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Journal of retailing and consumer services

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https://doi.org/10.1016/j.jretconser.2021.102699

Journal of Retailing and Consumer Services 63 (2021) 102699

Contents lists available at ScienceDirect

Journal of Retailing and Consumer Services

journal homepage: www.elsevier.com/locate/jretconser

Consumer acceptance of irradiated food and information disclosure – A retail imperative

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ARTICLE INFO

Keywords:
Irradiated foods
Risk
Information
Trust
And TPB

ABSTRACT

There is substantial contribution in the literature for understanding the complex nature of irradiated foods, the growing importance and the controversial views expended by consumers, yet acceptance of these foods for many have not met with optimal recognition. The study extends the theory of planned behaviour antecedents to analyse independent determinants and the influences of risk and trust. The indirect effects are also examined. The study uses multigroup analyses to identify whether consumer's concerns on information for irradiated foods act as moderators in order to provide a better explanatory power.

The data was analysed using Structural Equation Modelling on responses obtained from a sample of 322 consumers. The study found that the theory of planned behaviour antecedents successfully predicted behavioural intention for irradiated foods but with some limitations. The findings also demonstrate additional support to show that the robustness of the TPB framework is effective for irradiated foods and addresses the literature calls on research for more theoretical underpinnings. It further addresses retailer implications, as the ultimate decision falls with retailers who assess whether sales for irradiated foods are acceptable depending on consumer demand.

1. Introduction

Food irradiation is a secure and efficient way to extend shelf life, reduce spoilage, eliminate pests, and disable bacteria that cause food poisoning (Queensland Health, 2018). Irradiation is seen as a "treatment of food with energy from X-rays or gamma rays for a specific purpose." (Bruhn, 1995, p.214). While commercially it is used for pasteurization (Prakash, 2020), this process has been successful with meats, poultry, produce and grains (Tauxe, 2001). Irradiated foods processed with this treatment often fall under new or novel food processing technologies (Bearth and Siegrist, 2019; Balatsas-Lekkas et al., 2020; Siegrist and Hartmann, 2020).

Many international organisations like the International Atomic Energy Agency (IAEA), Food and Agriculture (FAO), and the WHO (World Health Organisation) or the Scientific Committee on Food of the European Commission have concluded that food irradiated with suitable technologies are equally safe and nutritionally acceptable (Farkas and Mohácsi-Farkas, 2011). Since 2000, consumers globally have shifted their focus to purchasing irradiated fresh produce, meat, seafood, and other foods (Eustice, 2017). Consumers rely on the information and benefits of the irradiation process to accept these foods (Gunes and Tekin, 2006). This process has gained momentum in the US (Shah et al., 2021) and other leading countries are South Africa, the Netherlands, Thailand, and France (Stefanova, Vasilev, and Spassov, 2010). Along with retailers playing a major role in selecting to offer irradiated foods depending on consumer choices (Roberts and Hénon, 2015).

Frequently, consumers express strong aversion towards highly processed foods and unusual food technologies (Bearth and Siegrist, 2019; Mostafavi et al., 2010) and irradiation is no exception. Some of the challenges include health claims, reforms in regulation and information on food labels (Crawford, 2020; Balatsas-Lekkas et al., 2020). Consumer acceptance of the food irradiation process in different parts of the globe is not uniform. In Argentina there is some uncertainty (Finten et al., 2017), Recent research shows Korean consumers have a negative

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https://doi.org/10.1016/j.jretconser.2021.102699
Received 20 April 2021; Received in revised form 29 June 2021; Accepted 25 July 2021
Available online 29 July 2021

perception of irradiated foods (Caputo, 2020). Australians have expressed some food concerns regarding irradiated foods, such as radioactivity issues, lack of choices, natural warning signs that are eliminated, designed not for consumer's benefits and the effects on food hygiene (State of Victoria, 2021). Even though more recent studies have shown that approximately around 60 countries have permitted irradiated of some foods and while the safety results are promising and regulated, many consumers show reluctance towards these foods (Castell-Perez and Moreira, 2021). Despite several studies confirming the safety and nutritional adequacy of these foods, consumers have shown resistance to change for the fear of the unknown (Lacroix and Vigneault, 2007; Castell-Perez et al., 2021; Burditt, 2019). Furthermore, irrational fear of nuclear technologies is some of the causes for lack of acceptance (Mostafavi et al., 2012; Molins, 2001).

Reluctance to accept have led to complexities (Bruhn, 1995; Gunes and Tekin, 2006; DeRuiter and Dwyer, 2002; Bearth and Siegrist, 2019). The buying expectation placed by producers in many instances have not been realised, as some consumers still show resistance towards these foods. The fact that consumers have become more sophisticated have resulted in a growing need to know what foods they are buying (Galati et al., 2019). To resolve this there is a call for the public to be convinced of the nature of these foods (Burditt, 2019). With existing uncertainty regarding the drivers on new food's judgment and consumer acceptance, researchers have often questioned whether food producers need to understand food technology, and their interrelated factors, such as effectiveness for consumer acceptance (Bearth and Siegrist, 2019). Some suggest that to increase acceptance from consumers for irradiated foods could be a question of appropriate information with research-oriented technical evidence (Shahbaz et al., 2016). The increased emphasis on consumer acceptance (Cottee et al., 1995; De Ruiter et al., 2002; Frishman, 2008; Fox et al., 2001) can be understood as a critical response to consumer resistance. The persistent negative feelings and high risks associated with these foods (Bearth and Siegrist, 2019), the impact of trust and the intention for all consumers to accept these irradiated foods requires more explicit investigation and must be extended to bridge this gap.

The aim of this study is twofold, first it uses the theory of planned behaviour antecedents to examine its explanatory power and analyse independent determinants and indirect effects of consumer acceptance, while also examining the influences of risk, and trust on the TPB model. Secondly, it uses multigroup analyses to identify whether consumer's concerns on information for irradiated foods act as moderators, as consumers engage in a more effortful and under deliberate considerations while making decisions on these foods.

The major contribution of this study is to explore the growing importance of irradiated food and to predict acceptance by understanding and extending the main determinants of the theory of planned behaviour. This research contributes to the retail environment by showing how retailers in their commercialisation of irradiated foods can implement changes of the negative view of these foods. A deeper understanding, but with some limitations, would support this relevant contribution.

1.1. Theoretical background and hypothesis development

The Theory of Planned Behaviour (thereafter TPB) has been established from the Theory of Reasoned Action (Ajzen, 2002) and suggests that behaviour is defined by a combination of people's intentions to participate in that behaviour, as well as their perceptions of control over the behaviour. Behavioural intentions, on the other hand, are predicted by attitudes, social norms and PBC. This methodological shift of the TPB has been widely applied to food consumption (Vermeir and Verbeke, 2008; Åstrosm, and Rise, 2001; Arvola et al., 2008). More recently, Lin and Roberts (2020) had conducted a meta-analysis and systematic review applying the theory of planned behaviour to forecast food safety. While there is some literature on TPB components such as attitudes, social norms and beliefs regarding irradiated foods (Gwira Baumblatt et al., 2017; Henson, 1995; Rimal et al., 2004; Frishman, 2008) or consumer acceptance of irradiated foods (Nayga, 2003; DeRuiter and Dwyer, 2002; Galati et al., 2019; Gunes and Tekin, 2006), trust and risk have been used in the TPB as additional explanatory factors (Lobb et al., 2007). This research recognises trust and risk as two important influencing variables that can be applied to drive wider insights and greater explanatory power for the model.

Lower confidence levels (Fox et al., 2001) and the perceived risk associated with consumer's assumption of foods treated with irradiation affecting their behaviour (Galati et al., 2019), suggests a need to examine the influence on perceived risk on the TPB model. Similarly, consumer trust in different actors play an important role in consumer's intention on acceptance of these foods. Consumer's trust can be realised in the systems when scientific organisation for creating greater awareness is clear, governments take a more proactive scientific position and effective efforts by industry to address irradiation issues (Eustice, 2017). On the other hand, it is the consumer's right to know that has been criticised with these foods. The current acceptance of irradiated foods is the largest with the more educated consumers in upscale markets (Bruhn, 2020). But the low level of confidence in food producers (Lobstein, 2019) and lack of trust suggests a failure to the prescribed government regimens. Thus, it is imperative to examine the extent to which trust influences the antecedent of the TPB model. Risk and trust are two influencing factors that carry a high impact on buying intention of irradiated foods and the integration of risk and trust in the TPB model is likely to demonstrate predictability of this model and the implications of the consumer's actions. The following paragraphs will present the proposed hypotheses.

1.2. Trust

Food safety information regarding trust has been under investigation (Lobb et al., 2007) and is critical for food acceptance. Trust is proven to impact the perceptions of risk and benefit for new food technologies (Roosen et al., 2015). By and large, there is considerable empirical proof that trust, and risk perceptions impact public acceptance of new technologies (Eiser, Miles and Frewer, 2002).

Siegrist et al. (2007) found that trust is crucial for influencing the effect stimulated by new food products. Results show that majority of the consumer's trust and would be willing to buy irradiated foods but were somewhat concerned about issues such as safety, taste, and nutritional value which are critical for food purchases (Spaulding et al., 2006). There were positive responses on trust regarding irradiated foods and willingness to pay a premium price on irradiated meat (Nayga et al., 2002). Consumers who trusted grocers and regulatory bodies indicated they would purchase irradiated foods (Cottee et al., 1995).

Research confirms that trust is a direct antecedent of intention to buy food (Giampietri et al., 2018). The TPB framework showed that mistrust lowers expectations regarding the benefit of organic food (Nuttavuthisit and Thøgersen, 2017). Lack of consumer trust is seen as a barrier to the expansion of the organic food market in Thailand (Nuttavuthisit and Thøgersen, 2017). Other areas of lack of trust involve categorisation of food irradiation (Koutchma et al., 2018).

In general, there is a lack of trust in how food is manufactured, invented, and managed, especially with likely pollutants or chemical remains from manufacturing (Meijer et al., 2020). Food manufacturers are perceived as untrustworthy sources (Meijer et al., 2020). Consumers have greater trust with medical professionals and food scientists and the least with governments when it comes to irradiated foods (Spaulding et al., 2006). Even though there is mistrust expressed with irradiated foods (Behrens et al., 2009), others have found a level of positive attitude and trust towards irradiated food (Hussin et al., 2018). Even within the context of other foods, trust was seen to positive affect consumer attitudes of convenience foods (Ricci et al., 2018). Therefore, it follows that:

H1a. : Trust in authorities positively influences consumer attitudes towards irradiated foods.

H1b. : Trust in authorities have a positive influence on social norms in favour of irradiated foods.

H1c. : Trust in authorities have a positive influence on PBC towards irradiated foods.

1.3. Risks

Food-related research has taken a lay psychometric approach which is perceived as multidimensional and is used to explain the expert opinions of disagreement for risks (Hansen et al., 2003). Consumers are more likely to be influenced by the psychological perception of the risk rather than the factual representation of risk (Pennings et al., 2002). Risk perception sets the foundation for guiding decisions about behaviour, lifestyles and the acceptability of consumer products depend on these risk perceptions (Frewer et al., 1994). It is also considered a critical explanatory variable of food choice (Zhang et al., 2018), and therefore it is important for incorporating this antecedent within the model.

Risks regarding food irradiation amplify public sector debates and over time it was found that entirely undermined representations of risk experienced regarding irradiation (Gauthier, 2010). Risk perception of irradiation is reliant on how the consumer sees the technology based on the information received (Galati et al., 2019). Uncertainty and inadequate knowledge regarding nuclear power have persuaded participants to claim for more communication openness concerning the benefits and risks of food irradiation impact on health, more particularly when it is continuously consumed (Behrens et al., 2009).

Chen (2017) found that risk has an association with an individual's intention to take safety measures for avoiding foods that include additives and was seen to influence consumer attitudes towards consuming food with additives (Chen, 2017). Risk is also seen to influence attitudes in terms of food safety (Lobb et al., 2007). A more recent experimental study demonstrated that consumers who have negative feelings towards nuclear power identified irradiated foods as having lower quality and accompanied by larger risks with lower acceptance of this type of technology (Bearth and Siegrist, 2019). They are also indecisive about the impact of these technologies association with possible risks and may perceive them as riskier (Siegrist, 2008). Consumers may be less resistant if risks by these practices are explained clearly (Nayga, 2003). This research argues that perceived risks negatively influence irradiated foods and thus hypothesized as under:

H2a. : Perceived risk negatively influences consumer's attitudes towards irradiated foods.

H2b. Perceived risk negatively influences PBC towards irradiated foods.

1.4. Attitudes

Attitudes refer to the evaluation of behaviour and have demonstrated the impact and forecast behaviours within the domain of food. Apart from consumers, food retailers, manufacturers and restaurants have their own attitudes towards irradiated food and are resistant to changes (Hunter, 2000). Attitudes toward innovative food technologies are uncertain and consumers draw on general attitudes in evaluating new food technologies (Siegrist, 2008). There was some support for the theory of reasoned action confirming that attitudes influenced behavioural intentions to consume irradiated food (Frishman, 2008). Many findings reveal that consumer attitudes towards irradiated foods are positive and consumers are willing to accept irradiated food (Bruhn, 1995). A study that examined consumer attitudes towards food irradiation showed around 45 % of consumers would buy irradiated foods (Resurreccion et al., 1995).

This is clear in those studies that have investigated consumer attitude to food irradiation in Brazil and reactions appeared to be similar between groups, while others show there were no differences between irradiated and nonirradiated food (Behrens et al., 2009). More recent research shows that association with consumers attitudes and opinions had low intent to purchase irradiated foods (Lima Filho et al., 2017). While on the other hand consumers had a positive attitude towards food irradiation and had intentions to accept (Hussin et al., 2018). Other researchers have shown that attitudes toward food irradiation were generally found to be negative (Teisl et al., 2009). Opposing attitudes of specific activist groups have formed public opinions, thus hampering the implementation of the food irradiation process, mainly in the European region (Farkas and Mohácsi-Farkas, 2011).

Although, there is still some confusion with differentiating irradiated foods from radioactive foods (Maherani et al., 2016), scholars have emphasised that there is a need to improve consumer attitudes for acceptance of these products (Behrens et al., 2009; Fox, 2002; Gunes and Tekin, 2006; Lima Filho et al., 2017; Galati et al., 2019). It is deemed essential for establishing more recognition and positive attitude with consumers to use irradiated foods (Galati et al., 2019). Besides these mixed findings regarding consumer purchase intention of irradiated foods, attitudes as a mediator should also be investigated for extending an understanding of why and how there is an observed mediating relationship (Cabuk et al., 2014). A food related study showed attitudes have a mediating effect on risk perception and intention, as well as trust and intention towards purchase intention (Cembalo et al., 2019). Furthermore, previous studies have shown attitudes as a mediator towards organic foods (Ashraf, 2020). In a similar analogy, attitudes towards food irradiation are likely to mediate when trust and risk influence attitude towards irradiated foods. Thus, we expect the following:

H3a. : Attitudes positively influences consumer's intention to accept irradiated foods.

H3b. : Attitudes indirectly influences trust in authorities and consumer's intention to accept irradiated foods.

H3c. : Attitudes indirectly influences risk perception and consumer's intention to accept irradiated foods.

1.5. Social norms

Social norms can be seen as social influences to act towards a behaviour (Ajzen, 2002) or the social pressure to act or not to act. Social norms are devised from normative beliefs concerning pressure from specific others and the individual's motive to conform (Ajzen, 2002). People observe social norms because they worry about social pressure, and how they conform to what is appropriate or useful (Arvola et al., 2008). They are seen as a notion cantered on how one must respond to the opinions or beliefs of others, such as peers, friends, or family members (Ajzen, 2002).

Cultural and social norms also affect why we purchase foods and the type of foods we eat. They also influence the acceptance of innovative technologies (Siegrist, 2008). Besides, in terms of other foods, social norms play an important role in influencing consumers' purchase intention, especially in halal food (Rachbini, 2018). Consumers that express a positive attitude regarding organic food, believe that there is normative support (Yazdanpanah and Forouzani, 2015; Al-Swidi et al., 2014). Yet, Tarkiainen and Sundqvist (2005) found no direct significance with social norms and intention for buying organic foods. There are mixed views regarding these foods.

Social norms have been shown to have a direct effect as well as mediating effect between self-efficacy and organic foods (Ashraf et al., 2021). Besides, consumer interaction with social groups and families have shown a positive impact on purchase behaviour of irradiated foods (Fox et al., 2001). Given the limited literature regarding the role of social norms in the context of irradiated foods and based on other

comparable foods and their relationship with social norms, we propose the following:

H4a. : Social norms in favour of irradiated food positively influence consumer's intention to accept irradiated foods.

H4b. : Social norms in favour of irradiated food have an indirect influence on trust in authorities and consumer acceptance of irradiated foods.

1.6. Perceived behavioural control (thereafter PBC)

Perceived behavioural control (PBC) is being in control or having the confidence to perform a behaviour (Ajzen, 2002). PBC has a direct and interactive effect on behavioural intention and behaviour. In other words, consumers should have the capacity to perform a likely behaviour that can be defined by the existence of factors which are likely to assist or dismiss this behaviour. Or the complexity or ease in facilitating the behaviour (Triandis, 1977). Bandura (1982) and his colleagues (idea of self-efficacy beliefs have indicated that consumer's behaviour is motivated by their confidence in their capability to facilitate the behaviour. Given the scarcity of literature of irradiated foods and the TPB model, we make use of other types of food influences. PBC has been used widely in the food literature, it was applied to analyse local food products (Kumar and Smith, 2018); halal foods (Rachbini, 2018); organic foods (Johe et al., 2016); and genetically modified foods (Zhang et al., 2018).

Some of the food-related behaviours have shown positive outcomes for PBC. For instance, Dean et al. (2008) found that PBC strongly influenced the organic apples purchase intention, but no support was shown for organic pizza. Thøgersen (2007) found positive significance for organic fresh tomatoes and organic tomato sauce buying behaviour. For instance, PBC was shown to have a direct effect as well as mediating effect between self-efficacy and organic foods (Ashraf et al., 2021). In relation to food such as fruit and vegetable consumption showed a significant indirect effect between PBC and intention (Lwin et al., 2020). PBC was also seen to be a mediator between response-efficacy and intention to buy organic foods (Boobalan and Nachimuthu, 2020). Similarly, PBC was shown to mediate the relationship between some identified antecedents and purchase intention of branded food products (Singh and Kathuria, 2016). Applying this food analogy for irradiated foods, the following hypotheses is proposed:

H5a. : PBC positively influences consumer's intention to accept irradiated foods.

H5b. : PBC has an indirect influence on trust in authorities and consumer's intention to accept irradiated foods.

H5c. : PBC has an indirect influence on risk perception and consumer's intention to accept irradiated foods.

2. Method

2.1. Research instrument

Based on the review of the literature the survey instrument was created. Several questions were adapted from Bearth et al. (2014) for trust and risks. Other survey questions were also drawn from, Farkas (2006) and Roberts (2014) and adapted. Many of the questions for the TPB were taken from the following literature and altered (Fishbein and Ajzen, 2010; Ajzen, 2002). The answers were measured with a five-point Likert scale. The demographic section involved age cohorts, sex, income level, education, and employment.

2.2. Sampling, surveying, and data analysis

A professional market research agency was appointed to conduct this research. The target population consisted of the primary food shopper in the household. The responses were obtained from 322 participants in Australia. Participants had to be above the age of 18 to respond to this survey. The sample size was adequate for performing the SEM analysis (Kline, 2015). A pilot study was administered before conducting the survey, for testing the questionnaire's clarity (De Vaus, 1993). In terms of the quality of the survey instrument, the latent variables Cronbach's alpha scores exceed the acceptable standard of 0.70 (Nunnally and Bernstein, 1994). The results demonstrate a satisfactory level of internal consistency for the survey instrument items.

For the data analysis, the research uses a multistep process that was proposed by Anderson and Gerbing (1992). Structural Equation Modelling was applied to conduct SEM using AMOS 26 version. Confirmatory Factor Analysis (CFA) was applied to evaluate the usefulness of the measurement model. i.e., the model fit. To establish scale's dimensionality for maintaining internal consistency, reliability tests and validity tests such as content, convergent, and discriminant were undertaken. To estimate the model and all SEM parameters, the research applies Maximum likelihood (ML) estimation as it is not only considered substantially more vigorous but also has an adequately large sample size of greater than 200 (Tabachnick and Fidell, 2001, p. 74). By concurrently assessing all of the given hypotheses, the relationships were established.

2.3. Results of the analysis

2.3.1. Profile of the participants

There were more males (54 %) than females (46 %) that responded to this survey. About 24 % were aged between 18 and 34 years; 37 % were aged between 35 and 54, and 39 % were aged between 55 and 65+. In terms of employment, 36 % were employed full time; 16 % part-time; 8 % Self-employed; 8 % unemployed, and 21 % were retired. Around 26 % had an income between $25,000-$49,000; 19 % between $75000–99,000 and 7 % was $100,000 plus. Those who completed high school were around 24 %; technical or trade certificate 28 %; university degree 28 % and PG degree or higher was at around 17 %.

2.4. The measurement-model

An exploratory factor analysis was conducted to explore the various factors which was then followed by the CFA (Confirmatory Factor Analysis). (Hair et al., 2006). The CFA is used to assess the fit of the model and construct validity. Specification of the model is the first stage for analysing CFA. Outcomes for the CFA showed a chi-square statistic was significant (χ 2 = 839.135, df = 427) suggesting that the model fits well. Since the sample size influences the value of χ 2 (Chen and Chen, 2010), the chi-square value the ratio to degrees of freedom (χ 2/df = 1.96) was used, which was lower than the cut-off value of 3 (Bagozzi and Yi, 1988). The CFI (the goodness-of-fit index) was 0.947 and the TLI was 0.938, which is equal to or more than the threshold of 0.9 (Hair et al., 2006). The RMSEA showed a value of 0.05, that is at an acceptable level (Hair et al., 2006). The hypothesized model appears to suit the data cantered on these above outlined fit indices.

Table 1 below, shows the factor loadings, mean values, standard deviations, Cronbach alpha, AVE, and CR values. The total number of responses was 322. As expressed in Table 1, the Average Variance of these constructs ranged between 0.50 and 0.72, which is above the threshold of 0.50, and the CR values are well above the 0.70 thresholds (Bagozzi and Yi, 1988), thus suggesting that the model maintains appropriate levels of convergent validity. The convergent validity has been established as follows; one indicating that the factor loadings are greater than 0.05 (Hair et al., 2006). Secondly, the average variance extracted for these factors is greater than 0.5 (Fornell and Larcker, 1981). Furthermore, the composite reliability of each of the dimensions acquired is greater than 0.6 (Bagozzi and Yi, 1988).

To check for reliability, two tests are conducted i.e., reliability for the

Table 1
Factor loadings, mean and standard deviations.

		FL	Mean	SDev
Risk AVE 0.69 CR 0.90				
1	I believe that irradiated foods are a risk for human health.	0.881	3.46	1.079
2	When I think of irradiated foods, I get an uneasy feeling	0.81	3.37	1.156
3	I think that certain irradiated ingredients or components in foods are unhealthy	0.858	3.48	1.051
4	I am worried about what effects irradiated ingredients or components in foods could have on my body.	0.793	3.47	1.21
Trust AVE 0.71 CR 0..92				
1	I trust scientists to provide the required accurate information.	0.807	3.82	1.052
2	I trust the Australian Public Health systems to make sound decisions.	0.807	3.74	1.053
3	I trust the regulators to make sure every necessary step is taken to protect consumers' health.	0.863	3.55	1.014
4	I trust the regulators concerning the licensing and control of irradiated foods.	0.903	3.5	1.054
5	I think that you can trust the regulators	0.838	3.53	1.065
PBC AVE 0. 54 CR 0. 87				
1	Irradiated food is readily available in the shops where I usually do my shopping.	0.645	3.27	1.004
2	I see myself as capable of purchasing irradiated food	0.818	3.46	0.96
3	There are likely to be plenty of opportunities for me to purchase irradiated food	0.715	3.5	0.958
4	I feel that purchasing irradiated food is totally within my control.	0.721	3.45	1.058
5	I am confident that I can purchase irradiated food	0.757	3.35	1.01
6	I have the necessary resources, time, and opportunities to purchase irradiated food.	0.767	3.32	0.996
Social Norms AVE 0.72 CR 0.94				
1	My colleagues and peers' positive opinions influence me to purchase irradiated food.	0.851	2.627	1.2546
2	My friends' positive opinions influence me to purchase irradiated food.	0.87	2.74	1.245
3	My parents' positive opinions influence me to purchase irradiated food.	0.862	2.59	1.282
4	Most people who are important to me would want me to purchase irradiated food.	0.87	2.86	1.184
5	Most people who are important to me would think I should purchase irradiated food.	0.846	2.8	1.155
6	Most people who are important to me would purchase irradiated food.	0.826	2.98	1.175
Attitudes towards irradiated foods AVE 0.58 CR 0.89				
1	Vital for commercial success.	0.744	3.35	1.013
2	Benefits food security and trade.	0.707	3.38	1.02
3	Reduces storage losses.	0.592	3.42	0.974
4	Reliable.	0.838	3.23	1.015
5	Safe.	0.892	3.18	1.062
6	Satisfying quality.	0.764	3.19	1.017
Intention/Acceptability AVE 0.56 CR 0.86				
1	I can accept that certain foods contain irradiated ingredients or components in foods.	0.803	3.22	1.124
2	Irradiated ingredients or components cannot be harmful; otherwise, they would not be contained in so many foods	0.78	3.02	1.156
3	I think it is unimportant to check on the packaging whether a food contains irradiated ingredients or components	0.697	2.81	1.252
4	It does not bother me if my foods contain irradiated ingredients or components.	0.842	3.22	1.124
5	I have more important things to do than worry about irradiated foods	0.628	3.15	1.2

items and reliability of the constructs (Fornell and Larcker, 1981; Hair et al., 1988). Item reliability of higher than 0.50 is regarded as an indication of reliability. Even though Chin (1998) suggests that the standardised loading should be greater than 0.7 for each item but also adequate is the value of 0.50. Validity is a scale or set of measures that precisely correspond to interested idea (Hair et al., 1988). Common method bias can be problematic when using self-administered surveys, more specifically when the same participant answers all the questionnaire items. Podsakoff et al. (2003), recommend Harman's single factor-test for assessing CMV (common method variance). The initial factor explained 29 % of the total variance, and is less than the recommended 50 % level, signifying that common method biases were not a major issue.

Table 2 shows the discriminant validity, where the AVE for each construct is required to be higher than the squared correlations among the construct and all other constructs in the model (Fornell and Larcker, 1981). As indicated in Table 2, all correlation measures were below 0.85, providing further evidence of discriminant validity. Besides, Fornell and Larcker (1981) also suggest that the square root of AVE should be larger than the correlation coefficient to have a positive discriminant validity (Fornell and Larcker, 1981).

2.5. Measurement invariance

Before testing the moderating effect of concerns on information disclosure and addressing whether the values of model parameters vary across groups, Byrne (2010) suggests that an examination strategy should start with testing the confirmatory factor analysis within each group separately to provide some evidence of fit (Byrne, 2010). Thus, testing for configural, metric and scalar invariance were deemed necessary. Outcomes for the invariance test is presented in Table 3. This is tested by regarding the difference in the $\chi 2$ ($\Delta\chi 2$) value. The values for $\Delta\chi 2$ and ΔCFI $\leq$0.01 among two nested models show support for invariance testing (Byrne, 2010; Cheung and Rensvold, 2002). However scalar invariance was not supported and indicated a decline in the fit of the model (Steenkamp and Baumgartner, 1998). Modification indices were applied to better the scalar invariance and identify non-invariant intercepts (Byrne, 2010). Several intercepts of some items had caused an increase of $\chi 2$ value. Improving the constraints ensured acceptability of the model fit when differentiated and thus the partial scalar invariance was considered. Following this, the test for the structural is assessed next by comparing multigroup with the same model.

2.6. Path model

The model has estimated six variables and the chi-square is not significant at the 0.05 significance level (χ 2 = 2.824, df = 2, p = .59). The fit indices demonstrate that this model is reasonably satisfactory: GFI 0.99, RMR 0.017, RMSEA 0.075, TLI 0.95, AGFI 0.93, NFI 0.99, CFI 0.99, IFI 0.99, and RFI 0.92. The model explains 0.35 percent of the variance of consumer acceptance.

Table 4 shows that while all other hypotheses are supported, hypothesis 4 b: Trust in authorities have a positive influence on social norms in favour of irradiated foods and Hypothesis 3a: PBC positively influences consumer's intention to accept irradiated foods are not supported. However, hypothesis 5 b Perceived risks negatively influences PBC towards irradiated foods was shown to have a positive influence.

For a better explanation of the results of the path model analysis, standardized indirect, direct and total effects were calculated by SPSS AMOS 26 using bootstrapping mediation analysis. A two-tail significance with 95 % bias-corrected bootstrap confidence intervals using 5000 bootstrap samples were used to analyse the results and are shown

Table 2
Discriminant validity.

	RISK	TRUST	PBC	Social Norms	Attitude	Int/Acc
Risk	**0.83**					
Trust	0.01	**0.84**				
PBC	0.13	0.55	**0.73**			
Social Norms	0.07	0.39	0.56	**0.85**		
Attitudes	−0.12	0.61	0.61	0.67	**0.76**	
Int/acceptance	−0.2	0.54	0.52	0.56	0.66	**0.75**

Table 3
Measurement invariance.

Consumer concerns	χ2	d.f.	χ2/df	Δχ2	Δdf	*p*-value	TLI	CFI	RMSEA
Configural	1486.293	854	1.74				0.905	0.919	0.048
Metric	1532.214	886	1.646	45.921	32	.052,831	0.907	0.917	0.048
Scalar	2871.361	913	3.145	1339.147	27	0.000	0.9	0.908	0.049
Partial Invariance	1559.703	908	1.718	27.489	22	0.19356	0.9	0.916	0.047

Table 4
Path model and hypotheses.

			Estimate	S.E.	C.R.
Trust	−−>	Attitudes	.474	.024	10.840***
Risk	−−>	Attitudes	-.283	.017	−7.208***
Trust	−−>	PBC	.458	.025	9.222***
Trust	−−>	Social Norms	.042	.045	0.751
Risk	−−>	PBC	.112	.019	2.311*
Social Norms	−−>	Acceptance	.157	.068	3.020**
PBC	−−>	Acceptance	.037	.122	.649
Attitudes	−−>	Acceptance	.876	.180	9.266***

Note: ***p < .001, **p < .05.

in Table 5.

The overall results of all the effects for the hypothetical model are shown in Table 4. The results show that hypothesis 1 b: Attitudes have an indirect influence on trust in authorities and consumer's intention to accept irradiated foods (β = 0.439) was significant (p < .05) and hypothesis 1c: Attitudes have an indirect influence on perceived risk and consumer's intention to accept irradiated food (β = −0.244) was significant (p < .05). However, risk showed a negative influence. One would expect that the higher the perceived risk, the lower the intention to accept irradiated foods. The following indirect effects were not found significant for H4b, H5b and H5c.

3. Discussion – combined model

This research shows that only attitudes and social norms that favour irradiated foods influencing consumer's intention to accept irradiated foods are significant. Risk showed a negative influence on attitude, this is supportive of other researcher's findings in terms of dietary changes (Sparks et al., 1995). PBC influencing consumer's intention to accept irradiated foods was not significant. This is an interesting finding, as PBC relates to the consumer's intention to perform the behaviour. This suggests that the outcomes cannot be determined by the consumer's actions or by external factors that are beyond their control (Bandura, 1982). This could indicate that consumers have limited control over performing this behaviour for many reasons, such as required resources or continuous availability of irradiated foods, subsequently their intentions to perform this behaviour would be low, even though they attribute favourably to attitudes and social norms (Madden et al., 1992).

Social norms are those expectations of consumers as to what they expect others to do or not to do. Unlike other studies, the social norm in this study was seen as a significant predictor and has a positive relationship with consumer's intention to accept irradiated foods. But on the other hand, trust was not found to influence social norms, thus one needs to examine the type of trust that is likely to lead to social norm's salience. Given that trust in authorities had no significance on social norms in favour of irradiated foods, suggests that normative influences conform to societal rules or represents the generalized viewpoint of irradiated foods.

This suggests that consumers' trust for irradiated foods is not enhanced when they see others using or buying these foods. This is unlike organic foods where consumer's trust and perception of others' behaviour were found positive (Petrescu et al., 2013).

Another plausible explanation is the consumer's familiarity with food irradiation which increases with trust. Having positive trust is a useful finding, more particularly for retailers, as they are slow in recognising this fact (Roberts, 2014). Once trust is established, it makes it easier for retailers to expose the benefits of irradiation foods to consumers for acquiring commercial successes. While the hypothesis for trust and attitude; and trust and PBC were positively related, this is supportive of the literature where trust in corporations was highly regarded (McCarthy and Murphy, 2013). Otherwise, these findings are consistent with much of the literature discussed above, our results show that many of the identified constructs help explain behavioural intention of irradiated foods, although some of these associations appear indirect.

Table 5
Total effects, direct effects and indirect effects.

TOTAL EFFECTS					
	RISK	**TRUST**	**PCE**	**S.NORMS**	**ATTITUDE**
PCE	.112	.458**	.000	.000	.000
SOCIAL NORMS		.042	.000	.000	.000
ATTITUDE	-.283***	.474***	.000	.000	.000
ACCEPTANCE	-.244***	.439***	.037	.157**	.876***
DIRECT EFFECTS					
PCE	.112	.458**	.000	.000	.000
SOCIAL NORMS	.000	.042	.000	.000	.000
ATTITUDE	-.283***	.474***	.000	.000	.000
ACCEPTANCE	000	.000	.037	.157**	.876***
INDIRECT EFFECTS					
PCE	000	.000	.000	.000	.000
SOCIAL NORMS	.000	.000	.000	.000	.000
ATTITUDE	.000	.000	.000	.000	.000
ACCEPTANCE	-.244***	.439***	.000	.000	.000

Note. ***p < .001; **p < .01.

4. Multigroup analysis

Research shows that information concerning the benefits of food irradiation evokes positive changes in consumer's perceptions and acceptance (Teisl et al., 2009). Similarly, others have found that information regarding food irradiation is the key to greater acceptance (DeRuiter and Dwyer, 2002). For consumers to feel contented with foods treated by innovative production processes, they must obtain consumer acceptance by way of effective education or information programs (Nayga, 2003). Amongst Malaysian consumers information was a critical factor influencing consumer's attitude and trust towards food irradiation (Rozekhi et al., 2018).

Generally, inadequate information and lack of confidence in dealing with science and technology are likely to evoke emotions of fear and distrust (Deliza, Rosenthal, and Silva, 2003). When there is information presented regarding food irradiation, consumers feel less anxious and are more receptive to the technology (Pohlman, Wood, and Mason, 1994). Information disclosure is important not only for marketing foods produced using these manufacturing practices but also for consumer information and health programs (Nayga, 2003). Attitudes towards technology may depend on the source of consumer's information (Teisl et al., 2009). Information is seen as having a positive and direct influence on consumer attitudes towards irradiated foods (Resurreccion et al., 1995) and since information on food irradiation are essential for greater acceptance (DeRuiter and Dwyer, 2002), it would be essential to ascertain whether the path coefficients for the relationships among the TPB dimensions, risk and trust were equal in both groups. The intention

is to examine a relatively under researched area as information is key in establishing acceptance for irradiated foods and how it can be influential for acceptance.

Cluster analysis was used as it enables to combine groups that are similar to each other. To investigate the heterogeneity of the sample, Hierarchical cluster analysis was employed using the ward's method to detect the two groups. The auto-clustering provided a summary indicating that after two clusters showed a large ratio of BIC changes, thus, two clusters were preferred as the third indicated and a large ratio and distance measures (Norušis, 2008). Questions for concerns regarding information were taken from Miles et al. (2004) and modified: I am concerned about the information on animal welfare standards in food production; I am concerned about the information for quality of food produced using intensive farming technology; I am concerned about the lack of information about food from the government; I am concerned about the conflicting information on food safety; I am concerned that information about what foods are good for you can change over time. From the 322 cases, 40 percent were assigned to group 1, those consumers that had high concern for information. In parallel, 60 percent were assigned to group 2, those that had a low concern for information. These results showed a statistically significant difference between consumers that had a low preference and a high preference for natural food determined by one-way ANOVA, following which a multigroup analysis was performed.

A two-step method was employed to analyse the multi-group comparison test. An unconstrained multi-group measurement model is undertaken (Hu and Bentler, 1999). The multi-group was used to assess variant and invariant models to ascertain if the measurement and structural components of the model were equal across preferences for high and low concerns for information regarding foods. The difference among the structural weight model and the measurement weight model is only taken into consideration. The result of this analysis shows that the $\Delta\chi 2 = 24.652$ $\Delta df = 8$, $p < .01$, thus there is a significant difference between the structural weight model and the measurement weight model. A significant Chi-square difference reveals that unconstrained model applies to the data better than the constrained model, suggesting that causal relationships have a moderating effect in the model (Byrne, 2010).

The multi-group comparison test is shown in Table 6 of the two groups concerning the TPB dimensions (i.e., attitudes, social norms, PBC, and acceptance) and the antecedents of irradiated foods (risks and trusts). Concerning the previous model, support for using the theory of planned behaviour in predicting and assessing acceptance of irradiated food was given. Fig. 1 shows the conceptual model with final empirical results of the path analysis and the high and low multigroup analysis.

Table 6
Multi-group comparison test.

Model	*B* high concerns	*β* low concerns	χ^2	*Df*	$\Delta\chi^2$	Δ df
Unconstrained			2.092	4		
Structural Path Weights			26.744	12	24.652	8**
TRUST→ ATTITUDE	.582***	.420***	2.867	5	.775	1
RISK→ ATTITUDE	-.252***	-.283***	3.064	5	.972	1
TRUST→ PBC	.538***	.407***	3.379	5	1.287	1
TRUST→ SOCIAL NORMS	-.083	.120	5.253	5	.075	1
RISK→ PBC	.070	.053	2.115	5	.879	1
SOCIAL NORMS→ ACCEPTANCE	.079	.188**	3.377	5	1.285	1
PBC→ ACCEPTANCE	.299**	-.047	9.475	5	7.383	1**
ATTITUDES→ ACCEPTANCE	.529***	1.012***	8.928	5	6.836	1**

Note: ***p < .001, **p < .05.

5. Discussion – multigroup analysis

The variant model showed that there were differences between the groups and three of the antecedents influenced the TPB antecedents differently. This distinction makes some sense, with regards to concerns regarding information for food disclosure.

When compared, four paths were significant for both groups, thus indicating consumer concerns regarding information for food disclosure shows a significant moderating link between trust and attitude; trust and PBC; attitudes and acceptance and a negative effect between risk and attitudes. While group 2 showed a moderating effect between social norms and acceptance, only group 1 showed a significant moderating effect between PBC and acceptance. However, the influence of trust on social norms and risks and PBC was not found significant for both groups of consumers.

Regarding the TPB antecedents, the results of the moderating effect test affirm only attitudes influence acceptance to be the significant moderating predictor for the two groups. Consumers who had low concerns regarding information for food disclosure had a slightly higher beta value towards attitudes ($\beta = 1.012$) than group 1 ($\beta = 0.529$). Social norms influenced consumer acceptance for the low preference group and PBC influences consumer acceptance was found significant for the high preference group. Trust in authorities associated with social norms was negative, indicating that consumers with high concerns demonstrated a negative relationship against trust with authorities. Similarly, risks positively associated with PBC and was significant for both groups.

The significant moderating result of attitudes impacting acceptance for both groups is supportive of other literature that found information about irradiated food substantially increased its acceptance (Gunes and Tekin, 2006). The results indicated that the model predicted 23 % (low group) and 52 % (high group) of the variance for consumer acceptance for irradiated foods. It shows that developing appropriate reasons for consumers with a high preference towards concerns for information regarding foods may be an effective way to go. The significant negative moderating relationship between risk and attitudes for both groups indicates that the greater the risk the lesser the positive attitude towards irradiated foods. Thus, even though consumers are more aware of the benefits of irradiation (Bruhn and Schutz, 1999), they still require more information on the impact of protective technologies such as food irradiation.

Trust and attitude showed a significant moderating relationship. Suggesting that the two groups' concern for information disclosure with trust also influenced their attitudes. This sheds light on the inadequacy of information within science and technology to make personal decisions encourage consumers to look at organisations or the authorities within the public who they would believe and trust for the required information to make choices that are well informed (Siegrist et al., 2000).

6. Retail implications

The current research contributes to the theory by extending the model and reporting on the significant effects. It ascertains that information is strongly related to consumer acceptance and this is consistent with other research findings (Gunes and Tekin, 2006). The findings also demonstrate suggestions to show the robustness of the TPB framework is useful in the food area and addresses the literature for more theoretical foundations (Milton and Mullan, 2010).

Multigroup analysis provided a more diagnostic value for understanding consumer acceptance when making food choices. In terms of irradiated foods disregarding the antecedent variables may lack depth and rigour, as risk and trust correspond favourably to a great extent. Some retailers are reluctant to offer irradiated foods due to the controversial nature expressed by consumers of this technology, increased pressure from advocacy groups and commodity organisations that have vested interest in consumer purchases (Rodriguez, 2007). Retailers

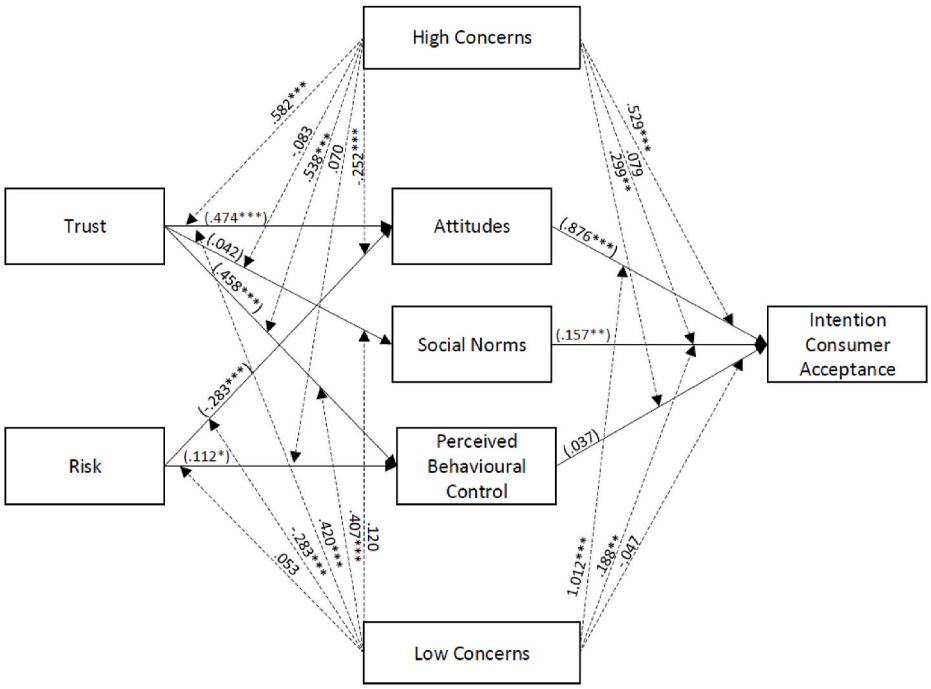

Fig. 1. Conceptual model.

should understand the nature of irradiated foods and how they can negatively influence attitudes, thus acquiring ways to mitigate those risks and developing positioning strategies for strengthening consumer acceptance.

Concerns regarding food irradiation are similar to other potential food safety issues like food additives, animal drugs, and pesticides (Bruhn, 1998). When consumers are concerned about food irradiation, they are highly unlikely to see the potential benefits of these processes and are likely to not adopt these foods (Henson, 1995), thus information disclosure plays a major role. These irradiated food concerns can be mitigated by producers and retailers providing information concerning the risks and benefits these methods (Deliza et al., 2003; Galati et al., 2019).

As per the risk theory of consumer behaviour (Bauer, 1960), Bauer indicated that benefits are often accompanied by risk, thus highlighting the product's core benefits is essential as consumers attempt to buy products based on benefits. Besides, trust with authorities was also significant except for social norms. Retailers can develop trust-building capacities to attract consumers with safety information from regulators, increasing public relations credibility from scientists, or through advertising in terms of health and safety and maintaining long-term customer service.

Roberts and Henon (2015) suggest that the belief held by food producers and retailers that consumer resistance is the major barrier is no longer but the need for factual, positive information on the benefits of food irradiation is still necessary. However, for retailers to increase retail sales of irradiated foods should pay greater notice to the risk factor in light of these findings. Providing information to consumers concerning irradiation labelling for making an informed choice are other initiatives that retailers will benefit from, as labels provide evidence for quality and safety. Retailers should consider the assessment of risk and trust underlying attitudes, social norms and perceived behavioural control that offer the possibility of developing key promotion strategies for consumer acceptance.

7. Theoretical contributions

This research extended the original TPB model with two additional predictors trust and risk, both of which are important for irradiated foods to further enhance the explanatory power. It shows how trust and risk play their role in explaining consumer's intention to accept irradiated foods. The TPB explained more than 35 % of variance in consumer's intention for acceptance. As compared to the MGA that explained more than 52 % variance and suggests that using an extended version of the TPB is appropriate for examining intention of acceptance for irradiated foods in Australia.

Apart from Frishman (2008), who examined how attitudes and subjective norms influence behavioral intentions to consume irradiated foods, this research is one of the very few that has extended the TPB model to investigate irradiated foods which advances existing research. First our findings show that all TPB antecedents as predicted by the theory showed positively related significance with the exception of PBC which was not significant. Further research is required as to why this is the case a plausible explanation may be due to lack of knowledge (Galati et al., 2019; Gunes and Tekin, 2006). The research confirms that trust and risk can be used in the TPB as additional explanatory factors (Lobb et al., 2007).

There is also a body of research that has emphasised on the predictive power of food concerns as a moderating factor (Akbar et al., 2019: Tandon et al., 2020). This work tested the extended model and broadened the function of food concerns among two consumer segments as a moderating factor within the context of food irradiation.

8. Limitations and future research directions

Scholarly future research can investigate the findings from this research and other misconceptions that consumers have about this type of food (Mostafavi et al., 2012). The study also provides better insights into the acceptance of irradiated foods, a highly debated topic in Australia. It is clear from this study the extended antecedents such as risk, and trust have an influencing role in the TPB antecedents.

This study has a few limitations. The study measures consumers who have brought irradiated foods in some form and were the main household buyer but are not necessarily other buyers and hence there are likely to be some biases with the responses, thus generalisations would necessitate some precautions. The multigroup analysis has much to

offer, and demographics could have been used to obtain a broader outlook. Other relationship variables such as beliefs and health impacts, should be pursued based on consumer acceptance context in which irradiated food patterns emerge. Furthermore, the health belief model and other competing models may improve and add robustness to the finding of this study for those concerned with health issues. Other demographic factors should be examined. This research has overall made a strong contribution to the irradiation food preference domain. It is among the first, which argues and evidences the significance of other antecedents such as risk and trust, as well as the moderating role of concerns regarding information disclosure that are key for making informed choices for irradiated foods.

Funding

I acknowledge with thanks the funding obtained from La Trobe School of Business Award Grant.

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