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Study of Morphology, Nutrition and Bioactive Compounds at Two Accessions Marigold (*Tagetes erecta*) in Kepahiang Regency

Wismalinda Rita[1*], Neli Definiati[2], Rita Zurina[3], Edi Susilo[4], Parwito[5]
[1,2,3]Animal Husbandry Study Program, Faculty of Agriculture & Animal Husbandry, University of Muhammadiyah Bengkulu
[4,5]Department of Agrotechnology, Faculty of Agriculture, University of Ratu Samban
Corresponding Author: Wismalinda Rita wismalindarita@umb.ac.id

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A B S T R A C T

Marigold (*Tagetes erecta*) is an ornamental herbaceous and medicinal plant that is easily cultivated, so many are found at various heights, such as in Kepahiang Bengkulu regency, Indonesia. In addition, marigolds contain nutrients and bioactive compounds that have yet to be fully utilized. This study aims to identify the morphology, nutrients and bioactive compounds of marigold flowers in Kepahiang district of Bengkulu, Indonesia. The study was conducted using a purposive sampling survey method by conducting non-experimental descriptive observations. Sampling locations were conducted around Kepahiang regency. The variables observed were morphological identification, nutrient content and bioactive compounds. Two accessions are found: marigold flowers with small petals of orange and marigold flowers with small petals of yellow. Orange marigold flowers with small petals-shaped protein (10.51%) are higher than the small yellow marigold (9.49%), while the protein content of leaves (5.96%) is lower than the protein marigold flowers. Small-sized orange Petals marigold flowers have a higher carotenoid content (166.41 mg/kg) than small-sized yellow petals flowers (85.89 mg/kg). But compared to flowers, marigold leaves have a higher chlorophyll content (246.93 mg/kg). Marigold flower with orange petals in a small shape has the best nutritional and bioactive compounds content for poultry feed

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INTRODUCTION

Marigold (*Tagetes erecta*) is an ornamental herb Marigold (*Tagetes erecta*) is a decorative and medicinal herbaceous plant known for a long time, is commonly used as a hedge and barrier plant and is easy to cultivate. Marigolds in Indonesia have many names, namely Kenikir, Randa Kencana, Ades (Indonesia), and tahi kotok (Sunda). Tagetes belongs to the Compositae family (Asteraceae); there are 59 species of marigolds, while the famous five species with the latin name *Tagetes erecta* Calendula officinalis, Tagetes patula, Tagetes lucida, and Tagetes tenuifolia (Chitrakar *et al*., 2019). Marigolds include annual flowering edible plants that are beautiful, stout and branched and grow upright as high as 0.6 – 0.9 m, with dark green pinnate leaves with a nice texture with flower colours ranging from bright yellow, brownish yellow, orange to brown double petals arrangement measuring 7.5-10 cm, and can reproduce by seed (Pratheesh *et al*., 2009).

Marigolds are native to South America and are now cultivated almost worldwide. Marigold plants can grow well in Indonesia because the growing conditions are very suitable for the environment. The growing requirements include sufficient sunlight exposure, planting in soil with a neutral pH, and good irrigation (Winarto, 2010).

Marigolds can be used as a source of supplements because this plant contains good carotenoids and nutrients. Marigolds are rich in bioactive compounds that are efficacious in health, namely yellow carotenoids containing xanthophylls with the main components lutein and zeaxanthin (Masa & Mojca, 2008). Marigold flower xanthophyll was reported to have a protective effect against degeneration (Age Macular Degeneration) (Berendschot *et al*., 2000), atherosclerosis and cardiovascular disease (Granado *et al.,* 2003), cancer (Gansukh, E *et al*., 2019), and oxidative damage (Wang *et al*., 2018). Marigolds also contain essential oils that are useful as anti-ageing (Maity *et al.,* 2011), antimicrobials (Dasgupta *et al*., 2012), insecticides (Nikkon *et al*., 2011) and analgesics (Bashir, 2018). Marigolds also act as a natural fungicide and anti-nematode (Salisbury & Ross, 1995). In addition, marigolds can also be used as a synthetic pigment, which serves as an anti-oxidant to ward off free radicals (Susanti *et al*.,2018).

More studies are still needed on marigold flowers' nutritional content and bioactive compounds (*Tagetes erecta*), especially local varieties widely available in Kepahiang regency, Bengkulu, Indonesia. Hence, this research needs to be done. The study aims to determine the morphology, nutrition and bioactive compounds in two accessions of marigolds in Kepahiang regency as poultry feed ingredients. Aqueous and medicinal plants are easily cultivated, so many are found at various heights, such as in Kepahiang Bengkulu regency, Indonesia. In addition, marigolds contain nutrients and bioactive compounds that have yet to be fully utilized. This study aims to identify the morphology, nutrients and bioactive compounds of marigold flowers in Kepahiang District of Bengkulu, Indonesia. The study was conducted using a purposive sampling survey method by conducting non-experimental descriptive observations. Sampling locations were conducted around Kepahiang regency. The variables observed were morphological identification, nutrient content and bioactive compounds. Two accessions are found: marigold flowers with small petals of orange and marigold flowers with small petals of yellow. Orange marigold flowers with small petals-shaped protein (10.51%) are higher than the small yellow marigold (9.49%), while the protein content of leaves (5.96%) is lower than the protein marigold flowers. Small-sized orange Petals marigold flowers have a higher carotenoid content (166.41 mg/kg) than small-sized yellow petals flowers (85.89 mg/kg). However, compared to flowers, marigold leaves have a higher chlorophyll content (246.93 mg/kg).

METHODS

Morphological Identification

Morphological identification is carried out by experimental observation. The location of the survey was in Kepahiang regency. Samples observed and measured directly include flower colour, petal shape, flower diameter, flower weight, leaf shape and stem shape.

Preparation of Marigold Flowers

The harvested marigold flowers are then separated from the stalks and petals. After that, they are dried using a sangria machine at 70°C for 24 hours. The dried marigold petals are then ground to obtain Marigold pollen (*Tagetes erecta*).

Nutritional Component Analysis

Nutritional components (dry matter, minerals, fats, proteins and coarse fibres) of marigold flower flour were carried out using the Association of Official Analytical Chemists (AOAC) (2005).

Analysis of The Content of Bioactive Compounds

Carotenoid content was measured using a spectrophotometer based on the method performed by Hendry and Grime (1993). The extract is filtered with filter paper and rarefied in a centrifuge. Filtrate as much as 20 ml is inserted into the tube cuvet spectrophotometer, then the absorbance measurement at wavelengths of 480 nm, 645 nm, and 663 nm. The equation calculates the carotenoid content (μmol/g):

$$\text{Carotenoid} = (A_{480} + 0.114 + A_{663} - 0.638 \text{ X } A_{645}) \text{ x V x } 10^3) / 112.5 \text{ x W}$$

Description:

A_{480} = Absorbance at a wavelength of 480 nm
A_{645} = Absorbance at a wavelength of 645 nm
A_{663} = Absorbance at a wavelength of 663 nm
V = Filtrate Volume (ml)
W = Sample weight (g)

Data Analysis

Data from morphological studies, nutrient content and bioactive compound analysis were analyzed descriptively.

RESULTS AND DISCUSSION

Phenotypic Identification

The survey results showed two accessions of marigolds in Kepahiang regency, namely: 1. Marigold flowers with orange petals and small size; 2.) Marigold flowers with petals are yellow and small in size. *Tagetes erecta* is spread over four districts with the accession of the orange petals in small, more commonly found districts of Kepahiang, Kabawetan, Ujan Mas and Merigi. In the same time, the yellow petals are small and found in the district Kepahiang and Kabawetan. The characterization of the two accessions of *Tagetes erecta* is presented in Figure 1 and Table.

Figure 1. Morphology of Two Accessions of *Tagetes erecta* in Kepahiang Regency

Table 1. Morphological Characterization of Two Accessions of Marigold Flower (*Tagetes Erecta*) in Kepahiang Regency

Color of Flower	Petals	Diameter (mm)	Weight (g)	Leaf	Rod shaped
Orange	Symmetrical (small size petal)	37.33	6.69	Pinnate compound leaves (*pinnatus*)	Round stem, sympodial branching and green in color
Yellow	Symmetrical (small size petal)	34.26	5.95	Pinnate compound leaves (*pinnatus*)	Round stem, sympodial branching and green in color

The orange accession has flowers with a diameter of 37.33 mm, which is wider than the Yellow accession *Tagetes erecta* (34.26 mm). Likewise, the weight of the Orange Crown is 6.69 g, while the yellow one is 5.95 g. While The Shape of the leaves and stems to the two accessions are almost the same compound leaves, many rip (*tinnitus*) and stem-shaped round, book-book, branching and green coloured.

Nutritional Content

Table 2. Results of Nutrient Content Analysis of Two Accessions of Marigold Flowers and Leaves (*Tagetes Erecta*) in Kepahiang Regency

Sample	Dry Weight (%)	Mineral (%)	Fat (%)	Protein (%)	Crude Fiber (%)
Orange Marigold Flowers	7.31	7.85	6.81	10.51	13.34
Yellow Marigold Flowers	6.40	8.08	4.42	9.49	14.31
Marigold Leaves	87.5	10.91	1.49	5.96	10.18

Orange marigold flowers with small crown-shaped protein (10.51%) are higher than yellow marigold small (9.49%), while the protein content of leaves (5.96%) is lower than the protein marigold flowers. Plants absorb nutrients in the soil through the roots and distribute them throughout the plant parts to the leaves so that plants form proteins and perform remodelling (catabolism). The formation of proteins starts from the process of anabolism and then transforms in the plant through the process of catabolism. Plants need Nitrogen as a nutrient to form proteins. *Nitrogen content* is the dominant element that affects plant growth. Hence, plants need Nitrogen to create protein, and nitrogen deficiency can be interpreted as a lack of protein. Plant proteins are closely related to tissue activity, so leaves contain more protein than stems. The protein content is reduced when the plant is ripe because the leaves and stems ratio diminishes. The crude protein content of the plant will decrease with the plant's increasing age. Proteins are composed of elements such as carbon, hydrogen, oxygen, and Nitrogen and sometimes contain sulfur and phosphorus. Protein quality largely determines the size of protein needs (Ramaiyulis, Salvia & Goddess. 2022).

The content of crude fibre accession of orange marigold flowers (13.34%) and yellow marigold flowers (14.31%) is higher than that of marigold leaves (10.18%). Crude fibre is a fibre component that does not dissolve in weak acid or alkaline solutions. Crude fiber content includes cellulose, hemicellulose, lignin, cutin and pentosan-pentosan. Cellulose is the main constituent of plant cell walls. The cellulose content in the cell wall of higher plants is about 35-50% of the dry weight of the plant (Saha, 2004). Cellulose is rarely found in its pure state but permanently binds to other substances, such as lignin and hemicellulose. Cellulose is found in plants as a building material for cell walls and fibres. Lignin is the builder of cell walls in plants. This function lignin has as a phenolic compound. Lignin is one of the wood-forming elements in plants. The location of lignin in plants is on the walls of specific cells in plant tissues. A set of lignin with cellulose and fibres on the cell wall forms a plant construction that is flexible and sturdy. This construction is characteristic of wood. The dissimilarity of the mechanical and physical properties of wood results from the presence of lignin, cellulose and fibre content in the cell walls of different plants.

Savitri *et al*., (2013) state that the crude fibre content of plants will increase due to the higher lignification process as the accumulation of photosynthesis increases with the age of the plant. The older the plant ages, the higher the crude fibre levels the plant cell walls show, which are getting harder and stronger as support (Bogdan, 1977). In addition, the high proportion of stems affects the crude fibre content; the increase in plant cell wall components will increase crude fibre content. Hajar *et al*., (2019) state that old fast plants will form plant cell dining, a fraction of coarse fibre. The higher the level of coarse fibre, the more difficult it is for livestock to digest.

The optimal content of crude fibre in poultry rations varies depending on the type: Quail maximum 7%, duck maximum 8%, and broiler maximum 6% (SNI, 2006). Crude fibre consists of cellulose, hemicellulose and lignin, most of which are bulky and cannot be digested by poultry (Wahju, 1997). Crude fibre in the diet of broiler chickens is needed in limited quantities, but its presence is closely related to the development of the digestive organs. If the chicken has excess coarse fibre, it will affect the gastrointestinal tract of the chicken (Ramaiyulis, Salvia & Goddess. 2022). High crude fibre triggers the organs of the digestive tract to work heavier, resulting in changes in the morphology and histology of the digestive tract. The influence of crude fibre on the weight of the digestive tract organs is closely related to the degree of digestibility of the ration. Crude fibre levels are too high to cause the digestion of nutrients to be lengthier and have lower productive energy values (Tillman *et al*., 1998). Crude fibre contains cellulose and other compounds that are difficult to digest compared to the extract without Nitrogen in the form of starch.

Chlorophyll and Carotenoids

The following are the results of the analysis of chlorophyll and carotenoid content of orange yellow marigold flowers and marigold leaves.

Table 3. Results of Bioactive Compound Content Analysis of Two Accessions of Marigold Flower (*Tagetes Erecta*) in Kepahiang Regency

Sample	Chlorophyll (mg/g)	Carotenoid (mg/kg)
Orange Marigold Flowers	0.23	166.41
Yellow Marigold Flowers	0.18	125.89
Marigold Leaves	2.21	85.93

Orange marigold flowers have a higher chlorophyll content (0.23 mg/g) than the yellow marigold accession (0.18), while the leaves of marigolds have a higher chlorophyll content of flowers (2.21 mg/g). Chlorophyll is a green color-giving pigment in plants, algae and photosynthetic bacteria. This pigment plays a role in plant photosynthesis by absorbing and converting light into chemical energy. Chlorophyll is the main factor affecting photosynthesis. The three primary functions of chlorophyll in photosynthesis are harnessing solar energy, triggering CO_2 fixation to produce carbohydrates and providing energy for the ecosystem. Carbohydrates produced in photosynthesis are converted into proteins, fats, nucleic acids and other organic molecules. Chlorophyll content is influenced by environmental factors, namely light intensity, temperature and air humidity. Temperature is an external factor affecting the formation or synthesis of chlorophyll in the leaves. Butar (2005) states that chlorophyll synthesis occurs in the grace (range) of the hottest temperatures in the dry season.

In addition, the entry of sizeable light intensity and high temperature will cause high evaporation. If not accompanied by a root system that can absorb water optimally, high evaporation n will cause dehydration. The light factor influences chlorophyll biosintesis. Light is needed to reduce protochlorophyllide A to chlorophyllide A and subsequently to form chlorophyll a. The reduction of protochlorophyllide A to chlorophyllide A takes place with the help of the enzyme por (protochlorophyllide oxidoreductase), which works actively when there is light. Low light intensity will lead to decreased metabolism, so the amount of carbohydrates produced will also decrease. Carbohydrates are primary metabolites that become the starting compounds for the formation of various other metabolites and organic molecules, such as chlorophyll (Banas *et al.*, 2011)

Small-sized orange Petals marigold flowers have a higher carotenoid content (166.41 mg/kg) than small-sized yellow petals flowers (125.89 mg/kg). However, compared to flowers, marigold leaves have a lower carotenoid content (85.93 mg/kg). Carotenoids are pigments that help chlorophyll absorb light, so the amount is not as much as chlorophyll. Carotenoid pigments absorb light at different wavelengths than chlorophyll absorbs. Thus, carotenoids and chlorophyll are complementary light-receiving pigments. This is by Campell & Reece (2002) that carotenoids are pigment accessories that help chlorophyll in photosynthesis. The relative content of carotenoids and chlorophyll varies in plant species.

CONCLUSIONS AND RECOMMENDATIONS

There are two accessions of marigolds (*Tagetes erecta*) in Kepahiang regency. Orange marigolds with small petals are found in four districts: Kepahiang, Kabawetan, Ujan Mas, and Merigi. Yellow petals and small-shaped marigolds are found in the districts of Kepahiang and Kabawetan.

The accession found was a marigold flower with orange petals in a small shape and a marigold flower accession with yellow petals in a small shape. The shape of the leaves and stems of the two Accessions were almost the same; the compound leaves were similar (tinnitus), and the stems were round, book-shaped, branched, and green.

Accession orange marigold flowers have a higher protein content (10.51%) and carotenoids (166.41%) than the yellow marigold flowers. The crude fibre is lower (13.34%) than the yellow marigold flowers (14.31%) and higher than the marigold leaves. Marigold flower with orange petals in a small shape has the best nutritional content for poultry feed.

FURTHER STUDY

This study still has limitations so that further research is needed related to the topic of Study of Morphology, Nutrition and Bioactive Compounds at Two Accessions Marigold (Tagetes erecta). In order to perfect this study and increase insight for readers.

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