The presence of hydroquinone, and mercury in skin toning creams, as well as lead in turmeric powder, pose potential health risks to Bangladeshi women

Bioresearch Communications
Volume 8, Issue 2, July 2022

DOI:
doi.org/10.3329/brc.v8i2.60644

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ABSTRACT: Skin toning creams and turmeric powders are widely used among Bangladeshi fashion and beauty concerned women and young girls in general. However, it has been reported that excessive use of skin toning cream and turmeric powder can cause various dermatological problems, including skin cancer. These creams and turmeric powder contain a wide variety of active ingredients, including Hydroquinone (HQ), Mercury (Hg), and Lead (Pb), that are toxic, and hazardous to health, especially after prolonged application. As a result, in the current study, we tried to assess HQ and Hg level in commonly used skin toning creams and Pb in turmeric powder in the context of Bangladeshi women collected from the local markets in Dhaka city. HQ, Hg, and Pb levels were analyzed for 40 different Bangladeshi skin toning cream products and 40 different turmeric powder samples. The HQ level was determined by the high-performance liquid chromatography (HPLC) method, the Hg level was determined by Cold Vapor Atomic Absorption Spectrophotometry (CV-AAS) using an automatic mercury analyzer, and Pb was measured by the flame atomic absorption spectrometry method. Among the 40 samples, 23 samples (57.5%) did not contain HQ, whereas 17 samples (42.5%) contained a high level of HQ compared to the standard limit. In the case of Hg analysis, we found that 28 (70%) out of 40 samples complied with the standard level of Hg, whereas 12 samples (30%) contained a higher level of Hg compared to the standard limit. Among the 40 samples of turmeric powder, 20 samples (50%) complied with the standard level of Pb, whereas 20 samples (50%) contained a high level of Pb compared to the standard limit. After three and six months of storage, we had similar results in all the samples for the three cases. After combining HQ and Hg data sets, we found that 14 (35%) out of the 40 samples had HQ and Hg levels within the standard limit, and 3 samples (7.5%) had higher quantities of both HQ and Hg levels and did not comply with the standard limit. 14 samples (35%) in the data set had higher HQ levels but complied only with the standard Hg level, whereas 9 samples (22.5%) had higher Hg levels and thus complied only with the standard HQ level. So, in 65% of the samples, we found the presence of excess level of either both HQ and Hg at the same time or any one of the measured chemical parameters. The use of these creams and turmeric powders, which did not comply with the standard limit, may pose a serious health risk to consumers. So, consumers should be aware of the risks associated with using these creams and turmeric powders, and policymakers should take appropriate measures to prevent the manufacturing and marketing of skin toning creams containing high levels of HQ and Hg and turmeric powder with high levels of Pb.

KEYWORDS: Hydroquinone, Mercury, Lead, Skin-toningcreams, HPLC, CV-AAS, flame-AAS

RECEIVED: 18 February 2022, ACCEPTED: 23 May 2022

TYPE: Original Research

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Introduction

Since time immemorial, humans have constantly labeled and stereotyped each other based on skin color. In most African and Asian communities, fairness is branded as beauty, grace, and high social status (Desmedt, Ates et al. 2016). The darker skin is seen as being of the lowest social value, whereas the lighter skin is regarded as having the highest social status. This perception encourages most women to engage in skin care products that lighten the skin, although most often they end up indulging in skin care products that either lighten or bleach the skin. Skin toning or bleaching products are types of cosmetics (creams, gels, lotions, and soaps) applied voluntarily to the skin. For centuries, women have been using skin creams for their beauty treatments. The majority of these skin creams have posed a potential risk to their health because they contain a variety of highly toxic active ingredients.Among these, different kinds of harmful chemicals, including hydroquinone ($C_6H_6O_2$), mercury (Hg), kojic acid, kojic acid dipalmitate, azleic acid, arbutin, bearberry, vitamin C, magnesium ascorbyl phosphate, calcium ascorbate, and L-ascorbic acid are predominant (Amponsah, Voegborlo et al. 2014). The commonly used toning agents are known to contain hydroquinone (HQ) and mercury (Hg) (Agorku, Kwaansa-Ansah et al. 2016).

Turmeric, also known as *Curcuma longa*, a rhizomatous perennial herb, is an inexpensive and natural way of treating several skin problems and getting flawless skin and has been used as a beauty product. Turmeric is effective in the treatment of acne due to its antiseptic and antibacterial properties that fight pimples and breakouts to provide a youthful glow to the skin. The turmeric face mask not only helps to clear acne scars and inflammation but also reduces oil secretion by the sebaceous glands. Being an excellent exfoliating agent, turmeric helps eliminate the signs of aging and lighten stretch marks. However, this helpful turmeric can be harmful when it is contaminated by lead (Pb) from soil during its harvesting.

HQ, a crystalline substance consisting of a benzene ring and two hydroxyl groups, is a hydroxyphenol that is naturally present in plants and foods such as coffee, cranberries, and blueberries (Parvez, Kang et al. 2006). It has been used successfully to treat many forms of epidermal hyperpigmentation, such as melasma, freckles, skin toning, and post-inflammatory hyperpigmentation (Desmedt, Courselle et al. 2015). HQ does not actually bleach the skin but rather is a strong inhibitor of melanin production, meaning it prevents the skin from making the substance responsible for skin color (Gbetoh and Amyot 2016). The US Food and Drug Administration (FDA) approved the use of HQ in over-the-counter topical creams in 1982, but later revoked its approval after it was discovered that HQ may be a carcinogen in rats after they were given it orally (Kooyers, Westerhof et al. 2006).The biosafety of HQ as a skin whitening ingredient remains controversial, although it has been in use topically for more than 50 years (Kooyers, Westerhof et al. 2006). Concern regarding the side effects of HQ has risen primarily because topical application of HQ may cause exogenous ochronosis, which causes the skin to produce blue and black pigments, resulting in the formation of blotches of dark spots on the skin. Along with these, benzene metabolites of HQ *in vivo* seem to be involved in bone marrow toxicity and even carcinogenesis with excessive use (Westerhof and Kooyers 2005). The chemical has been identified as both a potential clastogen and a mutagen (Gupta, Gover et al. 2006). To avoid potential toxicities caused by HQ, intense effort has been devoted in recent years to the screening of safe and effective ingredients as possible topical alternatives to HQ for both pharmaceutical and cosmetic purposes.

Cosmetic preparations containing Hg for bleaching purposes are an old practice and are mainly used by dark-skinned people, mostly in developing countries (Barr, Woodger et al. 1973). Hg in bleaching preparations is absorbed through the skin and accumulates in the body (Agorku, Kwaansa-Ansah et al. 2016), especially in the kidney where it mainly gathers in the tubular region, resulting in severe toxicity (Al-Saleh and health 2016). Some of these creams may contain up to 2% Hg that is harmful to health, resulting in Hg poisoning. The United States Food and Drugs Administration (US FDA) in 1992 established the maximum acceptable level of Hg in cosmetics to be 1 mg/kg (BDS 1382:2015G). There may be behavioral and neurological changes associated with overexposure to HG poisoning, such as excitability and quick-tempered behavior, lack of concentration, and loss of memory. Chronic exposure to Hg results in sensory impairments such as visual problems (e.g., constriction of visual fields, tunnel vision, and blindness) as well as hearing loss. Some individuals may experience skin changes such as painful swelling and pink coloration of the fingers and toes (acrodynia); persistent redness or inflammation of the skin (erythema); extreme sensitivity (hyperesthesia) of the affected areas; and tingling and sensory disturbances (Clarkson 1997, Boyd, Seger et al. 2000).

Lead, a bluish-grey metal present in small amounts in the earth's crust, occurs naturally in the environment and has many industrial uses, although a small amount of lead can be hazardous to human health. In occupational settings, exposure through inhalation is more common, whereas in the general population it is largely through ingestion. Lead is commonly incorporated into herbal remedies such as Indian Ayurveda preparations and remedies of Chinese origin. There are also risks of elevated blood lead levels caused by folk remedies like azrcon and greta, each of which contains about 95% lead. Following absorption, lead is taken up in the blood and deposited in soft tissues (brain, liver, kidney, bone marrow) and bone. Up to 94% of the body burden of lead occurs in bone, in which it has a half-life of years to decades, whereas in blood the half-life is about 30 days (Vupputuri, He et al. 2003). In adults, overexposure to lead may cause high blood pressure and damage to the reproductive organs. Neurological symptoms associated with lead overexposure include an impaired ability to coordinate voluntary movements (ataxia), brain damage (encephalopathy), seizures, convulsions, swelling of the optic nerve (papilledema), and/or impaired consciousness.

The aim of this work was to analyze the prevalence pattern of excess HQ and Hg in commercially available skin toning creams in the Bangladesh market and assess the risk of skin cancer associated with skin toning creams. The specific aims also included analysis of heavy metal (lead) content in turmeric powder used by the people of Bangladesh. This study will help to raise consumer awareness and make them aware of the importance of taking preventive measures to reduce chemical exposure. It would also help to investigate the determinants, the prevalence, and the user awareness associated with the use and misuse of skin-toning products and turmeric powders among women living in Bangladesh.

Materials and Methods

Sample collection

Different products of skin toning creams and turmeric powders were bought from the local markets in Dhaka, Bangladesh. A total of forty different Bangladeshi product samples of skin toning creams and forty different product samples of turmeric powders were collected to test the chemical parameters of HQ, Hg, and Pb. We also tested the same parameters after three and six months of storage to check the differences in the parameters.

Analysis of HQ

HQ in all the samples was determined by the High Performance Liquid Chromatography (HPLC) method following the protocol mentioned by Siddique, Parveen et al. (2012) using HPLC UV/visible detector-Agilent 1260. About 1.0 g of each skin toning cream sample was taken into the volumetric flask along with 25.0 ml of mobile phase (water: methanol, 40:60) followed by vigorous shaking until a homogenous suspension was obtained. The flask was immersed in a water bath maintained at 60 2°C for 10 minutes to enhance the extraction. The mixture was then allowed to cool to separate the fats and waxes in the sample. After that, filtration was done using a glass filter with a vacuum pump. The Standard HQ solutions (Sigma-Aldrich Reagent PlusH9003) as well as the blank solution were subjected to the same treatment.

Analysis of Hg

Hg in all the samples was determined by the cold vapor atomic absorption spectrophotometry (CV-AAS) method following the protocol mentioned by (Amponsah, Voegborlo et al. 2014) using an Automatic Mercury Analyzer Model HG-5000 (Japan) provided with the Hg-lamp and operated at a wavelength of 253.7 nm. The samples were digested for total Hg determination by a modified version of an open flask procedure developed at the National Institute for Minamata Disease (NIMD) Japan (Akagi and Nishimura 1991). A blank and standard solution digest using standard Hg solution were subjected to the same treatment (Agorku, Kwaansa-Ansah et al. 2016).

Analysis of Pb

Pb in all the samples was determined by the flame atomic absorption spectroscopy (Flame-AAS) method following the protocol mentioned by Cha, Lee et al. (2010). The 0.2 g of analyte was taken and put into the vessel. The 1 mL of spikesolution was added to the sample and then acidified with 7 mL of HNO_3 and 3 mL of HF before microwave digestion treatment (Tuzen, Sari et al. 2004). During treatment, the temperature was increased slowly from room temperature to 20°C with 1,200 W of power for 20 minutes. After cooling, vessel modules were disassembled and both lids and vessels were washed with distilled water to collect samples. These samples were filtered through a Whatman paper filter, and distilled water was further added. All apparatus was made of polypropylene to avoid HF reactions with glassware.

Result

The main purpose of our study was to verify the prevalence pattern of excess HQ and Hg in skin toning creams collected from the local markets in Dhaka, Bangladesh. This study also presents data on lead (Pb) concentration in turmeric powders. For this purpose, we investigated HQ and Hg chemical parameters in 40 different Bangladeshi skin toning cream products and Pb in 40 different samples of turmeric powders. We again evaluated the same parameters three and six months after storage to see whether there were any variations due to degradation of the Hydroquinone and oxidation of the Mercury. However, no appreciable changes were detected.

Analysis of Hydroquinone

Among the 40 samples, 23 samples (57.5%) did not contain HQ and 17 samples (42.5%) contained a high level of HQ compared to the standard limit (Table-01; Figure-01, 02). The highest concentration of HQ (239.07 mg/kg) was observed in sample-33 among the examined samples (Table-01). After three and six months of storage, we had similar results in all the samples. Figure 2 represents the concentration of excess HQ in different samples at different storage times along with the standard limit.

Table 1. Concentration of Hydroquinone in skin cream of different samples

Sample ID	Hydroquinone (mg/kg) Normal	Hydroquinone (mg/kg) After 3 months storage	Hydroquinone (mg/kg) After 6 months storage	Standard limit (mg/kg) (WHO/BDS)
1	1191.49	1191.52	1191.54	5
2	1524.37	1514.42	1504.87	
3	ND	ND	ND	
4	1831.29	1846.31	1877.87	
5	ND	ND	ND	
6	ND	ND	ND	
7	ND	ND	ND	
8	ND	ND	ND	
9	1259.91	1253.67	1254.9	
10	1696.23	1696.99	1697.88	
11	ND	ND	ND	
12	1342.37	1343.75	1345.9	
13	1570.83	1575.38	1577.84	
14	863.63	864.97	866.09	
15	ND	ND	ND	
16	ND	ND	ND	
17	453.09	454.13	455.98	

18	ND	ND	ND	
19	ND	ND	ND	
20	ND	ND	ND	
21	ND	ND	ND	
22	1799.69	1805.28	1809.09	
23	ND	ND	ND	
24	1912.77	1911.35	1900.15	
25	1813.54	1821.34	1834.01	
26	ND	ND	ND	
27	ND	ND	ND	
28	991.55	964.87	908	
29	1749.58	1756.02	1768.09	
30	ND	ND	ND	
31	ND	ND	ND	
32	ND	ND	ND	
33	2359.07	2357.98	2356.98	
34	ND	ND	ND	
35	ND	ND	ND	
36	1961.27	1989.26	2007	
37	2176.12	2181.35	2190.9	
38	ND	ND	ND	
39	ND	ND	ND	
40	ND	ND	ND	

[Here, ND means not detectable. 23 samples complied with the standard whereas 17 samples didn't comply.]

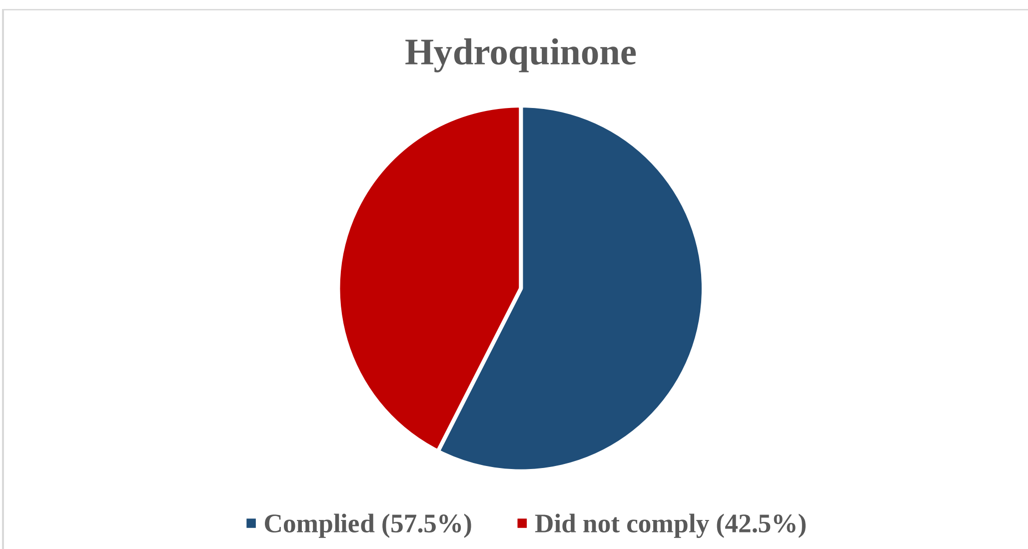

Figure1. Percentages of sample which complied and didn't comply with the standard limit of hydroquinone in the data set

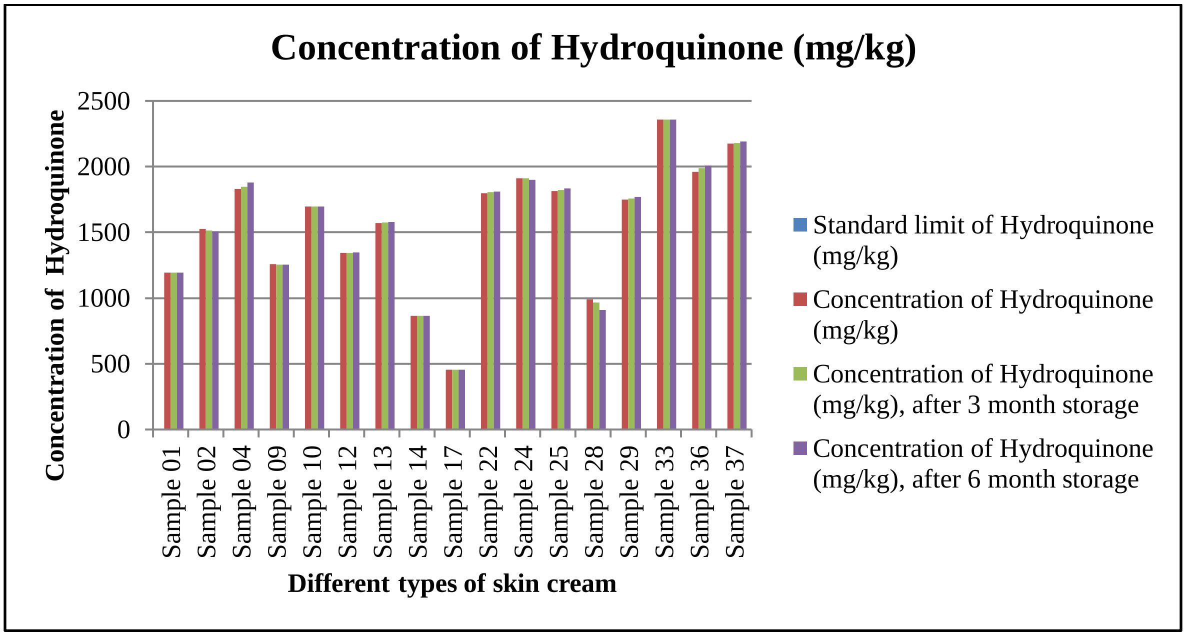

Figure 2. Concentration of excess hydroquinone in different samples of skin cream

Analysis of Mercury (Hg)

Among the 40 samples, 28 samples (70%) complied with the standard level of Hg and among them 20 samples (50%) did not contain any Hg. 12 samples (30%) contained a high level of Hg compared to the standard limit (Table-02; Figure-03, 04). The highest concentration of Hg (17.18 mg/kg) was observed in sample-27 among the examined samples (Table-02). After three and six months of storage, we had got the similar results in all the samples. Figure 4, represents the concentration of excess Hg in different samples at different storage times along with the standard limit.

Table 2. Concentration of Mercury (Hg) in skin cream of different samples

Sample ID	Mercury (mg/kg) Normal	Mercury (mg/kg) After 3 months storage	Mercury (mg/kg) After 6 months storage	Standard limit (mg/kg) (WHO/BDS)
1	0.027	0.026	0.025	1
2	3.28	3.26	3.24	
3	3.31	3.21	3.19	
4	ND	ND	ND	
5	ND	ND	ND	
6	0.3	0.31	0.34	
7	ND	ND	ND	
8	7.85	7.82	7.78	
9	ND	ND	ND	
10	8.843	8.72	8.53	
11	ND	ND	ND	
12	ND	ND	ND	
13	0.301	0.29	0.27	
14	ND	ND	ND	
15	0.762	0.76	0.76	
16	ND	ND	ND	
17	0.088	0.089	0.09	
18	14.84	14.85	14.87	

19	0.062	0.061	0.06	
20	15.15	15.12	15.08	
21	ND	ND	ND	
22	ND	ND	ND	
23	ND	ND	ND	
24	ND	ND	ND	
25	ND	ND	ND	
26	6.25	6.24	6.24	
27	17.18	17.32	17.54	
28	0.037	0.041	0.045	
29	ND	ND	ND	
30	ND	ND	ND	
31	9.18	9.78	9.98	
32	11.23	11.42	11.88	
33	ND	ND	ND	
34	ND	ND	ND	
35	0.023	0.023	0.023	
36	15.15	15.76	15.95	
37	ND	ND	ND	
38	12.42	12.41	12.42	
39	ND	ND	ND	
40	ND	ND	ND	

[Here, ND means not detectable. 28 samples complied with the standard whereas 12 samples didn't comply.]

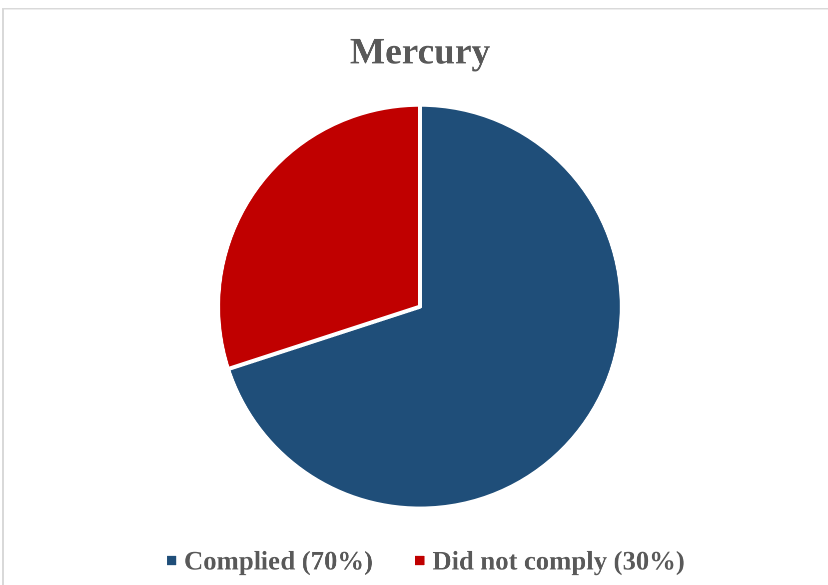

Figure 3. Percentages of sample which complied and didn't comply with the standard limit of Mercury in the data set

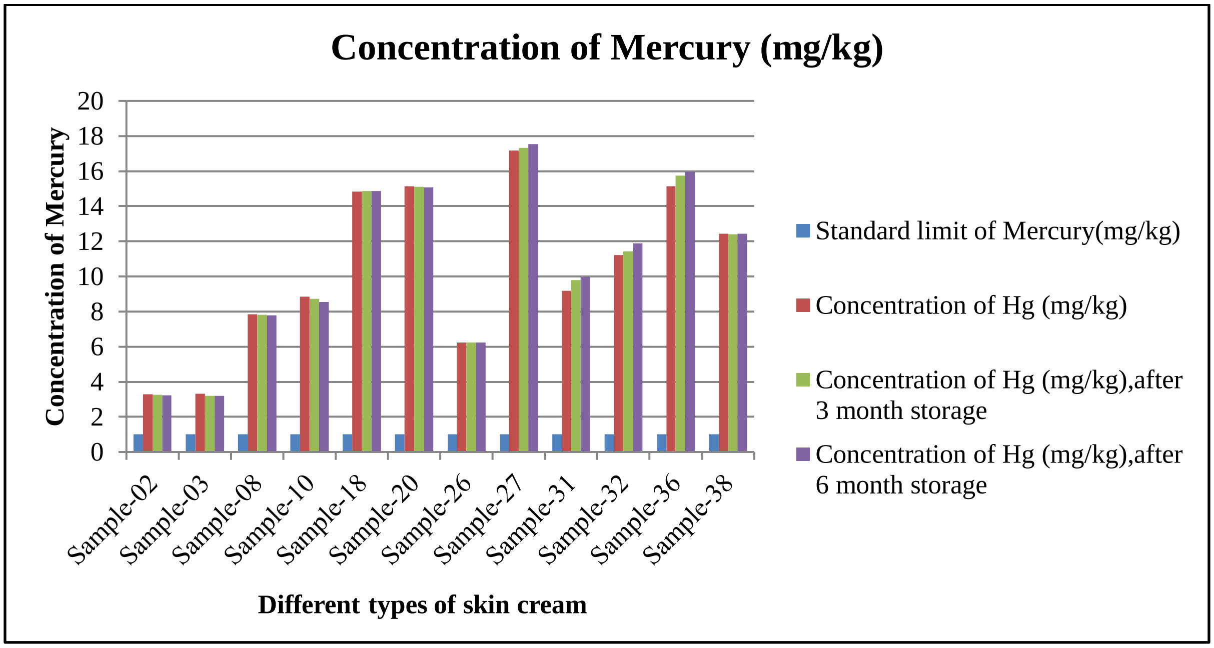

Figure 4. Concentration of excess Mercury (Hg) in different samples of skin cream

Among the forty samples in the data set, we found that fourteen samples (35%) had HQ and Hg levels within the standard limit, and among them, 10 samples had no HQ and Hg levels. We found 3 samples (7.5%) having a higher quantity of both HQ and Hg than the standard limit. 14 samples (35%) in the data set had higher HQ levels but complied only with the standard Hg level, whereas 9 samples (22.5%) had higher Hg levels and thus complied only with the standard hydroquinone level (Figure 5).

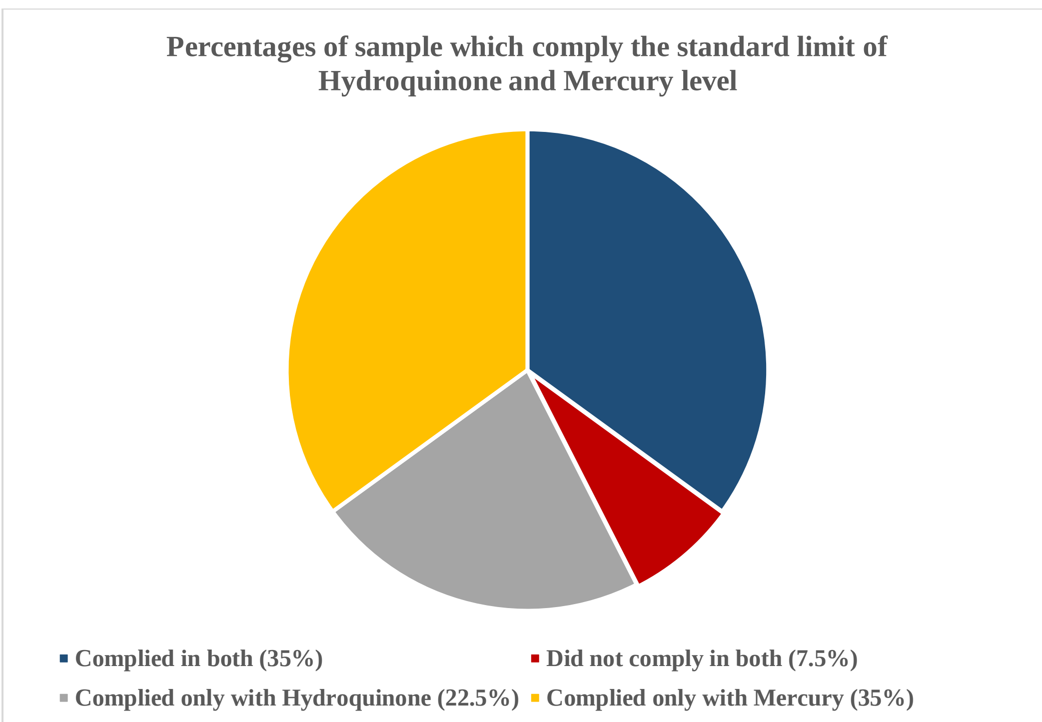

Figure 5. Percentages of sample which complied the standard limit of Hydroquinone and Mercury

Analysis of Lead (Pb)

Among the 40 samples of turmeric powder, 20 samples (50%) complied with the standard level of Pb, and among them, 9 samples (22.5%) did not contain any Pb. 20 samples (50%) contained a high level of Pb compared to the standard limit (Table-03; Figure-06, 07). The highest concentration of Pb (16.32 mg/kg) was observed in sample-31 among the examined samples (Table-02). After three and six months of storage, we had similar results in all the samples. Figure 7, represents the concentration of excess Pb in different samples at different storage times along with the standard limit.

Table 3. Concentration of Lead (Pb) in skin cream of different samples

Sample ID	Lead (mg/kg) Normal	Lead (mg/kg) After 3 months storage	Lead (mg/kg) After 6 months storage	Standard limit (mg/kg) (WHO/BDS)
1	11.41	11.39	11.33	2.5
2	15.99	15.79	15.62	
3	5.44	5.10	5.25	
4	5.30	5.36	4.77	
5	4.13	4.20	3.95	
6	5.61	5.67	5.44	
7	2.20	2.16	1.98	
8	14.77	14.38	15.80	
9	6.09	6.11	5.92	
10	ND	ND	ND	
11	ND	ND	ND	
12	7.68	7.70	7.45	
13	0.76	0.79	0.51	
14	1.41	1.39	1.55	
15	9.91	10.01	10.52	
16	ND	ND	ND	
17	ND	ND	ND	
18	ND	ND	ND	
19	14.84	14.17	14.07	
20	ND	ND	ND	
21	11.93	11.90	11.63	
22	12.80	12.71	12.74	
23	5.66	5.67	5.50	
24	5.98	5.91	5.82	
25	11.23	11.10	11.50	
26	2.23	2.13	2.17	
27	7.10	7.17	7.27	
28	1.25	1.10	1.31	
29	ND	ND	ND	
30	11.12	11.10	11.37	
31	16.32	16.10	16.83	
32	13.17	13.10	13.21	
33	1.55	1.45	1.32	
34	2.10	2.10	2.21	

35	1.32	1.09	2.17	
36	1.17	1.11	1.38	
37	2.22	2.10	2.43	
38	ND	ND	ND	
39	ND	ND	ND	
40	2.40	2.37	2.32	

[Here, ND means not detectable. 20 samples complied with the standard whereas 20 samples didn't comply.]

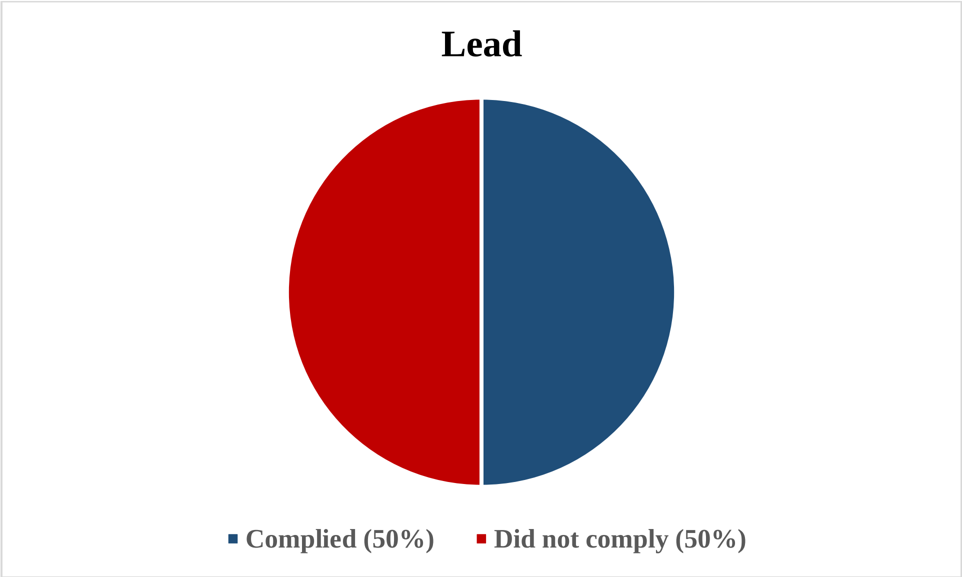

Figure 6. Percentages of sample which complied and didn't comply with the standard limit of Lead in the data set

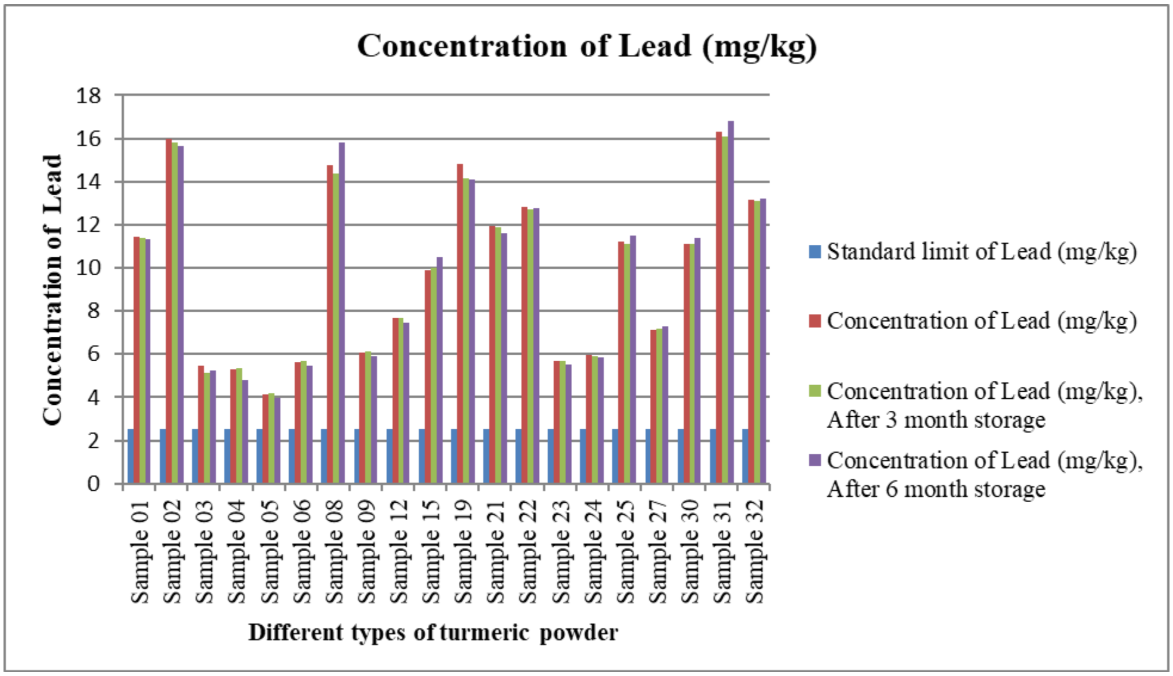

Figure 7. Concentration of excess Lead (Pb) in different samples of skin cream

Discussion

Skin-toning creams and turmeric powders are popularly used among Bangladeshi fashion and beauty-concerned women and young girls in general. However, it has been reported that excess use of skin cream and turmeric powder causes various dermatological problems, including skin cancer (Kooyers, Westerhof et al. 2006, Gbandama, Diabaté et al. 2019). Many years ago, the use of skin-toning creams was popular only among dark-skinned people. The trend has changed nowadays and their popularity has increased worldwide, even among Caucasians, who use them to diminish age spots or to give a lighter tone to the face or body (Kooyers, Westerhof et al. 2006). The production and sale of these products has generated big profits, especially in countries where laws are less stringent.Skin-toning creams are being manufactured and marketed even in local markets. A significant portion of women use these creams with the belief that they will look fairer. These creams are extensively promoted online and in the media. However, they may contain a wide variety of active ingredients that are toxic, especially after prolonged application. It was reported that these creams contain hydroquinone and mercury to a level that is hazardous to health (Amponsah, Voegborlo et al. 2014, Agorku, Kwaansa-Ansah et al. 2016). As a result, in the current study, we tried to assess the HQ and Hg levels in commonly used skin toning creams in the context of Bangladeshi women collected from the local markets in Dhaka city. For this purpose, different products of skin toning creams and turmeric powders were bought from the local markets in Dhaka, Bangladesh. A total of forty different Bangladeshi product samples of skin toning creams and forty different product samples of turmeric powders were collected to test the chemical parameters of HQ, Hg, and Pb. Furthermore, we evaluated the same parameters after three and six months of storage to see whether there were any alterations.

Among the 40 samples, 23 samples (57.5%) did not contain HQ and 17 samples (42.5%) contained a high level of HQ compared to the standard limit (Table-01; Figure-01, 02). The highest concentration of HQ (239.07 mg/kg) was observed in sample-33 among the examined samples (Table-01). After three and six months of storage, we had similar results in all the samples. In the case of Hg analysis, we found that 28 (70%) out of 40 samples complied with the standard level of Hg and among them, 20 samples (50%) did not contain any Hg. 12 samples (30%) contained a high level of Hg compared to the standard limit (Table-02; Figure-03, 04). The highest concentration of Hg (17.18 mg/kg) was observed in sample-27 among the examined samples (Table-02). After three and six months of storage, we had similar results in all the samples. After combining HQ and Hg data sets, we found that 14 (35%) out of the 40 samples had HQ and Hg levels within the standard limit, and among them, 10 samples had no HQ and Hg level. We have found 3 samples (7.5%) having a higher quantity of both HQ and Hg than the standard limit. 14 samples (35%) in the data set had higher HQ levels but complied only with the standard Hg level, whereas 9 samples (22.5%) had higher Hg levels and thus complied only with the standard hydroquinone level (Figure 5). So, in 65% of the samples, we found the presence of an excess level of either any one of the measured parameters or both. A similar study was conducted by Al-Saleh and Al-Doush (1997) on mercury concentration in creams obtained from the Saudi Arabian market and found an elevated level of Hg concentration (Al-Saleh, Al-Doush et al. 1997). Results of Hg determined in cosmetic products obtained from Dar es Salaam Market in Tanzania also showed a very high concentration of mercury in some creams and in some soaps compared to the standard limit. Kinabo et al. (2005) conducted the study and found that the total Hg level ranged from 0.16–25.30 mg/kg in cosmetic creams (Kinabo 2005).

Among the 40 samples of turmeric powder, 20 samples (50%) complied with the standard level of Pb, and among them, 9 samples (22.5%) did not contain any Pb. 20 samples (50%) contained a high level of Pb compared to the standard limit (Table-03; Figure-06, 07). The highest concentration of Pb (16.32 mg/kg) was observed in sample-31 among the examined samples (Table-02). After three and six months of storage, we had similar results in all the samples.

The overall results indicate that many of the skin-toning creams (65% of the data set) sold in the Bangladeshi market contained one or more toxic ingredients, and 50% of the turmeric powder contained high levels of Pb that, in most cases, were not listed on the packaging. The use of these creams and turmeric powder, which did not comply with the standard limit, may pose a serious health risk to women as HQ, Hg, and Pb levels are high and their continuous use may pose a severe threat to their health depending on the frequency of application, the duration of practice, the area of the body involved, as well as their use during pregnancy and lactation. HQ, Hg, and Pb can accumulate in the liver and kidneys, which can cause damage to these organs (Clarkson 1997). Moreover, HQ, Hg, and Pb are known cumulative agents that can be absorbed through the skin and can cause serious localized cutaneous conditions (Boyd, Seger et al. 2000, Ladizinski, Mistry et al. 2011).

So, consumers should be urged not to use products if there is no ingredients list on the label. Some skin toning creams demand that they contain HQ and Hg below the standard limit, but it was found that they contained high levels of HQ and Hg. This sort of information in the packaging paper misguides the users as well as causes concern for their health. The current sample-based study shed some light on the prevalence of HQ and Hg in skin toning creams and Pb in turmeric powders available in Bangladesh and will eventually help the general public understand the risk of developing various dermatological diseases, as well as neurological and kidney impairment, and even cancer, among chronic users. The results of the study will also assist policymakers in taking appropriate and stringent steps to prevent the manufacturing and marketing of skin-toning creams with high levels of HQ and Hg and turmeric powder with high levels of Pb.

Acknowledgement

This paper work is being supported by Biotechnology Research Centre, Dhaka University during the fisccal year 2021-22.

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