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Physicochemical and nutritional characteristics of bee pollen from Burkina Faso

Jean Axel T. KABORE[1]*, Ella W. R. COMPAORE[1], KY INOUSSA[1], Ousmane OUEDRAOGO[1], Fulbert NIKIEMA[2], Elie KABRE[2] and Mamoudou H. DICKO[1]

[1]Joseph KI-ZERBO University, UFR/SVT, Laboratory of Biochemistry, Biotechnology, Food Technology and Nutrition (LABIOTAN) 03 BP 7021 Ouagadougou 03, Burkina Faso.
[2]National Agency for Environmental, Food, Occupational and Health Product Safety (ANSSEAT) Burkina Faso.

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This prospective study consisted in determining the physico-chemical and nutritional composition of the pollen produced in different localities of Burkina Faso. The main constituents were determined by standard methods. The results show a mass proportion (g/100 g) of dry matter between 17.15 ± 3.69 to 34.65 ± 5.05 for proteins, 43.93 ± 2.05 to 59.11 ± 5, 05 for carbohydrates, 5.29 ± 0.05 to 18.94 ± 0.18 for total lipids and an energy value between 366.29 and 454.84 (Kcal/100 g). The pH, dry matter, Brix degree, titratable acidity, humidity, and total ash were respectively between 3.63 ± 0.056 and 5.3 ± 0.042, 91.15 ± 0.07 and 93.20 ± 0.14, 0.17 ± 0.03 and 2.06 ± 0.05, 4.49 ± 0.01 and 24.5 ± 0.00, 6.80 ± 0.14 and 8.85 ± 0.07, 2.19 ± 0.57 and 7.3 ± 0.57. The calcium, sodium, iron, zinc, potassium and magnesium contents were respectively between 4.91 ± 0.35 and 57.12 ± 0.176; 4.50 ± 0.007 and 8.94 ± 0.049; 4.82 ± 0.035 and 17.34 ± 0.530; 11.23 ± 0.021 and 59.33 ± 0.098; 8.60 ± 0.141 and 33.46 ± 0.742 and 2.75 ± 0.0127 and 108.88 ± 0.120. The results obtained on the physicochemical and nutritional characteristics of the pollen produced in Burkina Faso could be used in food formulation.

Key words: Pollen, physicochemical, nutritional characteristics, Burkina Faso.

INTRODUCTION

Bee products are nowadays used as food, food supplements, additives in cosmetic products and therapeutic API drugs. Pollen is one of these hive products presented in the form of microscopic grains contained in the anthers of the stamens of flowering plants (Prost and Le Conte, 2005). It is also the most important source of protein for the survival of bees (Almeida et al., 2005). Indeed, for food needs, beekeepers can collect bee pollen, in the form of pellets, by installing a trap or pollen trap at the entrance of the hive (Almeida et al., 2005).

Pollen can be used and consumed as a dietary supplement for its high dietary and dietary values. It is also rich in nutrients and biologically active substances (Silva et al., 2004). Its physicochemical and nutritive composition depends mainly on the bee species and the

*Corresponding author. E-mail: kaborejeanaxeltegwende@gmail.com. Tel: +22663304340, +22664868368.

climatic conditions of the production region.

The beekeeping sector is growing in Burkina Faso due to the growing demand for hive products (Bambio, 2020). The production of bee products has increased from around 500 tonnes over the period 2011-2015 (Bambio, 2020) to 1500 tonnes in 2022 (MEDIAPROD and CTA, 2022). One of the major constraints in this sector is the lack of knowledge of modern production techniques inherent in the lack of actor training (Bambio, 2020). Pollen production in Burkina Faso remains embryonic and its biochemical composition remains unknown. This may limit its use and consumption.

To date, practically no study to our knowledge has focused on the physicochemical and nutritional characterization of pollen from Burkina Faso. This characterization would be very important for the use of pollen in food and nutritional technology. The aim of this work is to constitute a database on the physicochemical and nutritional characteristics of the pollen produced in Burkina Faso. This database could be used in the formulation of pollen-based foods.

MATERIALS AND METHODS

Biological material

The biological material is made up of the samples of bee pollen. These pollen samples were collected based on availability and accessibility to beekeepers.

Sampling

Bee pollen was collected in Kenyann type hives in the following localities in Burkina Faso: Fada N'Gourma, Banfora, Tenkodogo, Koudougou, Sapouy and Bobo Dioulasso. These different localities are distributed in two different climatic domains characterizing each of the domains by different vegetation. The localities of Tenkodogo, Fada, Koudougou, and Sapouy are located in the northern Sudanese domain characterized by vegetation composed of shrubby savannah, while the localities of Bobo Dioulasso and Banfora are located in the southern Sudanese domain characterized by vegetation composed of wooded to shrubby savannah. Two samples per locality were taken, packaged in jars and kept in the refrigerator.

Method for determining the biochemical composition

The pH was measured using a pH meter according to the method of Doukani et al. (2013). The titratable acidity was determined by titration of 5 g of bee pollen according NF V 05-101, 1974 and the results are expressed as a percentage (%) of bee pollen. The total ashes were determined by incineration at 550°C for 4 h in a muffle furnace according to the ISO standard 2171 (2007).

The soluble dry extract or the Brix degree of the samples was determined using a digital refractometer. Moisture and dry matter were determined by oven drying (Gacem et al., 2011). The protein content was determined according to the ISO 16634 method, 2008. The fat content was made by Soxhlet extraction according to the method of AOAC 960.39 (1999) using hexane as solvent. Carbohydrates were assayed by the spectrophotometric method of Montreuil and Spik, 1969. The mineral content (calcium, magnesium, sodium, zinc, iron, copper) of the pollen samples was determined by flame atomic absorption spectrophotometry after mineralization of the samples according to the ISO 1762 standard, 2019. The theoretical energy value was calculated using the Merrill coefficients (Merill and Watt, 1955) adopted by the FAO in 1970.

Statistical analyzes

The results of the analysis are presented as mean ± standard deviation. The processing of the results was done by analysis of variance (ANOVA) at the significance level of 5%. These analyses were carried out with the software "XLSTAT version 2022.1."

RESULTS

The macronutrient and micronutrient composition of bee pollen samples varied by locality (Tables 1, 2, and 3). Table 1 presents the values of proteins, lipids, carbohydrates, ash, and energy. The protein varied from 17.15 (Koudougou) to 34.65 (Fada N'Gourma) (m/m). Pollens from Fada N'Gourma, Tenkodogo and Sapouy were the richest in protein with respective contents of 34.65, 28.65 and 27.32. Carbohydrate varied from 43.93 (Tenkodogo) to 59.11 ± 5.05 (Koudougou) (m/m). Pollens from Koudougou, Sapouy and Bobo Dioulasso were the richest in carbohydrate with respective contents of 59.11, 58.18 and 52.86 (m/m). The fat varied from 5.29 (Fada N'Gourma) to 18.94 (Banfora) (m/m). Pollens from Banfora, Tenkodogo and Bobo Dioulasso were the richest in fat with respective contents of 18.94, 18.28 and 14.80 (m/m). The energy values varied from 366.29 (Bobo) to 454.84 (Tenkodogo) (Kcal/100 g). Pollen from Tenkodogo had the highest energy value. Ash varied from 2.19 (Tenkodogo) to 7.3 (Banfora) (m/m). Pollen from Banfora contained the most minerals. At table 2, the pH varied from 3.63 (Bobo Dioulasso) to 5.3 (Tenkodogo). Pollen from Bobo Dioulasso had the highest pH value. The humidity varied from 6.80 (Sapouy) to 8.85 (Banfora). Pollens from Sapouy and Fada N'Gourma had the lowest humidity values with respective values of 6.80 and 6.85. The dry matter varied from 91.15 (Banfora) to 93.20 (Sapouy) (m/m). Pollens from Sapouy and Fada N'Gourma were the richest in dry matter with respective values of 93.20 and 93.15 (m/m). The Brix degree and the titratable acidity varied respectively from 0.17 (Fada) to 2.06 (Banfora) and from 4.49 (Tenkodogo) to 24.5 (Koudougou). Pollens from Banfora and Koudougou had the highest values respectively for Brix degree and titratable acidity. At the table 3, the Sodium contents vary from 4.50 (Bobo Dioulasso) to 8.94 (Banfora) (m/m). Pollens from Banfora and Koudougou were the richest in sodium with respective contents of 8.94 and 6.78 (m/m). Calcium contents vary from 4.91 (Koudougou) to 57.12 (Fada) (m/m). Pollens from Fada N'Gourma and Banfora were the richest in calcium with respective contents of 57.12 and 37.36 (m/m). The magnesium contents vary from 2.75 (Koudougou) to 108.88 (Fada N'Gourma) (m/m).

Table 1. Biochemical composition and energy value of pollen from different localities in Burkina Faso.

Pollen	Protein (m/m)	Lipid (m/m)	Carbohydrates (m/m)	Ash (m/m)	Energy value (kcal/100 g)
Koudougou	17.15± 3.69^{f}	12.2± 0.12^{d}	59.11± 3.89^{a}	4.54±0.06^{c}	414.84
Sapouy	27.32± 1.38^{c}	5.40± 0.13^{e}	58.18± 3.42^{b}	2.30±0.28^{e}	390.60
Fada N'Gourma	34.65± 5.05^{a}	5.29± 0.05^{f}	46.76± 2.28^{e}	6.45±1.06^{b}	373.25
Tenkodogo	28.65± 2.05^{b}	18.28± 0.18^{b}	43.93± 3.69^{f}	2.19±0.57^{e}	454.84
Bobo Dioulasso	21.65± 1.44^{d}	14.80± 0.14^{c}	52.86± 0.76^{c}	2.64±0.14^{d}	366.29
Banfora	17.82± 3.35^{e}	18.94± 0.18^{a}	47.09± 2.11^{d}	7.3±0.57^{a}	430.10

The values reported in the same column and bearing the different superscript letters are significantly different at the 5% level.
Source: Authors

Table *2*. Biochemical composition of pollen from different localities in Burkina Faso.

Pollen	pH	Humidity (m/m)	Dry matter (m/m)	Degree Brix	Titratable acidity (g/L)
Koudougou	4.4± 0.035^{c}	7.00± 0.28^{c}	93.00± 0.28^{c}	1.04±0.02^{b}	24.5± 0.00^{a}
Sapouy	3.7± 0.021^{e}	6.80± 0.14^{e}	93.20± 0.14^{a}	0.67±0.04^{c}	11.5± 0.70^{d}
Fada N'Gourma	4.6± 0.007^{b}	6.85± 0.07^{e}	93.15± 0.07^{b}	0.17±0.03^{e}	4.75± 0.35^{e}
Tenkodogo	5.3± 0.042^{a}	6.95± 0.35^{d}	93.05± 0.35^{b}	0.31±0.12^{d}	4.49± 0.01^{f}
Bobo Dioulasso	3.63± 0.056^{e}	8.05± 0.21^{b}	91.95± 0.21^{d}	0.66±0.02^{c}	20.25± 1.06^{c}
Banfora	4.09± 0.042^{d}	8.85± 0.07^{a}	91.15± 0.07^{e}	2.06±0.05^{a}	22.5± 2.12^{b}

The values reported in the same column and bearing the different superscript letters are significantly different at the 5% level.
Source: Authors

Table 1. Mineral salt content of pollen from different localities in Burkina Faso.

Pollen	Sodium (m/m)	Calcium (m/m)	Magnesium (m/m)	Zinc (m/m)	Potassium (m/m)	Iron (m/m)
Koudougou	6.78± 0.042^{b}	4.91± 0.35^{f}	2.75± 0.0127^{f}	17.94± 0.014^{c}	33.46± 0.742^{a}	17.34± 0.530^{a}
Sapouy	4.58± 0.007^{d}	9.03± 0.27^{d}	13.69± 0.070^{d}	11.99± 0.106^{d}	10.15± 0.509^{c}	5.41± 0.028^{c}
Fada N'Gourma	5.22± 0.014^{c}	57.12± 0.176^{a}	108.88± 0.120^{a}	59.33± 0.098^{a}	9.99± 0.657^{d}	5.43± 0.014^{c}
Tenkodogo	5.26± 0.007^{c}	8.87± 0.091^{e}	12.42± 0.035^{e}	11.23± 0.021^{f}	10.13± 1.393^{c}	5.28± 0.014^{d}
Bobo Dioulasso	4.50± 0.007^{e}	9.59± 0.077^{c}	14.62± 0.212^{c}	11.51± 0.007^{e}	8.60± 0.141^{e}	4.82± 0.035^{e}
Banfora	8.94± 0.049^{a}	37.36± 0.353^{b}	66.50± 0.318^{b}	46.06± 0.007^{b}	26.65± 1.294^{b}	13.68± 0.00^{b}

The (mean) values reported in the same column and bearing the different superscript letters are significantly different at the threshold of $P<0.05$.
Source: Authors

Pollens from Fada N'Gourma and Banfora were the richest in magnesium with respective contents of 108.88 and 66.50 (m/m). The zinc contents vary from 11.23 (Tenkodogo) to 59.33 (Fada N'Gourma) (m/m). These were the pollens from Fada N'Gourma and Banfora which had high zinc concentrations with respective contents of 59.33 and 46.06 (m/m).

Potassium contents vary from 8.60 (Bobo Dioulasso) to 33.46 (Koudougou) (m/m). Pollens from Koudougou and Banfora had high potassium concentrations with respective contents of 33.46 and 26.65 (m/m). Iron contents vary from 4.82 (Bobo Dioulasso) to 17.34 (Koudougou) (m/m). Pollens from Koudougou and Banfora were the richest in iron with respective contents of 17.34 and 13.68 (m/m).

DISCUSSION

The fat contents obtained from pollen samples from the localities of Banfora, Tenkodogo and Bobo Dioulasso were higher than those obtained by Souza et al. (2018) (14 g/100 g), Heldt et al. (2019) (4.64 g/100 g), Aličić et al. (2020) (6.78 g/100 g), Okumus et al. (2018) (13.30 g/100 g), Veysel et al. (2021) (10.951 g/100 g). The protein contents obtained from pollen samples from the

localities of Fada N'Gourma, Tenkodogo and Sapouy were higher than those obtained by Souza et al. (2018) (26.76 g/100 g), Liolios et al. (2016), (30.11 g/100 g), Heldt et al. (2019), (21.35 g/100 g) and El Ghouizi et al. (2021) (30.32 g/100 g). Total carbohydrate contents obtained from pollen samples from the localities of Koudougou, Sapouy and Bobo Dioulasso were higher than those obtained by Heldt et al. (2019) (15.50 g/100 g) but lower than that of Aličić et al. (2020) (73.76 g/100 g). Total ash contents obtained from pollen samples from the localities of Banfora, Fada N'Gourma and Koudougou were superior to those obtained by Souza et al. (2018) (2.83 g/100 g), Heldt et al. (2019) (2.22 g/100 g), El Ghouizi et al. (2021) (4.22 g/100 g), Aličić et al. (2020) (3.08 g/100 g), Okumus et al. (2018) (2.45 g/100 g), and Veysel et al. (2021) (2.44 g/100 g). The energy values obtained from the pollen samples from the localities of Tenkodogo, Banfora and Koudougou were higher than those obtained in the region of South America (Argentina and Brasil) by Souza et al. (2018) (368 Kcal/ 100 g of pollen). This difference in results can be explained by the diversity of floral species (Younsi and Lazizi, 2016).

The dry matter contents obtained from pollen samples from the localities of Sapouy, Fada N'Gourma and Tenkodogo were superior to those obtained by Veysel et al. (2021) (71.47-81.38 (g/100 g)). Moisture contents (8.85± 0.07, 8.05± 0.21, and 7.00± 0.28 (m/m)) obtained from pollen samples from the localities of Banfora, Bobo Dioulasso and Koudougou were the highest. Furthermore, the moisture content of Sapouy pollen has the lowest content (6.8 g/100 g).

This moisture content was higher compared to the maximum threshold value in Argentina and Brazil (3 g/100 g and 4 g/100 g). This content was close to the content obtained by Souza et al. (2018) (6.73 g/100 g). It was lower than that obtained by Heldt et al. (2019) (7.44 g/100 g), El Ghouizi et al. (2021) (10.7 g/100 g). However, this moisture content was higher than that obtained by Aličić et al. (2020) (6.07 g/100 g). High humidity of pollen can make spoilage possible particularly by moulds. This requires a conservation technique to obtain pollen with a humidity of less than or equal to 6% in order to facilitate conservation.

The pH values obtained from pollen samples from the localities of Tenkodogo, Fada N'Gourma and Koudougou were similar to those obtained by Souza et al. (2018) (4.0-6.0) and El Ghouizi et al. (2021) (4.19-4.82). The analysis of the titratable acidity showed us a fluctuation of the values. These results corroborated the values of Younsi and Lazizi, 2016) (6 g/L to 19 g/L). This fluctuation can be explained by the free acidity of fresh pollen due to the action of the natural lactic flora which is found in fresh pollen to hydrolyze organic compounds, particularly carbohydrates, to release organic acids.

The micronutrient contents of pollen from Fada N'Gourma were highest in Calcium, Magnesium and Zinc. The calcium content was higher than the calcium contents obtained by El Ghouizi et al. (2021) (2.273 mg/100 g) and Veysel et al. (2021) (54.031 mg/100 g) but lower than the content obtained by Heldt et al. (2019) (1120 mg/100 g). The magnesium content was also higher than the magnesium contents obtained by El Ghouizi et al. (2021) (79.335 mg/100 g) and Veysel et al. (2021) (99.076 mg/100g) but lower than that obtained by Heldt et al. (2019) (170 mg/100 g). The zinc content was also higher than the zinc contents obtained by El Ghouizi et al. (2021) (3.883 mg/100 g), Heldt et al. (2019) (50 mg/100 g) and Veysel et al. (2021) (3.126 mg/100 g). The potassium content obtained from pollen from Koudougou was lower than the potassium content obtained by Heldt et al. (2019) (360 mg/100 g), El Ghouizi et al. (2021) (468 55 mg/100 g) and Veysel et al. (2021) (54.031 mg/100 g). On the other hand, the iron content obtained in the same locality was higher than the iron content obtained by Heldt et al. (2019) (5.00 mg/100 g), El Ghouizi et al. (2021) (6.88 mg/100 g) and Veysel et al. (2021) (7.481 mg/100 g). The sodium content obtained from pollen from Banfora was lower than the sodium content obtained by Heldt et al. (2019) (36 mg/100 g) and El Ghouizi et al. (2021) (39.722 mg/100 g) but higher than the content (6.465 mg/100 g) obtained by Veysel et al. (2021). The botanical origin and the nature of the species foraged may be the cause of this difference in results (Younsi and Lazizi, 2016).

Conclusion

This study shows the nutritional richness of the pollen produced in Burkina Faso. Indeed, it is rich in carbohydrates, proteins and fats. It is also rich in micronutrients such as calcium (57.12 mg/100 g), magnesium (108.88 mg/100 g), zinc (59.33 mg/100 g), potassium (33.46 mg/100g) and iron (17.34 mg/100 g). The study shows that the biochemical composition of pollen produced in Burkina Faso varies depending on the region of origin but also is different from pollen from other countries. This difference could be explained by the floral diversity and the action of the natural lactic flora.

The results of this study could contribute to the popularization of pollen and to promote its technological and nutritional use.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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