

# Assessment of phthalate knowledge, plastic use practices and cheese handling among adults in Jeddah city (Saudi Arabia)

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## ABSTRACT

**Background:** Phthalates are chemical compounds that have the tendency to migrate into food and beverages, thereby leading to negative health consequences. **Aims:** was to assess the knowledge of phthalates and practices relating to plastic use among adults residing in Jeddah, Saudi Arabia, with an emphasis on cheese wrapped in plastic materials. **Material and Methods:** A total of 435 adult participants completed an online questionnaire consisting of three sections 1) socio-demographic characteristics, 2) knowledge-related phthalates, and 3) practices related to plastic use. All collected data were verified and analyzed using the Statistical Package for Social Sciences (SPSS). **Results:** Our findings revealed that 64.1% of the respondents had poor knowledge regarding plastics and phthalates with gender being a significant factor ( $p=0.0003$ ). The usage rate of plastic material was found to be remarkably high with 38.2% keeping the purchased cheese either in its original plastic wrapping or placed inside plastic boxes. Moreover, 53.6% never viewed the safe plastic number before purchasing the food products. However Interestingly enough, the type of plastics did not influence participant's decision-making process when it came down to purchasing or consuming cheese (45.1% & 46.2%, respectively). Respondents who had poor practice represented up to 85 %, while those with poor knowledge and practice constituted 65.1%. However, no significant link between these two factors could be established. **Conclusions:** Poor awareness levels concerning phthalates along with imprudent usage rates for plastics were observed among adults living within Jeddah city's boundaries; thus, appropriate interventions aimed at raising awareness need implementation so as minimize exposure risks associated with this issue.

**Keywords:** Phthalate, Plastic use, Cheese, Knowledge, Practice, Saudi Arabia.

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## 1 Introduction

Phthalates are a group of organic compounds that are used to soften polyvinylchloride and other plastics <sup>1</sup>. When added to plastic materials, they enhance the extensibility, elasticity, and workability of the polymers <sup>2</sup>. Therefore, they are omnipresent because of their wide use in products destined for human consumption <sup>3</sup>.

As such, biomonitoring studies have confirmed that all age groups of the general population are under continuous and ubiquitous exposure to phthalates <sup>4</sup>. According to the review published by Wang et al. <sup>5</sup>, human exposures to phthalate were significantly associated with negative effects on reproductive outcomes, asthma, allergy, diabetes mellitus type

2 and insulin resistance, and overweight / obesity. Consequently, the presence of phthalates in consumable plastic represents a universal health issue as reported by Giuliani et al. <sup>2</sup>.

Phthalates can be released into the environment during production up to the elimination route of plastic-based products. In addition, it is well established that phthalates are chemical compounds characterized by an easy migration into foods and beverages that are packaged into various plastic materials. Subsequently, food intake and drinking water are labeled as important routes of human exposure <sup>6, 7</sup>. The migration of phthalate can happen at any step of food processing and includes the preparation steps, storing, and transportation. In their review of food monitoring and

epidemiology data, Serrano et al.<sup>8</sup> concluded that diets high in dairy consumption resulted in increased risk of phthalate exposure. In alignment with this fact, it is also observed that most commercial milk products are packaged in plastic or other polymer materials and represent a potential source of phthalate migration<sup>9,10</sup>. Because of their high content of fats, milk and in particular dairy products possess a high tendency to be contaminated by phthalates<sup>2</sup>. Similarly, previous analytical and chemical studies have identified significant levels of phthalates in cheeses packed in plastic films, thereby raising health concerns<sup>11</sup>. In the Kingdom Saudi Arabia (KSA), cheese consumption is high and in Al-Daghri et al.'s study<sup>12</sup> conducted on Saudi children and adults showed that 38.7% of males and 35.4 % of females consumed this food item one to three times per day. In addition, a national representative survey in 2016 found that the mean of daily cheese consumption of men and women was  $43.7 \pm 0.9$  g/day<sup>13</sup>. Given the increasing evidence-based findings that correlate phthalate exposure with harmful health outcomes, it is crucial to identify the prevalence phthalate intake in the Saudi population. In addition, it is not possible to enforce a complete avoidance of plastic material packaging for dairy based food and drinks, therefore, increasing awareness among consumers should be a priority. This would include specific recommendations on how to select plastic of decent quality and utilize it appropriately. Moreover, emphasis could also be placed on indicating best practices related to purchase and consumption of cheese considering the phthalate translocation into the packaged food. In order to ensure a successful awareness campaign intervention, it is crucial to understand and identify the actual knowledge and practices in a given population. Thus, in the present study, the authors undertook a study to assess the awareness of a population of adults living in Jeddah, Saudi Arabia with regard to the potential presence of phthalates in packaged food and their practices relating to how they use and dispose of packaged plastic. This evaluation was performed using a newly developed questionnaire that was tested for reliability and validity.

## 2 Subjects and Methods

### 2.1 Study design and participants

A cross-sectional study was conducted from April to August 2023, with data collection performed through an online questionnaire. Participants were recruited using social media applications such as WhatsApp and Twitter. The objective of the study and nature of participation were thoroughly explained in the questionnaire announcement. Participants were granted the right to accept or refuse participation and to withdraw at any time. Participant data remained anonymous and confidential.

### 2.2 Sample size calculation and sampling technique

A total of 435 respondents aged 20 – 59 years and residents in Jeddah (KSA) participated in this study. Exclusion criteria included individuals with lactose intolerance or disliking cheese taste, as it might affect the habits of purchasing and consuming cheese. All participants were entirely aware of the participation requirements and informed that the participation was voluntary. The data collected remained confidential and anonymous. Prior carrying out the study, the IRB (Institutional Review Board) approval for the study protocol was obtained from the Research Ethics Committee (Ethics number 485-23) at King Abdulaziz University (Jeddah, KSA).

The convenience sampling method was used in this study. The sample size was calculated based on the sample size equation<sup>14</sup> based on the total population of Jeddah City<sup>15</sup> of 1,716,574, where the z score for 95% confidence level = 1.96, p = the prevalence of the factor under study was estimated to be 50%, as no data are available in the literature in KSA as per the prevalence of good level of knowledge regarding phthalate, q = 1-p = 50% and d = margin of error = 0.05%. Thus, the study's sample size was estimated to be a minimum of 384 participants. An additional 10% was included to avoid any missing or incomplete data. Thus, the final minimum total required was 423 participants.

### 2.3 Research tools

The online questionnaire in Arabic language used for data collection contained 3 sections.

**Section 1:** consisted of questions related to the collected socio-demographic information including sex, nationality, age, educational level, monthly income, and health status.

**Section 2:** concerned data on knowledge related to phthalates. 16 items were elaborated in this section based on definition and scientific facts on phthalates.<sup>2</sup> The items were formulated as statements to which respondents can approve by selecting the answer "yes" or disapprove by selecting "No." In addition, the respondent also could select "I do not know" or "I am not sure" if is not knowledgeable about the correct answer. For each correct answer, the respondents are attributed 2 points, while 0 point is earned if the answer is false. While a score of 1 is attributed in the case of responding by "I don't know" or "I am not sure". The minimum total scoring that could be obtained is 0 and maximum is 32. Categorization of knowledge was by considering a scoring of 16 as cut-off point which corresponds to 50% of maximum scoring. If the total obtained score is < 16 then the category is "poor knowledge", while if the total obtained score is >16 then the category is "good knowledge".

**Section 3:** The aim of this section was to evaluate practices regarding the use of plastic materials and more specifically regarding the purchase and consumption of cheese. The section was composed of 11 items with response categories based on the following frequency scale: never, rarely, sometimes, frequently, and always. The scoring for good practices was: 1 for never, 2 for rarely, 3 for sometimes, 4 for frequently, and 5 for always. A reverse scoring was considered for the negative practices where never was scored 5 points, rarely scored 4 points, sometimes scored 3 points, frequently scored 2 points, and always 1 point. The maximum and minimum total scoring obtainable was 55 and 11 points, respectively. The cut-off points to categorize the respondent as having a poor or good practice were 33 scores, corresponding to 50% of the difference between the total maximum and total minimum scores.

## 2.4 Validity and reliability of the questionnaire

Before using the questionnaire, it was subjected to a pre-testing procedure to ensure its validity and reliability. Therefore, the questionnaire was revised by a panel of 9 experts in nutrition and/or food sciences to assess its face validity. The results indicated that 88.9% of the experts judge the content of the questionnaire to be complete and comprehensible. In terms of relevance of the time required to complete the questionnaire, the average was  $8.9 \pm 1.4$  on a scale 0 – 10.

Moreover, the assessment of both Content Validity Index for individual items (I-CVI) and Content Validity index for scale (S-CVI) by the panel who evaluated the questionnaire considering the relevance of each question based on a 4-point Likert scale (1= not relevant, 2= relevant, 3= relevant and 4= truly relevant). S-CVI/Average and S-CVI/Universal agreement was calculated as reported by Rodrigues et al. <sup>16</sup>. For I-CVI, the obtained values were equal to 1 for 20 items, 0.89 for 5 items and 0.78 for 2 items. Content Validity Index for the scale (S-CVI)/Average was equal to 96.3%; Content Validity Index for the scale (S-CVI)/Universal agreement was 81.5% and the mean expert proportion 96.7%. Some modifications were performed based on the panel suggestions to improve the overall quality and merit of the questionnaire. As for reliability testing, the Alpha Cronbach's coefficient was 0.88 and 0.68 for the knowledge and practice sections, respectively. The Alpha Cronbach's coefficient  $\alpha = 0.72$  for the entire questionnaire was obtained, indicating that the questionnaire demonstrated acceptable internal consistency <sup>17</sup>. Taken together, the questionnaire was considered as valid and reliable and could be used for the study.

## 2.5 Data analysis

Results in the presented study are expressed in percentages or in mean  $\pm$  standard deviation (SD). Associations between socio-demographic characteristics and knowledge and practices were assessed using the Chi<sup>2</sup> test. ANOVA and T-test were applied to the test significance of mean differences according to the total scores obtained by respondents. A cut-off points of 0.05 for p-value was set for significance. All statistical analysis were performed using SPSS software (version 24.0).

**Table 1.** Socio-demographic characteristics of the studied population (n = 435)

Variable Data	n	%
<b>Gender</b>		
- Male	102	23.4
- Female	333	76.6
<b>Nationally</b>		
- Saudi	387	89.0
- Non-Saudi	48	11.0
<b>Age range (Years)</b>		
- 18 – 29	40	9.2
- 30 – 39	106	24.4
- 40 – 49	167	38.4
- 50 – 59	122	28.0
<b>Educational level</b>		
- Secondary School	55	12.6
- University degree	273	62.8
- Higher studies	107	24.6
<b>Income Monthly (SR)</b>		
- < 7750	97	22.3
- 7750 – 15300	171	39.3
- > 15300	167	38.4
<b>Health Status</b>		
- Healthy	286	65.7
- Unhealthy	149	34.3
<b>Total</b>	<b>435</b>	<b>100%</b>

## 3 Results

### 3.1 Socio-demographic characteristics

Table 1 summarizes the socio-demographic characteristics of the studied population. Of the total (n=435) group surveyed, 76.6% of the respondents were female, and the majority (89%) were Saudis. Age groups were all represented, with the highest proportion 40 – 49 years by 38.4%. In terms of educational level, 62.8% had a university degree versus about ¼ achieved higher studies. There were almost equal proportions for monthly income of 7,750 – 15,300 SAR and >15,300 SAR by 39.3% and 38.4%, respectively. Regarding health status, about two thirds (65.7%) self-report being healthy.

**Table 2.** Knowledge of the studied population regarding the phthalates (n=435) (in bold the correct answer)

Items	Answers							
	No		Not sure		I don't know		Yes	
	n	%	n	%	n	%	n	%
1. Phthalate esters are plastic materials	<b>19</b>	<b>4.4</b>	79	18.2	249	57.2	88	20.2
2. Phthalate esters are materials that add flexibility and transparency to plastics	3	0.7	84	19.3	250	57.5	<b>98</b>	<b>20.5</b>
3. Phthalate esters are chemically bonded to the plastic they are added to	<b>9</b>	<b>2.1</b>	88	20.2	244	56.1	94	21.6
4. Phthalate esters transfer to foods or products that are coated or packaged in plastic	7	1.6	90	20.7	237	54.5	<b>101</b>	<b>23.2</b>
5. Preservation at low temperature and cold foods causes greater translocation of phthalate esters to plastic-wrapped or packaged products	<b>40</b>	<b>9.2</b>	105	24.1	240	55.2	50	11.5
6. The lower the percentage of fat, the less transfer of phthalate esters to foods	<b>23</b>	<b>5.3</b>	107	24.6	266	61.1	39	9.0
7. Increasing the surface area exposed to plastic in packaging increases the transfer of phthalate ester	10	2.3	85	19.5	252	57.9	<b>88</b>	<b>20.2</b>
8. Reheating plastic-coated foods in the microwave reduces the translocation of phthalate esters from plastic to foods	<b>97</b>	<b>22.3</b>	73	16.8	217	49.9	48	11.0
9. Increasing the time-period for exposing foods to packaging or plastic packaging increases the transmission of phthalate esters	9	2.1	89	20.5	229	52.6	<b>108</b>	<b>24.8</b>
10. Consuming food products with content in phthalate esters affects the functions of liver and kidneys	3	0.7	87	20.0	231	53.1	<b>114</b>	<b>26.2</b>
11. Consumption of phthalate esters reduces thyroid activity	<b>9</b>	<b>2.1</b>	101	23.2	265	60.9	60	13.8
12. Consumption of phthalate esters may be a cause of weight loss	<b>34</b>	<b>7.8</b>	97	22.3	288	66.2	16	3.7
13. Consumption of phthalate esters is associated with the risk of metabolic disorders in humans	3	0.7	91	20.9	275	63.2	<b>66</b>	<b>15.2</b>
14. Consumption of phthalate esters affects the role of antioxidants in the human body	2	0.5	73	16.8	278	63.9	<b>82</b>	<b>18.9</b>
15. Phthalate esters cause an alteration in the secretion of endocrine hormones	2	0.5	87	20.0	280	64.4	<b>66</b>	<b>15.2</b>
16. Phthalate esters compounds lead to an imbalance in the secretion of sex hormones	4	0.9	89	20.5	287	66.0	<b>55</b>	<b>12.6</b>

### 3.2 Knowledge related to phthalates

Table 2 represents the participants (n=435) distribution according to their responses to the questions related to phthalates. It is evident that for all the questions, the highest percentage was in the category "I don't know" and in general, more than two-thirds either they did not know or were not sure of the answer. While the percentage of respondents who answered correctly was exceptionally low overall. The lowest percentage, 2.1% (n=9), was obtained for question 2 ("Phthalate esters are chemically bonded to the plastic they are added to") and question 11 ("Consumption of phthalate esters reduces thyroid activity"). Highest percentage of correct answers was observed for question 10 ("Consuming food products with content in phthalate esters affects the functions of liver and kidneys") at 26.2%, followed by question 9 ("Increasing the time-period for exposing foods to packaging or plastic packaging increases the transmission of phthalate esters") at 24.8%.

The knowledge of the respondents based on their scoring and according to their socio-demographic characteristics is presented in Table 3. Overall, 64.1% of the respondents belonged to the category "Poor knowledge" versus 35.2% considered as having good knowledge related to phthalates. Chi-square analysis revealed that gender was the only characteristic with significant association ( $p=0.0003$ ), as the proportion of women with good knowledge was greater compared to men. This result is confirmed by the T-test for mean, as the p-value is 0.0006, and the average score is  $16.7 \pm 1.7$  and  $17.5 \pm 2.7$  for men and women, respectively. In terms of nationality, age range, educational level, monthly income, and health status, the percentage of respondents with poor knowledge was higher as compared to good knowledge, although no significant association was obtained. Similarly, there were no mean differences between the subcategories of these characteristics according to the p-values (T-test or One-Way ANOVA).

**Table 3.** Knowledge of the studied population regarding the phthalates according to the socio-demographic characteristics (n=435)

Socio-demographic N=435	Poor knowledge (Total score ≤16) (n=279, 64.1%)		Good knowledge (Total score >16) (n = 156, 35.2%)		p-value*	Mean ± SD	p-value <sup>§</sup>
	n	%	n	%			
<b>Gender</b>							
- Male (n=102)	80	78.4	22	21.6	0.0003	16.7±17	0.0006
- Female (n=333)	199	59.8	134	40.2		17.5±2.7	
<b>Nationally</b>							
- Saudi (n=387)	254	65.6	133	34.4	0.064	17.7±2.4	0.21
- Non-Saudi (n=48)	25	52.1	23	47.9		17.3 ±2.5	
<b>Age range (Years)</b>							
- 18 – 29 (n=40)	26	65.0	14	35.0	0.88	17.1±2.1	0.65
- 30 – 39 (n=106)	68	64.2	38	35.8		17.3±2.3	
- 40 – 49 (n=167)	112	67.1	55	32.9		17.4±2.8	
- 50 – 59 (n=122)	73	59.8	49	40.2		17.4±2.3	
<b>Educational level</b>							
- Primary/Secondary School (n=52)	33	63.5	19	36.5	0.36	17.3±2.6	0.03
- University degree (n=273)	182	66.7	91	33.3		17.1±2.1	
- Higher studies (n=107)	63	58.9	44	41.1		17.8±3.1	
<b>Income Monthly (SR)</b>							
- < 7750 (n=97)	58	59.8	39	40.2	0.38	17.4±2.3	0.35
- 7750 – 15300 (n=171)	116	67.8	55	32.2		17.1±2.3	
- > 15300 (n=167)	105	62.9	62	37.1		17.5±2.8	
<b>Health Status</b>							
- Healthy (n=286)	182	63.6	104	36.4	0.76	17.5±2.8	0.41
- Unhealthy (n=149)	97	65.1	52	34.9		17.2±2.3	

(\*X2, §One way ANOVA or T-Test)

### 3.3 Practices related to plastic use and cheese consumption

The practices regarding plastic use and cheese consumption are summarized in Table 4. The use of plastic material was extremely high, with 43.4% of respondents consistently using plastic bags, followed by 33.1% and 30.1% for plastic bags in food packaging and plastic rolls, respectively. Plastic spoons and cups are less frequently utilized. When purchasing cheese wrapped in plastic or placed in plastic boxes, only 39.5% of respondents would transfer it to glass or non-plastic containers throughout its use, while 38.2% prefer storing it in the original packaging. For cheese wrapped or boxed in plastic, it is retained in plastic boxes, and the remaining portion is wrapped in plastic until consumption. Interestingly, more than half (53.6%) of respondents reported never checking the safe plastic number before purchasing a food product wrapped in it. Additionally, the type of plastic never influences the decision to purchase or

consume the cheese, as indicated by 45.1% and 46.2%, respectively.

The distribution of respondents based on their practice the phthalates, according to socio-demographic characteristics, is presented in Table 5. In general, the majority of the studied population (85.0%) demonstrated poor practice, while only 15% exhibited good practice. Subcategories within various socio-demographic characteristics exhibited similar trends, and no significant association with the level of practice was observed. This result is aligned with the comparison of the practice mean which was non-significant (p-value > 0.05). Furthermore, all mean values were significantly below the cut-off point of 33 scores.

**Table 4.** Practices related to plastic use and cheese consumption by the studied population (n=435)

	Never		Rarely		Sometimes		Frequently		Always	
	n	%	n	%	n	%	n	%	n	%
How often do you use plastic bags?	5	1.1	50	11.5	93	21.4	98	22.5	189	43.4
Do you look at the safe plastic number before purchasing the food product that is wrapped in it?	233	53.6	96	22.1	72	16.6	12	2.8	22	5.1
How often do you use plastic bags used for food packaging?	19	4.4	91	20.9	111	25.5	83	19.1	131	30.1
How often do you use plastic roll?	8	1.8	88	20.2	110	25.3	85	19.5	144	33.1
How often do you use plastic cups?	70	16.1	149	34.3	100	23.0	55	12.6	61	14.0
How often do you use plastic containers as foods package?	20	4.6	89	20.5	115	26.4	207	47.6	104	23.9
How often do you use plastic spoons?	61	14.0	173	39.8	103	23.7	48	11.0	50	11.5
When purchasing cheese is wrapped in plastic or placed in plastic boxes, it will be kept in the plastic boxes and the remaining part is wrapped in plastic until consumption	39	9.0	29	6.7	90	20.7	111	25.5	166	38.2
If the purchased cheese is wrapped in plastic or placed in plastic boxes, it will be transferred to glass or non-plastic containers throughout its use	172	39.5	115	26.4	72	16.6	39	9.0	37	8.5
The type of plastic used to wrap the cheese influences my decision to buy or not the food product	196	45.1	92	21.1	90	20.7	39	9.0	18	4.1
The type of plastic used in cheese packaging influences my decision to consume or not the food product	201	46.2	92	21.1	80	18.4	43	9.9	19	4.4

**Table 5.** Practices of the studied population regarding the phthalates according to the socio-demographic characteristics (n=435)

Socio-demographic N=435	Poor knowledge (Total scores≤16) (n=279, 64.1%)		Good knowledge (Total score >16) (n = 156, 35.2%)		p-value*	Mean ± SD	P-values
	n	%	n	%			
<b>Gender</b>							
- Male (n=102)	87	85.3	15	14.7	0.93	26.6±6.4	0.77
- Female (n=333)	283	85.0	50	15.0		26.4±6.7	
<b>Nationally</b>							
- Saudi (n=387)	331	85.5	56	14.5	0.43	26.5±6.5	0.42
- Non-Saudi (n=48)	39	81.3	9	18.8		25.6±7.8	
<b>Age range (Years)</b>							
- 18– 29 (n=40)	35	87.5	5	12.5	0.85	27.3±5.2	0.57
- 30 – 39 (n=106)	91	85.8	15	14.2		26.9±6.8	
- 40 – 49 (n=167)	143	55.6	24	14.4		26.5±6.6	
- 50 – 59 (n=122)	101	94.4	21	19.6		25.8±7.1	
<b>Educational level</b>							
- Primary/Secondary School (n=52)	44	80.0	11	20.0	0.31	27.3±7.1	0.32
- University degree (n=273)	231	84.6	42	15.4		26.6±6.6	
- Higher studies (n=107)	95	88.8	12	11.2		25.9±6.4	
<b>Income Monthly (SR)</b>							
- <7750 (n=97)	87	80.4	19	19.6	0.38	27.5±7.3	0.31
- 7750 – 15300 (n=171)	147	86.0	24	14.0		25.9±6.6	
- >15300 (n=167)	145	86.8	22	13.2		26.5±6.2	
<b>Health Status</b>							
- Healthy (n=286)	242	84.6	44	15.4	0.72	26.7±6.5	0.15
- Unhealthy (n=149)	128	85.9	21	14.1		26.0±6.9	

(\*X2, \$One way ANOVA or T-Test)

### 3.4 Association between knowledge and practice

Table 6 illustrates the association between knowledge of phthalates and practice regarding plastic use and cheese consumption among the studied population. More than half of participants showed poor knowledge and poor practice (65.1%). However, no significant relationship was found between the level of knowledge and practice ( $p=0.06$ ).

**Table 6.** Association between knowledge of phthalates and practice regarding the plastic use and cheese consumption among the studied population (n=435)

	Poor practice (Total score $\leq 33$ ) (n=370)		Good practice (Total score $> 33$ ) (n=65)		p-value*
	n	%	n	%	
Poor knowledge (Total score $\leq 16$ ) (n=279)	244	56.1	35	8.0	0.06
Good knowledge (Total score $> 16$ ) (n = 156)	126	29.0	30	6.9	

## 4 Discussion

In the light, this study aimed to assess knowledge related phthalates and plastic use practices, with a focus on cheese consumption among the adult population of Jeddah City (KSA). The interest in this study arises from continuous and alarming human dietary exposure to chemicals such as phthalates, which would lead to adverse consequences on human health<sup>18</sup>. There is therefore a priority issue for public health and should generate sufficient interest to be addressed by the community, scientific organizations, and authorities. However, no prior studies were conducted aiming to communicate an insight analysis to address the knowledge-gap among the adult population in Jeddah (KSA). Hence, results of this study would illuminate the opportunity to develop appropriate intervention and research for a larger scale.

Overall knowledge of the study population was poor, as evidenced by the fact that only 2.1% of the respondents answered Question 3 and Question 11 correctly, and the correct answer was provided by more than one quarter of respondents to one only question (Question 10). Additionally, almost two thirds of the respondents were classified into the poor knowledge subgroup because their total score was  $\leq 16$ . Overall, this fact is supported by Hu and Chen<sup>19</sup> who stated that phthalates are invisible chemicals

and several consumers may not be aware of their health risks due to lack of knowledge. Remarkably, socio-demographic characteristics have been demonstrated to influence knowledge. Thus, Bucci et al.<sup>20</sup> surveyed the general Canadian population to assess their perception of the risks associated with plastic products containing phthalate. These authors showed that participants with a higher level of education may be more aware of the chemical dangers of plastic products. In the present study, the level of education had no significant effect, in contrast women showed

significantly higher knowledge than men<sup>20</sup>. This could be explained the fact that sex affects roles and responsibilities, such that women care more about their health than men<sup>21</sup>.

In practice related to the use of plastic within the population studied, this is concerned as indicated by the present study's findings which clearly demonstrated that the overall use is extremely high, but supported with inappropriate consideration of the type of plastic material. In fact, apart from the high frequency of use of plastic items such as bags, cups, and rolls, the decision to purchase or consume cheese was not affected by the type of plastic used to wrap this food. Moreover, the practices adopted regarding cheese wrapped in plastic materials further confirm that the study population has a limited perception of risk and little consideration towards phthalates, which leads them to a high rate of exposure to this molecule. According to CDC (2009), as individuals can be exposed to phthalates at any time, manufacturers should respect the regulatory approach for phthalates in food contact applications and ensure compliance with the legislation required to minimize potential impacts on the vulnerable population<sup>22</sup>. CDC (2009) also pointed out that consumers who serve or sell food or beverages packaged with products containing phthalates increase exposure to phthalates through ingestion<sup>22</sup>. Likewise, the Saudi Food and Drug Authority published in 2013 regulation of food contact plastics under food packing regulations<sup>23</sup>. However, at the consumer level, effort should be implemented to increase adequate use of plastic and appropriate handling of food wrapped in plastic

materials. In our study, cheese was taken as a case study because of the high quantity and frequency consumption among population living in Saudi Arabia<sup>12</sup>. Cantonwine et al. revealed that using bottled water for cooking and plastic cisterns for water storage led to significant increase of phthalate esters concentration in consumer's urine<sup>24</sup>. In terms of the association between knowledge and practices, these two parameters were not significantly related. Similar findings were concluded by Hartmann and Klaschka, when comparing the frequency of purchasing plastics to phthalate awareness<sup>25</sup>. These researchers concluded that the public might assume that all plastic products to be considered safe for use.

Limitations of this study include convenience sampling technique and targeting one city population in KSA for data collection. Therefore, results may not be generalizable to all the adult population adult in KAS. Yet, the study's findings are promising in terms of giving a first insight analysis as per knowledge and practice towards phthalates, and specifically in purchasing, storing and consuming cheese wrapped in plastic materials. Another strength is the use of valid and reliable newly developed tools specifically for this study.

## 5 Conclusion

To the best of our knowledge, this is the first study to assess the knowledge and practices regarding phthalates, with a focus on cheese wrapped in plastic material among adults (both male and female) in Jeddah city (KSA). In general, except for gender no significant associations were found between the sociodemographic characteristics and knowledge/ practices. Both poor knowledge and poor practices are notably prevalent, indicating a high potential exposure to phthalates.

In summary, these results underscore an urgent need to develop and implement tailored interventions for the adult population in Jeddah City (KSA). For success and comprehensiveness, the intervention should incorporate multiple components, as recommended by Martin et al. (2022), including replacement products and/or diets, targeting various routes of exposure, and personalized and interactive educational components<sup>26</sup>. All these measures may contribute to reducing phthalate exposure in this population. Finally, more research studies are needed such There one aspect that would be interesting to add in the future research is including the attitude component in the study tool, expanding the study to cover other wrapped food products other than cheese, estimating actual risk exposure to phthalate from cheese consumption, covering larger geographic areas and assessing feasibility of a potential education interventional program.

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