Production of NPK-type mineral fertilizers from meat bone meal ash

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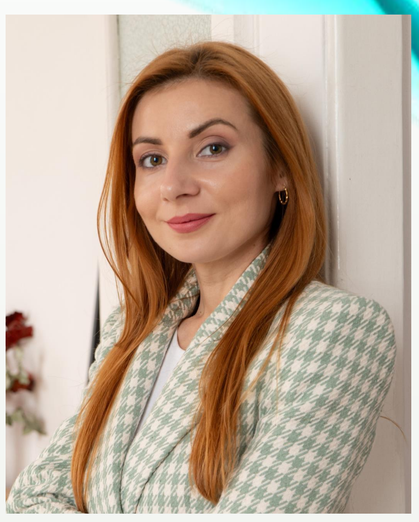

INTRODUCTION

The agricultural sector is facing increasing challenges. These include dynamic global population growth, significant economic development, and an increasing standard of living. The current population is about 8 billion, and forecasts predict that in 2050 the world's population will be over 9.8 billion (United Nations, 2017). This results in a constant increase in food consumption and forecasts an intensely increasing demand for agricultural raw materials. With an ever-increasing population, it is estimated that there is an urgent need to increase food production by up to 70% by then (van Dijk et al., 2021). Therefore, it is necessary to increase the efficiency of agricultural production by increasing the level of fertilization. Due to population growth, urbanization or industrialization, this growth must be effective enough to compensate for the constantly decreasing area devoted to cultivation (Almutari, 2023).

Considering the geopolitical situation, high prices of fertilizers and the European Union's policy aimed at the sustainable use of key natural resources, the issue of replacing conventional fertilizers with alternative fertilizers is very topical. One of the wastes with fertilizing potential is the ash after burning meat and bone meal, which contains mainly calcium (33.8-36.6%) and phosphorus (14.5-15.0%), occurring in the form of hydroxyapatite (Krupa-Zuczek et al., 2010).

The aim of the study was manufacturing and characterization of NPK-type mineral fertilizers based on meat bone meal ash (MBMA).

METHODOLOGY

The fertilizer that was intended to be obtained is an NPK fertilizer with a composition of 4-16-18. A fertilizer with this chemical composition could be intended for all crops such as cereals, potatoes, sugar beets, and would also be suitable for cruciferous vegetables, spinach, cucumbers and lettuce. To obtain the appropriate NPK ratio in fertilizers, the MBMA was enriched with simple mineral salts (KNO_3, NH_4NO_3, K_2SO_4, $(NH_4)_2SO_4$, urea), and then the resulting mixture was granulated with a sulfuric acid solution. Five fertilizer mixtures were produced with different mineral additives.

Obtained final products were characterized by using

- Spektrophotometric method (P content)
- Atomic absorption spectroscopy (K, Ca, Mg, Cu, Zn. Fe, Cr, Pb, Cd and Ni content)
- Distillation method (N content)
- X-ray difraction analysis
- 5-weeks nutrient release tests
- 2-weeks germination tests on cucumber seeds (*Cucumis sativus*)

Figure 1. Picture of fertilizer 2F

RESULTS

Table 1. Characterization of fertilizers based on MBMA

		Fertilizers				
		1F	**2F**	**3F**	**4F**	**5F**
Main nutrients	**N (%)**	7.16	6.22	6.90	4.21	5.56
	P_2O_5 (%)	18.7	17.7	18.0	17.4	16.1
	K_2O (%)	17.8	18.5	17.9	17.2	16.9
Secondary nutrients and micronutrients	**Ca (%)**	15.2	13.2	13.4	13.3	13.0
	Fe (mg/kg)	1664	1546	1592	1480	1371
	Mg (mg/kg)	4845	4481	4200	4750	4321
	Cu (mg/kg)	25.5	20.2	20.9	19.2	18.1
	Zn (mg/kg)	6.63	4.04	6.70	1.96	3.27
Heavy metals	**Cd (mg/kg)**	3.44	4.09	4.64	5.23	5.72
	Cr (mg/kg)	51.8	55.1	54.6	53.8	51.0
	Ni (mg/kg)	22.4	23.8	22.6	22.9	22.7
	Pb (mg/kg)	20.2	23.2	16.8	17.3	16.2

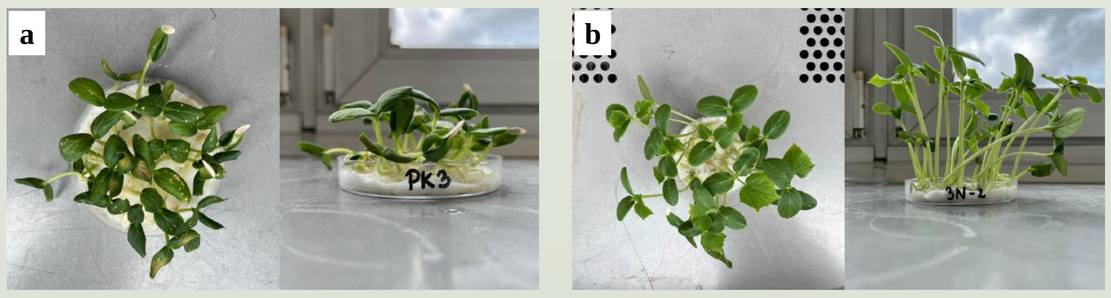

Figure 1. Pictures of sprouted cucumber seeds after 2 weeks of germination tests (a – control sample, b – fertilizer 3F

Table 2. Results of 2 weeks germination tests on cucumber

Fertilizers	**Average number of sprouted plants**	**Average length of the above-ground part of plants (cm)**	**Average wet weight of the above-ground parts of plants (g)**	**Average dry weight of the above-ground parts of plants (g)**
Control	21	2.0	4.02	0.30
MBMA	24	2.6	5.87	0.43
1F	23	6.4	9.60	0.63
2F	20	4.8	5.53	0.48
3F	21	5.3	7.73	0.58
4F	24	5.0	6.53	0.60
5F	8	1.5	0.80	0.13

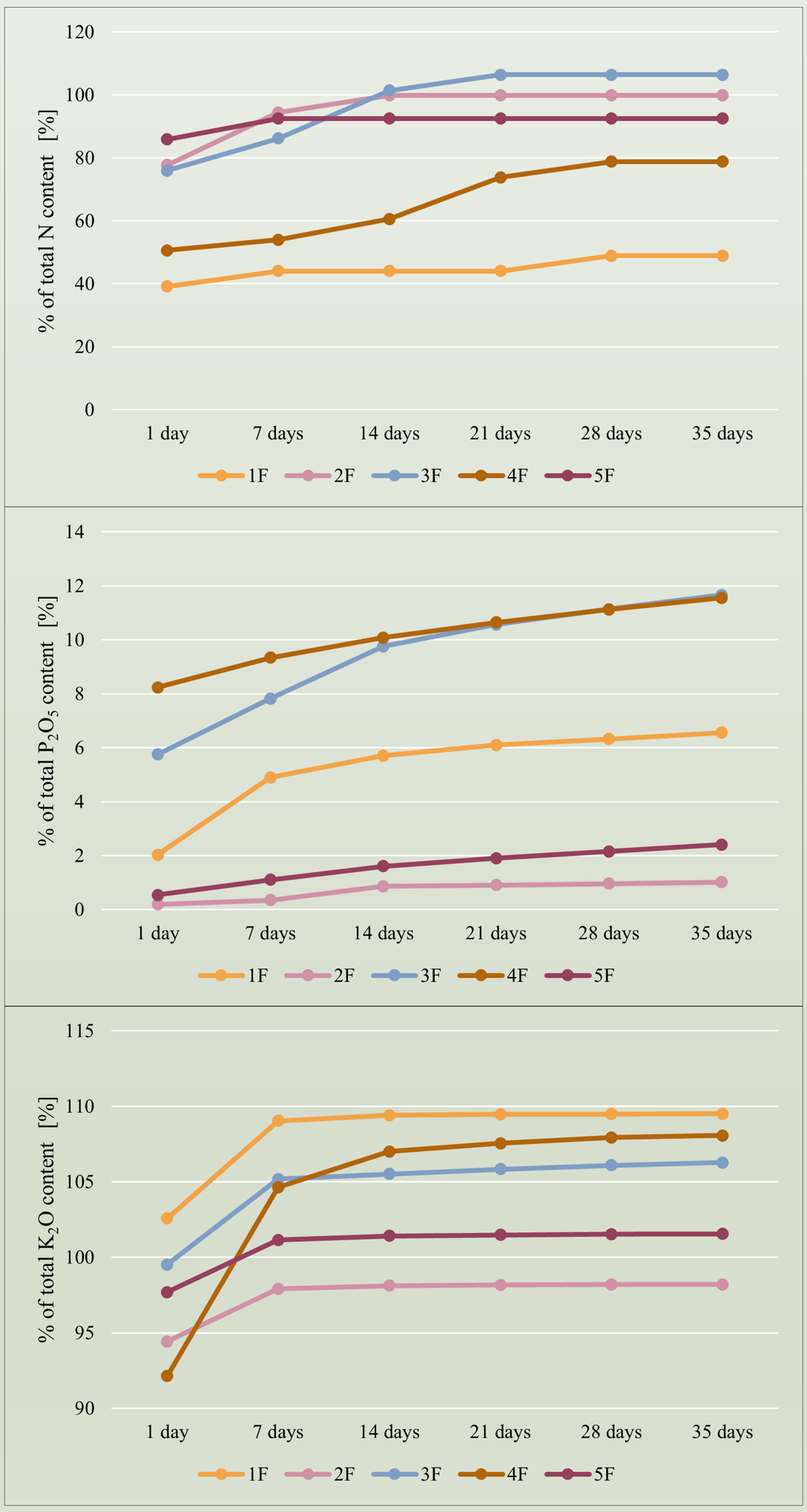

Figure 2. Nutrient release in fertilizers

CONCLUSIONS

The study results confirmed that it is possible to obtained granulated NPK-type mineral fertilizers based on MBMA. The total content of the main nutrients in the obtained products was in the range of 38-56-43.66%, so they met the requirements for NPK mineral fertilizers (20%). They were rich in secondary nutrients and microelements and did not contain large amounts of heavy metals. The Cd and Pb content were within the permissible range set up by Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019.

All fertilizers except 5F had a positive effect on the number of germinating cucumber seeds and their growth. The use of 1F-4F fertilizers resulted in increase the average length of the above-ground part of plants by 2-3 times. Also, for these fertilizers, a 2-fold increase in biomass was observed.

The study of the main nutrient release allowed to assume that the produced fertilizers were long-acting fertilizers in terms of phosphorus.

These studies may be an introduction to further research on the production of fertilizers using MBMA as a phosphorus source. In the future, it is necessary to research the production of fertilizers on a larger scale and conduct field tests.

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