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UTILIZATION OF SUNFLOWER HEADS AS A COMPONENT OF ANIMAL FEED PRODUCTION

ISKORISTIVOST GLAVE SUNCOKRETA KAO KOMPONENTE U PROIZVODNJI HRANE ZA ŽIVOTINJE

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SUMMARY

The sunflower (*Helianthus annuus* L.) is the most important oil plant in the Republic of Croatia for the production of edible oil from seeds. Subsequent to the oil production, the utilizable biomass of postharvest residues remains, being used for the production of solid biofuels, as well as the sunflower heads, which can be used as the ingredients for the production of animal feed. The aim of this study was to determine the physical and chemical properties of the sunflower head with seeds in order to be able to use the whole head in animal feed. The sunflower head, which usually has a diameter of 10 to 40 cm, contains 7% of protein, 16% of fiber, and 4% of oil subsequent to the separation of the seeds, while the sunflower seed contains 38 to 45% of oil and many unsaturated fatty acids, being a valuable source of vitamins.

By processing the seeds after extraction, a protein-rich cake, or meal, is obtained, which is also a high-quality animal feed. Three sunflower hybrids were used for the study: *Alexa SU*, *Driver CL*, and *Surimi CL*. The results demonstrate that the *Surimi CL* hybrid has better physical properties due to a larger head diameter and weight. The *Alexa SU* hybrid had better chemical properties, as it had a higher starch content and a lower water content and therefore should not be thermically treated before use, while the *Driver CL* hybrid had the highest fat content and the lowest ash content ($p<0,05$).

Keywords: sunflower, head, animal feed

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INTRODUCTION

The sunflower (*Helianthus annuus L*.) belongs to the order *Asterales*, the family *Asteraceae*, and the genus *Helianthus*, which comprises 51 species, 14 annuals, and 37 perennials (Kaya et al., 2012). The genus *Helianthus* originates from the North American continent, where it has been cultivated for thousands of years. The common sunflower is a widespread annual plant whose original geographic range are the Great Plains of the United States and Canada (Marek, 2019). It is believed that the sunflower was domesticated 3,000–5,000 years ago by the Native Americans, who used it primarily as a source of edible seeds (Smith, 2006; Heiser, 1951). At the beginning of the 16th century, the sunflower arrived in Europe via Spain as a part of the Spanish conquests of North America. Madrid and its botanical gardens are famous as the first place where the sunflower was cultivated before it found its way to the rest of the European continent, claims Heiser (1951).

The first phase of the sunflower expansion in Europe consisted of its use as an ornamental plant and later for nutritional and medicinal purposes (Putt, 1997). Although the sunflower originates from North America, more recently the majority of the world's sunflower production is grown in the Black Sea region, where more than a half of the world's production percentage and plant acreage is located (Kaya et al., 2008; Pistalu et al., 2013). However, due to its adaptability to different climates and soil conditions, sunflower is cultivated worldwide (Mushtaq et al., 2010; Laudadio et al., 2014; Brenes et al., 2008).

The sunflower plant has very different morphological characteristics depending on the genotype and developmental conditions. It consists of a well-developed root that penetrates deep into the soil and has a strong suction power; a stem that is thin, tender, and succulent in the first stages of growth and also very easily brittle, becoming thicker and firmer with age and becoming woody at the end of the growing season; 23 to 32 leaves; and the flowers collected in an inflorescence that is, in a head located at the top of the stem. An inflorescence diameter can vary in measure, being sized between 6 to 75 cm (Pickersgill and Anderson, 2010). The seed size and the number of seeds are the most important components of the sunflower yield, which depend on the diameter of the head (Pospišil, 2013). The shape varies from concave to convex, which is preferred. The more convex the head is, the better and more evenly developed the seeds thereupon are (Vratarić et al., 2004). At the edge of the head are the flowers whose petals are fused in a tongue shape and display a bright yellow color (Berglund and Fureby, 2007). The size of the head varies. It depends mainly on the genotype and the growing conditions that is, on the agroecological conditions and the sunflower cultivation technique. The diameter of the sunflower head influences the number of seeds per head and the weight of 1,000 seeds. A head diameter that is too large leads to a reduction in the number of seeds, a reduction in the oil content, an increase in the number of empty seeds, and an increase in the proportion of the husk in relation to the kernel.

Recently, sunflower has become one of the most important oil crops, as it significantly contributes to the edible vegetable-oil market due to its high unsaturated fatty-acid content and the absence of cholesterol, along with the rapeseed and soybean (Razi and Assad, 1998; Darvishzadeh et al., 2010). Sunflower seeds have a high content (38% to 50%) of high-quality oil mainly for human consumption. And the oil itself is a high-quality meal and a relatively inexpensive source of protein for poultry nutrition (Beski et al., 2015; Khan, 2018).

In addition, sunflower oil can be used for a wide range of products in the pharmaceutical and cosmetic industries, in floriculture, and also for the production of biofuels. Sunflowers are used as a component of silage and grain mixtures for bird feed too (Castro and Leite, 2018).

Subsequent to the processing of seeds into the oil, two by-products are produced, the cake and the meal, which contain a lot of proteins and vitamins and are ideal as a component of feed for fattening cattle and for feeding the pigs and poultry. The meal itself can contain up to 35% of crude protein and 25% of crude fiber, depending on the processing technique (Brenes et al., 2008). After the edible oil is extracted, the sunflower seed husk remains, which is produced as a waste worldwide and accounts for approximately 50% of the weight of the seeds as a solid lignocellulosic waste (Perea-Moreno et. al, 2018). A concern for the environment has encouraged the development of the improved wastetreatment technologies. In this sense, the thermal conversion of biomass residues

into solid fuels for energy production that is, into the high-value products is a cost-effective process from an economic point of view.

The total global production of oilseeds in 2023 amounted to 661 million tons, including 399 million tons of soybeans, 87 million tons of rapeseed, and 57 million tons of sunflower, with 70% of global production grown in Europe and the rest in the Americas, Asia, and Africa (FAO, 2023). In the total production of oilseeds in the Republic of Croatia, they even account for 90% of the market, as they represent the basic raw material for the production of edible oil, with a total production amounting to 153,000 tons (DZS, 2024).

Based on all this, the aim of this paper was to determine the physical and chemical properties of sunflower heads that is, the usability of sunflower heads as an animal feed ingredient.

MATERIALS AND METHODS

In order to investigate the usability of sunflower heads as an animal feed component, the analyses were conducted on the samples of three sunflower hybrids from the Agricultural Institute in Osijek (i.e., *Alexa SU*, *Driver CL*, and *Surimi CL*, respectively). The samples were randomly selected. All analyses were conducted immediately subsequent to the harvest on the sunflower heads without seeds, the seeds with husk, and the seeds without husk and with the husk only. The analyses were used to determine the physical and chemical properties. Concerning the physical characteristics, dimension, thickness (mm), diameter (mm), seed volume weight (g), and the weight without seed (g) were determined. The head dimensions were determined by a 0 – 150 mm digital caliper in 5 repetitions, and the volume was determined by a three-decimal scale.

With regard to the chemical properties, the water content was determined while applying the standard methods in a laboratory furnace (*Memmert UN55plus*, Germany) (HRN ISO 6540:2010), the ash content was determined in a *Nabertherm B170* muffle furnace (Lilienthal, Germany; HRN ISO 2171:2010), total starch content was determined by a polarimeter (KRŰSS, P3001, Germany; HRN ISO 6493:2001), and the oils were determined by a *Soxhlet* extractor R 304 (Behr Labortechnik GmbH, Germany) (HRN ISO 6492:2001).

Subsequent to the collection of laboratory research data, the data obtained was statistically processed using version 9.3 of the *SAS* statistical program (SAS Institute, Cary, NC, USA). The statistical analysis implied the calculation of the mean and standard deviation, as well as Tukey's post hoc HSD test to determine the differences between the observed samples.

RESULTS AND DISCUSSION

The results of physical and chemical sunflower-head analyses are figured in Tables 1 to 5.

The results of physical properties prove that the head thickness ranged from 73.45 mm to a much higher value of 84.03 mm, while the head diameter ranged from 141.91 mm to 172.96 mm (Table 1). The results demonstrate that the *Alexa SU* hybrid had a greater thickness, while the *Surimi CL* hybrid had a larger head diameter. The head weight amounted to 168.96 g with seed and 46.66 g without seed and was highest in the *Surimi CL* hybrid, while it was at its lowest in the *Driver SU* hybrid, wherefrom we may conclude that the *Surimi CL* hybrid is more suitable as a feed ingredient than the other hybrids.

Table 1 Physical properties of the sunflower head

Tablica 1. Fizikalna svojstva glave suncokreta

	Alexa SU	Driver CL	Surimi CL
Thickness / Debljina (mm)	84.03 ± 0.48^{b}	78.60 ± 1.29^{b}	73.45 ± 0.86^{b}
Diameter / Promjer (mm)	150.30 ± 1.69^{d}	141.90 ± 1.70^{d}	172.90 ± 1.48^{c}
Weight with seeds / Težina sa sjemenkama (g)	128.72 ± 38.42^{c}	125.48 ± 30.82^{c}	168.96 ± 27.99^{c}
Weight without seeds / Težina bez sjemenaka (g)	29.55 ± 10.20^{a}	30.02 ± 9.35^{a}	46.66 ± 9.00^{a}

Mean values ± SD values marked with identical letter are not significantly different ($p<0.05$) / Srednje vrijednosti ± SD vrijednosti označene identičnim slovom ne razlikuju se značajno ($p<0,05$)

Similar research was conducted by Mirzabe and Chegini (2016), who in their study determined the diameter of the sunflower head from 55.60 to 203.00 mm, which represents a very wide range of values depending on the selection of sunflower hybrids. According to Liu et. al. (2023), the diameter of the sunflower head amounted 150–250 mm, while Reagon and Snow (2006) determined a cross-section of only 31 mm, which is significantly lower than the values determined in this study.

The moisture content of the sunflower heads was between 11.51 and 12.10%, that of the seeds with husks between 4.72 and 5.91%, and that of the seeds without husks between 4.68 and 5.84%, with the highest values being obtained for the *Surimi CL* variety and the lowest being obtained for the *Alexa SU* variety (Table 2). The moisture content of the husk ranged from 9.72 to 11.42% and was highest in the *Driver CL* variety. According to research conducted by Matin et. al. (2019), the moisture content of sunflower husks amounted to 18.23%, which is a much higher moisture content, and such samples would need to be subjected to a drying process prior to the use.

The ash content is a total amount of minerals contained in the raw material that is, the amount of calcium, magnesium, phosphorus, potassium, and other elements. The ash content in sunflower, including the heads, is between 2 and 5% and can exceed 12% in processing (Krička et al., 2012), as some minerals are very important for an adequate nutrition, while some can even be toxic to animals. A high ash content is also unfavorable for energy production from biomass. Table 3 figures the high ash content of sunflower head, from 12.69 to 13.30 %, which makes this sample more favorable for feed production but not for energy production. The hybrid *Surimi CL* had the highest ash content of all samples, while the hybrid *Driver CL* had the lowest ash content. The values were adjusted pursuant to the Regulation on the Market Placement and Use of Animal Feed (*Official Gazette* 72/2011), according to which the ash content in animal feed must not exceed 3.5%. According to the studies conducted by Özelçam et. al. (2017), the ash content in sunflower heads was between 15.53 and 19.82%, which can be attributed to the differences in hybrids, climate, and soil conditions.

Table 2 Moisture content of the head, seeds with husk, seeds without husk, and sunflower husk (%)

Tablica 2. Sadržaj vlage u glavi, sjemenu s ljuskom, sjemenu bez ljuske i ljusci suncokreta (%)

Hibrid	Sunflower head Glava suncokreta	Seeds with husk Sjemenke s ljuskom	Seeds without husk Sjemenke bez ljuske	Husk Ljuska
Alexa SU	11.51 ± 0,15^{a}	4.72 ± 0,11^{a}	4.68 ± 0,07^{a}	10.09 ± 0,34^{ab}
Driver CL	12.09 ± 0,11^{b}	5.17 ± 0,13^{ab}	5.03 ± 0,09^{ab}	11.42 ± 0,01^{b}
Surimi CL	12.10 ± 0,14^{b}	5.93 ± 0,08^{b}	5.84 ± 0,36^{b}	9.72 ± 0,67^{a}

Mean values ± SD values marked with identical letter are not significantly different ($p<0.05$) / Srednje vrijednosti ± SD vrijednosti označene identičnim slovom ne razlikuju se značajno ($p<0,05$)

Table 3 Ash content of the head, seeds with husk, seeds without husk, and sunflower husk (%)

Tablica 3. Udio pepela u glavi, sjemenu s ljuskom, sjemenu bez ljuske i ljusci suncokreta (%)

Hibrid	Sunflower head Glava suncokreta	Seeds with husk Sjemenke s ljuskom	Seeds without husk Sjemenke bez ljuske	Husk Ljuska
Alexa SU	13.02 ± 0,39^{b}	4.28 ± 0,38^{b}	3.58 ± 0,07 ^{ab}	3.86 ± 0,09^{b}
Driver CL	12.69 ± 0,07^{a}	3.80 ± 0,26^{a}	3.48 ± 0,08^{a}	2.81 ± 0,07^{a}
Surimi CL	13.30 ± 0,29^{b}	4.21 ± 0,23^{b}	4.02 ± 0,09^{b}	4.05 ± 0,70^{b}

Mean values ± SD values marked with identical letter are not significantly different ($p<0.05$) / Srednje vrijednosti ± SD vrijednosti označene identičnim slovom ne razlikuju se značajno ($p<0,05$)

The starch content is very important in the production of animal feed and is one of the most important ingredients. It is the most important carbohydrate in animal nutrition and is hydrolyzed (i.e., broken down) into monosaccharides in the body. When feeding the adult (i.e., working and fattening) cattle, the mixtures with a higher proportion of nonfibrous carbohydrates, in this case starch, are preferred. It was detected in the fibrous material—that is, the sources of starch were the cereals and oilseeds which was also demonstrated in this study, whereby the starch content in the heads ranged between 0.11% to 0.43%, in the unhulled seeds between 0.63% to 0.84%, in the hulled seeds between 0.59% to 0.75%, and in the husks between 0.84 % to 1.05% (Table 4). The highest values were always achieved with the same variety, *Alexa SU*. According to studies conducted by Munshi et. al. (2003), the starch content in the sunflower head was between 0.9 and 1.8%, and thus it fluctuated between the values determined herein

The fats are the organic chemical compounds that are important and necessary as a source of energy in animal feed. Table 5 demonstrates that the fat content of the sunflower head in all parts was highest in the *Driver CL* hybrid, amounting 12.50% in the head, 36.14% in the unhulled seeds, 46.90% in the hulled seeds, and 6.49% in the husks, while it was at its lowest in the *Surimi CL* hybrid concerning all parameters studied. The results obtained are in conformity with the studies of Olowe et. al. (2013), who detected a fat content of 42.6 to 49.70% in the hulled seeds, while Weiss (2000) detected a slightly lower fat content (35.75–36.66%), which is a desirable amount in the production of animal feed.

CONCLUSION

According to our own investigations of physicochemical properties of sunflower heads, seeds without husk, seeds without husk and husks, it can be concluded that the sunflower heads are a good raw material for the production of animal feed. This is due to a large mass and a high content of starch and crude fat—that is, of the important components that have a positive effect on the quality of animal feed. The *Surimi CL* variety proved to be the best for the animal feed production in terms of physical properties, as it had the largest head diameter and seed weight, while the best varieties in terms of chemical composition are *Alexa Cl* (due to the highest starch and lower water content) and *Driver CL* (due to the highest fat and lowest ash content).

Table 4 Starch content of the head, seeds with husk, seeds without husk, and sunflower husk (%)

Tablica 4. Udio škroba u glavi, sjemenkama s ljuskom, sjemenkama bez ljuske i ljusci suncokreta (%)

Hibrid	Sunflower head Glava suncokreta	Seeds with husk Sjemenke s ljuskom	Seeds without husk Sjemenke bez ljuske	Husk Ljuska
Alexa SU	0.43 ± 0.06^{c}	0.83 ± 0.02^{b}	0.75 ± 0.01^{b}	1.05 ± 0.04^{b}
Driver CL	0.33 ± 0.06^{b}	0.74 ± 0.09^{ab}	0.67 ± 0.05^{ab}	0.92 ± 0.03^{ab}
Surimi CL	0.11 ± 0.04^{a}	0.63 ± 0.12^{a}	0.59 ± 0.04^{a}	0.84 ± 0.03^{a}

Mean values ± SD values marked with identical letter are not significantly different ($p<0.05$) / Srednje vrijednosti ± SD vrijednosti označene identičnim slovom ne razlikuju se značajno ($p<0,05$)

Table 5 Fat content of the head, seeds with husk, seeds without husk and sunflower husk (%)

Tablica 5. Sadržaj masti u glavi, sjemenkama s ljuskom, sjemenkama bez ljuske i ljusci suncokreta (%)

Hibrid	Sunflower head Glava suncokreta	Seeds with husk Sjemenke s ljuskom	Seeds without husk Sjemenke bez ljuske	Husk Ljuska
Alexa SU	10.75 ± 1.78^{a}	33.17 ± 4.85^{b}	46.76 ± 2.04^{b}	4.38 ± 0.69^{b}
Driver CL	12.50 ± 2.77^{b}	36.14 ± 2.79^{c}	46.90 ± 1.41^{b}	6.49 ± 2.17^{c}
Surimi CL	10.25 ± 0.10^{a}	25.88 ± 0.49^{a}	44.05 ± 1.92^{a}	2.51 ± 0.07^{a}

Mean values ± SD values marked with identical letter are not significantly different ($p<0.05$) / Srednje vrijednosti ± SD vrijednosti označene identičnim slovom ne razlikuju se značajno ($p<0,05$)

LITERATURE

1. Beski, S. S., Swick, R. A., Iji, P. A. (2015): Specialized protein products in broiler chicken nutrition: A review. Animal Nutrition, 1(2): 47-53.
2. Brenes, A., Centeno, C., Viveros, A., Arija, I. (2008): Effect of enzyme addition on the nutritive value of high oleic acid sunflower seeds in chicken diets. Poultry Science, 87(11), 2300-2310.
3. Berglund, M., Fureby, C. (2007): LES of supersonic combustion in a scramjet engine model. Proceedings of the Combustion Institute, 31(2): 2497-2504.
4. Castro, C. D., LEITE, R. D. C. (2018): Main aspects of sunflower production in Brazil.
5. Darvishzadeh, R., Pirzad, A., Hatami-Maleki, H., Kiani, S. P., Sarrafi, A. (2010): Evaluation of the reaction of sunflower inbred lines and their F1 hybrids to drought conditions using various stress tolerance indices. Spanish Journal of Agricultural Research, (4): 1037-1046.
6. Državni zavod za statistiku (2024): Površina i proizvodnja žitarica i ostalih usjeva u 2023.
7. FAO (2023): Oilseeds and oilseed products
8. Heiser, C. B. (1951): The sunflower among the North American Indians. Proceedings of the American Philosophical Society, 95(4): 432-448.
9. Kaya, A., Aydın, O., Dincer, I. (2008): Experimental and numerical investigation of heat and mass transfer during drying of Hayward kiwi fruits (Actinidia Deliciosa Planch). Journal of Food Engineering, 88(3): 323-330.
10. Kaya, Y., Jocic, S., Miladinovic, D. (2012): Sunflower. Technological Innovations in Major World Oil Crops, Volume 1: Breeding, 85-129
11. Khan, S. H. (2018). Recent advances in role of insects as alternative protein source in poultry nutrition. Journal of Applied Animal Research, 46(1): 1144-1157.
12. Krička, T., Kiš, D., Matin, A., Brlek, T., Bilandžija, N. (2012): Tehnologija mlinarstva, Osijek
13. Laudadio, V., Ceci, E., Lastella, N. M. B., Tufarelli, V. (2014): Effect of feeding low-fiber fraction of air-classified sunflower (*Helianthus annus* L.) meal on laying hen productive performance and egg yolk cholesterol. Poultry Science, 93(11): 2864-2869.
14. Liu, W., Ma, L., Zong, W., Liu, J., Li, M., Lian, G. (2023): Design and Experimentation of a Longitudinal Axial Flow Sunflower Oil Threshing Device. Agriculture, 13(4): 876.
15. Marek, L. F. (2019). Crop wild relatives of sunflower in North America. North American Crop Wild Relatives, Volume 2: Important Species, 453-483.
16. Matin, A., Majdak, T., Krička, T., Grubor, M. (2019): Valorization of sunflower husk after seeds convection drying for solid fuel production. Journal of Central European Agriculture, 20(1): 389-401.
17. Mirzabe, A. H., Chegini, G. R. (2016): Effect of air-jet impingement parameters on the removing of sunflower seeds from the heads in static conditions. Agricultural Engineering International: CIGR Journal, 18(2): 43-59.
18. Munshi, S. K., Kaushal, B., Bajaj, R. K. (2003): Compositional changes in seeds influenced by their positions in different whorls of mature sunflower head. Journal of the Science of Food and Agriculture, 83(15): 1622-1626.
19. Mushtaq, M. N., Cheema, Z. A., Khaliq, A., Naveed, M. R. (2010): A 75% reduction in herbicide use through integration with sorghum+ sunflower extracts for weed management in wheat. Journal of the Science of Food and Agriculture, 90(11): 1897-1904.
20. Olowe, V. I., Folarin, O. M., Adeniregun, O. O., Atayese, M. O., Adekunle, Y. A. (2013): Seed yield, head characteristics and oil content in sunflower varieties as influenced by seeds from single and multiple headed plants under humid tropical conditions. Annals of applied biology, 163(3): 394-402.
21. Özelçam, H., İpçak, H. H., Özüretmen, S. (2017): Feed value of sunflower heads in different varieties. International Journal of Agriculture, Environment and Bioresearch, 2(4): 58-63.
22. Perea-Moreno, M. A., Manzano-Agugliaro, F., Perea-Moreno, A. J. (2018): Sustainable energy based on sunflower seed husk boiler for residential buildings. Sustainability, 10(10): 3407.
23. Pickersgill, B., Anderson, G. J. (2010). Travels with Charley—sunflowers and beyond: an appreciation of the life and work of Charles B. Heiser, Jr. (1920-2010). Economic botany, 64: 281-286.
24. Pospišil, M. (2013): Ratarstvo II. dio-industrijsko bilje.
25. Pistalu, V., Cotianu, R., Lazin, V. (2013): Researches regarding the reaction of sunflower local and foreign hybrids to irrigation. Lucrări Ştiinţifice, Universitatea de Ştiinţe Agricole Şi Medicină Veterinară" Ion Ionescu de la Brad" Iaşi, Seria Horticultură, 56(2): 383-388.
26. Putt, E. D. (1997): Early history of sunflower. Sunflower technology and production, 35: 1-19.

27. Razi, H., Assad, M. T. (1998): Evaluating variability of important agronomic traits and drought tolerant criteria in sunflower cultivars. Isfahan University of Technology-Journal of Crop Production and Processing, 2(1): 31-44.
28. Reagon, M., Snow, A. A. (2006): Cultivated Helianthus annuus (Asteraceae) volunteers as a genetic "bridge" to weedy sunflower populations in North America. American Journal of Botany, 93(1): 127-133.
29. SAS 9.3. SAS Institute Inc., Cary, NC, USA.
30. Smith, B. D. (2006): Eastern North America as an independent center of plant domestication. Proceedings of the National Academy of Sciences, 103(33): 12223-12228.
31. Regulation on the placing on the market and use of animal feed (Official Journal 72/2011)
32. Vratarić, M., Jurković, D., Ivezić, M., Pospišil, M., Košutić, S., Sudarić, A., Josipović, M., Ćosić, J., Mađar, S., Raspudić, E., Vrgoč, D. (2004): Suncokret *Helianthus annuus* L., Poljoprivredni instutut Osijek
33. Weiss, E.A., (1983): Oilseed crops. Longman Group Ltd.
34. HRN EN ISO 2171:2010 (2010): Determination of ash yield by incineration. Croatian Standards Institute.
35. HRN EN ISO 6540:2010 (2010): Determination of moisture content. Croatian Standards Institute.
36. HRN ISO 6492:2001 (2001): Determination of fat content. Croatian Standards Institute.
37. HRN ISO 6493:2001 (2001): Determination of starch content - Polarimetric method. Croatian Standards Institute.

SAŽETAK

Suncokret (*Helianthus annuus* L.) je najvažnija uljarica u Republici Hrvatskoj za proizvodnju jestivoga ulja iz sjemenaka. Nakon proizvodnje ulja ostaje korisna biomasa posliježetvenih ostataka, koja se koristi za proizvodnju čvrstih biogoriva, kao i glave suncokreta, koje se mogu koristiti kao sastojci u proizvodnji hrane za životinje. Cilj ovoga istraživanja bio je odrediti fizikalna i kemijska svojstva glave suncokreta sa sjemenkama kako bi se cijela glava mogla koristiti u hrani za životinje. Glava suncokreta, koja obično ima promjer između 10 i 40 cm, sadrži 7 % proteina, 16 % vlakana i 4 % ulja nakon odvajanja sjemenaka, dok sjemenke suncokreta sadrže 38 - 45 % ulja i mnogo nezasićenih masnih kiselina te su vrijedan izvor vitamina. Doradom sjemenaka nakon ekstrakcije dobiva se pogača ili sačma, koja je bogata proteinima i također je visokokvalitetna hrana za životinje. Za istraživanje su korištena tri hibrida suncokreta: *Alexa SU*, *Driver CL* i *Surimi CL*. Dobiveni rezultati pokazuju da hibrid *Surimi CL* ima bolja fizikalna svojstva zbog većega promjera i težine glava. Hibrid *Alexa SU* je imao bolja kemijska svojstva jer je imao veći udio škroba i niži udio vode te se stoga ne treba termički obrađivati prije upotrebe, dok je hibrid *Driver CL* imao najveći udio masti i najmanji udio pepela ($p<0,05$).

Ključne riječi: suncokret, glava, hrana za životinje