Consumers' willingness to adopt genetically modified foods

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Abstract
Purpose – This study investigates consumers' willingness to adopt genetically modified foods (GM) and the role of innovation and behavioral determinants.
Design/methodology/approach – A new integrated model that expands the Health Belief Model (HBM) into the Innovation Diffusion Theory (IDT) was developed and examined. A total of 241 consumers were selected from the capital of Iran, Tehran, through a multistage random sampling. The data were analyzed using SEM-PLS modeling.
Findings – The extended HBM model was able to predict about 84% of the variance changes in consumers' willingness to adopt GM foods. The effects of net benefit and perceived compatibility on the willingness were also significant. In addition, the mediating effect of compatibility on the relationship between net benefit/self-efficacy and willingness to adopt GM foods was also significant.
Originality/value – This study contributes to the literature by developing the HBM into the IDT to assess consumers' willingness to adopt GM foods.

Keywords Genetically modified foods, Willingness to adopt, Health belief model, Compatibility, Net benefit
Paper type Research paper

1. Introduction
Presently, the role of sustainability in the context of production and consumption has gained considerable attention (Valente and Chaves, 2018). As the same time, given the importance of genetic engineering in sustainable agriculture production (Nicolia *et al.*, 2014), the use of genetically modified (GM) foods has been increasing due to its benefits (e.g. productivity) (Prati *et al.*, 2012). In spite of the potential benefits of GM products from commercial producers, the ambivalent effects of these products have been debated by consumers, policymakers and governments (Pino *et al.*, 2016; Montuori *et al.*, 2012; Domingo and Giné Bordonaba, 2011). Therefore, using transgenic food products faces pushback and public doubt (Hudson *et al.*, 2015; Magnusson and Koivisto Hursti, 2002; Renko *et al.*, 2003) and

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resistance from consumers (Colson and Huffman, 2011). In a study on GM foods, Gao and Knight (2009) reported ambiguous views on GM foods amongst Chinese consumers. In a related study, Ghasemi *et al.* (2019) investigated the factors affecting social risk perception associated with GM foods in Iran.

Given the necessity of technologies (e.g. gene technology) for innovations that ultimately result in economic growth, understanding the drivers of public adoption becomes imperative (Siegrist *et al.*, 2016). Chen and Li (2007) examined the role of public attitude in developing technologies related to GM foods to achieve favorable outcomes. Additionally, GM foods studies are needed to further assess consumers' willingness and behavioral reactions resulting from the benefits and risks of GM foods (Prati *et al.*, 2012; Costa-Font and Gil, 2009).

This study contributes to the GM foods literature by developing a new integrated model that expands the Health Belief Model (HBM) into the IDT and used to assess consumers' willingness to adopt GM foods. Previous scholars (e.g. Rodríguez-Entrena *et al.*, 2013) studied intention to adopt GM foods using the Theory of Planned Behavior (TPB) (Prati *et al.*, 2012). Intention impacts willingness of performing a behavior (Jiang *et al.*, 2016). Therefore, it is appropriate to apply components of HBM in this study to examine the willingness to adopt GM foods. Moreover, Yazdanpanah *et al.* (2015a) also used this model for investigation of consumers' willingness to use organic foods in Iran while taking into account perceived safety risk.

The extended conceptual framework, in this study, is based on the HBM due to its effectiveness in explaining health behavior (Irwin *et al.*, 1988). The purpose of this study is twofold: (1) How does GM foods willingness to adopt differs among consumers? and (2) What are the behavioral determinants that impact (positively or negatively) consumers' willingness to adopt GM foods?

2. Theoretical background and building hypotheses

2.1 Explanation of an extended health belief model

This study examines consumers' healthcare behavior toward GM foods using the extended HBM. HBM incorporates the expectancy-value perspective. In other words, perceived likelihood of the behavior outcomes and the evaluation of these outcomes (expected value) are important in one's attitude toward a behavior (Ng *et al.*, 2009). While HBM is focused on preventive health behavior (Rosenstock, 1974), recent scholars have proposed an extended HBM (Buglar *et al.*, 2010; Bylund *et al.*, 2011) to improve the potential power of this theory in healthcare behavior realization and evaluation. The HBM has been extended by adding perceived self-efficacy, cues to action and general health orientation into the basic HBM (comprising of perceived susceptibility, severity, benefits and barriers associated with a behavior), see Becker and Rosenstock (1987) and Ng *et al.* (2009).

In order to examine the benefits and risks associated with the adoption of GM foods, this study offers a new HBM in attempts to predict consumers' behavior related to GM foods. The features of our proposed model are the following:

(1) Regarding willingness to adopt GM foods, our proposed model applied some components of the previous extended HBM including: self-efficacy (efficacy expectations) and behavioral evaluation variables (perceived benefits (outcome expectations) and perceived barriers (or perceived risks of GM foods)).

The two factors (i.e. perceived benefits/risks) were added simultaneously in the form of a single variable (i.e. net benefit) to the proposed model whose causes and computation method are described in Section 2.1.1.

(2) Moreover, the general health orientation variable was not included in the model, instead it was substituted by gathering descriptive data on GM foods–related knowledge, consumption and its rate and duration. This could provide us with an overall judgment

on the status and awareness toward consumption of such products in the target community. As elaborated in the research methodology section, there is limited knowledge in this field that examines consumers of developing countries. A large number of studies that focus on personal and demographic characteristics indicate there is a relationship between such variables and willingness to adopt GM foods (e.g. Rodríguez-Entrena *et al.*, 2013; Martinez-Poveda *et al.*, 2009; Kikulwe *et al.*, 2011; Hudson *et al.*, 2015).

(3) In this study, we propose an integrated model of the HBM and the IDT. Similarly, Roden (2004) has offered certain modifications in HBM that mainly focused on health and promotion dimensions. Roden (2004) integrated the HBM with the Theory of Planned Behavior (TPB). Additionally, Akbari *et al.* (2019) developed an extended model in a study of consumers' intention to GM foods in Iran. This could help researchers by identifying viable variables affecting consumers' decisions and assist the researchers derive a model with higher prediction power. Hence, direct and mediating roles of the compatibility variable (as an important component of IDT) substituted the cues to action in the new model. Section 2.1.3 will explain the significance of compatibility and how it is applied. The structure of the proposed model is described below.

2.1.1 GM foods net benefit; difference between consumers' perceived benefits and perceived risks. In the literature, studies focusing on the benefits and risks of GM products are growing (Frewer *et al.*, 2013). Ribeiro *et al.* (2016), Mccomas *et al.* (2014) and Kikulwe *et al.* (2011) outlined the perceived benefits and risks, which are influential elements, toward GM foods/products attitude, and in turn, willingness to adopt.

In regards to GM foods, perceived benefits may include consumers' desired demands, such as price and quality. Broadly speaking, perceived benefits are mostly understood to have a positive effect on willingness to adopt (Kim *et al.*, 2008). In a related study, Yazdanpanah *et al.* (2015a) demonstrated there was a significant relationship between perceived benefits and willingness to use.

Moreover, perceived risk is conceptualized as "the nature and amount of risk perceived by a consumer in contemplating a particular purchase decision" (Cox and Rich, 1964). Additionally, perceived risks include concerns toward health and environmental safety, which may be associated with GM technology (Kikulwe *et al.*, 2011). In general, there are limited studies (e.g. Zhao *et al.*, 2017) showing the positive impact of perceived risk on intention. Consistent with the literature, the major debates are linked to perceived risks of GM foods. Hence, the behavioral reactions and oppositions (from organizations and consumers) toward their negative effects are well documented in the literature (Valente and Chaves, 2018; Saher *et al.*, 2006; Pino *et al.*, 2016; Mucci *et al.*, 2004; Bett *et al.*, 2010).

However, there is evidence to that shows existing no reciprocal link between perceived benefits and risks (Chen and Li, 2007). The negative effect of perceived risks on benefits or the mediating role of perceived benefits on the relation between perceived risks and attitudes are highlighted in previous studies (e.g. Prati *et al.* (2012) and Costa-Font and Gil (2009)).

Therefore, the scope of the study encompasses the benefits and risks in addition to the adoption of GM foods while not disregarding the assessment of their likely reciprocal impacts (or other possible variables). Hence, the impact of each of these factors should not be investigated independently. This led our study to suggest a complementary section, computation of *net benefit*, in order to shed more light on this phenomenon.

This study formulates "*net benefit*" as the amount of difference between consumers' total perceived benefits (including seven measurement items) and total perceived risks (including three measurement items) of GM foods. See Annex. Accordingly, from this reasoning, the following is hypothesized:

H1. Consumers' net benefit influences their willingness to adopt GM foods.

H2. Consumers' net benefit influences their perceived compatibility toward GM foods.

2.1.2 Consumers' self-efficacy. Perceived self-efficacy is the judgment toward execution ability to successfully act in order to face particular situations (Bandura, 1982). Some studies have stressed the effective role of self-efficacy in regards to behavioral intention (Cheung and Vogel, 2013; Chang and Tung, 2008). The effect of self-efficacy on willingness to use organic foods has also been examined by Yazdanpanah *et al.* (2015a). Furthermore, Bimbo *et al.* (2017) cited perceived self-efficacy toward the acceptance of functional dairy products. Hence, this factor is considered important to assess when examining willingness to adopt GM foods and understanding consumers' reactions. Therefore, consumers' self-efficacy has been included in the model as a consumer self-assessment of their capabilities to adopt GM foods. Accordingly, the following hypotheses are examined in this study (by using three measurement items; see Annex):

H3. Consumers' self-efficacy influences their willingness to adopt GM foods.

H4. Consumers' self-efficacy influences their perceived compatibility toward GM foods.

2.1.3 Consumers' perceived compatibility towards GM foods. HBM has also benefited from the introduction of compatibility, as an innovation attribute and an important subset of IDT in the context of adoption decisions (Rogers, 2003). Therefore, compatibility is considered an effective and key variable of the theory (compared to other components of the theory) is combined with Technology Acceptance Model (TAM) and is effective in explaining consumers' attitude and behavior (Chen *et al.*, 2002; Giovanis *et al.*, 2012; Vijayasarathy, 2004; Wu and Wang, 2005).

Furthermore, consumers' perceived compatibility toward GM foods was selected due to its newness in the extended HBM framework to advance the research on willingness to adopt GM foods. Previous studies have examined the extent to which GM products are in accordance with consumers' current demands, values and experiences which are considered predictors of behavioral intention (Wu and Wang, 2005; Chang and Tung, 2008). In other words, compatibility is in line with the cues to action in the HBM model, because it has the potential to stimulate GM foods adoption. Therefore, this study replaced cues to action with compatibility. Moreover, aside from a direct impact, previous studies revealed an indirect impact of compatibility on consumers' behavior by influencing other variables (Giovanis *et al.*, 2012; Wu and Wang, 2005).

Hence, due to the direct and indirect impacts of compatibility and its significance in connecting IDT to other models of innovation adoption, the mediating role was examined to assess its impacts on the relationship between net benefit/self-efficacy and willingness to adopt GM foods. Therefore, the following is hypothesized (based on Annex, five items have applied to measure this concept):

H5. Consumers' perceived compatibility influences willingness to adopt GM foods.

H6a. Consumers' perceived compatibility mediates the relationship between net benefit and willingness to adopt GM foods.

H6b. Consumers' perceived compatibility mediates the relationship between self-efficacy and willingness to adopt GM foods.

All determinants of the willingness to adopt GM foods are presented in Figure 1.

3. Research methodology

3.1 Context rationalization, sample features and data gathering

Related to the need for food security and debates of GM foods in developing countries, see Azadi and Ho (2010), Iran is an appropriate place to validate the integrated model on willingness to adopt GM foods and consumers' behavioral reaction.

The introduction of GM crops in Iran is mostly focused on productivity improvement including strategic crops, promotion of crop performance, coping with production challenges and promoting resistance of crops against possible stresses in the field. In this respect, large-scale production and marketing supply are not the goals of growing these GM crops. However, Iran has the option to import such products (Ghasemi *et al.*, 2013, 2019). Additionally, the Iranian government has committed to the Cartagena Protocol (i.e. the need to label GM foods) (Kazemi Najaf Abadi and Skandarian, 2015).

Currently, GM foods are in the early stages of their diffusion in Iran. Hence, it's important to examine how to effectively change consumers' attitudes and how to increase consumers' trust in such products. Iran is a populous country with an estimated 80 million population and requires an organized food supply chain. Additionally, Iran imports some of its food supply. Similar to other developing countries, Iran has a low percentage of knowledgeable consumers of GM foods. Additionally, the scientific community and policymakers disagree on production, import and consumption of these products. In the literature, there's a variety of insights on GM foods in Iran depicting criticism on such crops (Akbari *et al.*, 2019). Because adoption of such new products greatly rests on community adoption (Chen and Li, 2007), it's important to understand the factors that impact consumers' adoption and willingness to adopt GM foods because of the implications to policymakers (Akbari *et al.*, 2019).

Recent studies indicate there is an existing need to examine GM foods in Iran (Pouresmaeili *et al.*, 2017; Ghoochani *et al.*, 2018; Ghanian *et al.*, 2016; Akbari *et al.*, 2019; Ghasemi *et al.*, 2019). This study focuses on understanding the nature of GM technology/foods and the consequences of their adoption, resulting in various consumers' concerns and trust.

This study used a survey that was completed during 2017–2018 in the capital of Iran, Tehran. A total of 241 consumers were selected using a multistage random sampling method to participate in the survey. These participants were selected from 22 geographic areas of Tehran that have academic facilities, questionnaires were randomly distributed among students and graduate in the academic facilities. Participants were required to have completed or be currently enrolled in higher education because they were more than likely informed of GM foods (see Hudson *et al.*, 2015) and more likely to hold leadership power necessary to change attitude at the public level.

The sample size estimation was based on the ten times rule. SEM-PLS technique was appropriate for this study because the sample size was relatively small. The minimum sample size in this technique is required to be ten times larger than the largest number of formative indices used to measure a construct or ten times the largest number of structural paths to a particular structural model (Hair *et al.*, 2011).

The effects of economic, social and demographic variables on attitude and willingness to adopt have previously been considered in GM studies (see the replacement of general health

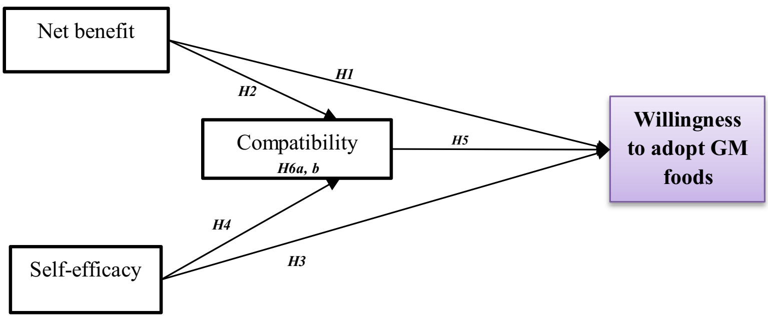

Figure 1.
GM foods determinants model

orientation, Section 2.1) (Rodríguez-Entrena *et al.*, 2013; Martinez-Poveda *et al.*, 2009; Kikulwe *et al.*, 2011; Hudson *et al.*, 2015). Following previous studies, this study also presents the sample profile data. The sample mean age was 32.75 years, 39% were 19–29 years old, 41.50% were 30–40 years old, 15.77% were 41–51 years old and 3.73% were 52–62 years old. Additionally, the sample consisted of 48.50% male, 51.50% female and overall were highly educated consumers (i.e. Bachelor's degree (19.50%), Master's Degree (42.70%) and Ph.D. degree (37.80%)). Furthermore, 95% of the participants were urban residents. The job profile of the sample consisted of: Student (48.20%), self-employed (10.40%), worker (31.50%), retired/pensioner (2.90%), unemployed (3.70%) and houseworker (3.30%). Based on the data, 92.9% of the participants had previously heard of GM foods, while 36.90% had never been consumers of GM foods. Those participants that had previously consumed GM foods had consumed these products on average of two years (mean value), the purchase frequency included: seldom (46.10%), often (12.40%), frequently (2.90%) and very frequently (1.70%).

The scales used in this study were borrowed from previous studies (see Table 1). Scales used consisted of 5-point Likert scales, ranging from 1 (strongly disagree) to 5 (strongly agree). Moreover, this instrument was pre-tested for face and content validity and internal consistency was also assessed. A panel of specialists initially evaluated the questionnaire items. After conducting some modifications resulting from the specialists' feedback and insights, a pilot study on a random sample of 30 consumers was performed. Cronbach's alpha values (ranged from 0.60 to 0.98) supported the internal consistency of the measurement items (Annex).

3.2 Model selection and measurement items

As mentioned earlier, previous studies have used the integrated behavioral model. This model was developed by including: Net benefit, self-efficacy, compatibility and willingness to adopt GM foods. Table 1 specifies each construct and its constituents.

When using structural equation modeling (SEM), correct model selection is a critical principle. Raykov and Marcoulides (1999) argues that model selection should encompass all available information on the models so far investigated. Hence, such information does not exclusively show up in terms of formal goodness of fit indicators but rather entails descriptive, inferential and alternative information and based on the parsimony principle. To this end, providing every possible data on the performance or mechanism of these models sounds useful in the selection of the model (but the information might no have any statistical relevance). Recent authors argue that model selection requires a subjective process and formal fit indices assist via objective constraints. Therefore, no formal principle has been established when selecting the right model selection.

Model selection in SEM is based on: (1) Optimistically a model provides an approximation that applies in the data-generation process. As a result, researchers should select a model with the best generalizability and (2) because of the likelihood of confirmation bias in separate

Table 1. Research measures

Construct/ Latent variable	Number of items	Mean ± SD	Source(s)
Net benefit	10	2.92 ± 0.54	Bett *et al.* (2010), De Steur *et al.* (2010), Costa-Font and Gil (2009)
Self-efficacy	3	2.76 ± 0.82	Jin (2014)
Compatibility	5	3.90 ± 1.90	Wu and Wang (2005), Chang and Tung (2008), Jin (2014)
Willingness to adopt GM foods	3	2.40 ± 1.23	Ajzen (2002), Arvola *et al.* (2008), Kim *et al.* (2014), Yazdanpanah *et al.* (2015b)

Note(s): $1 \leq M \leq 5$

evaluation of models, model selection is strongly recommended to evaluate theory-based models against each other (see Preacher (2006)).

Therefore, this study conducted comparisons on all rival possible models to determine which model had higher prediction power on consumers' willingness to adopt GM foods. Ultimately, we selected a model with the best generalizability to population. The model selected was developed via theoretical and descriptive/inferential outcomes of previous studies. The fit indicators were appropriate as illustrated in Table 2. A parsimonious model allows the researcher to focus on specific variables aimed at providing recommendations for the marketers, consumers and policymakers of GM food. Although there are several factors that affect consumers' behavior, presenting a holistic analysis comprising of all these factors does not satisfy the goal of this modeling (and such analysis is likely not practical using a unique model). Instead, this study considers a limited number of variables to investigate the performance of the model. Consequently, marketers and GM-related policies would apply these findings in order to increase adoption of GM food.

3.3 Data analysis

SEM was used to analyze the data and to examine the integrated model. Moreover, this model was analyzed using partial least squares (PLS) and Smart PLS 3.0 software. According to Hair *et al.* (2011), PLS-SEM is appropriate when the sample size is small and when the data is non-normal.

Following Chin (2010), this study initially assessed the measurement model and its fit indices and then the structural model was assessed. Moreover, the constructs' reliability, convergent validity and discriminant validity were assessed in the first stage. The hypotheses in the extended model were also tested in order to validate the proposed model. In this regard, path coefficients and R^2 values were estimated.

Construct	Measure sign	Loading	*T*-value	CR	AVE	*α*
Net benefit	NB1	0.834	31.504**	0.773	0.689	0.522
	NB2	0.774	28.934**			
	NB3	0.903	56.431**			
	NB4	0.809	32.032**			
	NB5	0.847	35.113**			
	NB6	0.798	31.356**			
	NB7	0.805	32.429**			
	NB8	−0.850	30.880**			
	NB9	−0.803	26.122**			
	NB10	−0.870	35.004**			
Self-efficacy	SE1	0.338	3.026**	0.764	0.55	0.567
	SE2	0.903	59.493**			
	SE3	0.846	28.950**			
Compatibility	C1	0.943	111.263**	0.980	0.906	0.974
	C2	0.945	106.570**			
	C3	0.947	91.313**			
	C4	0.965	176.725**			
	C5	0.960	144.689**			
Willingness to adopt GM foods	W1	0.980	242.779**	0.985	0.958	0.978
	W2	0.982	206.251**			
	W3	0.973	186.136**			
Fitting index	RMS_Theta	NFI			SRMR	
Estimated value	0.185	0.850			0.058	

Note(s): Factor loadings > 0.7; ***p* < 0.01; CR > 0.7; and AVE > 0.5

Table 2. Measures and model fitting indices

3.3.1 Assessment of the measurement model. In assessing the fit of the measurement model, SRMR (Standardized Root Mean Square Residual), NFI (Normed Fit Index) and RMS_Theta (Root Mean Squared Residual Covariance Matrix) were used during confirmatory factor analysis (Hair *et al.*, 2017; Henseler *et al.*, 2014). Estimated values of the measurement model are shown in Table 2.

Furthermore, standardized factor loading, CR (Composite Reliability), AVE (Average Variance Extracted) and α (Cronbach's Alpha) indices were also evaluated. Referring to Stevens (1992), factor loading values were accepted with cutoff point greater than 0.70, t-value > 3.00 and significance at $p < 0.01$. From Table 2, all CR values were higher than 0.75 which were acceptable indicating construct reliability (Hair *et al.*, 2017). Because 0.50 is the threshold designated as an acceptable level of AVE (Fornell and Larcker, 1981), the AVE values (greater than 0.50) indicate convergent validity. The study outputs also confirmed internal consistency reliability based on Cronbach's alpha values. Consequently, Table 3 displays both AVE square roots (0.74 < AVE < 0.97) and correlations ($0.62 < r < 0.90$) for the constructs in the model. Discriminant validity has been achieved because the square root of the AVE (for each construct) is greater than the correlation values (between the mentioned construct and also the other constructs) (Fornell and Larcker, 1981).

4. Results

In this section, the results of the investigation on the new extended HBM model and consumers' willingness to adopt GM foods are presented. First, some results are provided in the form of descriptive information (also, Section 3.1. contains descriptive information that demonstrates the sample profile) and then, the prediction power of the model explaining consumers' behavior is described.

4.1 Descriptive results

As previously demonstrated (c.f. Table 1), the mean scores (out of five) of the studied variables include net benefit (2.92), self-efficacy (2.76) and willingness to adopt GM foods (2.40) were low. These results show that the research participants perceive relatively low benefits and self-efficacy regarding the adoption of GM foods and almost have unpleasant willingness to adopt GM foods. Additionally, the compatibility mean score was 3.90 suggesting that most consumers believe that adoption of these products is compatible with their demands and expectations. This study provides the structural model showing the determinants of consumers' willingness to adopt GM foods.

4.2 Structural model investigation

The final step of SEM is the assessment of the structural model based on a confirmed and suitable measurement model. As mentioned earlier, the hypothesized model includes the relationships between assumed constructs (i.e. net benefit, self-efficacy, compatibility and willingness to adopt GM foods). In this way, the path coefficients of each causal relation

Table 3. Assessment of the discriminant validity

Constructs	1	2	3	4
1- Compatibility	*0.952*			
2- Willingness to adopt GM foods	0.903	*0.979*		
3- Net benefit	0.876	0.881	*0.830*	
4- Self-efficacy	0.654	0.628	0.632	*0.742*

Note(s): On-diagonal values represent AVE square roots; off-diagonal values represent correlation; $p < 0.01$

between two constructs was calculated and presented as β values followed by t-values presented for all causal relationships (Table 4).

Based on this Table 4 and at 1% error, net benefit has a positive effect on willingness to adopt GM foods ($\beta = 0.377$; $t = 5.867$). This result supports H1 which states that the more net benefit of GM foods understood by consumers (or the higher benefit and less risk), the more willingness is shown to adopt such commodities. H2 was also supported ($\beta = 0.773$; $t = 22.428$). H2 states that the more net benefit that is understood by consumers (or the higher benefit and less risk), the higher the perceived compatibility of such meals with his/her needs and expectations.

However, self-efficacy did not significantly impact willingness to adopt GM foods ($\beta = 0.025$; $t = 0.682$), rejecting H3. Self-efficacy significantly influenced perceived compatibility ($\beta = 0.165$; $t = 4.056$). Therefore, the positive impact of self-efficacy on perceived compatibility shows that consumers that self-assess their capabilities to adopt GM foods are likely to consider such products as more compatible.

Furthermore, there was a positive effect of compatibility on willingness to adopt GM foods ($\beta = 0.556$; $t = 8.434$) supporting H5. In other words, if GM foods are more compatible with demands, values and prior experiences of consumers, their willingness to adopt GM foods is greater.

In addition, the mediating role of compatibility between net benefit and willingness ($\beta = 0.430$; $t = 7.239$) and self-efficacy and willingness ($\beta = 0.091$; $t = 4.032$) were significant, supporting H6a and H6b, respectively.

The findings reveal that the level at which GM food is perceived by consumers as a compatible product positively impacts the willingness to adopt GM foods. In addition to the direct impact of compatibility on willingness to adopt GM foods, it also has indirect effects. In other word, direct impact of net benefit and self-efficacy on consumers' willingness is mediated by compatibility. Moreover, the findings show the variation in willingness to adopt GM foods based on the net-benefit and self-efficacy in spite of variation of GM foods compatibility. As hypothesized in H3, the direct impact of self-efficacy on willingness to adopt GM foods was not supported and more understanding is needed. It is also recommended that the indirect impact of self-efficacy on willingness to adopt GM foods needs further generalizability investigation despite H6b being supported.

Hypothesis	Path	Direct effect β	Direct effect t	Indirect effect β	Indirect effect t	Total effect β	Total effect t	Decision
H1	Net Benefit - > Willingness	0.377	5.867**	0.430	7.239**	0.808	25.120**	Accepted
H2	Net Benefit - > Compatibility	0.773	22.428**	–	–	0.773	22.428**	Accepted
H3	Self-efficacy - > Willingness	0.025	0.682^{ns}	0.091	4.032**	0.116	2.868**	Rejected
H4	Self-efficacy - > Compatibility	0.165	4.056**	–	–	0.165	4.056**	Accepted
H5	Compatibility - > Willingness	0.556	8.434**	–	–	0.556	8.434**	Accepted
H6a	Net Benefit - > Compatibility - > Willingness	–	–	–	–	0.430	7.239**	Accepted
H6b	Self-efficacy - > Compatibility - > Willingness	–	–	–	–	0.091	4.032**	Accepted

Note(s): ns = Not significant; **$p < 0.01$

Table 4. Estimated effects on willingness to adopt GM foods

In order to further assess the structural model, we use the R^2 value (coefficient of determination). Referring to Chin (1998), substantial (= 0.67), moderate (= 0.33) and weak (= 0.19) R^2 coefficients have been considered. In this regard, R^2 values are demonstrated in Figure 2. Accordingly, the extended HBM model predicts about 84% of the variance changes in consumers' willingness to adopt GM foods.

Q^2 value (predictive relevance) is the other measure which has been used to assess prediction power in the structural model. In doing this, small, medium and large Q^2 values are used to specify this power at 0.02, 0.15 and 0.35, respectively (Henseler *et al.*, 2009). Hence, the Q^2 value in this study is 0.767 and indicates a good and large predictive power for the structural model related to changes of the proposed constructs.

5. Discussion

The purpose of this study was to investigate consumers' willingness to adopt GM foods and its determinants. To our knowledge, there is considerable demand for conducting such studies in the context of developing countries like Iran (Ghanian *et al.*, 2016; Ghoochani *et al.*, 2018; Pouresmaeili *et al.*, 2017; Akbari *et al.*, 2019; Ghasemi *et al.*, 2019). Accordingly, this study presents a general view on Iranian consumers' willingness to adopt GM foods. This research contributes to the growing academic literature on GM foods and their consequences by developing a new integrated model which simultaneously employs a combination of the HBM and IDT.

Moreover, the self-efficacy component (with no modification) was applied from HBM theory. Additionally, a new variable (i.e. net-benefit) was added to the model which extends some components of the prior model (e.g. perceived barriers and perceived benefits). The study also provides descriptive and demographic data rather than general health orientation in the modeling process. The reason for such selection relies on the significance of these components in previous GM foods adoption studies (Rodríguez-Entrena *et al.*, 2013; Martinez-Poveda *et al.*, 2009; Kikulwe *et al.*, 2011; Hudson *et al.*, 2015). Another reason is the lack of relevant knowledge amid researchers, community and consumers in developing countries, in addition to disagreement between scientific community and policymakers on production, import and consumption of these products (Akbari *et al.*, 2019). The new integrated model included compatibility as major and effective part of the IDT theory in determining consumers' behavior. Direct and indirect mediating effects of compatibility (rather than cues to action) were investigated, mainly due to its potential to drive decisions on GM foods adoption.

The extended model was tested among 241 consumers with a higher education degree in Tehran. Results depicted a sample consisting of a wide range of ages and gender groups. Hence, the sample characteristics are proportional to the target society. This substantially improves model validation and generalizability of the findings.

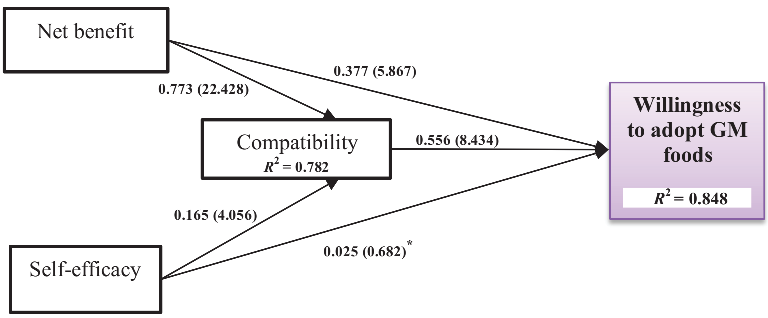

Figure 2.
Path Model Display (* = Not significant path)

According to previous studies, GM foods entail some risks (e.g. health, environmental and equity concerns) and this risky nature often influences consumers' mind during the food decision-making process. Therefore, it's not surprising that consumers see these products as doubtful and even undesirable (see Colson and Huffman (2011); Hudson *et al.* (2015); and Magnusson and Koivisto Hursti (2002)). Furthermore, the following issues have been raised in this study:

(1) Although, 92.9% of the respondents were already aware and had heard about GM foods, the major portion (36.9%) never consumed such foods. Moreover, a large percentage (46.1%) seldom purchases these GM foods.

(2) The mean scores for net benefit, self-efficacy and willingness to adopt GM foods were relatively low, while compatibility had a higher mean score when GM food products displayed greater compatibility to respondents' demands and expectations.

Furthermore, analysis of the outcomes of the extended model affirms that the model and its combined components borrowed from the HBM theory have remarkable potential and power in determining consumers' behavior and willingness to adopt GM foods. The proposed model predicts almost 84% of the variance changes in willingness.

Thus, the findings revealed that net benefit and compatibility are the most important predictors of consumers' willingness to adopt GM foods. However, the influence of self-efficacy on willingness to adopt GM foods was not significant which does not align with previous investigations (Chang and Tung, 2008; Cheung and Vogel, 2013; Yazdanpanah *et al.*, 2015a). Self-efficacy has also been found to have an indirect effect in willingness to adopt GM foods through consumers' perceived compatibility.

In particular, the significance of net benefit on the willingness to adopt GM foods was highlighted in this study. The results show there is a competitive nature between perceived benefits and perceived risks of GM foods. In this sense, if the adoption benefits of GM foods can compensate their perceived risks, acceptance of these products can be expected. Similar to previous studies on the relation between benefits perception and willingness (Prati *et al.*, 2012; Kim *et al.*, 2008; Yazdanpanah *et al.*, 2015a), perceived net benefit positively impacts the willingness to adopt GM foods. The positive effect of perceived benefits on behavioral intention has previously been found related to GM crops in Iran (Ghoochani *et al.*, 2018).

Consistent with the literature on compatibility (Chang and Tung, 2008; Wu and Wang, 2005), the higher level of perceived compatibility positively impacted consumers' willingness to adopt GM foods. According to Rogers (2003), the decision process may be affected by individual factors (e.g. potential health and environmental benefits, needs, experiences, beliefs and values). Therefore, the compliance of GM foods with these factors effectively impacts the adoption of GM foods by consumers.

Similar to previous literature (Chen *et al.*, 2002; Giovanis *et al.*, 2012; Vijayasarathy, 2004; Wu and Wang, 2005), compatibility played a major role in the proposed extended model. Additionally, compatibility reveals the linkage of our proposed research model and the IDT theory. On the other hand, compatibility has a direct and mediating role in relation to consumers' willingness to adopt GM foods. Therefore, the relationships between net benefit perception and willingness to adopt GM foods and self-efficacy and willingness to adopt GM foods is mediated by compatibility. Thus, compatibility may be a viable replacement for cues to action in the HBM and could illustrate, directly or indirectly, its potential to drive willingness to adopt GM foods.

5.1 Theoretical and practical implications

Risk perception plays an important role in information need and information seeking toward these products (Zhu *et al.*, 2018). Therefore, accurate knowledge and information toward the benefits and disadvantages of GM products, rules/policies and effective standards and control tools are needed to minimize public doubt and improve consumers' decision-making power. For example, the development of a system of traceability for GM food and ingredients was emphasized by Miles *et al.* (2005). Similarly, Kajale and Becker (2013) encouraged a mandatory labeling policy of GM foods for Indian consumers.

According to the influence of net benefit on consumers' willingness to adopt GM foods, managers and policymakers can take the net benefits of GM foods into account to influence consumers' willingness to adopt GM foods. Hence, this finding can help develop appropriate policies and programs (e.g. conducting educational programs through campaigns via social media, workshops, school education, posters) to inform consumers about the advantages and disadvantages of GM foods, while providing accurate and trustworthy information for society as a whole.

An important contribution of our model is compatibility and its direct and mediating effects that can be employed to improve consumers' willingness to adopt GM foods. Although this process is not straightforward. Marketers need to learn consumers' experiences, values and demands in order to target them with GM foods that have higher likelihood to be compatible with consumers' demands and needs. In other words, emphasis on the health, ethicality and safety of such foods can align better for certain consumers when promoting the adoption of GM foods while minimizing the social, economic and environmental threats.

5.2 Limitations and further studies

These results were derived from a case study and recommend that our proposed integrated model is tested in other contexts. In order to improve generalizability, we recommend that the extended proposed model should be tested using with a diverse group of participants (e.g. producers, researchers, specialists and policymakers that having differential knowledge), particularly in other developing countries. This would enable generalizability of the findings across distinct communities and counties.

Furthermore, we recommend that the extended HBM should be analyzed and combined with other innovation adoption and psychology theories to increase its applicability and creditability. In relation to the rejection of the hypothesized direct effect of self-efficacy, future studies should investigate the role of this variable on consumers' willingness to adopt GM foods. Additionally, socio-demographic and knowledge-based variables underlying consumers' willingness to adopt GM foods demand further investigation.

6. Conclusions

This research reflects the growing demand to understand GM foods adoption and related determinants which lead to different behavioral reactions among various consumers, especially across developing countries. This study, therefore, attempts to focus on consumers' willingness to adopt GM foods in the capital of Iran, Tehran. For this purpose, a sample of 241 highly-educated participants that were knowledgeable about GM foods were selected from 22 geographic areas in Tehran using a multistage random sampling method.

This study contributes to the GM foods literature by using a new extended HBM model to investigate consumers' willingness to adopt GM goods. To this end, SEM, PLS technique and Smart PLS 3.0 software were used for the data analysis.

The research findings show that doubt and lack of confidence on GM foods existed among the respondents. Despite their awareness, as demonstrated by higher mean scores pertaining to compatibility of such products, most respondents were either reluctant or seldom purchase these foods. This result was also supported by low mean scores in net benefit, self-efficacy and willingness to adopt GM foods. Therefore, we recommend that in order to increase the confidence-making and risk reduction of consumers, precise knowledge and information diffusion on advantages and disadvantages of GM foods should be promoted to consumers. Additionally, enacting policies, rules and standards related to GM foods is also imperative to influence consumers' willingness to adopt GM foods.

Our analysis shows that the proposed model has good predictive power (close to 84%) in predicting variance changes in willingness to adopt GM foods. According to this, net benefit and compatibility displayed positive and direct effects on willingness to adopt GM foods. Therefore, these two variables can be utilized as two highly important predictors. However, the direct influence of self-efficacy on the consumers' willingness ultimately resulted in non-significant results.

Moreover, the results showed that compatibility played a mediating role as supported by IDT. Therefore, net benefit and self-efficacy indirectly impact willingness to adopt GM foods through the mediating effect of perceived compatibility towards these products.

Therefore, future studies are recommended to probe and extend this integrated model in different countries and with distinct populations. In addition, developing policies and programs is imperative to introduce net benefit aspects of GM foods to potential consumers. Moreover, it is recommended that these policies and programs focus on the evaluation, selection and introduction of GM food products that meet the needs, values and expectations with limited risks and threats to consumers in order to increase consumers' willingness to adopt GM food.

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Annex
Measurement items

Net benefit

Perceived benefits

NB1. GM food can improve the health of consumers.

NB2. GM food can be a good substitute for some medicines.

NB3. The development of GM food should be encouraged.

NB4. GM food will lower environmental pollution.

NB5. GM food can prevent diseases.

NB6. The quality of GM food is better than of conventional food.

NB7. In the long run, a successful (Nationality) genetically modified food industry will be good for the economy.

Perceived risks

NB8. GM products are harmful to human beings.

NB9. GM products are harmful to livestock.

NB10. Eating genetically modified food will be harmful to my health and my family's health.

Compatibility

I think that eating GM foods. . .

C1. . .could be appropriate for my nutrition style.

C2. . .may be suitable for most aspects of my life.

C3. . .would fit well with the way I like to feed.

C4. . .would be appropriate for my nutrition.

C5. . .would fit my lifestyle.

Self-efficacy

SE1. Eating GM foods is under my control.

SE2. I will get used to feed through GM foods.

SE3. I will get used to obtaining the relevant information for using GM products.

Willingness to adopt GM foods

W1. I intend to consume GM foods if they are available for purchase.

W2. I plan to consume GM foods if they are available for purchase.

W3. I will try to consume GM foods if they are available for purchase.

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