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Insecticidal Activity of Six Botanical Powders against the Cowpea Seed Beetle *Callosobruchus maculatus* F. (Coleoptera: Bruchidae)

Fouad, H. A. ; Hasnaa B. Abdelmeged and A. M. A. Salman*

Plant protection Department, Faculty of Agriculture, Sohag University

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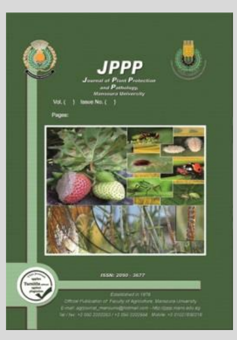

ABSTRACT

Six plant powders including *Cinnamomum zeylanicum* (Lauraceae), *Cuminum cyminum* (Apiaceae), *Curcuma longa* (Zingiberaceae), *Hyphaene thebaica* (Arecaceae), *Lawsonia inermis* (Lythraceae) and *Zingiber officinale* (Zingiberaceae) were tested against *Callosobruchus maculatus* adults at four treatment levels of 20, 40, 60 and 80 gm of plant powders per Kg of cowpea seeds. Lethal concentration was determined at 24, 48 and 72 h after treatment, and lethal time was determined at 80 gm/Kg^{-1} concentration. The results showed that, all botanical powders had effect on *C. maculates* and *L. inermis* was the most toxic, and the least toxic powder was *C. zeylanicum*. Furthermore, plant powder *L. inermis* at 80 gm/Kg^{-1} achieved a lowest LT_{50} value. The tested botanical powders represent valuable tools with potential of integration into the management of *C. maculates* adults.

Keywords: Lethal concentration, lethal time, *Callosobruchus maculatus*, botanical insecticides, pest control.

INTRODUCTION

There is a continuous need to protect the stored products against deterioration, especially loss of quality and weight during storage, mainly due to pests, including insects. Legumes make grand part of commodities maintained in storage, and represent an important component of the world food supply. After harvest, the legumes is usually stored on-farm or in large commercial storages, where it can be infested by a variety of insect pests. Among them, *Callosobruchus maculatus* (Coleoptera: Bruchidae) is one of most widespread and destructive insect pest of stored leguminous seeds throughout the world. It is feeding on different leguminous seeds of family Fabaceae and estimated loss to be above 80% of seeds after 7 months of storage (Ouedraogo *et al*., 1996). To control this pest, synthetic insecticides are used during storage of seeds. But the continuous use of chemical pesticides for control of stored-grain pests has resulted in serious problems such as insecticide resistance, residual pollution of the environment, toxicity to consumers and residues on legumes (Mohan *et al*., 2010). Plant materials have gained a reputation as being potentially bioactive compounds against many insect species, including stored product insects, which has portrayed them as safer tools in terms of the environment and human health compared with synthetic insecticides (Mishra *et al*., 2012; Isman and Grieneisen, 2014).

Among the plant species, several locally available species has been reported to be repellent and toxic to *C. maculatus* (Mahfuz and Khalequzzaman, 2007; Mahmoudvand *et al.* 2011). Many botanical families demonstrated insecticidal activities against coleopteran pests of stored grain. For examples; family Lythraceae (Suleiman and Suleiman, 2014), Lauraceae (Demirel and Erdoğan, 2017), Apiaceae (Ebadollahi *et al.* 2012), Arecaceae (Souza et al. 2008) and Zingiberaceae (Chaubey, 2013). The plant species from the families mentioned above were chosen in this investigation because in addition to being scarcely attacked by insects, they are easily available to farmers either as ornamental and medicinal plants or weeds. Therefore, the present study was conducted to evaluate whether leaf powders from *Cinnamomum zeylanicum* (Lauraceae), *Cuminum cyminum* (Apiaceae), *Curcuma longa* (Zingiberaceae), *Hyphaene thebaica* (Arecaceae), *Lawsonia inermis* (Lythraceae) and *Zingiber officinale* (Zingiberaceae) would adequately control *C. maculatus* adults.

MATERIALS AND METHODS

Insect rearing

The original population of *C. maculatus* was field-collected from small farms in the Sohag region, Egypt, and the population was maintained on pest- and insecticide-free cowpea beans under laboratory in an incubator unit at 25 ± 2 °C, 70 ± 10% relative humidity (RH) and darkness. The food media used was whole cowpea seeds. The newly emerged adults were used for the experiments.

Parts of the plants collected

Leaves of *L. inermis*, inner bark of *C. zeylanicum*, seeds of *C. cyminum*, fruits of *H. thebaica*, rhizomes of *Z. officinale* and rhizomes of *C. longa* were collected from organic farmers in Upper Egypt (Table 1).

Table 1. Plant powders evaluated for insecticidal activity against *Callosobruchus maculates*

Botanicals	Common name	Family	Parts used
Cinnamomum zeylanicum	Cinnamon	Lauraceae	Inner bark
Cuminum cyminum	Cumin	*Apiaceae*	Seed
Curcuma longa	Turmeric	*Zingiberaceae*	Rhizome
Hyphaene thebaica	Hyphaene	Arecaceae	Fruit
Lawsonia inermis	Henna	Lythraceae	Leaf
Zingiber officinale	Ginger	*Zingiberaceae*	Rhizome

* **Corresponding author.**
E-mail address: profdrahmedsalman@yahoo.com
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The samples were ground with an electric mill to prepare powders. The pulverized contents obtained in each plant was kept in separate black polyethylene bags and kept under laboratory condition.

Insecticidal activity

To determine the lethal concentrations of cinnamon, cumin, henna, hyphaene, ginger and turmeric powders to adult *C. maculates* concentration-mortality bioassay was used. These bioassays followed procedures previously described elsewhere (Ojo and Ogunleye, 2013). Briefly, four concentration of each powder were tested in the bioassay 20, 40, 60 and 80 gm kg-1 of cowpea seeds. Each powder was applied using a 0.2, 0.4, 0.6 and 0.8 gm to 10 g of disinfested cowpea seeds that were placed in 250 mL glass jars. After the application, the jars were manually shaken for 1 minute to ensure a complete distribution of the powder. Twenty-five unsexed newly emerged (0-24 h old) adult *C. maculatus* adults were placed in each jar then the jars were sealed with a fine porous cloth to allow ventilation. The jars were arranged in a Completely Randomized Design (CRD) with four replications and kept in incubator under the constant conditions of 27±2˚C, 75±5% relative humidity, 12 h photophase. In each treatment, observations were made and recorded for toxicity effect on mortality rates after 24, 48 and 72 h exposure period. Adults were considered dead if they display no response after probed with a pointed object.

The concentration of 80 gm kg-1 from each plant powder was chosen to be used for analyzing the rate of death after 24 and 48 and 72 h of exposure for calculate the lethal time values.

Statistical analyses

All data collected from the toxicity of the botanical powders on contaminated cowpea seeds were calculated using PROBIT analysis (Finney, 1971). The median lethal concentration (LC_{50}) and lethal time (LT_{50}) were obtained by PROC PROBIT model using SAS software (SAS Institute 2002).

RESULTS AND DISCUSSION

Results

The mortality levels obtained in the concentration-mortality bioassays were satisfactorily described by the probit model (Tables 2, 3 and 4). Among the six plant powders tested for insecticidal activity, the plant powders of *L. inermis* was the most effective in controlling adult *C. maculates*, with an LC_{50} of 88.83, 62.57 and 44.93 gm Kg^{-1}, after 24, 48 and 72 h of exposure, respectively (Tables 2, 3, 4). The level of effectiveness was followed by *Z. officinale*, *C. zeylanicum*, *C. cyminum*, *C. longa* and *H. thebaica*.

The obtained results revealed that the effect of botanical powders has declined by the passage of time. The LT_{50} of 80 g/Kg^{-1} from *L. inermis* leaf powder on *C. maculatus* adults was calculated as 26.82 h (Table 5).

Table 2. Toxicity of cinnamon, Cumin, Henna, Hyphaene, Ginger and Turmeric powders on adults of *Callosobruchus maculatus* after 24 h.

Powders	LC_{50} (95% FL)	LC_{75} (95% FL)	Slope ± SE	X^2	*P*
Henna	88.83 (73.68-121.26)	181.11 (130.08-334.02)	2.18 ± 0.35	9.65	0.79
Cinnamon	107.17 (85.58-161.52)	217.63 (148.30-460.97)	2.19 ± 0.38	6.33	0.95
Cumin	104.53 (84.92-151.02)	201.07 (141.81-390.43)	2.37 ± 0.39	6.89	0.94
Hyphaene	105.45 (85.16-154.64)	206.53 (143.93-413.53)	2.31 ± 0.39	5.99	0.97
Ginger	92.32 (76.31-127.28)	184.91 (132.58-342.69)	2.24 ± 0.36	5.92	0.97
Turmeric	101.10 (82.18-145.53)	200.80 (140.86-393.98)	2.26 ± 0.38	6.44	0.95

LC: Lethal concentration (gm kg-1); FL = Fiducial limits; χ2 = Chi-square for lack-of-fit to the probit model, and P = Probability associated with the chisquare statistic; SD standard error.

Table 3. Toxicity of cinnamon, Cumin, Henna, Hyphaene, Ginger and Turmeric powders on adults of *Callosobruchus maculatus* after 48 h.

Powders	LC_{50} (95% FL)	LC_{75} (95% FL)	Slope ± SE	X^2	*P*
Henna	62.57 (55.0-73.91)	118.12 (95.16-167.05)	2.44 ± 0.33	18.30	0.19
Cinnamon	98.35 (77.55-153.25)	232.39 (150.15-570.06)	1.81 ± 0.33	7.14	0.93
Cumin	89.63 (73.46-125.70)	192.11 (134.35-378.09)	2.04 ± 0.34	6.65	0.95
Hyphaene	86.55 (71.75-118.08)	181.0 (129.32-337.80)	2.11 ± 0.34	7.00	0.93
Ginger	74.45 (63.59-94.19)	150.02 (113.31-244.50)	2.22 ± 0.33	11.59	0.64
Turmeric	89.89 (73.57-126.53)	193.46 (134.88-383.80)	2.03 ± 0.34	8.24	0.88

LC: Lethal concentration (gm kg-1); FL = Fiducial limits; χ2 = Chi-square for lack-of-fit to the probit model, and P = Probability associated with the chisquare statistic; SD standard error.

Table 4. Toxicity of cinnamon, Cumin, Henna, Hyphaene, Ginger and Turmeric powders on adults of *Callosobruchus maculatus* after 72 h.

Powders	LC_{50} (95% FL)	LC_{75} (95% FL)	Slope ± SE	X^2	*P*
Henna	44.93 (37.31-53.97)	74.93 (61.18-106.21)	3.04 ± 0.50	34.04	0.002
Cinnamon	66.74 (57.85-81.33)	132.51 (103.14-201.93)	2.26 ± 0.32	11.94	0.61
Cumin	55.36 (46.93-68.11)	100.90 (79.21-157.34)	2.59 ± 0.41	23.32	0.06
Hyphaene	69.19 (59.25-86.57)	143.80 (108.75-234.09)	2.12 ± 0.32	17.41	0.24
Ginger	45.96 (38.48-55.03)	76.94 (62.90-108.62)	3.02 ± 0.49	31.80	0.004
Turmeric	64.73 (55.86-79.27)	133.51 (102.75-209.08)	2.15 ± 0.32	13.82	0.46

LC: Lethal concentration (g kg-1); FL = Fiducial limits; χ2 = Chi-square for lack-of-fit to the probit model, and P = Probability associated with the chisquare statistic; SD standard error.

Table 5. LT_{50} values of toxicity of cinnamon, Cumin, Henna, Hyphaene, Ginger and Turmeric powders on adults of *Callosobruchus maculates* at concentration of 80 g/ Kg^{-1}.

Powders	LT_{25} (95% FL)	LT_{50} (95% FL)	Slope ± SE	X^2	P
Henna	15.43 (10.18-19.64)	26.82 (21.54-31.09)	2.81 ± 0.42	11.77	0.30
Cinnamon	15.54 (13.29-21.35)	42.37 (31.36-55.94)	2.19 ± 0.38	6.33	0.95
Cumin	16.81 (9.48-22.39)	35.63 (28.62-41.97)	2.07 ± 0.38	8.33	0.60
Hyphaene	12.91 (2.83-20.75)	41.13 (29.78-54.08)	1.34 ± 0.37	3.57	0.96
Ginger	16.57 (11.04-20.95)	29.44 (24.05-33.91)	2.70 ± 0.41	12.30	0.26
Turmeric	11.89 (2.34-19.64)	38.15 (26.34-49.40)	1.33 ± 0.37	3.25	0.97

LT: Lethal time (h); FL = Fiducial limits; $\chi 2$ = Chi-square for lack-of-fit to the probit model, and P = Probability associated with the chi-square statistic; SD standard error;

Discussion

Botanical insecticides are among the most interesting options for cheaper, safer and eco-friendly replacements for synthetic insecticides (Stevenson *et al*. 2017). Here, we demonstrated that effect of cinnamon, cumin, henna, hyphaene, ginger and turmeric powders on control of *C. maculatus* on stored cowpea beans.

The present investigation demonstrated that mortality of *C. maculatus* adults varied according to plant species, concentrations of plant powder and time period of exposure. *L. inermis* had lower LC_{50} and LC_{90} values, hence the most toxic plant powder to *C. maculatus*.

These results are in concordance with previous studies reported the insecticidal toxicity of *L. inermis* leaves that successfully control cowpea weevil (Jose and Adesina 2014; Suleiman and Suleiman, 2014; Chudasama et al. 2015) as well as other stored grain insects such as; *Sitophlus zeamais* (Suleiman et al., 2012) and *Tribolium castaneum* (Kamal et al. 2016). The insecticidal activity of *L. inermis* leaves may attribute to its major constituents (i.e., eugenol, hexadecanoic acid, Phytol, α-terpineol and Etherphenylvinyl (Kidanemariam et al. 2013).

Our result also showed that other tested plant powders exhibited strong insecticidal activity against *C. maculatus* adults with varying values. These findings clearly support the results of the other studies for susceptible of *C. maculatus* to the tested plants. Oil of *Z. officinale* rhizomes was exhibited insecticidal and antifeeding activities against *C. chinensis*, *T. castaneum* and *S. oryzae* (Chaubey, 2012a, 2012b, 2013). Plant oil of *Z. officinale* was found more effective and exhibited toxicity against *C. maculates* followed by *C. zeylanicum* oil (Sushmita *et al*. 2019). Essential oil of *C. cyminum* had high fumigant activity on *C. maculates*, with LC_{50} value 11.385 μL/L air (Ebadollahi *et al*. 2012). Essential oils *C. longa* and *Z. officinale* caused 50-70% and 52-80 % of mortality against *C. maculates*, respectively (Krishnappa *et al*. 2011).

The plant powder is normally a mixture of tens to hundreds of individual constituents. The insecticidal constituents of plant powder are mostly monoterpenoids (Ahn et al., 1998; Regnault-Roger et al., 2002). Active ingredients in the botanical insecticide may have different mechanisms of action against insects. These constituents may act on the insects' nervous system by disturbing the functions of GABAergic (Tong and Coats, 2012) and aminergic (Kostyukovsky et al. 2002) systems and by inhibiting actions of acetylcholinesterase (Abdelgaleil *et al*. 2016).

Thus, our findings revealed adequate insecticidal activities of *L. inermis* and *Z. officinale* leaf powders against *C. maculatus*, which make them suitable tools that can be integrated into management programs of *C. maculatus*, especially for storage facilities. Further work is also needed to test the applicability and efficacy of different formulations from these plants under different kind of storage facilities.

REFERENCES

Abdelgaleil SA, Mohamed MI, Shawir MS, and HK Abou-Taleb, 2016. Chemical composition, insecticidal and biochemical effects of essential oils of different plant species from Northern Egypt on the rice weevil, *Sitophilus oryzae* L. Journal of Pest Science, 89(1):219-229.

Ahn Y.I., S.B. Lee, H.S. Lee and G.H. Kim, (1998). Insecticidal and acaricidal activity of caravacrol and β-thujaplicine derived from *Thujopsis dolabrata* var. hondai sawdust. Journal of Chemical Ecology, 24: 1-90.

Chaubey M. K. (2013). Biological Activities of *Zingiber officinale* (Zingiberaceae) and *Piper cubeba* (Piperaceae) Essential Oils Against Pulse Beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae). Pakistan Journal of Biological Sciences, 16 (11): 517-523.

Chaubey, M. K. (2012a). Responses of *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (Coleoptera: Curculionidae) against essential oils and pure compounds. Herba Polonica, 58(3), 33–45.

Chaubey, M. K. (2012b). Biological effects of essential oils against rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Journal of Essential Oil Bearing Plants, 15, 809–815.

Chudasama J. A., Sagarka N. B., and Sharma, S. (2015). Deterrent effect of plant extracts against *Callosobruchus maculatus* on stored cowpea in Saurashtra (Gujarat, India) Journal of Applied and Natural Science, 7 (1): 18 – 191.

Demirel N. and Erdoğan C. 2017. Insecticidal effects of essential oils from Labiatae and Lauraceae families against cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in stored pea seeds. Entomology and Applied Science Letters 4 (1): 13-19.

Ebadollahi A., Nouri-Ganbalani G., Hoseini S. A., Sadeghi G. R. (2012). Insecticidal Activity of Essential Oils of Five Aromatic Plants Against *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) Under Laboratory Conditions. Journal of Essential Oil Bearing Plants, 15 (2): 256- 262.

Finney D. J. (1971). Probit analysis. 3rd edition. Cambridge University Press, Cambridge, pp: 318

Isman MB, Grieneisen ML. (2014). Botanical insecticide research: many publications, limited useful data. Trends in Plant Science. 19(3):140–5.

Jose A. R. and Adesina J. M. (2014): Oviposition, Infestation Deterrent Activity and Phytochemical screening of Heliotropium indicum and Lawsonia inermis against *Callosobruchus maculates* Fabricius (Coleoptera: Chrysomelidae) on Cowpea Seeds. International Journal of Molecular Zoology,Vol. 4, No. 1, 1-8.

Kamal K. B. Nusrat S. and M.A. Rabbi (2016): Evaluation of insecticidal activity of *Lawsonia inermis* Linn. against the red flour beetle, *Tribolium castaneum* (Herbst) NPAIJ, 12(1): 8-011.

Kidanemariam T. K., Tesema T. K., Asressu K. H., Boru A. D. (2013). Chemical Investigation of *Lawsonia inermis* L. Leaves from Afar Region, Ethiopia. Oriental Journal of Chemistry, 29 (3): 1129-1134.

Kostyukovsky M, Rafaeli A, Gileadi C, Demchenko N, Shaaya E. (2002). Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: possible mode of action against insect pests. Pest Management Science, 58(11):1101–1106.

Krishnappa K., Lakshmanan S., Elumalai K. and Jayakumar S. 2011. Insecticidal action of certain essential oils against *Callosobruchus maculatus* (Coleoptpera: Bruchidae). International Journal of Current Agricultrual Sciences, 1(2): 10-14.

Lee, S., C.J. Peterson and J.R. Coats, 2003. Fumigation toxicity of monoterpenoids to several stored product insects. Journal of Stored Products Research, 39: 77-85.

Mahfuz, I. & Khalequzzaman, M. (2007). Contact and fumigant toxicity of essential oils against *Callosobruchus maculatus*. University journal of zoology Rajshahi Univ. 26:63-66.

Mahmoudvand, M., Abbasipour, H., Hosseinpour, M.H., Rastegar, F. & Basij, M. (2011). Using some Plant Essential Oils as natural fumigants against adults of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Munis Entomology & Zoology 6:150-154.

Mishra B. B., Tripathi S. P., Tripathi C. P. M., 2012.- Repellent effect of leaves essential oils from *Eucalyptus globulus* (Mirtaceae) and *Ocimum basilicum* (Lamiaceae) against two major stored grain insect pests of coleopterans.- Nature and Science, 10 (2): 50-54.

Mohan S., Pretheep-Kumar P., Balasubramanian P., 2010.- Insecticide resistance- stored-product insects.- LAP Lambert Academic Publishing.

Ojo D. O. and Ogunleye R. F. 2013. Comparative effectiveness of the powders of some underutilized botanicals for the control of *Callosobruchus maculatus* (Coleoptera: Bruchidae). Journal of Plant Diseases and Protection, 120 (5/6): 227–232.

Ouedraogo A.P., Sou S., Monge J.P., Huignard J., Tran B., Credland P.F. (1996) Influence of temperature and humidity on populations of *Callosobruchus maculatus* (Coleoptera: Bruchidae) and its parasitoid *Dinarmus basalis* (Hymenoptera: Pteromalidae) in two zones of Burkina Faso. Bulletin of entomological research, 86: 695-702.

Regnault-Roger, C., B.J. Philigene and C. Vincent, (2002). Biopesticides Dorigiu Vegetales. Tec and Doc Eds., Paris, Pages: 337.

SAS Institute (2016). SAS/STAT User’s Guide. SAS, editor. Cary, NC, USA.2008.

Sciences, 16 (11): 517-523.

Souza A. P., Marques M. R., Mahmoud T. S., Caputo B. A., Canhete G. M., Leite C. B., de Lima D. P. 2008. Bioprospecting insecticidal compounds from plants native to Mato Grosso do Sul, Brazil. Acta Botanica Brasilica, 22(4): 1136-1140.

Stevenson PC, Isman MB, Belmain SR. (2017). Pesticidal plants in Africa: a global vision of new biological control products from local uses. Industrial Crops and Products. 2017.

Suleiman, M. and Suleiman, H. Y. (2014). Control of *Callosobruchus maculatus* (F.) [Coleoptera: Bruchidae] using leaf powders of *Euphorbia balsamifera* L. and *Lawsonia inermis* L. International Journal of Science, Environment and Technology, 3(1): 100 – 109.

Suleiman, M., Ibrahim, N. D. and Majeed, Q. (2012). Control of *Sitophilus zeamais* (Motsch) [Coleoptera: Curculionidae] on sorghum using some plant powders. International Journal of Agriculture and Forestry, 2 (1): 53 – 57.

Sushmita T.H., Gupta M.K., Singh KI and Karthik S. (2019). Contact toxicity of some plant volatile oils against pulse beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae). Journal of Entomology and Zoology Studies, 7(1): 597-599.

Tong F and Coats JR. Quantitative structure–activity relationships of monoterpenoid binding activities to the housefly GABA receptor. Pest Management Science, 68(8):1122-1129.

النشاط الابادى لستة مساحيق نباتية ضد خنفساء اللوبيا *Callosobruchus maculatus* F. (Coleoptera: Bruchidae)

هانى احمد فؤاد ، حسناء بدوى عبد المجيد و احمد محمود على سالمان

قسم وقاية النبات ، كلية الزراعة ، جامعة سوهاج

ستة مساحيق نباتية بما في ذلك الحناء، القرفة، الكمون، الدوم، الزنجبيل و الكركم كانت أختبرت ضد الحشرات البالغة لخنفساء اللوبيا بأستخدام أربعة مستويات هى 20 ، ٤٠ ، ٦٠ و ٨٠ جم من مساحيق النباتات المختبرة لكل كيلوغرام من بذور اللوبيا. تم تحديد التركيز القاتل عند ٢٤ و ٤٨ و ٧٢ ساعة بعد المعاملة ، وتم تحديد الوقت اللازم للآبادة عند تركيز ٨٠ جم من النباتات / كجم من بذور اللوبيا. أظهرت النتائج أن جميع مساحيق النباتات المختبرة كان لها تأثير على خنفساء اللوبيا وأن مسحوق الحناء كان الأكثر سمية ، وكان أقل مسحوق سام هو مسحوق القرفة. علاوة على ذلك ، أظهرت النتائج أن مسحوق الحناء عند ٨٠ جم / كجم حقق أدنى قيمة للوقت اللازم لقتل ٥٠% من العشيرة. تمثل المساحيق النباتية المختبرة أدوات قيمة مع إمكانية دمجها في إدارة الحشرات البالغة من خنفساء اللوبيا.