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DETERMINATION AND IMPLICATIONS OF IODINE VALUE IN CHEMICAL ANALYSIS

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ABSTRACT:
Vegetable oils are triglyceride extracts derived from plant sources, consisting of fatty acid chains that can be saturated or unsaturated hydrocarbons. These oils are classified as simple triglycerides or mixed triglycerides based on their composition. The level of saturation or unsaturation is quantified by the iodine value of the oil sample. This research aimed to compare the iodine values of four different vegetable oils: Mustard oil, Safflower oil, Sunflower oil, and Coconut oil (both marketed and crude samples). The samples were procured from general provision stores and raw material production plants. The vegetable oils were analysed for their iodine values, yielding the following results: Sunflower oil (marketed) = 104.05 and (crude) = 158.62, Coconut oil (marketed) = 209.38 and (crude) = 38.07, Mustard oil (marketed) = 285.52 and (crude) = 171.31, Safflower oil (marketed) = 228.42 and (crude) = 133.24, etc. These values were evaluated and calculated in the institute laboratory.

Introduction:

Vegetable oils are triglycerides extracted from various plant sources such as vegetables, seeds, nuts, fruits, and cereal grains. Examples include almond oil, coconut oil, cocoa butter, olive oil, sunflower oil, safflower oil, soybean oil, walnut oil, and wheat germ oil, among others. These oils have been integral to human culture for millennia, serving purposes ranging from cooking and dietary supplements to fuel sources and cosmetic applications[1].

Composition and Nutrition:

Vegetable oils primarily consist of triglycerides and are typically liquid at room temperature. They exhibit a diverse range of fatty acids compared to animal fats. For instance, olive oil contains oleic acid, a monounsaturated fatty acid known to promote healthy cholesterol levels (HDL) and potentially reduce the risk of heart disease. Polyunsaturated fatty acids like alpha-linolenic acid (omega-3) and linoleic acid (omega-6) are abundant in many vegetable oils

listed. These essential fatty acids play crucial roles in maintaining cell membranes, aiding in cholesterol metabolism, and facilitating the absorption of fat-soluble vitamins A, D, E, and K. Vegetable oils are extracted using various methods such as pressing, extraction with solvents, distillation, and maceration. Essential oils, extracted through distillation, differ in properties and uses from pressed or leached vegetable oils. Linseed oil, for example, is notable for its high content of alpha-linolenic acid among vegetable oils, making it a valuable dietary source of this essential fatty acid. Certain vegetable oils, such as coconut oil, cottonseed oil, palm oil, and palm kernel oil, are notably high in saturated fats. These oils tend to be viscous or even semi-solid at room temperature. For instance, coconut oil contains saturated fatty acids like caprylic acid, capric acid, lauric acid, and myristic acid. Saturated fats are known to elevate levels of low-density lipoprotein (LDL) cholesterol in the bloodstream, which correlates with an increased risk of heart disease [2].

Coconut Oil:

Coconut oil is a refined fixed oil derived from the dried solid part of the endosperm of *Cocos nucifera* L.

Chemical Composition: Coconut oil typically contains:

- Not less than 1.5% w/w of caprylic acid,
- Not less than 5.0% and not more than 4.0% w/w of capric acid,
- Not less than 4.0% and not more than 9.0% w/w of lauric acid,
- Not less than 40.0% and not more than 50.0% w/w of myristic acid,
- Not less than 15.0% and not more than 20.0% w/w of palmitic acid,
- Not less than 7.0% and not more than 12.0% w/w of stearic acid,
- Not less than 4.0% and not more than 10.0% w/w of oleic acid,
- Not less than 1.0% and not more than 3.0% w/w of linoleic acid.

Nutritional Information: Coconut oil is approximately 99% fat, predominantly saturated fats (about 82% of total). In a 100g serving, coconut oil provides 890 calories. It contains approximately 3mg of vitamin E, 0.6 µg of vitamin K, and trace amounts of minerals like iron.

Description: Coconut oil appears as a white to light yellow mass or colorless to light yellow clear oil.

Physical Properties:

- Melting Range: 23°C to 26°C
- Refractive Index: Approximately 1.449 at 40°C
- Peroxide Value: Not more than 5.0
- Unsaponifiable Matter: Not more than 1.0%, determined on 5.0g
- Iodine Value: 82 to 90 [3]*

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Mustard Oil:

Mustard oil can refer to either the pressed oil used for cooking or a pungent essential oil known as volatile oil of mustard. The essential oil is obtained by grinding mustard seed, mixing the grounds with water, and isolating the resulting volatile oil through distillation. Pressed mustard oil serves as cooking oil in certain cultures, although its sale is restricted in some countries due to its high erucic acid content. Varieties of mustard seed with lower erucic acid levels also exist.

Chemical Composition: Mustard oil contains approximately:

- 60% monounsaturated fatty acids (42% erucic acid and 12% oleic acid),
- 21% polyunsaturated fats (6% omega-3 alpha-linolenic acid and 15% omega-6 linoleic acid),
- 12% saturated fats.

Nutritional Information: In a 100g serving, mustard oil provides 884 calories, entirely from fat. Its fat composition includes 11% saturated fat, 59% monounsaturated fat, and 21% polyunsaturated fat.

Physical Properties:

- Melting Range: 48°C to 25°C
- Refractive Index: Approximately 1.47
- Iodine Value: 98 to 110
- Peroxide Value: 0.83 meq/kg [4]*

This overview highlights the chemical compositions and nutritional aspects of coconut oil and mustard oil, emphasizing their saturated fat content and unique properties.

Figure 1: Various types of Oils

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Iodine Value:

The iodine value represents the amount of grams of iodine that can be absorbed by the fatty acids present in 100 grams of a given oil or fat sample. It is a measure of the degree of unsaturation in the fatty acids, specifically indicating the presence of double bonds that react with iodine compounds. A higher iodine value indicates a greater number of C=C bonds in the fat[5].

All fats and oils are composed of fatty acid molecules classified into saturated, monounsaturated, and polyunsaturated categories. Natural oils typically contain a mixture of these fatty acids. For example, soybean oil is predominantly polyunsaturated but also contains monounsaturated and saturated fatty acids. Coconut oil, on the other hand, consists mainly of saturated fatty acids with smaller amounts of monounsaturated and polyunsaturated fatty acids[6].

Formula: The formula to calculate the iodine value is: Iodine Value=(b−a)×1.269W\text{Iodine Value} = \frac{(b - a) \times 1.269}{W}Iodine Value=W(b−a)×1.269

Where:

- WWW = Weight in grams of the substance
- bbb = Reading with blank
- aaa = Reading with sample

Methods to Determine Iodine Value:

There are two main methods used to determine iodine value in vegetable oils:

1. **Iodine Monochloride Method (Wijs Method):**
    - Accurately weigh the sample in a dry 500 ml iodine flask.
    - Add 10 ml of carbon tetrachloride and dissolve.
    - Add 20 ml of iodine monochloride solution, stopper the flask, and allow it to stand in the dark at a temperature between 15°C to 25°C for 30 minutes.
    - Add 15 ml of potassium iodide solution to the flask, carefully remove the stopper, dilute with 100 ml of water, shake, and titrate with 0.1 M sodium thiosulphate using starch solution as an indicator. Note the ml required (a).
    - Repeat the procedure without the sample and note the ml required (b).
    - Calculate the iodine value using the formula above.
2. **Iodine Monobromide Method (Hanus Method):**
    - Accurately weigh the sample in a dry 300 ml iodine flask previously rinsed with glacial acetic acid.
    - Add 15 ml of chloroform and dissolve.
    - Slowly add 25.0 ml of iodine monobromide solution from a burette, stopper the flask, and allow it to stand in the dark for 30 minutes (or as specified).
    - Add 10 ml of potassium iodide solution and 100 ml of water to the flask.
    - Titrate with sodium thiosulphate using starch solution as an indicator and note the ml required (a).
    - Repeat the procedure without the sample and note the ml required (b).

- Calculate the iodine value using the formula above.

Aim: The aim of this study is to determine the iodine value of various vegetable oils and compare the values between commercially marketed oils and crude oils.

Requirements:

- **Apparatus:** Burette (50 ml), stand, 100 ml measuring cylinder, 100 ml, 500 ml, and 300 ml beakers, 10 ml measuring cylinder, 100 ml volumetric flask, 250 ml stoppered bottle, analytical balance, tripod stand, wire gauze, funnel, stopper[7].
- **Vegetable Oils:** Safflower oil (marketed and crude), sunflower oil (marketed and crude), coconut oil (marketed and crude), mustard oil (marketed and crude).
- **Chemicals:** Iodine monochloride, carbon tetrachloride, potassium iodide solution, 0.1 M sodium thiosulphate, starch solution.

This methodical approach allows for the accurate determination and comparison of iodine values in different vegetable oils, providing insights into their chemical composition and potential applications[8].

Principle: The iodine value is a measure of the number of grams of iodine that can be absorbed by the fatty acids present in 100 grams of a given oil or fat sample. It quantifies the degree of unsaturation in the fatty acids, specifically indicating the presence of double bonds which react with iodine compounds. A higher iodine value indicates a greater number of C=C bonds in the fat[9].

Formula: Iodine Value=(b−a)×1.269W\text{Iodine Value} = \frac{(b - a) \times 1.269}{W}Iodine Value=W(b−a)×1.269
Where:

- WWW = Weight in grams of substance
- bbb = Reading with blank
- aaa = Reading with sample

Procedure:

Starch Solution:

- Take 1 g of starch and dissolve it in 10 ml of water.
- Boil 90 ml of water separately.
- Add the starch suspension into the boiling water until it becomes gelatinized.

0.1M Sodium Thiosulphate:

- Dissolve 25 gm of sodium thiosulphate and 0.2 gm of sodium carbonate in 700 ml of water, and make up the volume to 1000 ml.

Potassium Iodide:

- Dissolve 5 gm of potassium iodide in 10 ml of water.
- Mix the two solutions and dilute with water to make up 100 ml.

Potassium Iodide Solution as per IP:

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- For 1.5 g, dissolve 1.5 g of potassium iodide in 100 ml of 1% sodium bicarbonate solution.

Procedure for 1/10th Portion:

- Take 1 gm of the substance and add 1 ml of carbon tetrachloride and 2 ml of iodine monochloride.
- Cool the mixture to 15-30°C and allow it to stand for 30 minutes.
- Add 1.5 ml of potassium iodide solution and 10 ml of water.
- Add starch solution as an indicator.
- Titrate the mixture with 0.1 M sodium thiosulphate.

This method allows for the precise determination of the iodine value in vegetable oils, facilitating analysis of their chemical composition and unsaturation levels.

Conclusion:

The vegetable oil samples underwent analysis to determine their iodine values, yielding the following results: For groundnut oil, the iodine values were as follows: Sunflower marketed oil = 104.05 and crude oil = 158.62, coconut marketed oil = 209.38 and crude oil = 38.07, mustard marketed oil = 285.52 and crude oil = 171.31, safflower marketed oil = 228.42 and crude oil = 133.24, among others. This analysis highlights the distinction between saturation and unsaturation in raw (crude oils) versus processed or marketed food oils. Understanding the saturation levels in food oils helps in selecting healthier options for daily dietary intake.

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