article was to review the design solutions of devices used for honey dehydration. The conducted analysis included literature reports from patent databases, solutions described in scientific publications as well as commercial solutions. The final conclusion of the considerations points out that the topic of honey dewatering is a current problem, the solution of which has been worked on since the 1970s, and which solutions are nowadays refined, modified and implemented for industrial production.

Słowa kluczowe: miód, odwadnianie, urządzenia do zagęszczania.

Celem pracy zaprezentowanej w artykule był przegląd rozwiązań konstrukcyjnych urządzeń stosowanych do zagęszczania (odwadniania) miodu. Przeprowadzona analiza obejmowała zarówno doniesienia literaturowe z baz patentowych, rozwiązania opisane w publikacjach naukowych jak i rozwiązania komercyjne. Wniosek końcowy rozważań zwraca uwagę, iż temat odwadniania miodu jest aktualnym problemem, nad rozwiązaniem którego pracowano już od lat 70 XX wieku, a które to rozwiązania w dzisiejszych czasach są dopracowywane, modyfikowane i wdrażane do produkcji przemysłowej.

ADMISSION

Honey, as a natural product obtained by beekeepers in various climatic and nutrient conditions, is often characterized by a significant variability in its properties, especially in terms of water content. Often, in Polish climatic conditions, honey is obtained with a water content exceeding the required level of 20%. This problem occurs especially when obtaining honey during intensive fertility (rape, raspberry, acacia, buckwheat). Literature data indicate a large range in water content depending on the type of honey and the conditions of its acquisition. Studies by Piekut and Borawska [6] and Popek [7] carried out in 2001-2003 show that the average water content ranges from 15.5% for nectar and honeydew honeys to even 18.6% for linden honey and 19.6% for buckwheat. Studies of varietal honeys obtained from the Warmia and Mazury region, carried out on 584 samples, showed that in as many as 353 cases (60.5%) they do not meet the quality standards in terms of water content in honey [8]. In addition to the problem of too high water content in relation to the norms, it should also be noted that honeys with an increased water content are quickly fermented under the influence of osmophilic fungi of the genus *Saccharomyces* and *Zygosaccharomyces*, including Torula, *Torulopsis*, *Hansenaula* and *Pichia* [1, 14]. Problems related to obtaining honey with too high water content and the fact that consumers seek varietal honeys that meet the standards and are of high quality, make such honey producers subject their products to thickening processes. Information on this subject appears in literature reports both in Europe, North America and Asia. at present, the simpler way of dehydrating the honey is to leave the combs in the stream of heated air [9]. However, this process is ineffective, therefore, new methods and constructions of devices for honey dewatering are sought, allowing on the one hand to obtain a product that meets quality standards, and on the other, so effective that they do not significantly increase production costs. Information on patented structures can be found in the literature since the 1970s [10, 11, 12, 13]. Already then, this problem was noticed and the designers were looking for appropriate constructions for honey thickening devices. The following part of the article presents a literature analysis of design solutions for honey thickening / dewatering devices.

ANALYSIS OF THE STRUCTURE OF DEVICES FOR HONEY DEHYDRATION

Design solutions of honey concentrating devices are in most cases based on the design solutions of devices for thickening products with high sugar concentration, such as molasses and sugar syrups, which have been widely used for years [10, 11]. In devices of this type, however, an obstacle

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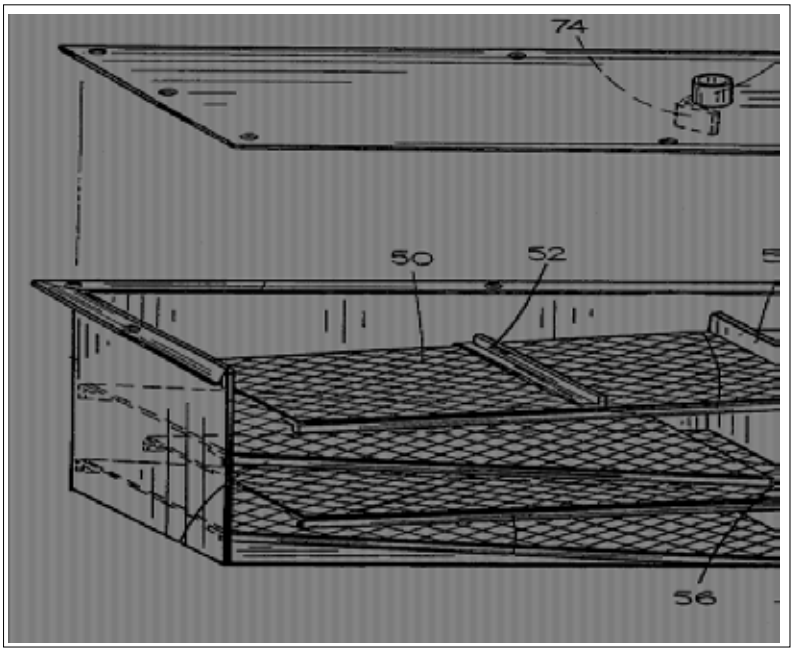

Fig. 1. Apparatus for drying honey [13].
Rys. 1. Aparat do odwadniania miodu [13].

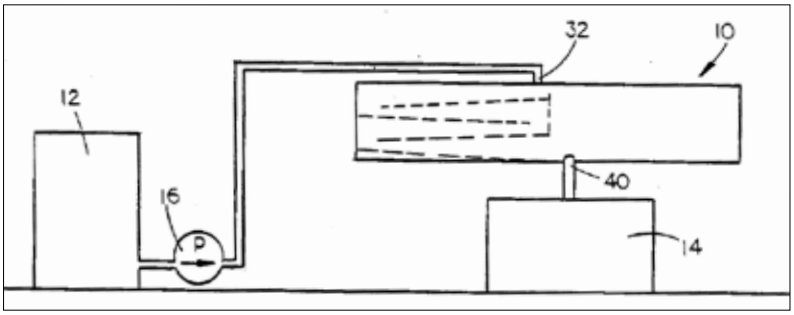

Fig. 2. Block diagram of the honey thickening device according to US patent 4763572 [13].
Rys. 2. Schemat blokowy urządzenia do zagęszczania miodu wg patentu USA 4763572 [13].

Fig. 3. Honey concentrator operating at French Bee Farm [16].
Rys. 3. Urządzenie do zagęszczania miodu pracujące w firmie French Bee Farm [16].

is the thermolability of honey, which limits the possibility of using high temperatures, close to the boiling point of water. Therefore, the constructions of honey concentrating devices are based mainly on solutions that use the flow of heated air over a thin layer of honey. An example of such a solution is the construction of the device according to US patent No. 4763572 [13]. The device is shown in Fig. 1. This device consists of a compacting chamber 18, inside which there is a set of shelves 50 arranged at an angle allowing the gravitational flow of honey with a layer of appropriate thickness. The honey is delivered by the pump to the upper part of the chamber through the connector 32 (Fig. 1). The bar 52 determines the thickness of the flowing honey layer. The strip 54 prevents the honey from overflowing into the air drying system 64.

The principle of operation of this device is based on the flow of honey in a thin layer over the shelves 50 countercurrently to the heated air supplied by the fan 62. The air circulates through the device in a closed circuit. After contact with the honey, it is directed to the condenser 60, where, at a reduced temperature, water condenses therefrom, which is then removed from the device through a pipe 66. The dried air is heated with a heater 58 and directed back to the drying chamber. The dehydrated honey flows out of the device 40. In the above solution, the honey is taken from the storage tank 12 (Fig. 2) by means of a pump 16 and goes through the stub pipe 32 to the compacting device 10. After compacting, it is transported through a pipe 40 to the tank 14.

The solution described in USP 4763572 was implemented in the French Bee Farm honey packaging company (Fig. 3) [16].

In the case of the above implementation, the dehydration device cooperates with a honey tank with a capacity of 2000 liters, in which there is a heating system that maintains a constant temperature of honey at 32 ° C (Fig. 3). The air in the dewatering zone (in contact with the honey) has a temperature of about 45 ° C. This system works in a closed circuit, which allows multiple honey flow to the drying device until the appropriate water content in the honey is obtained.

Similar to the solution presented above was presented in US Patent No. 4472450 [12]. In this case, the device has an increased mass exchange surface through a special construction of the compaction chamber, which enables the process to be carried out in a continuous or cyclical manner. This device is made in the form of a cylindrical chamber 24 with an axially placed shaft 27 on which are mounted parallel circular metal plates 29 separated by sleeves 57 (Fig. 4, Fig. 5). The sleeve 57 makes it possible to adjust the distance between the plates and hence the number of plates, which constitute the water mass exchange surface

between the honey supplied to the device via the line 21 and the air heated by air flowing through the chamber between the connectors AI and AO. The honey fills from 5% to 45% of the volume of the drainage chamber 24, while the device is in operation, the shaft with the plates rotates, thanks to which the honey is intensively mixed and, due to its viscosity, the honey is distributed in an even, thin layer on the plates. A drying air stream flows between the plates, which is fed by the fan through the AI connector and has a temperature from 45 ° C to even 75 ° C. After flowing through the drainage chamber, the air is directed outside the device through the AO connector.

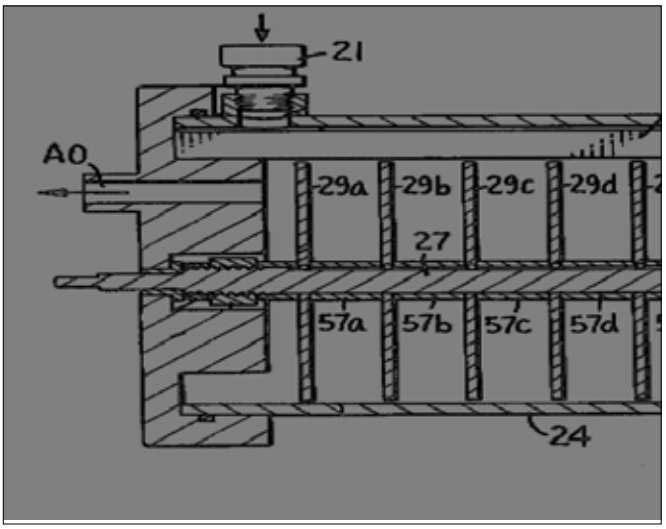

Fig. 4. Device for the concentration of honey [12].
Rys. 4. Urządzenie do zagęszczania miodu [12].

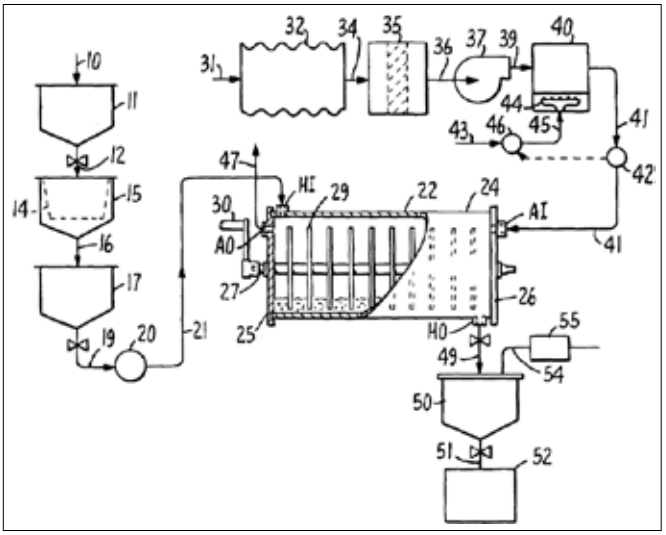

Fig. 5. Block diagram of the honey thickening device according to US Patent No. 4472450 [12].
Rys. 5. Schemat blokowy urządzenia do zagęszczania miodu według patentu USA nr 4472450 [12].

The drying air flows through the system in an open circuit (Fig. 5). It is sucked in by the fan 37, then it flows through the solar preheater 32, filter 35 and directed to the heater, where it reaches a temperature of 40 to 75° C, from where it is then forced into the drying chamber of the dryer through the connection AI. After flowing through the working chamber 24, the air escapes through the pipe 47 to the atmosphere.

Honey to be concentrated is supplied to the tank 11, then it flows through the filter 14 in the tank 15 and goes to the buffer tank 17 from where it is pumped by the pump 20 to the drainage chamber 22 via the connection HI. After compacting in the chamber 22 with the H0 spout and goes to the buffer tank 50, from where it can be directed directly to the packaging 45-55 or to the storage tank 52. The above-described patent solution has different designs of the drainage chamber (Fig. 6, Fig. 7) The drainage chamber 24 can be additionally equipped with vertical partitions 71 (Fig. 6) ensuring longer stay of honey in the drainage zone. The working element of the chamber may also be a horizontal screw 72 transporting the honey from the inlet port HI to the outlet port HO (Fig. 7).

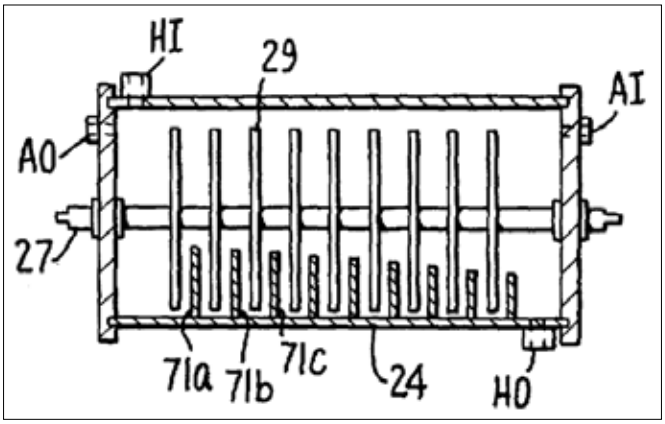

Fig. 6. Construction of the drying chamber according to US patent No. 4472450 with additional baffles [12].
Rys. 6. Konstrukcja komory odwadniania wg patentu USA nr 4472450 z dodatkowymi przegrodami [12].

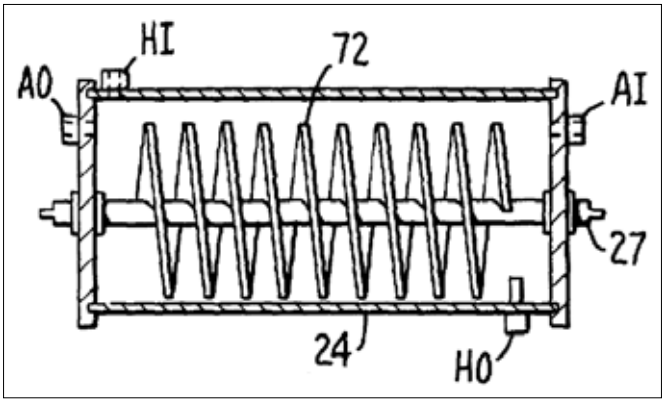

Fig. 7. Construction of the drying chamber according to US patent No. 4472450 with a working element in the form of a horizontal screw [12].
Rys. 7. Konstrukcja komory odwadniania wg patentu USA nr 4472450 z elementem roboczym w postaci ślimaka poziomego [12].

The design solution constituting the essence of the USP 4472450 patent was used in the design solution of the device offered by the Polish company Łysoń [15]. The principle of operation of this device is analogous to that described in the above patent, but the device operates cyclically (Fig. 8).

Fig. 8. Łysoń honey dehydrating device [15].
Rys. 8. Urządzenie do odwadniania miodu firmy Łysoń [15].

Fig. 9. Construction of the TurboHive-A device by Honema [17].
Rys. 9. Konstrukcja urządzenia TurboHive-A firmy Honema [17].

Solutions from US Patent 4472450 were also implemented by the beekeeping equipment manufacturer Honema under the trade name HONEMA TurboHive-A (Fig. 9). In this solution, the method of supplying air to the drainage chamber was modified. In the structure shown in Fig. 8, the heated working air is directed directly to the surface of individual discs with a thin layer of honey using a horizontal pipe with appropriate incisions. This solution allows to optimize the air stream distribution inside the drainage chamber and to eliminate the risk of the formation of dead zones reducing the intensity of drainage [17].

Honema also offers a similar to the above-described device called HONEMA TurboHive-V (Fig. 10), operating under reduced pressure. The use of reduced pressure in the working chamber allows the intensification of the process of water mass exchange between the heated working air and the honey. In this device, as in the TurboHive-A device, air with low relative humidity flowing through the working chamber receives excess water from the honey, and the process is carried out at reduced pressure in the working chamber [17].

Fig. 10. Design of the TurboHive-V by Honema [17].
Rys. 10. Konstrukcja urządzenia TurboHive-V firmy Honema [17].

Fig. 11. Construction of the Honema HDM device [17].
Rys. 11. Konstrukcja urządzenia HDM firmy Honema [17].

In another solution offered by Honema, the mass exchange surface is designed as a horizontal spiral agitator (Fig. 11). The use of such a construction of the agitator allowed to reduce the dimensions of the device while maintaining a large working surface of the agitator compared to the model TurboHive-A. This device works similarly to the TurboHive-A at atmospheric pressure and the drying air heated by an electric heater flows in an open circuit, removing excess water from the honey [17].

Another design solution of the honey concentrator is described in the French patent FR2645042 [4]. The described structure (Fig. 12) consists of 3 parallel shafts 5 with vertically placed round steel plates 6. The plates 6 play the role of agitators and the honey flow surface and mass exchange during drying. Honey is delivered through the connector 3 and received through the connector 2. The dewatering process is carried out cyclically with the drying air closed circuit. The working air is heated and dehumidified from the excess moisture with the flow forced by the compressor system, where first, at a reduced temperature, water is condensed from the air on the evaporator 10, and then the air is heated by the heater 11.

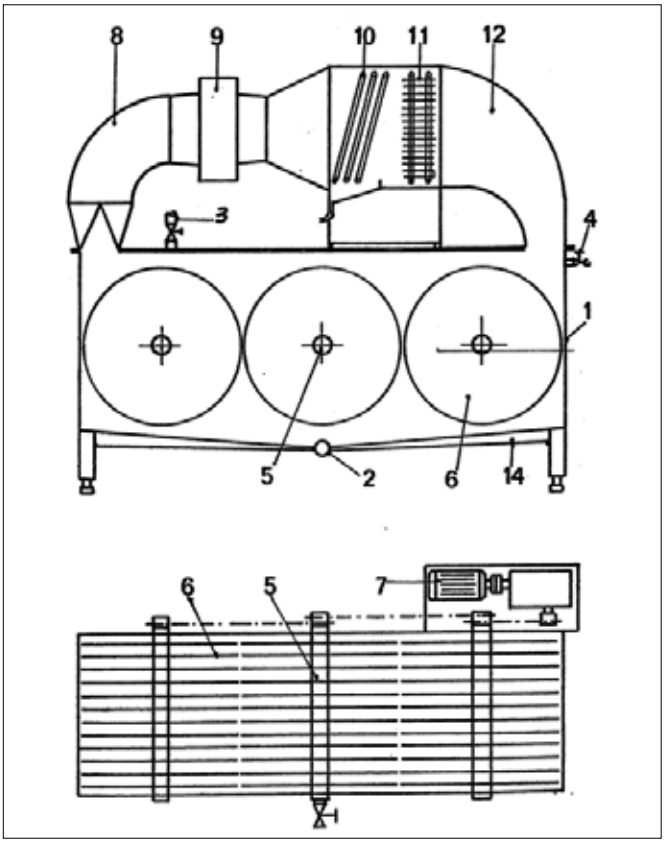

Fig. 12. Diagram of the device according to the patent FR2645042 [4].

Rys. 12. Schemat urządzenia według patentu FR2645042 [4].

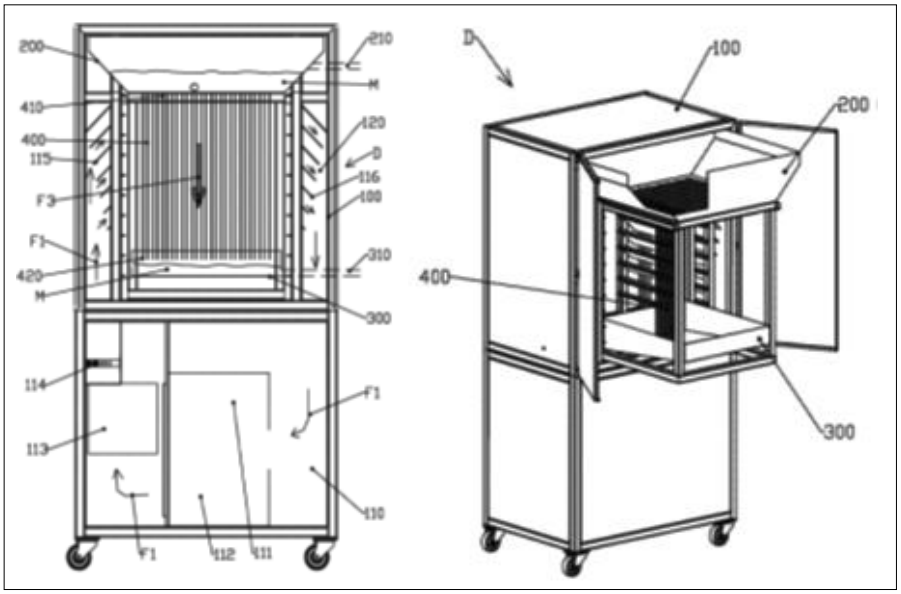

Fig. 13. Diagram of the device structure according to the patent FR No. 051499 [5].

Rys. 13. Schemat konstrukcji urządzenia wg patentu FR nr 051499 [5].

Patent FR No. 051499 [5] describes a device using a different design of the drainage chamber 100 in the form of a large number of vertical bars 400 on which honey flows through a thin layer by gravity during the drainage process (Fig. 13). The working chamber 100 is placed between the two upper tanks with the honey for drainage 200 and the lower 300, into which the dried honey flows. There are holes of adjustable size in the bottom of the upper tank 200, from each opening a steel rod 400 is lowered vertically downwards, over which honey flows in a thin layer. The stream of heated air with low relative humidity flows crosswise into the honey, evenly distributed over the entire height of the drainage chamber 100 by means of a fan system 115. The working air dewatering system in the above patent solution is analogous to the structure from the FR Patent 2645042. Moist air at the outlet 116 from the drainage chamber is directed to the condenser 111 of the compressor device and then the heater 113 and again goes to the drainage chamber 100.

Testing of an analogous device based on the solution described in FR Patent No. 051499 was carried out by Gill et al. [2]. This device was additionally equipped with a lower tank placed in a thermostatic water jacket, and the system operated in a closed circuit for the flow of honey in a cyclical manner (Fig. 14).

Liquid honey was transported to the upper tank by a circulating pump. The honey was dried with the use of heated atmospheric air in an open circuit. The air is forced into the dehydration chamber by a blower through the mesh, which breaks the main stream into parallel air streams, evenly distributed in the de-watering chamber.

All the structures presented above are stationary solutions for dehydration of honey in liquid form and for cooperation with external honey tanks. A mobile solution intended for installation on standard honey barrels is presented in Polish patent no. PL 218759 fig. 15 [3]. It consists of three main elements of the drainage chamber 2, the screw conveyor 4 with the drive 5 and the working air drying system. The device uses

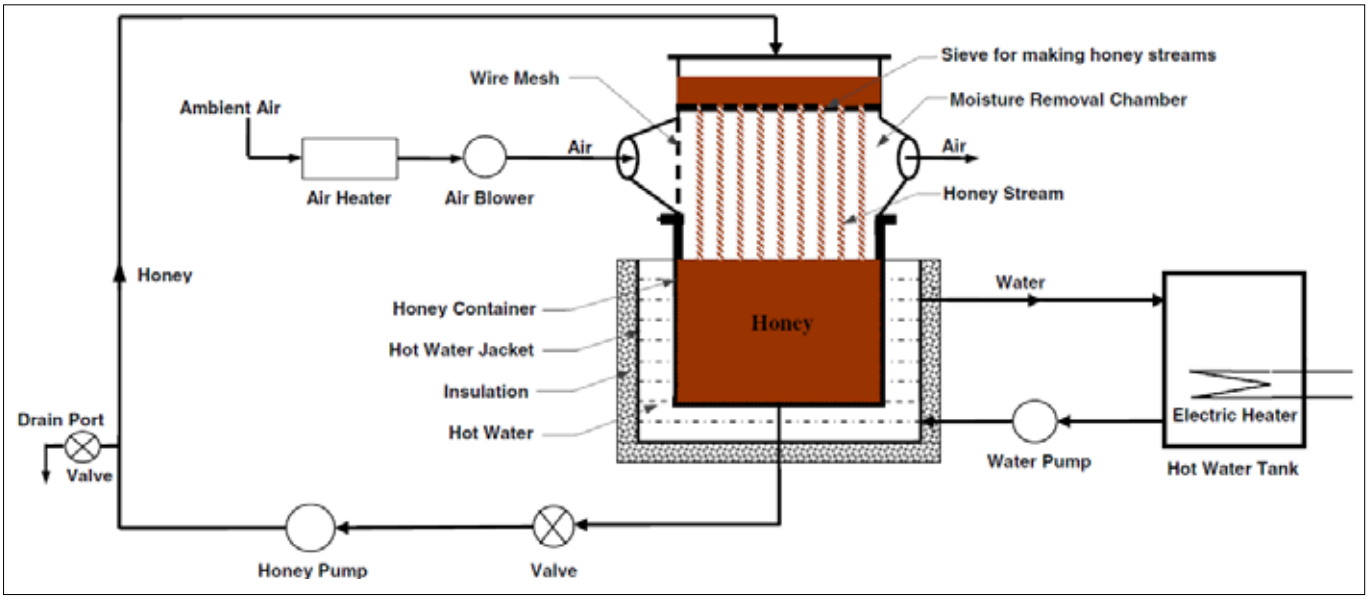

Fig. 14. Diagram of the structure of the honey concentrator [2].
Rys. 14. Schemat konstrukcji urządzenia do zagęszczania miodu [2].

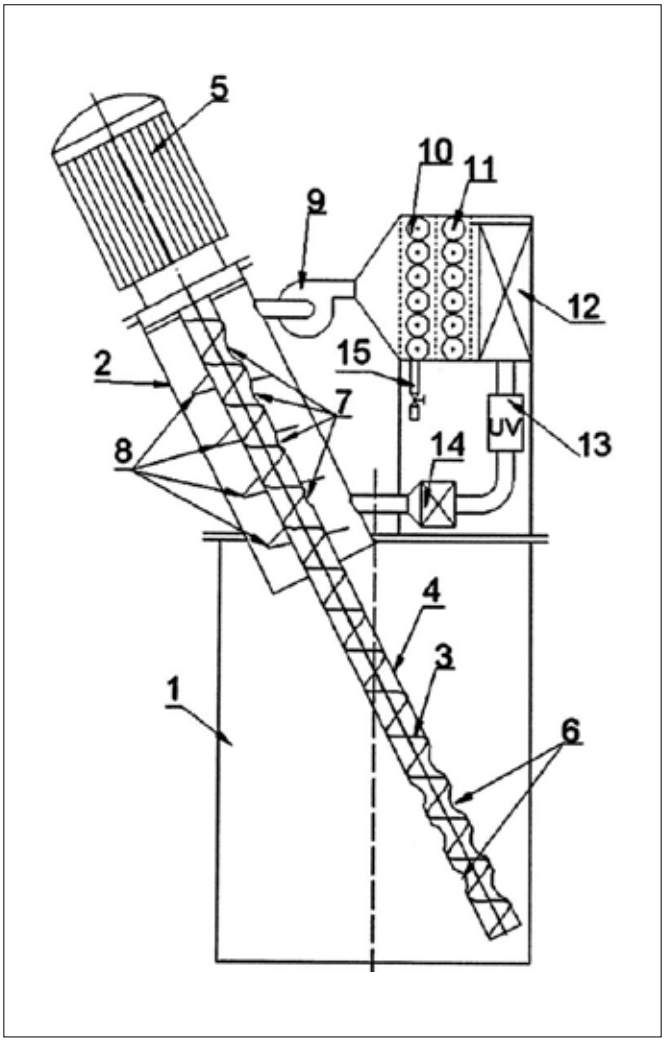

Fig. 15. Device for dehydration of honey in a liquid and semi-liquid state acc. To patent PL 218759 [3].
Rys. 15. Urządzenie do dehydratacji miodu w stanie płynnym i półpłynnym wg. patentu PL 218759 [3].

a screw system transporting honey from the barrel 1 to the drainage chamber 2 to enable the dewatering of honey both in liquid and semi-liquid form. The honey is taken through the holes 6 in the conveyor tube 4 and lifted with the screw 3 up to the drying chamber 2. In the drainage chamber 2 it flows out through the holes 7 and flows by gravity down the spiral plates 8 down the chamber. The heated operating air flows in a closed circuit against the flowing honey. The air circulation is forced by a fan 9. After flowing through the dehydrating chamber, the working air is directed to the evaporator 10 of the compressor device. The excess moisture in the air condenses at the dew point. The air is then preheated on the condenser 11 of the compressor device and finally reheated to the required process temperature on the heater 12. After sterilization with UV lamps, it again goes to the drainage chamber.

SUMMARY

The design solutions of honey thickening devices presented in the above analysis focus on dewatering honey in liquid form using heated air with a reduced water content as a drying agent. They are mostly stationary devices equipped with chambers into which honey should be pumped. These devices usually operate in a cyclic system, after each cycle the processed raw material should be drained and the device refilled.

The presented analysis shows that the topic of honey dewatering is a current problem, the solution of which has been worked on since the 1970s, and which solutions are nowadays refined, modified and implemented for industrial production. Along with the growing expectations of honey recipients, new methods and constructions of devices for honey dewatering are constantly searched for, allowing on the one hand to obtain a product that meets quality standards, and on the other, so effective that they do not significantly increase production costs.

PODSUMOWANIE

Zaprezentowane w powyższej analizie rozwiązania konstrukcyjne urządzeń do zagęszczania miodu skupiają się na odwadnianiu miodu w postaci płynnej przy wykorzystaniu podgrzanego powietrza o obniżonej zawartości wody, jako czynnika osuszającego. Są to w większości urządzenia stacjonarne wyposażone w komory do których miód należy przetłoczyć. Urządzenia te zwykle pracują w układzie cyklicznym, po każdym cyklu obrabiany surowiec powinien być spuszczony a urządzenie ponownie napełnione.

Przedstawiona analiza pokazuje, iż temat odwadniania miodu jest aktualnym problemem nad rozwiązaniem którego pracowano już od lat 70 XX wieku, a które to rozwiązania w dzisiejszych czasach są dopracowywane, modyfikowane i wdrażane do produkcji przemysłowej. Wraz z rosnącymi oczekiwaniami odbiorców miodu poszukuje się ciągle nowych metod i konstrukcji urządzeń do odwadniania miodu pozwalających z jednej strony na uzyskanie produktu spełniającego normy jakościowe a z drugiej na tyle efektywnych, że nie podrażają w sposób znaczący kosztów produkcji.

REFFERENCES

[1] **FRAZIER W. C., D. C. WESTHDORFF. 1978.** Food microbiology. Mc Graw-Hil Book Comp., New York: 185–193.

[2] **GILL R. S., V. S. HANS, S. SINGH, P.P. SINGH, S.S. DHALIWAL. 2015.** „A small scale honey dehydrator". J Food Sci Technol 52(10): 6695–6702.

[3] **MIASTKOWSKI K., S. BAKIER. Patent PL 218759. 2015.** Urządzenie do zagęszczania miodu w stanie płynnym i półpłynnym.

[4] **Patent FR2645042. 1989:** Concentrateur en couches minces dans gaz neurte ur air deshydratate pour produits visqueux et sensible.

[5] **Patent PCT/FR2010/051499. 2010:** Device for dehumidifying food products such as honey.

[6] **PIEKUT J., M. H. BORAWSKA 2007.** „Ocena miodów laboratoryjna i przez konsumentów". Pszczelarstwo nr 1: 7–8.

[7] **POPEK S. 2003.** „Identyfication of honey types". Nahrung/Food 47: 39–40.

[8] **SIUDA M., J. WILDE M. KOMOROWSKA-CHMIELEWSKA. 2003.** Jakość miodów oferowanych przez pszczelarzy województwa warmińsko-mazurskiego. Materiały z XL Naukowej Konferencji Pszczelarskiej. Puławy: 120–121.

[9] **STANFORD M. T. 2011.** Moisture in honey. Dokument elektroniczny ENY 130 http://edis.ifas.ufl.edu.

[10] **United States Patent 3483032. 1969.** Method of drying sugar-containing materials.

[11] **United States Patent 3718484. 1970.** Solidified product from high fructose corn syrup and process for the preparation thereof.

[12] **United States Patent 4472450. 1984.** Removing water from honey at ambient pressure.

[13] **United States Patent 4763572. 1988.** Apparatus for removing moisture from honey.

[14] **WOJTACKI M. 1989.** „Fermentacja miodu". Pszczelnictwo nr 4: 17–18;

[15] www 1: https://lyson.com.pl/miod-i-jego-obrobka/2598-urzadzenie-do-kremowania-i-osuszania-miodu-150kg-ok-110l-2059766047970.html

REFFERENCES

[1] **FRAZIER W. C., D. C. WESTHDORFF. 1978.** Food microbiology. Mc Graw-Hil Book Comp., New York: 185-193.

[2] **GILL R. S., V. S. HANS, S. SINGH, P.P. SINGH, S.S. DHALIWAL. 2015.** "A small scale honey dehydrator". J Food Sci Technol 52(10): 6695–6702.

[3] **MIASTKOWSKI K., S. BAKIER. Patent PL 218759. 2015.** Urzadzenie do zageszczania miodu w stanie plynnym i polplynnym.

[4] **Patent FR2645042. 1989:** Concentrateur en couches minces dans gaz neurte ur air deshydratate pour produits visqueux et sensible.

[5] **Patent PCT/FR2010/051499. 2010:** Device for dehumidifying food products such as honey.

[6] **PIEKUT J., M. H. BORAWSKA 2007.** „Ocena miodow laboratoryjna i przez konsumentow". Pszczelarstwo nr 1: 7–8.

[7] **POPEK S. 2003.** "Identyfication of honey types". Nahrung/Food 47: 39–40.

[8] **SIUDA M., J. WILDE M. KOMOROWSKA-CHMIELEWSKA. 2003.** Jakosc miodow oferowanych przez pszczelarzy wojewodztwa warminsko-mazurskiego. Materialy z XL Naukowej Konferencji Pszczelarskiej. Pulawy: 120–121.

[9] **STANFORD M. T. 2011.** Moisture in honey. Dokument elektroniczny ENY 130 http://edis.ifas.ufl.edu.

[10] **United States Patent 3483032. 1969.** Method of drying sugar-containing materials.

[11] **United States Patent 3718484. 1970.** Solidified product from high fructose corn syrup and process for the preparation thereof.

[12] **United States Patent 4472450. 1984.** Removing water from honey at ambient pressure.

[13] **United States Patent 4763572. 1988.** Apparatus for removing moisture from honey.

[14] **WOJTACKI M. 1989.** „Fermentacja miodu". Pszczelnictwo nr 4: 17–18;

[15] www 1: https://lyson.com.pl/miod-i-jego-obrobka/2598-urzadzenie-do-kremowania-i-osuszania-miodu-150kg-ok-110l-2059766047970.html

[16] www 2: www.frenchbeefarm.com/drying_down_honey.html

[17] www 3: www.honeyequipment.com/honey-drying-equipment/atmospheric-condensate-honey-dryer.html

[16] www 2: www.frenchbeefarm.com/drying_down_honey.html

[17] www 3: www.honeyequipment.com/honey-drying-equipment/atmospheric-condensate-honey-dryer.html