Dear Mutiara,
Please see attached file
Best regards
Son Radu

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Website: www.myfoodresearch.com

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Subject: Manuscript for Research Journal

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Dear editor FRJ,

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Mutiara Nugraheni

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9 Juli 2018 09.13

Dear Mutiara,

Our apologies for the delay. Please see attached file for comments on your manuscript.

Best regards

Son Radu

---

Dear Dr. Mutiara,

Manuscript FR-2018-098 entitled "PHYTOCHEMICAL COMPOUNDS AND ANTIOXIDANT ACTIVITY OF COLEUS TUBEROSUS FLESH AND PEEL ON DIFFERENT SOLVENT" which you submitted to Food Research, has been reviewed. The comments of the reviewer(s) are included in the attached file.

The reviewer(s) have recommended publication, but also suggest some revisions to your manuscript. Therefore, I invite you to respond to the reviewer(s)' comments and revise your manuscript. Once the revised manuscript is prepared, please send it back to me for further processing.

Because we are trying to facilitate timely publication of manuscripts submitted to Food Research, your revised manuscript should be submitted by 17th June 2018. If it is not possible for you to submit your revision by this date, please let us know.

Once again, thank you for submitting your manuscript to Food Research and I look forward to receiving your revised manuscript.

Sincerely,

Professor Dr. Son Radu

Editor-in-Chief, Food Research

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Please indicate your recommendation by circling one of the items below:

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COMMENT SHEET

Using item 2 in page 1 as a guideline, please indicate the reasons for your recommendations. Most author(s) will appreciate frankness, combined with a modicum of tact. Even if you recommend that the manuscript be accepted for publication, please provide some general comments to the author(s).

1. Abstract must be edited.
   Lines 1-4 need to be written clearly.
   First line is a problem statement followed by methods used.

2. References in the text, et al. must be italic.
   References cited together must arrange in ascending order, starting with older reference followed by latest reference

3. scientific formula must be written correctly

4. Method
   The extraction process, please explain more detail.
   temperature ... 45°C not 45oC .... check all

5. Result and Discussion
   Please describe the mechanisms of Coleus tuberosus extract could inhibit the formation of MDA black-TBA
   Provide an explanation of the solvent that can be optimal extraction of phytochemicals compounds
   Give more explanation in the relationship between phytochemical compounds, with antioxidant activity

6. check spelling errors/mistakes

7. Reference section must be edited to follow strictly Food Research format.

8. The manuscript NEEDS improving in ENGLISH language editing. Those MARKED IN RED needs editing.

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16 Juli 2018 09.21
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Manuscript ID: FR-2018-098
Manuscript Title: Phytochemical compounds and antioxidant activity of Coleus tuberosus flesh and peel on different solvent

A technical check was performed on your manuscript. Before we can proceed, I would like to clarify a few points that I have commented in the manuscript. Please refer to the attachment.

1. Please have your manuscript checked for English Language Proficiency. The sentences are improperly structured with many grammatical errors and spelling errors. You may employ an Editorial Service for the purpose or you may have a native English Language speaker to check the manuscript. Please be informed that if we received a revised manuscript with minimal changes/improvement, you will be subjected to Editorial Charges by the Journal.
2. Please provide full addresses for all affiliations.
3. Please edit the format of the numbers presented in the table. We use 0.05, not 0.05.
4. Scientific names for plants should be written in the proper way. C. tuberosus, not C. Tuberous. If the name has been mentioned full at the beginning of the manuscript, it can then be abbreviated.

Please use the attached copy to make your revisions as it has been corrected to the Journal’s format. Once you have done, kindly revert the copy to me as soon as possible. Please note the faster you respond, the quicker we will process your manuscript.

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I sent the attached revisions to the article. Thank you
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Food Research <foodresearch.my@outlook.com>
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Dear Mutia,

Sila check balik Figure 1 di dalam manuskrip.

Ekstrak chloroform C. tuberosus peel adalah 39,96. Tetapi bar-nya di dalam chart adalah lebih rendah daripada Ekstrak methanol C. tuberosus flesh yang mempunyai nilai 15,41. Ini tidak betul.

Setelah anda selesai mengedit Figure 1, sila hantar kembali kepada saya.

Thanks & Regards,
Dr. Vivian New
Editor
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Dear editor,

I send again the revised article. Thank you for your attention.

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25 Juli 2018 19.29

Dear Dr. Mutiara,

It is a great pleasure to accept your manuscript FR-2018-098 entitled 'Phytochemical compounds and antioxidant activity of Coleus tuberosus flesh and peel on different solvent' for publication in Food Research.

I would like to inform you that we had improved the brevity and language of your manuscript after performing a thorough technical check on your manuscript. Please refer to the attachment for the copy of the improvement. This is also to raise the language quality of the manuscript and to attract more readers to your published research work.

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Mutia Nugrahreni

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Please see the attachment for the invoice INV18027. We hope that you can make the payment as soon as possible before 17 August 2018 for us to complete the publication of your manuscript. The manuscript information e.g. volume, issue, page numbers and DOI, will be provided once we have received the payment.

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Phytochemical compounds and antioxidant activity of *Coleus tuberosus* flesh and peel on different solvent

1Nugraheni, M.2Santoso, U.and3Windarwati

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Article history:
Received : 25 May 2018
Received in revised form : 15 July 2018
Accepted : 18 July 2018
Available Online : xx July 2018

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Abstract
Three different solvents are used to extract the phytochemical compounds on the peel and flesh of *Coleus tuberosus*. The results of extraction with different solvent then compared on the levels of phytochemicals compounds and its antioxidant activity. Extraction of bioactive compounds was done by the maceration method using methanol, ethyl acetate, and chloroform for 7 days with 1:5 (w/v). Determination of total phenolic contents, and flavonoids by spectrophotometric method. Evaluation of antioxidant activity by DPPH, peroxide value and TBA value. The results showed that the methanol solvent can extract more total phenolic and flavonoids compounds than the ethyl acetate and chloroform. Antioxidant activity of methanol extracts was higher on extracts of ethyl acetate and chloroform both on the flesh or the peel of *Coleus tuberosus*. The extract of the peel of *Coleus tuberosus* has antioxidant activity higher than the flesh extracts that use solvent ethanol, ethyl acetate or chloroform. There is a positive and significant correlation between total phenolic and flavonoids content against DPPH and a negative and significant correlation with peroxide and TBA value.

Keywords: total phenolic, flavonoid, *Coleus tuberosus*

1. Introduction

*Coleus tuberosus* include local tubers that belong to *Lamiaceae* family, sub *nepetoideae* family, tribe *Ocimeae* and has an important role in food security that
contains some types of bioactive compounds known to function as antioxidants and anti-cancer. The bioactive compounds identified from *Coleus tuberosus* were triterpenic acid including ursolic acid and oleanolic acid, total phenol and flavonoid (Mathe et al., 2007; Nugraheni et al., 2011). Some research shows that bioactive compounds in fruits and vegetables namely total phenolic content, flavonoid, and triterpenic acid have the ability as an antioxidant (Fu et al., 2017; Shiraishi et al., 2018). The potential as antioxidants is associated with the ability to free radicals scavenging, donates hydrogen atoms or electrons and the metal chelating so that have an impact on the decrease the risk of degenerative disease such as cancer and diabetes mellitus (Wang et al., 2018; Arif et al., 2018).

The effort to obtain a natural antioxidant from plants, fruits and vegetables by several methods of solvent extraction, maceration, supercritical fluid extraction and so on. However, the number of bioactive compounds and antioxidant activity is not only depending on how the extraction but more influenced by the type of solvent used. Extraction process aims to get certain parts of ingredients that contain bioactive compounds (Azmir et al., 2013; Resende et al., 2017). The extraction method used by many is distillation and use solvent extraction. Use solvent extraction can be done with the two ways are an aqueous phase and organic phase. Extraction of the aqueous phase is done using the solvent water, while the organic phase uses solvent organic (Bodoira et al., 2017; Chen et al., 2017).

Based on the polarity, the type of solvent used to extract and how to extract may affect their ability to prevent oxidation. The solvent is polar, able to extract the alkaloid compounds, total phenolic, flavonoids, carotenoids, tannin, sugar, amino acids, and glycosides content. The purpose of this research is to know the
phytochemical compounds and antioxidant activity of *Coleus tuberosus* flesh and peel on different solvent.

2. **Materials and methods**

2.1. **Chemicals and reagents**

The chemical materials are methanol, ethyl acetate, and chloroform, distilled water, Reagen Follin-Ciocalteu, NaCO3, and the Gallic acid, quercetin as standard, NaNO2, AlCl3.6H2O, NaOH, BHT, 11-diphenyl-2-picrylhydrazyl (DPPH) (Sigma Aldrich) linoleic acid, chloroform (HPLC grade), quercetin (Sigma Aldrich) standard.

2.2. **Sample preparation**

*Coleus tuberosus* peel separated from the flesh using a peeler. *Coleus tuberosus* flesh sliced thin with a thickness of 1-1.5 mm. The flesh and peel of *Coleus tuberosus* then dried with cabinet drier at a temperature of 40°C during 24 hours. The next step was milled and sifted with Tyler sieve 80 mesh. The peel and flesh flour of the *Coleus tuberosus* obtained then stored in a freezer (-20°C) to be used for further analysis.

2.3. **Extraction process**

The peel and flesh of the *Coleus tuberosus* flour extracted by maceration method using solvents methanol, ethyl acetate, and chloroform. The ratio of the peel or flesh flour and solvent is 1:5 (w/v). The process of maceration is carried out for 7 days. After 7 days, then the solution is filtered using a Whatman No. 1. The solvent that still exists in the extract was evaporated. So the dry extract is obtained from the different solvent, methanol, ethyl acetate and chloroform. The Extracts were stored in the freezer temperature -22°C.
2.4. **Determination of total phenolic content**

The different solvent i.e. methanol, ethyl acetate and chloroform extract of *Coleus tuberous* were determined using spectrophotometric method (Singleton *et al.*, 1999). As much as 0.2 mL different extract with a concentration of 100 mg/L, 2.5 mL of Folin-Ciocalteu reagent 10%, and 2 mL 7.5% Na$_2$CO$_3$ are mixed and incubated for 15 minutes at a temperature of 45°C. The absorbance of the solution is measured using the spectrophotometer at a wavelength of 765 nm. The content of total phenolic expressed as milligrams (mg) of gallic acid equivalent per gram of the dried extract (mg of GAE/g extract). Each sample was analyzed in triplicate and then obtain the mean value.

2.5. **Determination of total flavonoids content**

Analysis of the levels of flavonoids is done with spectrophotometric method (Quettier-Deleu *et al.*, 2000). Determination of flavonoids content is carried out by spectrophotometry using reagent aluminium chloride. As many as 1 mL aqueous solution extracts with a concentration of 1000 mg/L, at add with 1 mL 2% AlCl dissolved with ethanol 50% homogenized, and then use the vortex during the 20-minute incubation, mix the solution for 24 hours. The absorbance was measured at 415 nm. The calculation was done intriplicate measurements and the content of flavonoids was expressed in terms of quercetin equivalents (mg of quercetin/g of extract).

2.6. **Evaluation of antioxidant activity by the method of DPPH**

Evaluation of antioxidant activity is performed with the DPPH method (Singh *et al.*, 2009). As much as 2 mL of DPPH (0.1 mM in methanol solution), added 40 µg/ml extracting the peel and flesh of *Coleus tuberous* using methanol, ethyl acetate,
and chloroform as the solvent. All solution homogenized with vortex, which is then allowed for 30 minutes at room temperature protected from light. The absorbance of the solution is measured at a wavelength of 517 nm. Concentration BHT 40 μg/ml used as comparative compound. pembanding. Radical scavenging activity calculated:

\[
\frac{A_0 - A_1}{A_0} \times 100\%
\]

A₀ is the absorbance of the control (without the extract) and A₁ is absorbance BHT or peel/flesh extracts of Coleus tuberosus with different solvents

2.7. Antioxidant activity evaluation with peroxide value

Evaluation of antioxidant activity with peroxide value used Ferric thiocyanate (FTC) method (Zahin et al., 2009). The methanol, ethyl acetate and chloroform extract of Coleus tuberosus flesh and peel (40 μg/ml) and BHT (40 μg/ml) in absolute ethanol, 4.1 ml of 2.5% linoleic acid in absolute ethanol, 8.0 ml of 0.05 M phosphate buffer (pH 7.0) and 3.9 ml of water was placed in a vial with a screw cap and then placed in an oven at 40°C in the dark. To 0.1 ml of this solution was added 9.7 ml of 75% ethanol and 0.1 ml of 30% ammonium thiocyanate. Precisely 3 minutes after addition of 0.1 ml of 0.02 M ferrous chloride in 3.5% HCl to the reaction mixture, the absorbance of red colour was measured at 500 nm each 24 hours until 5 days. All measurements were carried out in triplicate. The value of numbers revealed by peroxide milliequivalent per 1000 g of sample.

2.8. Antioxidant activity evaluation with thiobarbituric acid (TBA)

Evaluation of thiobarbituric acid (TBA) referred to Zahin et al. (2009). Two ml of 0.67% 2-thiobarbituric acid and 2 ml of 20% trichloroacetic acid was added to 1 ml
of the sample solution, as prepared in the FTC method. The mixture was placed in a
boiling water bath. After cooling, was centrifuged at 3000 rpm for 20 min. The
absorbance of the supernatant was measured at 552 nm. Antioxidant activity was
based on the absorbance on the final day of the FTC method. Malonaldehyde
concentration calculated with standard 1,1,3,3-tetraethoxypropane (TEP). The
standard curve used malonaldehyde 1,1,3,3-tetraethoxypropane solution (TEP).
Numbers TBA stated as mg MDA/1000 gr of the sample.

2.9. The statistical analysis

The Correlation between the treatment (relationship between total phenolics
content components with the level of total and total antioxidant activity and phenolic
content relationship with antioxidant activity) tested with Pearson correlation bivariat.
The computer program used is the Statistical Product and Service Solution (SPSS)
12.0 for windows.

3. Results and discussion

3.1. Levels of phytochemicals

Polarity differences can give different results in the extract of phytochemical
compounds in vegetables and fruits. So the necessary efforts to the selection of the
type of solvent compound to obtain optimum results on the type of different bio-
active compounds. Extraction process of total flavonoids and phenolic content are
done using three solvent namely methanol, ethyl acetate and chloroform. The use of
different solvent is performed to find out the type of solvent that can extract the
optimum of total phenols and flavonoids level. The extraction was done by the
maceration method for 7 days.

The levels of total phenolic and flavonoids in extracts of Coleus tuberosus
peel and flesh with different solvent showed in Table 1. The peel extract contains
total phenolic and flavonoids were greater than the flesh extract of *Coleus tuberous*. This results in accordance with the research (Ahmadi-Alfazi *et al.*, 2015; Saidani *et al.*, 2017) which shows that the peel extract has total phenolic and flavonoid content is higher than that of the flesh extract. Total phenolics compounds acres fills up in higher amounts extracted in more polar solvent. Based on this results shows that the number of total phenolic and flavonoids use methanol as a greater than solvent extraction using ethyl acetate and chloroform. This shows that the total phenolic content and flavonoids have a polar non polar than tendency. Many research also shows that the extraction of total phenolic and flavonoids use polar solvent can provide greater results than using a non polar solvent (Do *et al.*, 2014; Pintac *et al.*, 2018).

3.2. *Antioxidant activity DPPH method*

DPPH method is used to evaluate the activity of antioxidant a substance. It was evaluated by measuring scavenging free radicals using synthetic radical is 1, 1, 2, 2- diphenyl picky hydrazil (DPPH). The DPPH changes detected by looking at the decline of the DPPH absorbance of the solution when added with antioxidant compounds. The greater decrease in absorbance, it indicates the greater antioxidant activity that belongs to the test solution. Figure 1 showed that bioactive compounds extracted using methanol have the highest antioxidant activity than ethyl acetate and chloroform extracts.

The Figure 1 also showed that the tendency of peel have a higher antioxidant activity than the flesh of *Coleus tuberous*. This relates to the difference between the content of total phenolics and flavonoids on the flesh and peel (Table 1). The methanol extract which contains total phenolic and flavonoids extract greater than
that of ethyl acetate and chloroform extract, demonstrated greater antioxidant activity
when compared to the antioxidant activity of the extract of ethyl acetate and
chloroform (Figure 1). Antioxidant activity differences on the flesh and peel related
with differences in the bioactive compounds (Wang et al., 2012; Raudone et al.,
2017). Research Medini et al. (2014) stated that total phenolics and flavonoids have
a good free radical scavenging ability and can be used as a radical scavenger,
acting possibly as a primary antioxidant.

This Research proves that the percentage of radical scavenging activity on
the peel of *Coleus tuberous* is greater than the flesh. The peel that contains more
bioactive compounds has greater ability to transfer hydrogen atoms to DPPH free
radicals, so that the formation of a compound difenil picrilhidrazin stable is greater
than the flesh. The higher difenil picrilhidrazin that formed shows higher antioxidant
capability, especially on the scavenging of free radicals. Antioxidant activity
differences were allegedly caused by bioactive compounds that are in the peel and
flesh of *Coleus tuberous*, suppose maslinic acid and phytosterol (stigmasterol, beta-
sitosterol, campesterol) (Fu et al., 2014; Prasad et al., 2016).

3.3. **Antioxidant analysis with peroxide value method**

Antioxidant activity with peroxide value method is used to find out the
capabilities of the peel and flesh extract of *Coleus tuberosus* in different solvents in
inhibiting the lipids peroxidation. Peroxide that formed as a result of the process of
oxidation that occurs in the oil during the incubation period (Halvorsen et al., 2011).
Table 2 shows that the bioactive compounds found in extract peel and flesh of
methanol, ethyl acetate and chloroform can reduce the radical hydroxyl, radical
peroxide, and super peroxide on the system of an emulsion, so that may inhibit the
oxidation. Antioxidants neutralize free radicals play a role in by giving one of its electrons to the free radicals so that it becomes non-radical forms. The rate of increase in the number of peroxides can be inhibited by the addition of antioxidants. Peroxide value in the linoleic system increased with increasing the time of incubation with the peel or flesh of methanol, ethyl acetate, chloroform extract of *Coleus tuberosus*, and BHT. Peroxide number in the system that given methanol, ethyl acetate, chloroform extract of *Coleus tuberosus* peel or flesh and BHT were lower than controls. This research proved that the extract of methanol, ethyl acetate, chloroform of *Coleus tuberosus* extract and BHT can suppress the formation on linoleic acid hydroperoxide.

The methanol extract of *Coleus tuberosus* flesh or peel can suppress numbers peroxide higher than chloroform and ethyl acetate extract. This is shown by the lowest of number of meq peroxide on 5th days with methanol extracts compared to ethyl acetate and chloroform extracts. The methanol, ethyl acetate and chloroform extract of *Coleus tuberosus* peel may inhibit lipids peroxidation greater than the methanol, ethyl acetate and chloroform extract from *Coleus tuberosus* flesh. Based on Table 2, peel or flesh extracts of *Coleus tuberosus* in different solvent can inhibit lipids peroxidation compared with the control.

Methanol extract, ethyl acetate extract and chloroform extract of flesh and peel of *Coleus tuberosus*, and BHT added to the system are able to inhibit lipids peroxidation, so ammonium thiocyanate Fe[Fe(SCN)6] formed less. Free radicals can be formed from the oxidation of linoleic acid as a result of the process of incubation at a temperature of 40°C. This makes the fatty acid will be changed to lipid peroxide oxidizes Fe2+ to Fe3+. Iron cations that increase the number of oxidation will react specifically with ammonium tiosianat Fe[Fe(SCN)6] forming the
The ability of antioxidant inhibits oxidation is shown with at least Fe$^{2+}$ which are oxidized by peroxide linoleic acid to Fe$^{3+}$, which is indicated by the decrease in the formation of the color red. Lipid autooxidation which is a chain reaction of free radicals blocked by methanol, ethyl acetate and chloroform extract of flesh and peel of *Coleus tuberosus* by stopping the reaction on the termination stage. Methanol, ethyl acetate, and chloroform extract of *Coleus tuberosus* peel were capable of inhibiting the lipids peroxidation greater than the methanol, ethyl acetate and chloroform extract of *Coleus tuberosus* flesh. This is related to the content of the total phenolic content and total flavonoid on the peel were greater than the flesh one (see Table 1). Differences in the ability of antioxidant activity relates to the difference content of total phenol and flavonoids in the flesh and peel (Aalolam *et al.*, 2016). Many research shows that phenol shows antioxidant activity based on FTC method (Gharibi *et al.*, 2013; Yu *et al.*, 2013).

### 3.4. Antioxidant activity evaluation with TBA

Antioxidant activity of methanol extract, ethyl acetate extract and chloroform extract from the flesh and peel of *Coleus tuberosus* and BHT were evaluated using TBA method. The malondialdehyde of linoleic acid that incubated with methanol extract, ethyl acetate extract and chloroform extract from the flesh and the peel, BHT, showed increasing for 5 days of observation. Table 3 shows that the bioactive compounds extract from methanol solvent both on the peel and flesh have higher antioxidative capabilities compared with the type of solvent that others.

This research suggests that the antioxidant activity of methanol extract of *Coleus tuberosus* flesh or peel have the highest antioxidant activity compared ethyl acetate and chloroform extract. On 5th day, methanol extract of *Coleus tuberosus*
peel and flesh has the lowest mg MDA compared to ethyl acetate and chloroform extract of *Coleus tuberosus* peel and flesh. The sequence of the inhibitory ability of MDA-TBA is to methanol extract > ethyl acetate extract > chloroform extract, respectively. The ability to inhibit the formation of the complex MDA-TBA on methanolic extract, ethyl acetate extract and chloroform extract of *Coleus tuberosus* related with total phenolic and flavonoid content (Table 1). These results are consistent with research that indicates that the content of phenols and flavonoids in the sample had the ability to suppress the MDA on the evaluation of antioxidants with TBA (Adebiyiab et al., 2017).

Some research has shown that the extract of *Coleus tuberosus* also contains bioactive compounds such as ursolic acid oleanolic acid (Nugraheni et al., 2011), maslinic acid, and phytosterol compounds may inhibit peroxidation lipids by pressing the formation of MDA so that the condensation reaction between the MDA and TBA that form the complex of the MDA-TBA can be hindered (Khennouf et al., 2010). Antioxidant activity difference is related to the difference in the content of bioactive compounds that are located on the peel or the flesh, so that influence on the ability of the formation of the complex MDA-TBA (Jung et al., 2011).

3.5. A correlation between phytochemical compounds with antioxidant activity three methods (DPPH antioxidant, FTC and TBA)

There is a correlation between the number of total phenolic and flavonoids on extract of *Coleus tuberosus* peel and flesh with antioxidant activity. Table 4 shows that the total phenolic and flavonoids have a positive and significant correlation with the DPPH method. This shows the high content of total phenols and flavonoids can increase antioxidant activity with the DPPH method.
The Total phenolic content and total flavonoid with TBA and Peroxide value showed a negative and significant correlation. It means that the higher levels of total phenolic and flavonoids have an impact on the low level of peroxide and TBA value. Low level of peroxide and the TBA value shows that the extract has higher antioxidant activity. Total phenolic content compounds have the ability to scavenging of free radicals, it is proved by the existence of the existence of a strong correlation between the total phenolic content compounds and RSA (Pandey et al., 2017; Shao et al., 2018).

A correlation between the method of determination of antioxidant activity shows that the DPPH have a negative correlation with TBA and peroxide value. This indicates, the evaluation of antioxidant activity with the DPPH method is inversely proportional to the number and peroxide TBA. A high percentage of DPPH method showed a high antioxidant activity. While low peroxide value and TBA value low indicates a high antioxidant activity, related to its ability to inhibit the lipids peroxidation.

4. Conclusion

Solvent namely methanol can extract the greater content of total phenolic content, and flavonoid. The methanolic extract has antioxidant activity greater than ethyl acetate extract and chloroform extract on the antioxidant analysis with DPPH method, peroxide value and TBA value. The peel of Coleus tuberosus that extracted with methanol, ethyl acetate and chloroform have total phenolic content, and flavonoid is greater than the flesh of Coleus tuberosus. Methanol extract, ethyl acetate extract, and chloroform extract of Coleus tuberosus peel have a higher antioxidant activity than the methanol extract, ethyl acetate extract, and chloroform extract of Coleus tuberosus flesh based on DPPH, Peroxide value and TBA value.
Conflict of interest

The authors declare no conflict of interest

Acknowledgements

Authors would like to thank The Directorate General of Higher Education, Ministry of National Education in accordance with the Agreement of the implementation of the National Competitive Research Grants number: 180/SP2H/DP2M/III/2010.

References


Halvorsen, B.L. and Blomhoff R. (2011). Determination of lipid oxidation products in vegetable oils and marine omega-3 supplements. *Citation: Food and Nutrition Research*, 55, 5792. doi: 10.3402/fnr.v55i0.5792


https://doi.org/10.1016/j.scienta.2017.01.005


Table 1. The levels of total phenols and total flavonoids on *C. tuberosus* flesh and peel in different solvent.

<table>
<thead>
<tr>
<th>Kind of extract</th>
<th>TPC (mg GAE/g)</th>
<th>TFC (mgQCE/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol extract</td>
<td>7.73±0.08&lt;sup&gt;IC&lt;/sup&gt;</td>
<td>8.55±0.07&lt;sup&gt;IC&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate extract</td>
<td>6.20±0.11&lt;sup&gt;CB&lt;/sup&gt;</td>
<td>5.52±0.19&lt;sup&gt;EB&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform extract</td>
<td>1.78±0.03&lt;sup&gt;IA&lt;/sup&gt;</td>
<td>1.61±0.09&lt;sup&gt;CA&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol extract</td>
<td>7.24±0.10&lt;sup&gt;IB&lt;/sup&gt;</td>
<td>2.31±0.13&lt;sup&gt;IC&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate extract</td>
<td>7.14±0.12&lt;sup&gt;DB&lt;/sup&gt;</td>
<td>1.45±0.17&lt;sup&gt;IB&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform extract</td>
<td>1.84±0.08&lt;sup&gt;IA&lt;/sup&gt;</td>
<td>0.27±0.03&lt;sup&gt;CA&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences in flesh and peel of *C. tuberosus* on different solvent at P < 0.05.

Different capital letters (A-C) within the column in *C. tuberosus* flesh or peel indicate significant differences in different solvent at P < 0.05.
Table 2. The peroxide value on different solvent of the flesh and peel of *Coleus tuberosus*, BHT and control; incubation on 40°C, for 5 days (meq peroxide/1000g of sample)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Peel</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero time</td>
<td>1 days</td>
<td>2 days</td>
<td>3 days</td>
<td>4 days</td>
<td>5 days</td>
</tr>
<tr>
<td>Methanol</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.09±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.42±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.52±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.62±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.56±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.73±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.83±0.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.13±0.08&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.78±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.32±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.52±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.51±0.07&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.26±0.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.73±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Flesh</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.15±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.91±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.79±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.69±0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.41±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.77±0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.25±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.87±0.10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.79±0.08&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.08±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.18±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.62±0.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.52±0.04&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.87±0.08&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>BHT</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.33±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.48±0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.58±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.64±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.72±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kontrol</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.08±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.15±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.54±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.89±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.50±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences at P < 0.05.
Table 3. TBA value on different solvent of the peel and flesh of *Coleus tuberosus*, BHT and control (as mg MDA/1000 g of sample)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Zero time</th>
<th>1 days</th>
<th>2 days</th>
<th>3 days</th>
<th>4 days</th>
<th>5 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>1.39±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.37±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.94±0.06&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.31±0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.89±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.08±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>1.32±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.65±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.45±0.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.38±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.24±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.47±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>1.30±0.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.55±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.96±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.39±0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.20±0.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.39±0.34&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>1.36±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.41±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.11±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.14±0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.13±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.92±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>1.35±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.69±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.24±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.41±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.23±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.08±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>1.36±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.35±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.33±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.83±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.78±0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.52±0.12&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BHT</td>
<td>1.30±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.72±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.80±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.08±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.21±0.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.84±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kontrol</td>
<td>1.32±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.96±0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.56±0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.05±0.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.87±0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.47±0.13&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences at P < 0.05.
Table 4. Correlation of bioactive compounds with antioxidant activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DPPH</th>
<th>TBA value</th>
<th>Peroxide value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total phenolic</td>
<td>0.639*</td>
<td>-0.990*</td>
<td>-0.706*</td>
</tr>
<tr>
<td>Total Flavonoids</td>
<td>0.983*</td>
<td>-0.604*</td>
<td>-0.785*</td>
</tr>
<tr>
<td>DPPH</td>
<td>1</td>
<td>-0.829*</td>
<td>-0.634*</td>
</tr>
<tr>
<td>Peroxide value</td>
<td>-0.634*</td>
<td>0.692*</td>
<td>1</td>
</tr>
<tr>
<td>TBA value</td>
<td>-0.829*</td>
<td>1</td>
<td>0.692*</td>
</tr>
</tbody>
</table>

** Significant correlation at 0.05 level
Figure 1. Antioxidant activity of Coleus tuberosus peel and flesh with different solvents based on DPPH method.

- Methanol extract of C. tuberosus peel
- Ethyl acetate extract of C. tuberosus peel
- Chloroform extract of C. tuberosus peel
- Methanol extract of C. tuberosus flesh
- Ethyl acetate of C. tuberosus flesh
- Chloroform extract of C. tuberosus flesh
- BHT

Radical scavenging activity (%)
Phytochemical compounds and antioxidant activity of Coleus tuberosus flesh and peel on different solvent

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Article history:
Received: 25 May 2018
Received in revised form: 15 July 2018
Accepted: 24 July 2018
Available Online: XX August 2018

Abstract

Three different solvents were used to extract the phytochemical compounds in the peel and flesh of Coleus tuberosus. The results of extraction with different solvents were compared based on the levels of phytochemicals compounds and its antioxidant activity. Extraction of bioactive compounds was done by the maceration method using methanol, ethyl acetate, and chloroform for seven days at a ratio of 1:5 (w/v). Determination of total phenolic contents and flavonoids was conducted via spectrophotometric method. Antioxidant activity was evaluated based on DPPH, peroxide value and TBA value. The results showed that the methanol solvent extracted higher total phenolic and flavonoids compounds than the ethyl acetate and chloroform. The antioxidant activity of methanol extracts was higher compared to ethyl acetate and chloroform extracts for both flesh and peel of C. tuberosus. The extract of the peel of C. tuberosus had antioxidant activity higher compared to the flesh extract with the use of methanol, ethyl acetate or chloroform as solvent. There was a positive and significant correlation between total phenolic and flavonoids content against DPPH and a negative and significant correlation with peroxide and TBA value.

1. Introduction

Coleus tuberosus include local tubers that belong to Lamiaceae family, sub nepetoideae family, tribe Ocimeae and has an essential role in food security that contains some types of bioactive compounds known to function as antioxidants and anti-cancer. The bioactive compounds identified from C. tuberosus were triterpenic acid including ursolic acid and oleanolic acid, total phenol and flavonoid (Mathe et al., 2007; Nugraheni et al., 2011). Some research showed that bioactive compounds in fruits and vegetables namely total phenolic content, flavonoid, and triterpenic acid have the ability as an antioxidant (Fu et al., 2017; Shiraishi et al., 2018). The potential of an antioxidant is associated with the ability to free scavenging radicals, donates hydrogen atoms or electrons and chelates metal to decrease the risk of degenerative disease such as cancer and diabetes mellitus (Wang et al., 2018; Arif et al., 2018).

The effort to obtain natural antioxidants from plants, fruits and vegetables can be performed by several methods of solvent extraction, maceration, supercritical fluid extraction and so on. However, the number of bioactive compounds and antioxidant activity does not only depend on the extraction process but, it is also influenced by the type of solvent used. The extraction process aims to get certain parts of ingredients that contain bioactive compounds (Azmit et al., 2013; Resende et al., 2017). The extraction method used by many is distillation and solvent extraction. Solvent extraction can be done in the two ways: aqueous phase and organic phase. Extraction of the aqueous phase is done using water as solvent, while the organic phase uses organic solvent (Bodoira et al., 2017; Chen et al., 2017).

Based on the polarity, the type of solvent and the method may affect their ability to prevent oxidation. If the solvent is polar, it is able to extract the alkaloid compounds, total phenolic, flavonoids, carotenoids, tannin, sugar, amino acids, and glycosides content. The objectives of this research were to identify the phytochemical compounds and to evaluate the antioxidant activity of C. tuberosus flesh and peel using different solvents.
2. Materials and methods

2.1. Chemicals and reagents

The chemical materials used were methanol, ethyl acetate, distilled water, Folin-Ciocalteu reagent, NaCO₃, and gallic acid, NaN₂O₃, AlCl₃,6H₂O, NaOH, BHT, 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Sigma Aldrich) linoleic acid, chloroform (HPLC grade), quercetin (Sigma Aldrich) as standard.

2.2. Sample preparation

C. tuberosus peel was separated from the flesh using a peeler. The flesh was then thinly sliced with a thickness of 1-1.5 mm. The flesh and peel were examined as a subject separately. The flesh and peel of C. tuberosus were dried with a cabinet drier at a temperature of 40°C for 24 hrs. After drying, the dried peel and flesh was milled into flour and sifted using a Tyler sieve 80 mesh before storing at -20°C for further analysis.

2.3. Extraction process

The peel and flesh flour were subjected to extraction by maceration method using solvents methanol, ethyl acetate, and chloroform. The ratio of flour to solvent was 1:5 (w/v). The process of maceration was carried out for seven days. After seven days, the solution was filtered with Whatman No. 1 filter paper and evaporated using a rotavapor to remove the solvent. The extracts were then stored at -22°C.

2.4. Determination of total phenolic content

The total phenolic content of the different solvents, i.e., methanol, ethyl acetate and chloroform, extract of C. tuberosus flour were determined using spectrophotometric method (Singleton et al., 1999). At a concentration of 100 mg/L, 0.2 mL of the extract were added to 2.5 mL of 10% Folin-Ciocalteu reagent and 2 mL of 7.5% Na₂CO₃. The mixture was incubated for 15 mins at 45°C. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 765 nm. The content of total phenolic was expressed as milligrams (mg) of gallic acid equivalent per gram of the dried extract (mg of GAE/g extract). Each sample was analyzed in triplicate to obtain an average value.

2.5. Determination of total flavonoid content

The analysis of the levels of flavonoids was done with spectrophotometric method (Quettier-Deleu et al., 2000). At a concentration of 1000 mg/L, 1 mL of the aqueous solution extract was added to 1 mL 2% AlCl₃ dissolved with ethanol 50%. At the twentieth minute of incubation, the mixture was homogenized using the vortex and the absorbance was measured at 415 nm. The analysis was done in triplicate measurements, and the content of flavonoids was expressed as quercetin equivalents (mg of quercetin/g of extract).

2.6. Antioxidant activity evaluation: DPPH method

Evaluation of antioxidant activity was performed with the DPPH method (Singh et al., 2009). The extracts were aliquoted (40 µg/mL) and mixed with 2 mL of DPPH (0.1 mM in methanol solution). The solution was homogenized with vortex, which was stand for 30 mins at room temperature, protected from light. The absorbance of the solution was measured at a wavelength of 517 nm. The butylated hydroxytoluene (BHT) concentration at 40 µg/ml was used as the comparative compound. The radical scavenging activity was calculated using the formula:

\[
\frac{A_0 - A_1}{A_0} \times 100\%
\]

Where A₀ is the absorbance of the control (without the extract), and A₁ is the absorbance of BHT or the extract.

2.7. Antioxidant activity evaluation: peroxide value

The peroxide value was determined using the ferric thiocyanate (FTC) method (Zahin et al., 2009) for antioxidant activity. The extracts (40 µg/mL) were mixed with BHT (40 µg/mL) in absolute ethanol, 4.1 mL of 2.5% linoleic acid in absolute ethanol, 8.0 mL of 0.05 M phosphate buffer (pH 7.0) and 3.9 mL of water was placed in a screw cap vial and incubated at 40°C in dark. To 0.1 mL of this solution was added 9.7 mL of 75% ethanol and 0.1 mL of 30% ammonium thiocyanate. Precisely after 3 mins, 0.1 mL of 0.02 M ferrous chloride in 3.5% HCl was added to the reaction mixture and the absorbance of was measured at 500 nm at 24 hrs interval until five days. All measurements were carried out in triplicate. The peroxide value was expressed as milliequivalent per 1000 g of sample.

2.8. Antioxidant activity evaluation: thiobarbituric acid (TBA)

The antioxidant activity evaluation with thiobarbituric acid (TBA) was referred to Zahin et al. (2009). The sample solution (1 mL) was added with 2 mL of 0.67% 2-thiobarbituric acid and 2 mL of 20% trichloroacetic acid, as prepared in the FTC method. The mixture was placed in a boiling water bath. After cooling, was centrifuged at 3000 rpm for 20 mins. The absorbance of the supernatant was measured at 552 nm. The antioxidant activity was based on the absorbance on the final day of the FTC method. Malonaldehyde concentration calculated with standard 1,1,3,3-tetraethoxypropane (TEP). The standard curve used malonaldehyde 1,1,3,3-tetraethoxypropane solution...
The results were in agreement with the research conducted by Ahmad-Alfazi et al. (2015) and Saidani et al. (2017). Total phenolics compounds across fills up in higher amounts extracted with a more polar solvent. Based on this result, it was shown that the number of total phenolic and flavonoids extracted using methanol was higher than the extraction using ethyl acetate and chloroform. The higher number of total phenolic and flavonoids extracted using methanol indicates that the total phenolic content and flavonoids have polar-non-polar bonds than a tendency. Many research also showed that the extraction of total phenolic and flavonoids using polar solvents can provide significant results than using a non-polar solvent (Do et al., 2014; Pintac et al., 2018).

3. Results and discussion

3.1. Levels of phytochemicals

Polarity differences can give different results in the extract of phytochemical compounds in vegetables and fruits. The necessary efforts to the selection of the type of solvent compound to obtain optimum results on the type of different bioactive compounds are required. The extraction process of total flavonoids and phenolic content were done using three solvents namely methanol, ethyl acetate, and chloroform. The use of different solvents was to find out the type of solvent that can extract the optimum of total phenols and flavonoids level. The extraction was done by the maceration method for seven days.

Table 1. The levels of total phenols and total flavonoids on C. tuberosus flesh and peel in different solvent

<table>
<thead>
<tr>
<th>Solvent</th>
<th>TPC (mg GAE/g)</th>
<th>TFC (mgQCE/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peel</td>
<td>Flesh</td>
</tr>
<tr>
<td>Methanol extract</td>
<td>7.73±0.08fC</td>
<td>7.24±0.10dC</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>6.20±0.11cB</td>
<td>7.14±0.12dB</td>
</tr>
<tr>
<td>Chloroform extract</td>
<td>1.78±0.03aA</td>
<td>1.84±0.08bA</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences in flesh and peel of C. tuberosus on different solvent at P < 0.05.
Different capital letters (A-C) within the column in C. tuberosus flesh or peel indicate significant differences in different solvents at P < 0.05.

The levels of total phenolic and flavonoids of the extracts of C. tuberosus peel and flesh with different solvents are shown in Table 1. The peel extract contents of total phenolic and flavonoids were higher than the flesh extract of C. tuberosus. The results were in agreement with the research conducted by Ahmad-Alfazi et al. (2015) and Saidani et al. (2017). Total phenolics compounds across fills up in higher amounts extracted with a more polar solvent. Based on this result, it was shown that the number of total phenolic and flavonoids extracted using methanol was higher than the.

Figure 1. Antioxidant activity of C. tuberosus peel and flesh with different solvent based on DPPH method

DPPH method is used to evaluate the activity of antioxidant a substance. It was evaluated by measuring scavenging free radicals using a synthetic radical which is 1, 1, 2, 2- diphenyl picrylhydrazin (DPPH). The DPPH changes are detected by the decrease of the DPPH absorbance in the solution when added with antioxidant compounds. Figure 1 shows the antioxidant activity value measured using the DPPH method. The significant decrease in absorbance indicates a higher antioxidant activity of the solution. The methanol extract which contains higher total phenol and flavonoids extract than that of ethyl acetate and chloroform extract demonstrated greater antioxidant activity when compared to the antioxidant activity of the extract of ethyl acetate and chloroform (Figure 1).

Figure 1 also shows the tendency of peel had a higher antioxidant activity than the flesh of C. tuberosus. The different antioxidant activity relates to the difference between the content of total phenolics and flavonoids in the flesh and peel (Table 1). Antioxidant activity differences on the flesh and peel can be related to the differences in the bioactive compounds (Wang et al., 2012; Raudone et al., 2017). Medini et al. (2014) stated that total phenolics and flavonoids have an excellent free radical scavenging ability and can be used as a radical scavenger, acting possibly as a primary antioxidant.

This research proves that the percentage of radical scavenging activity on the peel of C. tuberosus is higher than the flesh. The peel contained more bioactive compounds which have the greater ability to transfer...
hydrogen atoms to DPPH free radicals to form a stable compound diphenyl picrylhydrazyl stable. The higher diphenyl picrylhydrazyl that formed shows higher antioxidant capability, especially on the scavenging of free radicals. Antioxidant activity differences were allegedly caused by bioactive compounds that are in the peel and flesh of C. tuberosus, suppose maslinic acid and phytosterol (stigmasterol, beta-sitosterol, campesterol) (Fu et al., 2014; Prasad et al., 2016).

3.3. Antioxidant analysis with peroxide value method

Antioxidant activity with peroxide value method was used to find out the capabilities of the peel and flesh extract of C. tuberosus in different solvents in inhibiting the lipids peroxidation. Peroxide is formed as a result of the process of oxidation that occurs in the oil during the incubation period (Halvorsen et al., 2011). Table 2 shows that the bioactive compounds found in extract peel and flesh of methanol, ethyl acetate, and chloroform can reduce the radical hydroxyl, radical peroxide, and super peroxide on the system of an emulsion to inhibit oxidation. Antioxidants neutralize free radicals by giving one of its electrons to the free radicals and transforms into non-radical forms. The addition of antioxidants can inhibit the rate of increase in the number of peroxides.

Peroxide value in the linoleic system increased with increasing incubation time of the peel or flesh of methanol, ethyl acetate, and chloroform extract of C. tuberosus peel or flesh and BHT were lower than controls. This research proved that the extract of methanol, ethyl acetate, chloroform of C. tuberosus peel and flesh extract and BHT could suppress the formation of linoleic acid hydroperoxide.

The methanol extract of C. tuberosus flesh or peel can suppress peroxide value higher than chloroform and ethyl acetate extract. The ability to suppress peroxide value was shown by the lowest of a number of meq peroxide on the fifth day with methanol extracts compared to ethyl acetate and chloroform extracts. The methanol, ethyl acetate and chloroform extract of C. tuberosus peel inhibit lipid peroxidation greater than the methanol, ethyl acetate and chloroform extract from C. tuberosus flesh.

Methanol extract, ethyl acetate extract and chloroform extract of flesh and peel of C. tuberosus, and BHT added to the system can inhibit lipid peroxidation, hence ammonium thiocyanate is formed less. The oxidation of linoleic acid can create free radicals as a result of the incubation process at 40°C. Free radicals cause the fatty acid to change to lipid peroxide and oxidizes Fe²⁺ to Fe³⁺ cations that increase the number of oxidation will react specifically with ammonium thiocyanate, forming ammonium hexothiocyanotoferrate (III) (NH₄)₃[Fe(SCN)₆] and the color red. The ability of the antioxidant to inhibit oxidation is shown with the least amount of Fe²⁺ oxidized by peroxide linoleic acid to Fe³⁺, which is indicated by the decrease in redness intensity. Lipid autooxidation is a chain reaction of free radicals that might be blocked by methanol, ethyl acetate and chloroform extract of flesh and peel of C. tuberosus, therefore, stopping the reaction at the termination stage.

Methanol, ethyl acetate, and chloroform extract of C. tuberosus peel can inhibit lipid peroxidation greater than the methanol, ethyl acetate and chloroform extract of C. tuberosus flesh. The higher inhibition of the peel extract can be related to the content of the total phenolic content and total flavonoid that was higher than the flesh extract (see Table 1). The difference in the ability of antioxidant activity can also be related to the different content of total phenol and flavonoids in the flesh and peel (Aalolam et al., 2016). Many research has proven that phenol showed antioxidant activity based on FTC method (Gharibi et al., 2013; Yu et al., 2013).

Table 2. The peroxide value on different solvent of the flesh and peel of C. tuberosus, BHT and control; incubation on 40°C, for 5 days (meq peroxide/1000g of sample)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Zero time</th>
<th>1 days</th>
<th>2 days</th>
<th>3 days</th>
<th>4 days</th>
<th>5 days</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.09±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.42±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.52±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.62±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.56±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51±0.04&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.73±0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.83±0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.13±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.78±0.08&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.32±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.52±0.04&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.51±0.07&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.26±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.73±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Flesh</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.15±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.91±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.79±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.69±0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.41±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.77±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.25±0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.87±0.10&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.79±0.08&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.08±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52±0.02&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.18±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.62±0.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.52±0.04&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.87±0.08&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>BHT</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.33±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.48±0.03&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.58±0.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.64±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.72±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control</td>
<td>0.07±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.08±0.05&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.15±0.08&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.54±0.07&lt;sup&gt;f&lt;/sup&gt;</td>
<td>2.89±0.08&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.50±0.07&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences at P < 0.05.

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Table 3. TBA value on different solvent of the peel and flesh of *C. tuberosus*, BHT and control (as mg MDA/1000 g of sample)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Zero time</th>
<th>1 days</th>
<th>2 days</th>
<th>3 days</th>
<th>4 days</th>
<th>5 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>1.39±0.03a</td>
<td>2.37±0.06b</td>
<td>2.94±0.06b</td>
<td>5.31±0.50c</td>
<td>5.89±0.04a</td>
<td>6.08±0.02a</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>1.32±0.04a</td>
<td>1.65±0.07b</td>
<td>2.45±0.23a</td>
<td>8.38±0.08b</td>
<td>8.24±0.05c</td>
<td>7.47±0.02c</td>
</tr>
<tr>
<td>Chloroform</td>
<td>1.30±0.06b</td>
<td>3.55±0.08c</td>
<td>3.96±0.07b</td>
<td>9.39±0.20c</td>
<td>10.20±0.34a</td>
<td>8.39±0.34c</td>
</tr>
<tr>
<td>Flesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>1.36±0.05a</td>
<td>2.41±0.07c</td>
<td>3.11±0.07b</td>
<td>7.14±0.11b</td>
<td>8.13±0.06b</td>
<td>6.92±0.03b</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>1.35±0.08a</td>
<td>1.69±0.03b</td>
<td>2.24±0.08b</td>
<td>8.41±0.09c</td>
<td>8.23±0.04d</td>
<td>8.08±0.01d</td>
</tr>
<tr>
<td>Chloroform</td>
<td>1.36±0.05a</td>
<td>1.35±0.09c</td>
<td>4.33±0.20d</td>
<td>9.83±0.09f</td>
<td>11.78±0.15d</td>
<td>9.52±0.12f</td>
</tr>
<tr>
<td>BHT</td>
<td>1.30±0.05a</td>
<td>2.72±0.04d</td>
<td>3.80±0.05e</td>
<td>8.08±0.07d</td>
<td>9.71±0.10c</td>
<td>7.84±0.09d</td>
</tr>
<tr>
<td>Control</td>
<td>1.32±0.05a</td>
<td>4.96±0.13f</td>
<td>5.56±0.16e</td>
<td>8.05±0.20g</td>
<td>11.87±0.13f</td>
<td>11.47±0.13g</td>
</tr>
</tbody>
</table>

Different letters (a-f) within the column indicate significant differences at P < 0.05.

3.4. Antioxidant activity evaluation with TBA

Antioxidant activity of methanol extract, ethyl acetate extract and chloroform extract from the flesh and peel of *C. tuberosus* and BHT were evaluated using the TBA method. The malondialdehyde of linoleic acid incubated with methanol extract, ethyl acetate extract and chloroform extract from the flesh and the peel, BHT, increased after five days of observation. Table 3 shows that the bioactive compounds extract from methanol solvent for both peel and flesh extract have higher antioxidative capabilities compared to the other solvents.

This research suggests that the antioxidant activity of methanol extract of *C. tuberosus* flesh or peel have the highest antioxidant activity compared ethyl acetate and chloroform extract. However, on the fifth day, the methanol extract of *C. tuberosus* peel and flesh had the lowest mg MDA compared to ethyl acetate and chloroform extract of *C. tuberosus* peel and flesh. The sequence of the inhibitory ability of MDA-TBA is methanol extract > ethyl acetate extract > chloroform extract. The ability to inhibit the formation of the complex MDA-TBA is related to the total phenolic and flavonoid content (Table 1). These results were consistent with other research that indicated the content of phenols and flavonoids in the sample could suppress the MDA on the evaluation of antioxidants with TBA (Adebiyiab et al., 2017).

Some research showed that the extract of *C. tuberosus* also contains bioactive compounds such as ursolic acid, oleic acid (Nugraheni et al., 2011), maslinic acid, and phytoesterol compounds may inhibit peroxidation lipids by suppressing the formation of MDA so that the condensation reaction between the MDA and TBA that form the complex of the MDA-TBA can be hindered (Khennouf et al., 2010). The antioxidant activity difference is related to the difference in the content of bioactive compounds that are located on the peel or the flesh and thus, influence the ability of the formation of the complex MDA-TBA (Jung et al., 2011).

3.5. A correlation between phytochemical compounds with antioxidant activity three methods (DPPH, antioxidant, FTC, and TBA)

Table 4. Correlation of bioactive compounds with antioxidant activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DPPH</th>
<th>TBA value</th>
<th>Peroxide value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total phenolic</td>
<td>0.639*</td>
<td>-0.990*</td>
<td>-0.706*</td>
</tr>
<tr>
<td>Total Flavonoids</td>
<td>0.983*</td>
<td>-0.604*</td>
<td>-0.785*</td>
</tr>
<tr>
<td>DPPH</td>
<td>1</td>
<td>-0.829*</td>
<td>-0.634*</td>
</tr>
<tr>
<td>Peroxide value</td>
<td>-0.634*</td>
<td>0.692*</td>
<td>1</td>
</tr>
<tr>
<td>TBA value</td>
<td>-0.829*</td>
<td>1</td>
<td>0.692*</td>
</tr>
</tbody>
</table>

* Significant correlation at 0.05 level

There is a correlation between the number of total phenolic and flavonoids on the extracts of *C. tuberosus* peel and flesh with antioxidant activity. Table 4 shows that the total phenolic and flavonoids have a positive and significant correlation with the DPPH method. This shows the high content of total phenols and flavonoids can increase antioxidant activity with the DPPH method.

The total phenolic content and total flavonoid with TBA and Peroxide value showed a negative and significant correlation. It indicates that higher levels of total phenolic and flavonoids have an impact on the low level of peroxide and TBA value. The low level of peroxide and the TBA value shows that the extract has antioxidant activity. Phenolic compounds have the ability to scavenge free radicals; it is proven by the existence of the strong correlation between the total phenolic content compounds and RSA (Pandey et al., 2017; Shao et al., 2018).

A correlation between the method of determination of antioxidant activity shows that the DPPH have a negative correlation with TBA and peroxide value. A negative correlation indicates that the evaluation of antioxidant activity with the DPPH method is inversely
proportional to the number and peroxide TBA. A high percentage of DPPH method showed high antioxidant activity. While low peroxide value and TBA value low indicate a high antioxidant activity, related to its ability to inhibit the lipids peroxidation.

4. Conclusion

Methanol is shown to extract higher content of total phenolic content, and flavonoid. The methanolic extract has greater antioxidant activity than ethyl acetate extract and chloroform extract on the antioxidant analysis with the DPPH method, peroxide value, and TBA value. The peel of C. tuberosus extracted with methanol, ethyl acetate and chloroform have higher total phenolic content, and flavonoid than the flesh of C. tuberosus. The peel extract of C. tuberosus had higher antioxidant activity compared to the flesh extract based on DPPH, peroxide value and TBA value.

Conflict of interest

The authors declare no conflict of interest

Acknowledgements

Authors would like to thank The Directorate General of Higher Education, Ministry of National Education following the Agreement of the implementation of the National Competitive Research Grants number: 180/SP2H/DP2M/III/2010.

References


Bodoira, R., Rossi, Y., Montenegro, M., Maestri, D. and Velez, A. (2017). Extraction of antioxidant polyphenolic compounds from peanut skin using water-ethanol at high pressure and temperature conditions. The Journal of Supercritical Fluids, 128, 57-65. https://doi.org/10.1016/j.supflu.2017.05.011


Halvorsen, B.L. and Blomhoff R. (2011). Determination of lipid oxidation products in vegetable oils and marine omega-3 supplements. Food and Nutrition Research, 55, 5792.doi: 10.3402/fnr.v55i0.5792

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