Comparative Physicochemical Evaluation of Branded and Unbranded Vanaspati Ghee in Hyderabad, Sindh, and Its Implications for Human Health

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ABSTRACT

The current study carried out to evaluate main physicochemical quality indices for total twenty three samples of vanaspati ghee, including eight branded and fifteen unbranded products from local market of Hyderabad Sindh, Pakistan. Fundamental and essential parameters were assessed such as moisture content, free fatty acid (FFA), peroxide value (PV), iodine value (IV) and saponification value (SV) in addition to heavy metals Arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), nickel (Ni) and zinc (Zn). Branded vanaspati ghee samples showed consistent results with lower moisture, FFA, PV value and light color, however unbranded ghee samples indicated greater variability in the results including significantly higher moisture content up to 0.205%, elevated FFA level up to 0.612% and variable SV and IV. This variation might be due to improper processing conditions, inconsistent hydrogenation and due to possible adulteration with other raw oils. Additionally, higher levels of Zn, Cu, Cd and Pb were observed in some unbranded samples suggesting the possible contamination risks. Generally, the results underscore the need for stricter quality control, adherence to regulatory standards and enforcement of food safety regulations are essential to minimize contamination risks and protect consumer health.

Keywords: Physicochemical analysis, hydrogenation, vanaspati ghee, heavy metals, health impact

1. INTRODUCTION

The vegetable oil or fat are a basic and important source of energy and required in hour daily life as an essential part of human diet. The edible fat basically exists in form of triglycerides, which are the combined form of different fatty acids with glycerol backbone. However, different types of fatty acids, like saturated, monounsaturated, and polyunsaturated has a large effect on their physical and chemical properties. These lipids are very important as they provide energy, aid in absorption of fat soluble vitamins and are main building blocks for steroid hormones production[1, 2]. Subsequently, to stay healthy and fit the fat quality and their formation via different process are an important step as we consumed them as a part of our diet. Vegetable oils and fats come from a wide variety of plants, together with seeds (soybean, canola, sunflower), nuts (peanut, walnuts), fruits (palm, olive), and bran (rice bran). The vegetable oils obtained direct from plant and seeds after extraction process are in crude form that contains many impurities and high consistency. Therefore these oils passed through several refining process to make them suitable for cooking and frying. Industrial modification processes such as hydrogenation/partial hydrogenation, fractionation, and interesterification are commonly applied in order to enhance their functional characteristics. One of the common processes of partial hydrogenation has been widely utilized to improve oxidative stability, texture and shelf life by transforming liquid oils into semi-solid fats [3]. Vegetable ghee or vanaspati is a common multipurpose cooking fat in Pakistan and other parts of South Asia[4]. Ghee is traditionally manufactured from the milk fat of cows or buffaloes, but due to its limited availability and rising demand, it has become somewhat expensive[5]. As a result, vanaspati has emerged as a more affordable option. In order to produce commercially viable vanaspati, several vegetable oils such soybean, rapeseed, cottonseed, and palm oil are blended and then passed through a process call partial partially hydrogenation to produce the required semi-solid consistency. The vegetable fat characteristics at room temperature such as, the smooth melting behavior, appealing color and particularly the solid texture and resistance to oxidative rancidity are all anticipated to be similar to the physicochemical features of conventional ghee[6, 7].

In recent years due to population expansion, urbanization and shifting eating patterns Pakistan has seen a drastic effect on the rising consumption of vanaspati ghee and edible oils. The edible oil /ghee business has grown rapidly and noticeably becoming a large industrial sector with many units that significantly contributes to the economy. However this rapid expansion has also raised serious concerns about public health as it is directly related to product quality and whether products comply with regulatory standards. Now a day, finding pure desi ghee with certainty is difficult, as the common practice of adulterating desi ghee with vanaspati is common to increase sale and money. This compromises the product reliability and consumer trust. Additionally the manufacturer often fail to regularly meets the criteria of quality requirements such as the standard set by the Pakistan standard and quality control authority (PSQCA)[8,9]. Another problem in vanaspati ghee is the presence of trans fatty acid (TFA) which are formed as a result of partial hydrogenation process. The formation of TFA has significant adverse effect on human health and their consumption linked to cardiovascular diseases (CVD), because TFA raises the level of bad cholesterol (low density lipoprotein LDL) while decreasing the level of good cholesterol (high density lipoprotein HDL). The TFA are basically unsaturated fatty acids having one double bond in trans configuration is being effected by the processing and storage conditions like temperature, pressure, catalysts and reaction time[10]. The monitoring of TFA level in ghee/oil is an important public health concern as an imbalance in these products may lead to inflammation, atherosclerosis and other metabolic issues. Other than TFA the important physicochemical parameters such as free fatty acids (FFA) content and peroxide value (PV), Iodine value (IV), and saponification value (SV) are frequently and routinely used to evaluate the quality of vanaspati ghee. These parameters are imperative as they determine the quality, appearance and stability of the product which are important to consumers. However due to unpredictable climate condition the temperature of the Sindh Pakistan has drastically increased over the long term which can affect the formation of unwanted by products such as FFA and PV in the ghee/ oil. Elevated FFAs levels can indicate poor quality raw material and inappropriate processing condition that may have negative metabolic effects. Similarly the, high peroxide value reflects the oxidative damage of oil fat which can be harmful to public health and also reduce the overall quality of product[11,12]. Heavy metals including chromium, lead, zinc and cadmium are tiny, invisible and toxic contaminants that can enter in our food through polluted water, soil or during processing. These metals are now found in most commonly used vegetable ghee products. Even at low concentrations they can accumulate in the body over time, potentially affecting the organs and causing serious health issues such as cancer, kidney damage and other chronic diseases. This makes it crucial to monitor and control their level to ensure both food safety and public health[13]. Physicochemical parameters of edible oils and fats are important characteristics that indicate their stability, freshness, and overall safety. In recent years, Pakistan’s edible oil and ghee industry has grown significantly, with the number of oil processing units increasing from 100 in 2013 to 150 in 2026. Additionally, production increased from 3.4 million tons in 2013 to 4.5 million in 2026 with a market turnover exceeding 2.5 trillion.

However the increase in the production unit has shifted the small business into large scale industries and the requirement to monitor the quality of the product becomes more challenging. With growing awareness of the health hazards that directly related to poor fat quality it is now restricted by the quality control authority too less than 2% or zero trans[14-16]. Only limited literature is available on the quality evaluation of vanaspati ghee commercially available in Pakistan. Sherazi et al., worked on the GC-MS evaluation and lipid bioactivity of hydrogenated vanaspati ghee/oil. Another study by Kandhro et al., reported on the physicochemical characteristics of vanaspati ghee and oil, where the authors comprehensively evaluated oil and ghee quality. Amir et al., reported the quality parameters of vanaspati ghee and blended oil marketed in Baluchistan[17-19]. Consequently, the quality evaluation of vanaspati ghee has gained significant importance to meet quality standard criteria and protect public health. To monitor the adulteration, level of trans-fat as well as overall stability of ghee it is imperative to rigorously assess the product. In this regards, the current study aims to evaluate the quality of vanaspati ghee commercially available in Hyderabad Sindh. This study focuses on the Comprehensive assessment that encourages healthier consumption habits, promote better standards and enable informed customer choices.

2. EXPERIMENTAL

2.1 Materials and Methods

Sample of branded and unbranded vanaspati ghee were collected from local market in Hyderabad. Eight samples of branded ghee and fifteen samples of unbranded ghee were obtained. For each single sample three replicates were purchased to follow proper sampling and analysis protocol. The collected samples were shifted to labeled sample container and stored in a refrigerator for further analytical use. All chemicals used in the experiments were of analytical grade and sourced form E-Merck (Germany).

2.2 Physico-chemical Evaluation Parameters

2.2.1 Color

The color of all branded and unbranded samples was measured using a lovibond tintometer (Model F BS 684) following the standard AOCS protocol[12].

2.2.2 Melting Point

The slip melting point of vanaspati ghee samples was determined following the AOCS standard protocol[12].

2.2.3 Moisture Content

The moisture of the branded and unbranded samples of vanaspati ghee was calculated according to the Association of the Official Analytical Chemist (AOAC) [20] method. All samples were homogenized and put into an oven at an average temperature of around 105 ± 2 °C until it reached a constant weight.

2.2.4 Free Fatty Acid Value

In the measurement of FFA in the entire branded and unbranded sample, a standard method of titration was employed as reported in the literature[20]. Ghee sample was heated with the aim of making ghee homogenized and weigh and dissolved in neutral ethanol. Phenolphthalein indictor (2 droplets) were added to the mixture solution and titrated against standardized concentration of sodium hydroxide (0.1N).

2.2.5 Iodine Value

IV was identified using standard AOAC method of oil and fats[20]. Determination of iodine numbers is a measure of the unsaturation of oil/fat samples, and is given in the form of the quantity of grams of iodine that is absorbed by hundred grams of oil. Vegetable vanaspati ghee sample was dissolved in 15 mL of carbon tetrachloride (CCl_4), 25 mL of Wijs' reagent and 10mL of freshly prepared solution of potassium iodide (5% KI). The mixture was thoroughly blended and left in the dark over half hour to carry out the process. Freely released iodine in the mixture with the sample was then titrated by placing 0.1 N standard sodium thiosulfate ($Na_2S_2O_3$) normally as an indicator in this reaction.

$$\text{Iodine Value (g of } I_2 / 100\text{ g sample)} = \frac{\text{(Blank reading - sample reading) x N of } Na_2S_2O_3 \text{ x 12.69}}{\text{Weight of sample (g)}}$$

2.2.6 Saponification Value

AOCS standard method was used to determine the SV[20]. SV is the number of mg of potassium hydroxide required to saponify one gram of fat and oil. The type of fatty acid that is present in the fat and oil affects the SV. A minimum of 2 g of the vanaspati samples was refluxed with 95% ethanolic potassium hydroxide (25 mL) for no less than 60 minutes. After refluxed the sample was then titrated with the 0.5 N HCl standardized solution with few drops of phenolphthalein indictor on top of it.

The given formula was used to find the SV:

$$\text{Saponification Value(mg/g of fat)} = \frac{\text{(Blank value - Sample value)} \times \text{Molarity of HCl} \times 56.1\text{sample}}{\text{Weight of sample (g)}}$$

2.2.7 Peroxide Value

AOCS method Cd 8b-90 was used to determine PV[20]. The 2 g of vanaspati ghee sample was dissolved in 15 mL of glacial acetic acid: chloroform (3:2 v/v %) and saturated solution of potassium iodide (0.25 mL). The resultant solution was titrated in the presence of 1% starch indicator solution with the standardized solution of $Na_2S_2O_3$ (0.1N) against the solution.

The PV was calculated by the formula:

$$\text{Peroxide value (mEq/Kg of fat)} = \frac{\text{(Blank value - Sample value) x Normality of } Na_2S_2O_3}{\text{Weight of sample (g)}} \times 100$$

2.2.8 Heavy Metals

Possible heavy metals contamination was analysed in all samples of branded and unbranded vanaspati ghee by ICP-OES from thermo Fisher. The model iCAP 6300 Duo ICP-OES was used with inert Argon gas as a plasma source.

3. RESULTS AND DISCUSSION

3. 1 Physicochemical Characteristics of Vanaspati Ghee Samples

A total twenty-three vanaspati ghee samples (8 branded and 15 unbranded) were taken from local markets in Pakistan, so that the physicochemical quality could be assessed. The study showed large differences in the physicochemical properties of branded and unbranded vanaspati ghee samples, which could be related to the way in which the products were manufactured. The quality of the raw materials used in processing, and the conditions under which they were stored after manufacturing.

3. 2 Moisture Content

Moisture content is the fraction of the amount of water of in the sample to amount of the solid in the sample which is presented as weight by weight percentage. The results revealed that the moisture content ranged from 0.081-0.205% in unbranded ghee samples while 0.094-0.177% found in branded ghee samples. The comparatively higher moisture levels was found in branded sample (BVG-4) 0.094 while highest percentage was observed in (BVG-1) 0.177, as shown in Table 2. Furthermore, the lowest percentage was found in sample (UBVG-12) 0.081 while higher percentage was noticed in (UBVG-14)

0.205 respectively (Figure 1). The suggested standard limits of moisture content and impurities for the vanaspati ghee and cooking oil were 0.150%[11]. The moisture content of ghee is important as it determines the stability of the oil and shelf life[17]. Moisture content of a material is influenced by its hygroscopic properties. Hygroscopicity refers to the tendency of a material to absorb some amount of water from the surrounding environment depends on conditions such as temperature and humidity. Therefore it is imperative to carefully control the conditions of temperature and humidity during processing or storage when handling ghee product to maintain its quality[21].

3.3 Melting Point

The melting point of branded vanaspati ghee ranged from 31.457-36.781°C as showed in Figure 2. The melting points of the samples varied widely, showing that the hydrogenation process was not consistent for all of them. This likely affected the fatty acid composition in each sample. Some unbranded samples had higher melting points, which could indicate a higher level of saturated fats and possible formation of trans-fats due to improper processing. Generally, melting point of vanaspati must not exceed 40 °C as higher values may represent poor quality and reduced stability of the product. On the other hand, if melting point of vanaspati is very low, its structure will become fluid like and two-phase, which is not favorable for consumers. Therefore, neither fully hydrogenated nor initial vegetable oils were suitable individually for use as vanaspati ghee production[22].

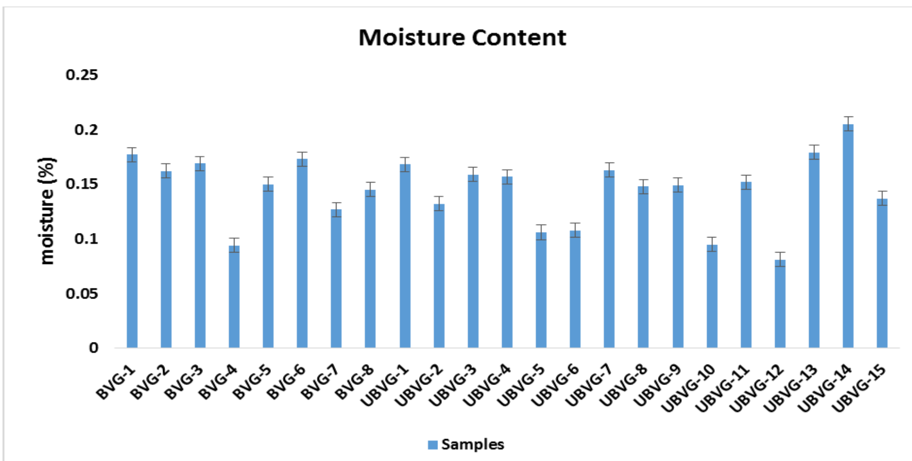

Figure 1. Moisture content of different branded and unbranded vanaspati ghee samples

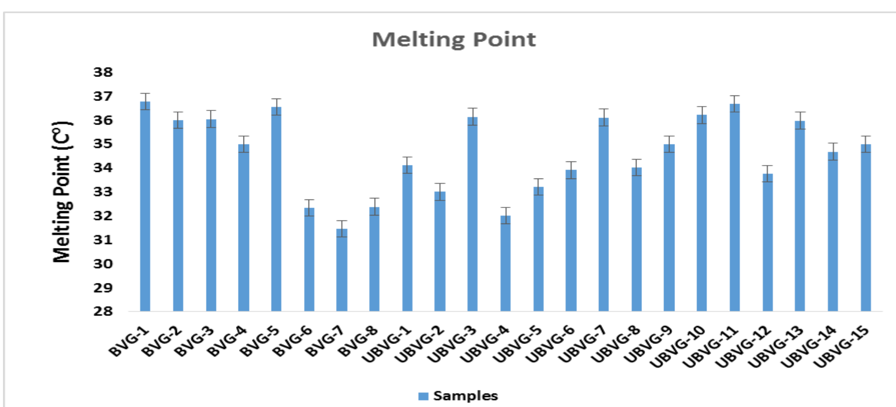

Figure 2. Melting point of different branded and unbranded vanaspati ghee samples

3.4 Free Fatty Acid

Now a day there is a prompt development inedible oil refining industry in Pakistan owing to rise in the public demand but it is observed that mostly local industries fail to compliance with the standard set by Pakistan Standard Quality Authority (PSQCA). Different physicochemical tests often used to check the Vanaspati ghee quality. Free fatty acid (FFA) analysis provides useful information about the raw cooking oil quality, efficacy of neutralization process during industrial refining step and conditions of storage[23]. Increased level of FFA may cause many metabolic disorders in humans including insulin resistance and other health complications[10]. The FFA content, expressed as percentage of oleic acid, varied between (0.112-0.612%) in branded samples, and unbranded samples. The higher value was recorded in sample (BVG-4) 0.293 while form UBVG samples higher value recorded in 0.612 in UBVG-12 as shown in Figure 3. The unbranded samples showed higher level of FFA (Table 2), which may result from using, lower quality crude oils, the type of contains or the storage conditions. Statistical analysis revealed a significant difference ($p<0.05$) between branded and unbranded samples.

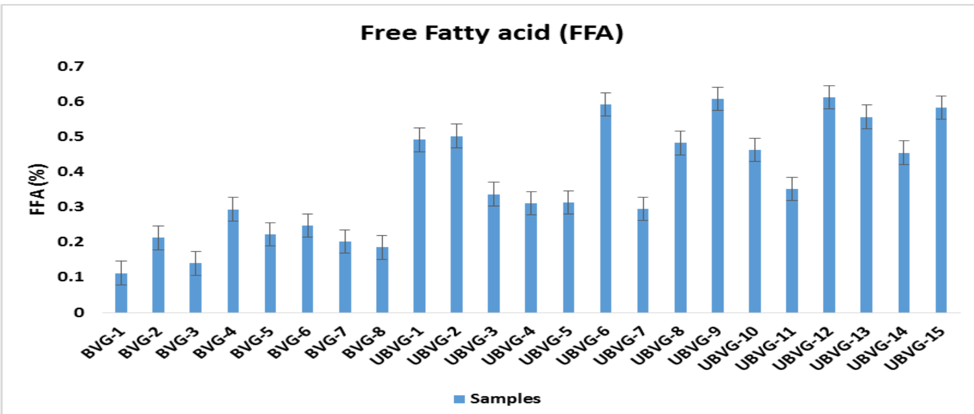

Figure 3. Free fatty acid content in branded versus unbranded vanaspati ghee samples

3.5 Color Analysis

The color of vanaspati ghee comes from the addition of coloring pigments during its preparation. Color measurements revealed that branded samples had relatively uniform light yellow to pale cream shades, whereas unbranded samples varied significantly, ranging from deep yellow to off-white tones as shown in Table 1. The inconsistency in unbranded products may be attributed to uncontrolled addition of colorants or differences in raw material quality. High color values are usually the results of an inadequate bleaching process during refining of raw oil, which leaves behind residual pigments and other impurities[23].

Table 1. Color analysis of different branded and unbranded vanaspati ghee samples

Samples		Color index
Branded Vanaspati Ghee	BVG-1	R=0.310 Y=3.000
	BVG-2	R=0.380 Y=2.997
	BVG-3	R=0.350 Y=3.000
	BVG-4	R=0.392 Y=2.935
	BVG-5	R=0.302 Y=2.897
	BVG-6	R=0.320 Y=2.400
	BVG-7	R=0.310 Y=2.757
	BVG-8	R=0.310 Y=2.345

	UBVG-1	R= 0.410 Y=3.012
	UBVG-2	R=0.513 Y=3.101
	UBVG-3	R=0.457 Y=2.998
	UBVG-4	R=0.501 Y=3.091
	UBVG-5	R=0.411 Y=3.098
	UBVG-6	R=0.506 Y=3.009
	UBVG-7	R=0.399 Y=3.123
Unbranded Vanaspati Ghee	UBVG-8	R=0.299 Y=3.00
	UBVG-9	R=0.388 Y=3.156
	UBVG-10	R=0.431 Y=2.987
	UBVG-11	R=0.400 Y=3.400
	UBVG-12	R=0.567 Y=3.625
	UBVG-13	R=0.510 Y=2.775
	UBVG-14	R=0.438 Y=3.241
	UBVG-15	R=0.273 Y=3.115

3.6 Peroxide Value

The peroxide value measures the amount of peroxide oxygen present in one kilogram of oil or fat sample. Ideally, the industrialist aims to achieve the lowest possible peroxide value while avoiding the formation of secondary oxidation products. The analysis indicated that peroxide values for the sample range from 1.993-8.951 meqO_2/Kg as illustrated in figure 4. The unbranded sample of ghee exhibited higher PV values (Table 2), reflecting greater oxidative damage, which may result from less efficient processing conditions and increased exposure common factors such as to air or light. However the Pakistan Standard Quality Control Authority (PSQCA) and Codex Alimentarius Commission recommend a maximum limit of 10 meqO_2/Kg oil and therefore all results were in good agreement with standard PSQCA respectively[24].

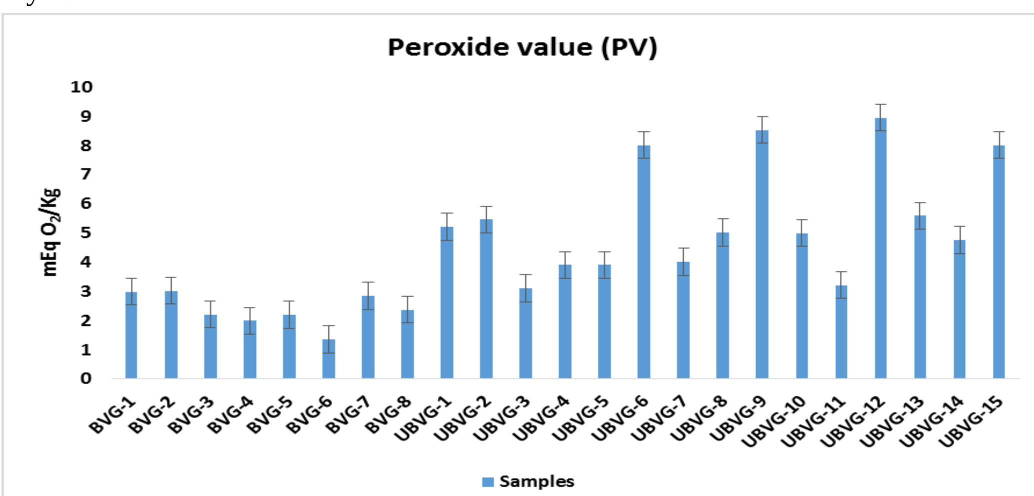

Figure 4. Peroxide value of different branded and unbranded vanaspati ghee samples

3.7 Saponification Value

Saponification values were relatively consistent across samples, with branded and unbranded samples ranging from 123.358-222.489 mgKOH/g. In BVG samples the higher value was noticed 189.620 in BVG-1 while lower was noticed 123.358 in BVG-8. Whereas, in UBVG sample higher value recorded 222.489 in UBVG-4 and lowest value was recorded in (UBVG-14) 128.253 as shown in Figure 5. However, few unbranded samples exhibited unusually high values (Table 2), which may indicate the presence of shorter-chain fatty acids or adulteration. The saponification values obtained were significantly lower than the standard value of oil and fat (>250 mgKOH/g), indicating the variation in fatty acids composition. Saponification value is the key factor for detecting adulteration, as it reflects the average chain length and molecular weight of the fatty acids in oil/fat. Lower saponification value represents higher proportion of long chain fatty acids and fewer medium chain fatty acids in the sample[25, 26].

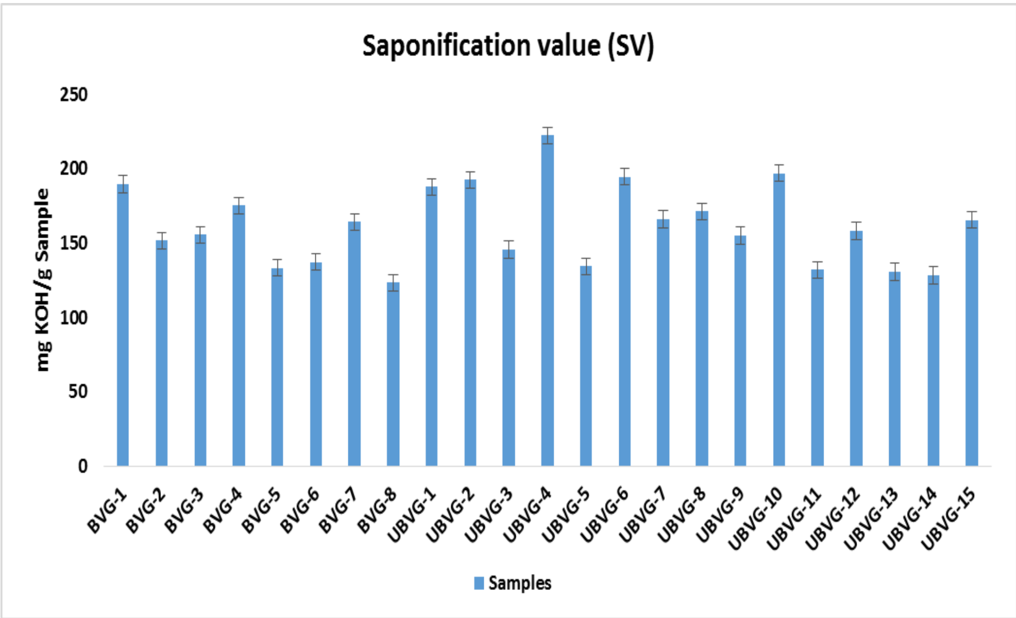

Figure 5. Saponification value of different branded and unbranded vanaspati ghee samples

3.8 Iodine Value

The iodine value, representing the degree of unsaturation, ranged between 81.215-146.230 g/100g in branded and unbranded samples. It was noticed that the lowest value observed in BVG sample was 88.650 while the higher value was found to be a 124.341. Comparatively in UBVG sample lowest value recorded was 62.350 in UBVG-2 and higher value 146.230 was observed in UBVG-13 (Figure 6). However, both categories remained within acceptable limits (Table 2), but small differences indicating variation in oils used for hydrogenation. Some unbranded sample showed lower iodine values indicate more saturation might be due to over hydrogenation. Higher iodine values of the samples indicate the presence of more unsaturated fatty acid bonds. The greater the degree of unsaturation, the more rapid the oil tends to be oxidized[27].

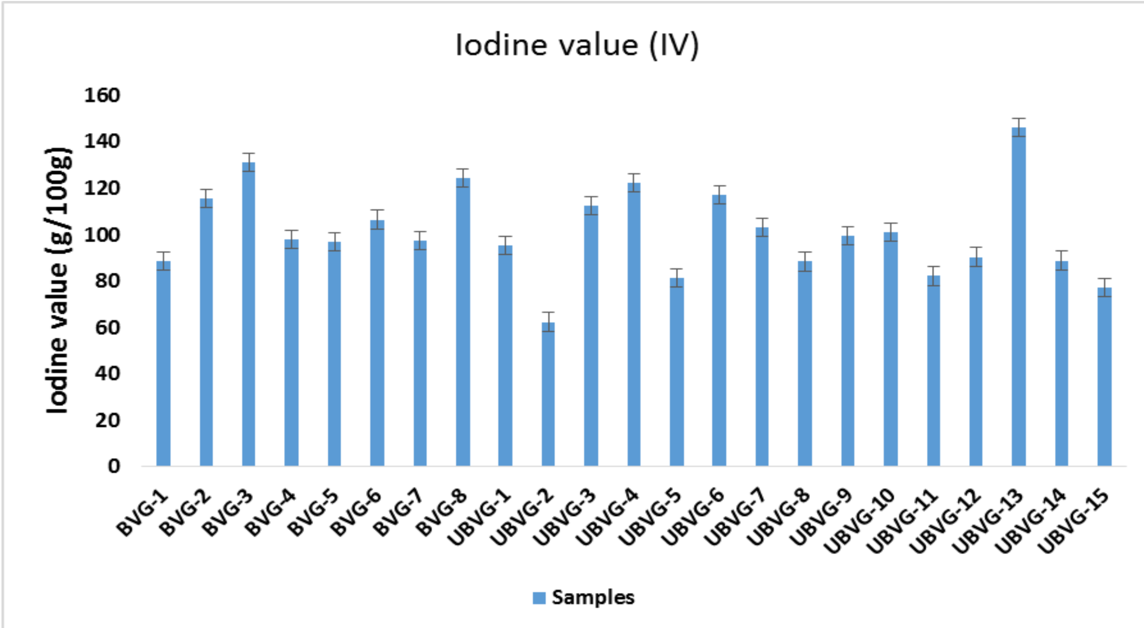

Figure 6. Iodine value of different branded and unbranded vanaspati ghee samples

3.9 Heavy Metals Concentration in Vanaspati Ghee Samples

The concentrations of selected heavy metals, including As, Cd, Cu, Pb, Ni, and Zn, were determined in twenty-three vanaspati ghee samples comprising both branded (n=8) and unbranded (n=15) products collected from local markets as presented in Table 3. In this regard, the results revealed that the concentration of As was found in branded and unbranded samples ranging from 0.012 to 0.052. The higher level was observed in branded samples BVG-5 and lower level was recorded in BVG-8. Whereas, the unbranded samples higher concentration was observed in UBVG-2 and lower value was noticed in UBVG-7 respectively. The Cd levels were relatively low in branded samples, ranging between 0.024-0.051, whereas unbranded samples showed comparatively higher concentrations 0.039-0.057. While most of the samples remain in safety limits given by W.H.O. Unbranded ghee samples showed higher level of Cd concentration suggesting possible contamination from materials or from environmental sources[28]. Additionally, the content of Cu was found in the range of 0.310-1.613 mg/Kg in branded samples and 0.179-2.674 mg/Kg in unbranded samples respectively. The elevated level of Cu was present in the unbranded samples pointing to inconsistent quality control during production. The contaminations may arise from processes equipment’s or mainly due to environmental exposure. The Pb concentration was detected 0.031-0.109 mg/Kg in unbranded ghee and 0.020-0.100 mg/Kg in branded ghee samples. While most branded ghee samples remain in permissible limits, the higher concentration of Pb in unbranded samples may results from processing conditions, storage conditions and environmental exposure as reported in previous studies[29, 30]. The Ni level was found in branded samples from 0.139-0.216 mg/Kg and 0.128-0.217 mg/Kg in unbranded samples. The content of Ni in most samples was in safe limit, with the slight increase in some unbranded samples. Finally the content of Zn was observed in branded samples 1.394-3.800 mg/Kg range while unbranded samples from 0.891-4.234 mg/Kg range. The significantly higher values was observed in unbranded linked to the contamination from raw material to processing unit.

Table 2. Comparatively results of physico-chemical parameters of branded and unbranded samples

Samples		**Moisture content (%)**	**M.Pt (^{0}C)**	**PV** (meqO_2/Kg)	**SV (mgKOH/g)**	**FFA (%)**	**IV (g/100g)**
Branded Vanaspati Ghee	BVG-1	0.177±0.008	36.781±0.529	2.985±0.078	189.620±2.489	0.112±0.001	88.650±0.583
	BVG-2	0.162±0.003	35.998±0.583	3.025±0.082	151.830±1.588	0.212±0.005	115.699±1.549
	BVG-3	0.169±0.005	36.046±0.487	2.211±0.064	155.642±1.475	0.140±0.004	131.163±1.520
	BVG-4	0.094±0.002	34.999±0.583	1.993±0.089	175.280±1.334	0.293±0.009	97.960±1.571
	BVG-5	0.150±0.002	36.555±0.586	2.195±0.045	133.302±1.493	0.222±0.005	96.897±1.537
	BVG-6	0.173±0.001	32.344±0.348	1.357±0.092	137.248±1.437	0.247±0.004	106.384±1.403
	BVG-7	0.127±0.006	31.457±0.427	2.842±0.071	164.347±1.372	0.202±0.003	97.375±1.272
	BVG-8	0.145±0.001	32.384±0.212	2.372±0.081	123.358±1.238	0.185±0.002	124.341±1.356
Unbranded Vanaspati Ghee	UBVG-1	0.168±0.004	34.123±0.561	5.213±0.057	187.920±1.561	0.491±0.005	95.425±1.581
	UBVG-2	0.132±0.001	33.004±0.497	5.456±0.058	192.540±1.589	0.502±0.019	62.350±1.597
	UBVG-3	0.159±0.001	36.145±0.352	3.110±0.058	145.620±1.551	0.336±0.003	112.500±1.529
	UBVG-4	0.157±0.003	32.013±0.220	3.905±0.057	222.489±1.531	0.311±0.012	122.200±1.587
	UBVG-5	0.106±0.002	33.211±0.359	3.907±0.057	134.302±1.566	0.313±0.002	81.215±1.582
	UBVG-6	0.108±0.001	33.911±0.560	8.012±0.158	194.721±1.583	0.592±0.010	117.077±1.535
	UBVG-7	0.163±0.003	36.111±0.416	4.013±0.067	166.153±1.489	0.295±0.004	103.102±1.519
	UBVG-8	0.148±0.001	34.014±0.440	5.014±0.067	171.353±1.543	0.482±0.015	88.426±1.526
	UBVG-9	0.149±0.002	35.001±0.325	8.530±0.160	155.098±1.573	0.607±0.016	99.375±1.542
	UBVG-10	0.095±0.002	36.211±0.497	4.995±0.120	197.018±1.486	0.462±0.007	101.119±1.835
	UBVG-11	0.152±0.007	36.681±0.436	3.213±0.028	132.117±1.550	0.351±0.006	82.185±1.536
	UBVG-12	0.081±0.006	33.755±0.560	8.951±0.158	158.198±1.577	0.612±0.019	90.383±1.718
	UBVG-13	0.179±0.009	35.981±0.579	5.589±0.057	130.765±1.577	0.556±0.018	146.230±1.575
	UBVG-14	0.205±0.001	34.685±0.503	4.757±0.075	128.253±1.540	0.454±0.011	`88.760±1.417
	UBVG-15	0.137±0.004	35.005±0.317	8.010±0.155	165.436±1.592	0.583±0.017	77.079±0.561

Values are represented in the table as mean standard ±deviation (S.D)

Table 3. Level of heavy metals in branded and unbranded vanaspati Ghee samples

Samples		**Arsenic (As) mg/Kg**	**Cadmium (Cd) mg/Kg**	**Copper (Cu) mg/Kg**	**Lead (Pb) mg/Kg**	**Nickel (Ni) mg/Kg**	**Zinc (Zn) mg/Kg**
Branded Vanaspati Ghee	BVG-1	0.023±0.006	0.024±0.004	0.640±0.003	0.025±0.009	0.185±0.002	2.180±0.102
	BVG-2	0.021±0.003	0.027±0.003	0.310±0.001	0.020±0.001	0.206±0.006	2.650±0.103
	BVG-3	0.018±0.001	0.042±0.003	0.820±0.002	0.022±0.003	0.139±0.009	3.800±0.208
	BVG-4	0.023±0.002	0.033±0.002	0.450±0.001	0.024±0.004	0.172±0.007	2.110±0.107
	BVG-5	0.027±0.0017	0.040±0.001	1.266±0.006	0.094±0.002	0.216±0.006	2.320±0.105
	BVG-6	0.022±0.0013	0.051±0.003	1.613±0.010	0.061±0.003	0.209±0.004	3.610±0.208
	BVG-7	0.031±0.0019	0.038±0.005	0.444±0.004	0.070±0.001	0.205±0.003	1.394±0.103
	BVG-8	0.016±0.009	0.028±0.001	0.601±0.002	0.100±0.004	0.203±0.010	2.666±0.120
Unbranded Vanaspati Ghee	UBVG-1	0.050±0.002	0.039±0.002	0.755±0.003	0.086±0.001	0.215±0.008	1.804±0.107
	UBVG-2	0.052±0.003	0.043±0.003	0.198±0.002	0.075±0.002	0.207±0.010	0.891±0.003
	UBVG-3	0.049±0.001	0.057±0.001	1.598±0.005	0.031±0.001	0.205±0.009	2.148±0.104
	UBVG-4	0.027±0.005	0.053±0.001	0.179±0.001	0.103±0.001	0.241±0.006	2.965±0.110
	UBVG-5	0.028±0.003	0.056±0.004	0.211±0.010	0.088±0.002	0.192±0.008	2.440±0.108
	UBVG-6	0.019±0.001	0.055±0.005	0.349±0.021	0.092±0.005	0.204±0.010	1.663±0.006
	UBVG-7	0.012±0.009	0.053±0.001	0.258±0.010	0.094±0.004	0.205±0.004	1.745±0.102
	UBVG-8	0.035±0.002	0.049±0.004	2.674±0.041	0.080±0.005	0.202±0.002	2.554±0.109
	UBVG-9	0.042±0.001	0.054±0.002	0.713±0.032	0.106±0.009	0.201±0.006	4.234±0.308
	UBVG-10	0.031±0.003	0.055±0.002	1.286±0.090	0.088±0.004	0.207±0.006	2.869±0.101
	UBVG-11	0.049±0.006	0.052±0.009	0.543±0.021	0.104±0.002	0.207±0.009	2.161±0.102
	UBVG-12	0.050±0.004	0.057±0.003	0.661±0.041	0.107±0.001	0.217±0.008	1.496±0.023
	UBVG-13	0.039±0.004	0.047±0.004	0.637±0.029	0.106±0.004	0.128±0.007	1.383±0.042
	UBVG-14	0.046±0.001	0.051±0.001	0.773±0.031	0.089±0.008	0.208±0.001	2.121±0.093
	UBVG-15	0.044±0.005	0.051±0.002	0.437±0.001	0.109±0.003	0.183±0.005	2.036±0.102

Values are represented in the table as mean standard ±deviation (S.D)

4. CONCLUSION

The increase in the consumption of unbranded vanaspati ghee, driven by economic pressures, rises significant concerns for quality of food and public health our study reveals that unbranded products sold in the market products normally fail to meet critical quality parameters, including moisture content, free fatty acids, and oxidative stability. These deficiencies reduce nutritional value and escalation of health risks, predominantly during high-temperature cooking, where an unwanted by products significantly increases that makes the sample rancid and unacceptable for the consumer health. In addition elevated level of heavy metals such as cadmium was also exceed the permissible limit that can lead to increased further health issues. These outcomes highlight the elevated levels of heavy metals such as cadmium and lead further exacerbate these risks. These findings underscore the crucial need for stringent regulatory measures. Unbranded ghee, particularly products lacking appropriate labeling or sterilization accreditation, must undergo rigorous quality testing before reaching consumers. Strengthening production standards and strict implementations of food safety regulations are essential to safeguard public health and preclude exposure to substandard or harmful food products.

Declaration of Competing Interest

There is no known competing interest of authors with others.

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Supplementary material

All excel and tabulated data files will be available from authors on request

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