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New sustainable ideas for materialistic solutions of smart city in India: A review from allahabad city

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Abstract

Taking into account the application of the "sustainable and smart city" conception with the shift in modern town-building priorities in the newly selected city to make them a smart city in India, the article explains the opportunity of this conception for improving economic opportunities, infrastructure and services, management created before town-building (especially Prayagraj). The author has evaluated the key components of the "sustainable and smart city" idea, its course of growth and evolution, its standards and solutions, and the reasons and barriers stipulating their application. The article provides information about the "smart" market's capacity and structure, application stages, and scenarios. Investigations have been done about this conception's use in India. This paper aims to offer and suggest sustainable solutions that can improve, alter, and promote Prayagraj's development as a smart city, model village, or Adarsh village, and also cover the managerial implications of the article for sustainable and smart cities in India that can resolve the issue of slum regions before transforming them into smart towns, smart cities, or smart metro cities that have future transformation ideas with the growing population and finally set new and sustainable environment in a smart city in Prayagraj.

Introduction

In recent decades, “sustainable and smart city” concepts have moved from theory to practice. The Internet of Things (IoT), Internet connectivity, and advancements in big data processing have made the “Smart City” vision a reality. Among “Smart cities” characteristics are sustainability and environmental compliance, public involvement in management, effective information utilization, improved service quality, and higher living standards“.

India may enhance economic development and economic development by enhancing economic prospects, infrastructure and services, and management through a “Sustainable Smart” (smart city/village/network/etc.) approach. On the other side, establishing new settlements in the conquered lands becomes urgent. India is devoting significant resources to this problem; orders have been placed, and a working committee has been set up to tackle this issue. The newspaper quoted the prime minister as saying, “Residential areas freed from Armenian rule will soon be rebuilt using a smart city/village model.

“ Prayagraj's implementation of the Smart idea is a real factor in creating the zone based on current needs, the provision of sustainable development, and regional growth. Examining the ”Smart city” concept from every angle is necessary to achieve this goal.

The term “Smart city” is used widely nowadays, yet no universally accepted meaning exists. Yet, this term might be interpreted differently among nations, institutions, and written works. The IBM Company, widely regarded as the pioneer of solutions in smart cities, defines it in terms of the given, associated, and intellectual quality indicators. An “innovation city and sustainable city,” as defined by the Indian government, “apply solutions completely for the environment and citizens' welfare.” According to the Indian Parliament and an American think tank on smart cities, a “smart city” employs information and communication technologies (ICTs) to address societal issues. The nation is confident in these urban centres' strategic importance in reducing poverty and inequality, combating unemployment, and ensuring efficient energy flow [13].

“ Strong parties and assets already present in a city area or community service as a foundation for new opportunities made possible by increased use of digital and telecommunication technologies, innovations, and information where both legacy and cutting-edge networks and services coexist” as defined by the Asian infrastructure bank (AIB), is what the AIB means by a “smart city.” To summarize, the phrase “smart city” often refers to networks in both cities and rural areas that make use of information and technology to foster growth and innovation. It provides the simplified definition we use to identify smart cities: A “smart city” is an intelligent organism that can hear, see, and understand its environment. A smart city is antithetical to a densely populated area. Management in a “smart” environment is based on a trove of data collected on all the processes that affect its element (population life).

“The use of information and communication technologies (ICT), the sheer volume of relevant data, and the regulated mutual organizational activity system of all subjects are all factors that contribute to the development of intelligent and sustainable processes (government, business, and population). New concepts such as the Internet of Things (IoT), Big Data, and information management are introduced to city planning under the banner of “Smart and Sustainable.”.“ The main characteristics of sustainability and the concept of a smart city can be explained as follows [26], drawing from the work of organizations such as the International Organization for Standardization, the International Electrotechnical Commission, the Union of International Telecommunication, the Telecommunication Standards Institute of Europe, and any other pertinent organizations.

Fig. 1 mentions some essential features that make a city smart. A smart city comprises modern methods to make mobility easier, with continuous infrastructure modernization to support the development. It explains how improved places for social gatherings with more activities for socializing result in increasing the life quality to constitute the basic pillars of a smart city. Using eco-friendly techniques with smart and digital technology can help attain smart city objectives. The huge capacity of structural and non-structural information created by data on the processes that shape each city is one of its defining features (traffic flow, trade turnover, environmental situation, etc.). The management of a conventional city does not make full use of such data. Big data analysis in a “Smart City” provides crucial context for developing effective administration strategies. Table 1 lists many sources that help gather information for deciding whether a city is a smart city.

However, most “smart city” initiatives integrate with existing infrastructure gradually. A “smart city” incorporates every conceivable form of technological advancement. As a result, local governments can pursue their solutions [21]. Implementing “sustainable and Smart city” solutions is experiencing a period of rapid expansion worldwide. This idea will soon be implemented in over 2,500 locations with various project approaches. A

city's “ground-up” building is one of the application models (in an empty area) Case in point: Indore. It's the world's first plan for a carbon–neutral green city—a metropolis powered entirely by solar and other green energy. By 2025, the first Eco city sample would have been completed [20]. It's important to remember that the technologies that form the “Smart City” idea are all at different points in their life cycles [29].

Smart city solutions are being adopted at drastically different rates in different parts of the world. In 1990, the connection between technological progress and the future of I.T. was widely recognized. The concept of an IT-reliant “smart city” was originally advocated even back then. Before then, people saw “smart cities” as a way to lessen their negative effects on the natural world. During its inception in the early 2000s, the “Smart House” concept was focused primarily on improving technological and institutional frameworks. Because of this, cutting-edge technologies emerged [28]. Most innovative products that fail to gain widespread consumer acceptance seldom see a second production run. Several years of trial and error have led urbanists to suggest a new model for smart cities. In developing this approach, residents' engagement with implementing and improving smart technological solutions was considered. The paradigm of a modern smart city includes more than just cutting-edge technology. It's a location where innovative ideas provide people with new chances. People in smart cities can better use their time, money, and resources due to the digitization of formerly analogue practices [9]. So, we can see the generational shifts in smart city development in Table 2.

Many “smart cities” are being studied for their technological potential. One of the primary variables of technical application is the social and economic aspects of the “smart city” concept. According to the McKinsey Global Institute, using smart city technologies could boost sensitivity to unusual circumstances by 20–35%, resulting in a 10% decrease in mortality. Due to accidents, a 15–20% reduction in average travel time and an 8–15% reduction in urban resident morbidity [9]. Technologies used in “smart cities” are highly effective In finding answers to problems at the individual and organizational levels [6]. With the help of digital twins, cities can better predict and plan for the future (in terms of things like population growth, tourist traffic, communal and housing needs, resource conservation, the development of social and transportation infrastructure, and so on), resulting in a more positive relationship between citizens and the government. Technologies used in “smart cities” are highly effective. In India, some cities have ranked among the top smart cities like. Delhi, Mumbai, and Chennai are the two smart cities in the list of smart world cities with good living facilities.

Even Jamshedpur is a smart city declared by the smart world city ranking. Still, due to industrial centralization, it is populated, and the flow behind this city is also polluted. This river is the Damodar River, and Mahanadi has the same condition. As we see in the case of Prayagraj city, it is situated in the back of Holi Ganga and Yamuna river and

Saraswati rivers which is physically not visible.. in the top clean city rank in the smart city list 2023. It is a position of 20th. The 'Swachh Survekshan-2021′ results were released on Saturday, showing that Sangam City's standing has dropped. According to the poll results published by the union housing and urban affairs ministry, the city is placed 26th in the Country and fifth in the state. But by the year 2023, it has risen to the top. Prayagraj is ranked number twenty among India's “smart cities” on the Oeverall Clean Cities Index.

City and community infrastructure is the primary tool of a “Sustainable and Smart city,” as stated in Table 3. This includes the widespread implementation of digital and engineering solutions related to smart city benefits.
Rising urban populations in many nations and the potential environmental benefits of using handmade goods in high-tech settings like “smart cities”.

- License for the sustainable market in smart cities in India, especially in Prayagraj.
- Use of A.I. and ML for Shaping and Safety of Society.
- Use of GPS, GAGAN, GLONAS, and IRINS.
- The usage of modern protocols for mobile phone communication,
- Internet of Things (IoT), which is rapidly expanding on the global market;
- Lower the cost of applying Smart City solutions;
- The feasibility of potential solutions at the level of local governments is impacted by various factors, including but not limited to state support for the growth of the “Smart City” ecosystem in various regions of the world, growing consumer demand, and other elements.

Many components of the Smart City system are not yet ready for widespread implementation.

The implication of Smart City's prohibitively high price tag for underdeveloped countries' digital and new infrastructure development. In underdeveloped nations, the Smart City ecosystem is not evolving fast enough to support the city's long-term viability.

Many medium and small communities lack a strategic perspective on Smart City's potential because of a lack of qualified employees, funding, and other problems.

Economic and financial developments have shifted because of the shift in societal development priorities brought on by technical progress in the modern era. As a consequence of this, sustainable cities that promote sustainability on all fronts (social, economic, and environmental) face a variety of difficulties, such as climate change,

population growth, urban flow, political unpredictability, economic uncertainty, increasing transportation in addition to the organization of road traffic, the establishment of communications, the supply of energy and water, concerns around rising urban economies, and increasing population demands, and so on. These challenges are novel threats to city economies. Sustainable solutions to urban challenges, the adoption of digital solutions and technology, and enhanced quality of life are all possible due to urban transformation.

In return, it hastens our understanding of the global trend toward better city planning and higher living standards for urban dwellers by applying collected experience, infrastructure optimization, technical advancements, and organizational reforms. There will be 9.2 billion people globally by 2050, up from 7.6 billion today, and 6.8 million will call Prayagraj city home [24]. There are more than 10 million people in India now, and 56 per cent reside in urban or suburban areas [25]. Rapid urbanization calls for transportation, healthcare, energy supplies, and public safety improvements. Public safety in developed nations relies heavily on cutting-edge technology like machine learning and artificial intelligence, large-scale data processing, and the Internet of Things (IoT). The yearly Economist safe city rankings are based on 76 factors (the 2021 report includes 60 cities). All digital and medical technology areas, infrastructure, and environmental and personal security are evaluated. Hence, the sustainable and Smart“ (smart city/village/network/etc.) conception is the cutting-edge approach to constructing territorial units, as evidenced by the global trend.

Section snippets

The objective of the study

- To study the smart city approaches and review the development of the smart city in India.…
- To suggest ideas for making a sustainable and smart city in Allahabad…

…

Activities carried out in India in relation to the “smart city” idea

Since independence, the planning of cities and towns has been based on the five-year plans developed, executed and monitored by the Planning Commission. The initial plans focused on providing housing provisions, slum clearance and rehabilitation of people experiencing poverty. Master plans were prepared for major cities that promoted low-

density settlements but were expensive. In the intermediate plans, the approach shifted from slum clearance to slum improvement and development of small and…

Research methodology

This chapter provides a comprehensive overview of the study of sustainable and smart cities. This article also uses secondary data collected through more conventional means of group communication, such as group thinks [27] or by a few individuals who tend to speak up at meetings. Sources range from the Ministry of Urban and Planning Development to Smart City Author to the Press Information Beuro Report to the National Institution of Transforming India (NITI) Ayog's Report on Vision 2047 for…

Discussion and analysis

In Japan, Singapore, United Arab Emirates, European Union, and North American markets, smart city solutions are in high demand. In the medium term, the Asian market could be the most dynamic for smart city solutions. The global adoption of smart technologies has increased. Today's two primary components of the global market are “smart” services and “smart” government. According to [6], smart energy and smart transportation are the fastest-applied solutions. The state of the globe determines the …

Conclusion

There is an immediate need to implement the concept of the “smart city” or “smart village” in India; we can conclude by summing those mentioned above. And this environment is favourable. There is a material and technical foundation and infrastructure for the application of digital technology solutions. It denotes the presence of capable employees and professionals in implementing novel solutions. Implementing the concept of a smart city or village in India cannot be avoided. The quantity of…

Limits and foreseeable future

There is a need for a better and more in-depth study in this field to fix the issue because, even in this paper, we only concentrated on a small area and chose a literature review that is inadequate on a global scale to address smart cities. So, All relevant fields of study can be included in future research, which can be consolidated using more performance-focused Delphi methodologies. Policymakers and people will benefit from the practical results of this, which could hasten the development…

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper....

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Leveraging Digital Advertising to Enhance Online Marketing Strategies: A Research Perspective

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Abstract: The growth of the internet is altering business practices, notably those in retail establishments where company models use electronic commerce to handle transactions. This study's goal is to investigate the best practices for online advertising implementation and capturing consumer interest in purchasing. Additionally, this study used a descriptive survey method with verification. With a sample size of 96 customers, the population in this study consists of Lazada users in the city of Bandung. The results demonstrate that the use of online advertising has a direct influence on customers' intent to purchase through the Lazada website. The rapid development of information technology has had an impact on community in supporting various business activities, both large and small, so that they can be widely recognized global. The most obvious impact is that apart from being known, it can also increase sales volume and profit. Digital Marketing is one of the marketing media that has a huge impact. With using digital marketing in this case is social media, especially in every e-commerce application to increase sales, especially in the era of globalization social media affects so sales volume has increased rapidly compared to the old way of selling. Digital marketing is seen as the best media as the most effective means of promotion and efficiently and able to increase sales volume significantly.

Keywords: Digital Advertising, Marketing Strategy, Innovation or Creativity.

1. INTRODUCTION

The growth of the internet altered business practices, particularly those in the retail industry, where the business model it uses to provide a service digitally is known as e- commerce [1]. Online trading increased in Indonesia 78% annually in 2018, according to the 2018 PPRO study, outpacing Mexico 59%, the Philippines 51%, Colombia 45%, and the United Arab Emirates (UAE) 33% 2018.

Compared to 2015, when it was just IDR 200 trillion, the transaction value at online trading in Indonesia in 2018 was Rp 1,850 trillion, an increase of 9 time [2].

According to trending business in 2019, the three categories of e-commerce that are most prevalent in Indonesia are B2B (Business to Business), B2C (Business to Consumer), and C2C (Consumer to Consumer) [3]. Six well-known

online markets in Indonesia currently dominate the state of e-commerce and online marketplaces: Blibli, Jd.id, Lazada (B2C), and Bukalapak, Shopee, and Tokopedia (C2C) [4]. Each has benefits over the others when compared, according to consumer trust in a number of different areas [5]. Serviced are product guarantees, high-quality services, and system efficacy [6]. It became increasingly difficult to distinguish between B2C and C2C e-commerce categories when an official store was included on a C2C marketplace [7].B2C marketplaces, however, can maximize excellence in providing a customer experience through service quality, as demonstrated by Lazada's eLogistics, which independently offers on-demand services for one-day delivery and accepts a variety of payment options, including cash-on-delivery (dailysocial, 2019)Along with the advances produced by e-commerce companies, change the framework for growth [8]. In order to make purchasing and selling online using smartphone devices more convenient, Indonesia's online shopping market is similar to the number of individuals with credit cards, bank accounts, and internet users [9]. Indonesians are more enthusiastic Shop online using shopping applications (dailysocial, 2019) [10]. It forces retailers to spend a lot of money on advertising and promotion to draw customers. Results from Adstensity's ad spending marketplace's monitoring of television ads up until December 16th, 2018 totaled IDR 4.97 trillion (Pertiwi, 2018) [11].

The market for television advertising has grown in size as a result of public spending trends during the offline to online shift and the perception of television as an efficient medium.with a consumption habit that is comparatively high, to achieve the lower middle class (daily social,2019) for the entirety of Southeast Asia [12]. Lazada led all online marketplaces in terms of traffic in 2018 and held a 25% market share in e-commerce, followed by Shopee, Tokopedia, and Bukalapak. Up till the end of 2018, in Indonesia Lazada and Tokopedia are the two most popular marketplace applications [13]. 2018 (Fenalose) Lazada, with 58.2 million monthly visitors, is only in fourth place for the Indonesian market through the end of 2018[[14]]. Two local marketplace applications, Tokopedia (168 million users per month) and Bukalapak, are in the top two spots (116 million people per month) [15]. Shopee, with 67.6 million monthly visitors, is in third place [16]. 2019 (iprice insight). The purpose of this study is to investigate how consumers might realize their buying interests through the "Adoption of advertising in online environments [17]." Online shoppers from the Lazada website served as the research sample [18].

2. LITERATURE REVIEW

Online Marketing

Activities related to sales, advertising, promotion, and pricing are included in marketing [19]. Any business that promotes a good or service using Internet media or the network "www" is said to be engaging in internet marketing, often known as e-marketing or online marketing [20]. A website Marketing is a communication activity that uses the Internet and other media [21]. Online marketing presents a wealth of opportunities for this business, which is evolving and will require ongoing strategy development in the future. Kotler and Armstrong (2011) define online marketing as initiatives to market goods and services and create customer relationships online, which may be translated as initiatives to market goods and services and create consumer relationships online. Kotler and Armstrong (2011) define online marketing as initiatives to market goods and services and create customer relationships online [22]. which may be translated as initiatives to market goods and services and create consumer relationships online. A large public network (internet) comprising networks linking computer network users from all over the world to one another and serving as a significant information storage facility is also revealed by Kotler and Armstrong (2011) [23]. E-commerce, sometimes referred to as online marketing, is the word used to describe the sale of products and services through the internet [24]. The two main types of items purchased online are clothing and computers. Security is one of the reasons why they favor cash on delivery (COD) or transfer payments made through ATMs [25].

General internet marketing activities embracing or centering around topics that are relevant to product production crafting marketing language or copywriting, soliciting, or purchasing. Web design activities (web design), banner advertising, company promotions through information search engines (search engines), email (e-mail), email advertising, affiliate marketing (affiliate marketing), interactive advertising (interactive advertising), and others are typically included in this internet marketing.

Online Advertising

Advertising is an information medium that is created in a way to draw in audiences, be unique, and have features that are definite and convincing so that audiences are willingly persuaded to behave in the way the advertiser desire.

Advertising is a method of communication used to inform and persuade an audience to make a purchasing choice regarding a good or service, in this example, potential consumers (Haider & Shakib, 2017). Advertising is any sort of non-personal, sponsor-funded presentation and promotion of ideas, products, or services. According to Kotler and Keller (2016), advertising encompasses any non-personal presentations and promotions of concepts, products, or services by the sponsor for a fee.

Ship (2003) also highlighted that advertising as a method of persuasion is not directly based on information about the benefits of a product, but rather is prepared in a way that induces a person to engage in an activity or make a purchase by emitting a joyful, mind-altering experience. Television, radio, newspapers, and magazines have long since dominated the advertising medium. However, in modern times, online advertising has taken the lead in advertising endeavors and efforts (Kotler and Armstrong, 2010). According to Aksa & Kartini's (2015) research, internet advertising is typically found on websites developed by businesses that target the activity. Promotion, then the online advertisements that show up as long as internet users have a notion of them. This is connected to how the adverts appear and are designed, which can create a positive impression of internet advertising. However, the positioning of online advertising in terms of layout merits consideration because it irritates internet users. Then, according to Wei, Jerome, and Shan (2010), "the internet is a network of internationally connected computers that provides businesses with pricey and practical instruments for advertising and consumer communication. The term "internet advertising" applies to this. The internet is a vital component in marketing. Many Company websites are handled by the marketing department. The Internet has a profound effect on how businesses interact with their clients and forge relationships with them.

Consumer Buying Interest

Purchase intention is the desire to make a purchase of a good or service with the expectation of receiving some sort of benefit from it. People who are interested in something will have the desire or power to engage in a sequence of activities to approach or get the item. Interest is tied to something personal as well as related to attitudes. One type of consumer behavior is the desire or interest to purchase a good or service. Potential consumers, also known as consumers who haven't made a purchase yet but are likely to do so in the future or prospective purchasers, are the consumer form of interest in making a purchase. Consumer buying interest, according to Kotler and Keller (2016), is a consumer behavior in which consumers have strong urges to select, utilize, and consume or even covet a product that offered. Next, Schiffman and Kanuk (2010) demonstrated that a consumer's buying interest may be characterized as a satisfaction with the thing expressed by payment or sacrifice. However, Kotler, Bowen, and Makens (2014) point out that a number of factors, including the following, shape customer buying interest. That is :

The degree of the negative features that others hold against the alternative that the consumer loves and the willingness of the consumer to follow others will determine how much the attitude of others reduces their liking for that alternative.

Unexpected circumstances may influence how consumers feel about making purchases in the future. It relies on how confident consumers are in their ability to decide whether or not to purchase a product. Consumers can make the following five sub-purchase decisions to carry out their purchase intentions: Brand decisions, Supplier decisions, Quantity decisions, Timing decisions, and Payment method decisions.

Additionally, according to Schiffman and Kanuk (2004:25), customer interest in making a purchase can be sparked by external stimuli, understanding of a need, recognition of a product, and appraisal of alternatives. Social and cultural variables, as well as effort marketing, make up this external effect. The marketing communications mix is under issue in terms of marketing activities. Kotler and Keller state the following (2016), Advertising, sales promotion, events and experiences, community relations and publicity, direct marketing, marketing interactive, word of mouth marketing, and personal selling are the eight different types of marketing communication mix. Seock & Bailey (2007) claim that a strong brand image is necessary to pique customers' interest in making purchases. According to Kotler and Keller (2016), buying behavior is impacted by four factors: (culture, subculture, and social classes), social roles, families, and reference groups also status), Personal (age and life cycle stage, employment and financial condition, character and self- concept, way of life and values), (Motivation, perception, learning, emotions, memory) Psychological [29]. According to Ferdinand (2006), consumer purchasing behavior may be quantified in terms of buying interest:

Transactional interest, or the propensity for someone to purchase a good; interest referential, or the propensity of a person to recommend things to others; demonstrating preference for someone's principal product, or preferential interest. If anything happens to the preference product, this preference can be updated; as for Explorative Interests, which depicts the behavior of someone who Always seeking information about items of interest and looking for more data that bolsters the pros of the product.

3. METHOD

Cross-sectional study design is being used in this investigation. Data for this study were gathered in January 2019. research technique sampling (sample) Purposive sampling was used, using Bandung Lazada users as the population [30]. The sample for this study consisted of internet users who were at least 18 years old. 96 Lazada consumers were chosen as a sample in this study, which employed a large number of samples. Regression and analysis of correlation are used to determine the link between this variable and other factors.

The survey approach was employed in this study. One such growing online shopping destination in Asia is Lazada. Online purchasing has grown more popular in the Philippines as a result of ongoing e-commerce advances (Maala et al, 2018). As a result, thanks to web advertising, anyone may find out about us and the products we sell. The execution of an advertising campaign cannot be separated from The objective is to aid in a product's successful marketing so that sales and earnings can rise. Advertising will have an impact on consumer interest in purchasing; otherwise, the business would have difficulty attracting new clients. Therefore, the assumption is made that the use of internet advertising can affect client interest in making purchases.

A model for the following study may be created based on the preceding description of the link between online advertising and customer interest in online purchases:

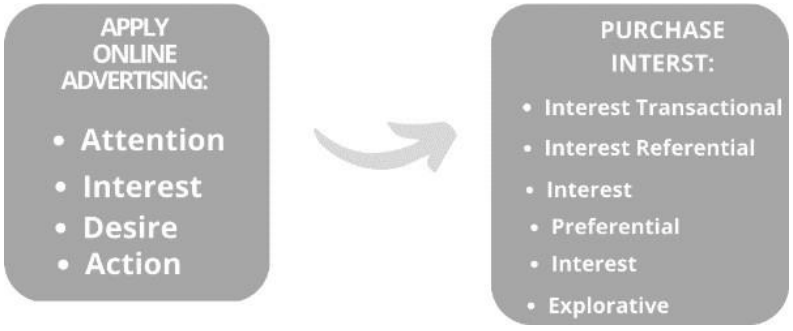

Figure 1. Research Model

4. RESULTS AND DISCUSSION

After learning about the variables studied by Lazada customers in the city of Bandung from the results of the descriptive analysis that was done, a verification analysis was then conducted on the data that had been obtained with the goal of learning how much of a significant impact the use of advertising and service delivery in raising interest in purchases on the online marketplace Lazada. Statistical testing was conducted using SPSS (Statistical Product and Service Solution) version 23 to determine the extent to which the implementation of advertising and service delivery increased purchase interest on online marketplace Lazada in the city of Bandung. However, the data must first be transformed before being handled with SPSS. Using the use of the MSI software, interval data utilizing the Successive Method Interval (MSI) (stat97.xla). The results of a regression analysis using SPSS (Statistical Product and Service Solution) version 23 data processing assistance yielded the value of the independent variable regression coefficient on the dependent variable. This regression study seeks to quantify the extent to which the application variable advertisement (X) has an impact on the buying interest variable (Y). The following are the outcomes of the data processing that was done:

According to the above table, the beta value of the online ad implementation variable (X) is 0.539, and the beta value of the regression coefficient of the variable the application of advertising (X1) to interest variables buy (Y) is 0.539, as shown in the following illustration:

Figure 2. Independent Variable Regression Coefficient to the Dependent Variable

Based on the aforementioned image, it is known that the application of advertising (X1) to interest variables buy (Y) has a value multiple linear regression coefficient of 0.539, and that the value regression from other variables outside the model (error) is 0.097. The analysis's findings imply that variable advertising implementation With a coefficient value of 0.539, there is a beneficial impact on purchasing interest. It indicates that buying interest will likewise grow by 0.539 if effective advertising is used and all other independent factors are held constant.

The findings of a verification investigation about the impact of ad deployment on purchasing interest on the Bandung-based Lazada online marketplace will next be reviewed. Ad Adoption Effects Against Buying Interests on Lazada in Bandung City's Online Marketplace. The purchase interest is positively and significantly impacted by application advertising by 0.539. Consequently, purchase intent may be influenced by an application.

Table 1. Dependent Variable: Purchase Intention

Coefficients					
		Unstandardized Coefficients	Standardized Coefficients		
Model	B	Std. error	Beta	T	Sig
(Constant)	2.860	026		110.305	00.0
Penerwhat Advertisement Online	539	097	632	5.572	00.0

The findings of this study demonstrate the direct impact of advertising on purchase intention. Research by Gunawan & Dharmayanti (2014) and Herdaningtyas & Iriani supports these findings (2017). This study also revealed a result that the use of online advertising via the internet can have an impact without the use of mediating factors by stating that his research requires a deep attitude component generating interest in online purchasing among customers, Aqsa & Kartini's (2015) research is refuted. However, this study disproves prior research by Yuniyanto & Siren (2018) that claimed brand familiarity served as a moderating factor in the relationship between online advertising and purchase interest.

5. CONCLUSION

It can be inferred from research on the use of advertising in fulfilling customers' purchase intentions on Lazada in the city of Bandung that the use of advertising online has a favorable impact on purchasing interest in the sense that Lazada's online advertising efforts are more effective the more clients are interested in purchasing from them. This study also shown that advertising implementation can affect consumers' propensity to buy without the need of a mediating factor or moderating, so to speak, if internet advertising is implemented as effectively as feasible, customer buying interest may be generated. It can be concluded from research on the use of advertising in fulfilling customer purchase intentions at Lazada in the city of Bandung that the use of online advertising has a beneficial impact on

purchase intention. clients are interested in buying from them. This study also shows that the implementation of advertising can affect the consumer's tendency to buy without the need for mediating or moderating factors. So, to say, if internet advertising is implemented as effectively as possible, customer buying interest can be generated.

There are many benefits to using online advertising methods especially in this fast- paced digital era in reaching information to everyone Targeting gives you the ability to display ads to reach people with special interests — that is, those who are interested in your products and services — and show them relevant ads. we can also easily determine the target market the most advantageous benefit of online advertising, is that it can be placed wherever your target market spends its time online. For example, you sell baby equipment and advertise on the Google search engine. You can set your ad to appear on the search results page when people enter the keyword “baby” in a search engine. Advertising on social media is also in principle the same. You can arrange for your ads to appear according to the preferences of these social media users.

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ORIGINAL PAPER

Effective method of minimizing the acrylamide and 5-hydroxymethylfurfural formation in french fries by lactic acid fermentation

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Abstract
Acrylamide (AA) and 5-hydroxymethylfurfural (HMF) are processing toxicants that are formed when food is fried. They are toxic and are thought to be a health hazard because of their high consumption levels in the diets of urban people. The purpose of this study was to minimize the formation of AA and HMF in french fries by lactic acid fermentation (*Lactobacillus plantarum* strain NCDC LP 20). HMF was quantified with a UV-spectrophotometer and AA was determined by HPLC–DAD. Fermentation without blanching reduced the amount of HMF and AA in french fries by about 85.52% and 53.96%, respectively. Additionally, the combined effect of fermentation and blanching enhanced the rate of reduction in the amount of HMF and AA, i.e., 91.11% and 57.50%, respectively. Results showed that reducing sugar content is highly correlated with the level of acrylamide ($r = 0.905$, $p \leq 0.001$) and level of HMF ($r = 0.927$, $p < 0.001$) than the asparagine content. The color and texture of the fried sample treated with fermentation were better compared to the control sample hence can be recommended as an effective method of reducing processing toxicants.

Keywords Fermentation · Reducing sugar · Acrylamide · Hydroxymethylfurfural · Processing toxicants · Lactic acid bacteria

Practical application

This research will help the Indian food industry to reduce the content of acrylamide (AA) and 5-hydroxymethylfurfural (HMF) within foods by using lactic acid fermentation and it will also improve the nutritional value and taste. Most industries are not considering a costly way of mitigation in that condition they can consider this research. This will often make the customer conscious of consumable goods, that they should determine what amount can always be consumed every day to protect themselves from process contaminants i.e., HMF and AA.

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Introduction

Acrylamide (AA), which is typically formed during the thermal processing of foods high in protein and carbohydrates, was classified as "probably carcinogenic to humans" (Group 2A) in 1994 by the International Agency for Research on Cancer (IARC). Maillard-type reactions are the primary pathways for the formation of acrylamide in various foods that have been subjected to high temperatures in the presence of asparagine [1, 2]. 5-Hydroxymethylfurfural (HMF) is formed during the thermal processing of reducing sugars via the Maillard or caramelization reactions and was classified as a possible carcinogen (Group 2B) by IARC. The formation of HMF in food products is directly related to the amount of heat applied during the processing of carbohydrate-rich products and ingredients. Numerous studies have been initiated to determine the AA's toxicological effect. Several toxicological effects on the human body have been reported, including neurotoxicity, genotoxicity, carcinogenicity, and reproductive toxicity [3–5]. A previous pilot study showed that french fries had a high amount of HMF and AA, above the benchmark level of 40 mg/kg

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and 500 g/kg respectively [6], that are formed during the frying process resulting in an unavoidable exposure to AA via the consumption of fried products. [7, 8]. To produce safe products, scientists are now attempting to discover how harmful substances are formed during thermal processing and working to prevent or inhibit the formation of these toxicants. The European Union has set a benchmark level of AA for specific food products to serve as a guide. To meet the European Union's maximum benchmark level of AA in potato-based fried products such as french fries, producers must engage in a discussion about AA to keep the AA level within European regulations. Lactic acid fermentation of potato and carrot slices has been shown to reduce sugar levels, the product of the Maillard reaction, and lactic acid bacteria (LAB) produce lactic acid because the vegetable has a low pH which gave the sour taste of deep-fried potatoes [9, 10]. Researchers who studied deep-fried potato and carrot chips say that *Lactobacillus plantarum* NC_8 may help cut down on the amount of AA in the chips [11, 12]. LAB tends to produce exopolysaccharides which serve as probiotics. Exopolysaccharides (EPS) produced by LAB are biopolymer, high in molecular weight excreted as slimy texture or capsular shape, it is used as natural additives, stabilizer, emulsifier, and act as antioxidants activity [13]. No study has been reported on the effect of LAB fermentation in terms of minimization of processing toxicants as well as physiochemical, sensory, textural, and morphological properties of fried potato strips. This new research shows that lactic acid fermentation enhances the taste and texture of deep-fried potatoes and the aim is to optimize the fermentation time and condition for independent variables, i.e., asparagine and reducing sugar of potato strips after frying. Lactic acid fermentation before deep frying can be used as an industrial process for the minimization of AA and HMF formation in french fries. Further, the comparison was done to optimize the condition with other variables of potato strips after the deep-frying process. The study also determines whether the reduction in the amount of AA and HMF was caused by the reduced amount of reducing sugar alone or whether the *L. plantarum* strain also affects the amount of asparagine during the fermentation process.

Material and method

Preparation of french fries

For the preparation of french fries, 15 kg of potatoes (*Solanum tuberosum*) of processing variety *frysona* were procured from the Central Potato Research Institute in Modipuram, Meerut, India, and stored at 8–10 °C until french fries were prepared. Peeled potatoes were cut by using a mechanical french fry cutter ($10 \times 10 \times 65$ mm). Reducing sugars and asparagine content was quantified in the unfried samples. HMF and AA levels were analyzed in all treatments of fried samples. On separate days, each frying trial was done. Because the order of the experiments was not the same each time, there were not any systematic errors and no outside factors could change the results.

Bacterial culture

The lyophilized culture of *Lactobacillus plantarum* strain-NCDC LP 20 (National Collection of Dairy Culture, ICAR-NDRI, Karnal, India) was grown for 18 h at 37 °C in de Man, Rogosa, and Sharpe agar (MRS) broth medium using the loopful inoculum before being harvested at the highest possible density of 10^9 colony-forming units (CFU/mL) and centrifuged it for 10 min at 6000 rpm. After that, the pellet was washed with distilled water 2–3 times and dissolved in 1 L of water to 10^9 CFU/mL at 37 °C. The potato strips were submerged in water until they were further treated. Fermentation was carried out using 1 kg of potato strips in 2-L jars with a cell inoculum of 1 L at 10^9 CFU/mL. Each analysis used the same batch of potato strips divided into three portions (100 g each); one portion was used as a control (untreated), another portion was treated with fermentation, and the third portion was treated with both fermentation and blanching. Blanching was carried out by dipping potato strips in hot water at 90 °C for 10 min to deactivate the enzymatic reaction. The potato strips were fermented for various time intervals i.e., 15, 30, 45, 60, 75, 90, and 120 min at 37 °C. All potato strips from all experiments were fried in refined soybean oil for 8 min at 160 ± 2 °C. Samples were dried in a hot air oven to remove moisture and then homogenized in a grinder for further chemical analysis. Samples were photographed, and duplicate samples were analyzed for proximate, HMF, and AA.

Asparagine analysis

Asparagine was analyzed by a spectrophotometer [14]. The samples were extracted in methanol followed by grinding in a 10 mL solution (1:4 with methanol: 0.133 M Tris HCI (pH 6.0). The pH was adjusted to 6. The extracted solution was centrifuged with an alcoholic ninhydrin solution for analysis of the amino acid standard. After incubating the solution at 37 °C for 3 h, absorbance was recorded at 340 nm on the spectrophotometer. For the blank, 1 mL of methanol-Tris and 9 mL of ethanolic ninhydrin were used.

Moisture content

Fried samples were crushed in a pestle mortar and dried in a hot air oven at 70 °C for 12–24 h [15].

Color value

The color value of the raw and fried French fries was determined with an Xrite (Grandville, MI, USA). Lightness (L*) ranges from 0 to 100 and a* (green to red) and b* (blue to yellow) range from − 120 to 120 were recorded to calculate the total color differences are referred to as the Euclidean distance (ΔE) by using the following formula.

$$\Delta E = \sqrt{\left\{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2\right\}}$$

where, ΔL, Δa, and Δb are the difference between L*-L, a*-a, and b*-b respectively. L*, a*, b* refer to the color value of french fries, and l, a, and b refer to the color value of raw potato strips. Browning index (BI) was based on the CIE values of l*a*b* [16]:-

$$BI = \{100 \times (X - 0.31)\}/(0.17)$$

Where, $X = (a^* + 1.75L)(5.645L + a^* - 3.012b^*)$

Hydroxymethyl-furfural (HMF)

The HMF of french fries was determined with a UV-spectrophotometer [17]. Weigh 5 g of the homogenized sample and transferred it into a 50 mL volumetric flask add 25 mL of water. Add 0.5 mL each of Carrez I and II solutions (one to two drops of alcohol might also be added to suppress the surface foam) to make up the volume up to the mark. Filter it, and discarded the first 10 mL. Transfer the 5 mL of supernatant in each two-test tube and then add 5 mL of ultrapure water to the sample and 5 mL of 0.2% bisulfite to the blank test tubes and take absorbance at 284 and 336 nm of the sample against the standard.

Acrylamide (AA)

The AA content in french fries was analysed by HPLC–DAD (Agilent 1260 Infinity model). This method consisted of three sections, which were AA standards preparation, sample preparation, purification, and the detailed procedure discussed in our previous study [7].

Fat content

The oil content of samples was gravimetrically determined by using petroleum ether as the solvent with the Soxhlet system [15].

Reducing sugar

The reducing sugar content was determined by the dinitrosalysalic acid (DNSA) method [18].

Texture (hardness)

The texture characteristics of French fries were determined using a stable microsystem TA-XT2i texture analyzer prepared with a small three-point bend rig probe (Texture Technology Corp, UK). The studies used a pretest speed of 1.0 mm/s, a test speed of 1 mm/s, a post-test speed of 10 mm/s, a distance of 20 mm, and a 5 kg load cell. The hardness value was expressed in Newtons as the mean peak compression force (N). The average number of first positive peaks in the texture analyzer graph that came up when the product was compressed was used to figure out how feasible it was.

Sensory evaluation

Prepared french fries (control and treatments) were evaluated using a nine-point hedonic scale (1-extremely dislike, 9-extremely like) by a semi-trained panel. Sensory descriptors of the samples were color, flavor, texture, and overall acceptability [19].

Scanning electron microscope (SEM)

Homogenized samples were defatted in the Soxhlet system by using petroleum ether as a solvent. Then the sample was dried in a hot air oven at a very low temperature (50 °C) to eliminate moisture. The defatted and dehydrated samples were suspended on a microscopic slide using double-sided adhesive carbon tape and covered the sample with a 25 nm thick graphite layer using a vacuum evaporator (Jeol-Model-JEE420). Scanning electron microscope (SEM) images of a sample were taken with the magnification of 300× at an accelerating voltage of 10 kV or 15 kV (EPMA, JEOL Ltd, model-JXA8100). Analysis was performed with the support of the Department of Mineralogy and Petrology, University of Allahabad [20].

Statistical analysis

RSM was used to optimize and investigate the effect of various fermentation process variables. The experiments were conducted using a 7 × 3 factorial design with two independent variables, namely fermentation time (15, 30, 45, 60,

Table 1 Table of experiment design

Run	Fermentation time	Types of condition	Asparagine (mg/100 g)	Reducing sugar (mg/100 g)
1	15	Control	226.3 ± 1.2	90.1 ± 3.5
2	15	Non-Blanched	224.0 ± 2.5	86.2 ± 1.8
3	15	Blanched	223.3 ± 1.2	79.7 ± 0.1
4	30	Control	226.9 ± 1.5	88.5 ± 3.4
5	30	Non-Blanched	225.4 ± 0.4	89.1 ± 3.7
6	30	Blanched	223.7 ± 0.5	82.7 ± 6.9
7	45	Control	227.1 ± 1.6	87.7 ± 1.5
8	45	Non-Blanched	225.0 ± 0.5	86.8 ± 1.9
9	45	Blanched	223.7 ± 0.8	62.1 ± 8.6
10	60	Control	226.7 ± 1.5	87.1 ± 2.6
11	60	Non-Blanched	223.2 ± 2.4	76.2 ± 3.1
12	60	Blanched	223.1 ± 0.8	61.7 ± 7.7
13	75	Control	226.7 ± 1.3	80.7 ± 5.8
14	75	Non-Blanched	223.9 ± 2.3	84.4 ± 1.1
15	75	Blanched	223.3 ± 0.6	71.3 ± 1.9
16	90	Control	226.2 ± 1	83.5 ± 0.4
17	90	Non-Blanched	221.9 ± 1.3	75.4 ± 1.6
18	90	Blanched	220.3 ± 0.4	61.1 ± 1.5
19	120	Control	226.2 ± 1.1	83.5 ± 0.4
20	120	Non-Blanched	221.9 ± 1.9	76.2 ± 0.4
21	120	Blanched	220.4 ± 0.3 ±	60.7 ± 1.5

All value is shown to mean value with SD

75, 90, 120 min) and types of conditions (Control, Non-blanched, Blanched). The total number of experiments is 21 and each experiment was conducted in replicate (n = 3). Table 1, which we have titled "Table of experiment design," contains a summary of the total experiments. Design of experiment (DOE), analysis of variance (ANOVA), coefficient, regression, and correlation was performed by statistical software Minitab 21. The significance of mean comparisons was assessed by the Tukey test, with the values expressed as means ± standard deviations. All the data presented are the mean values of triplicates (n = 3), obtained from three different runs.

Results and discussion

Levels of reducing sugars in the potato strips before deep-frying

LAB fermentation reduced the pH from 6.7 to 4.3 after 120 min of fermentation of potato strips. The proposed model was linear and significant (< 0.01) with the coefficient determination (R^2) i.e., 91.10% (Table 2). As indicated in

Table 2 Analysis of variance data for the response variable

Source	Coefficient	
Fermentation time (min)	Asparagine	Reducing sugar
15	0.311	6.55***
30	1.093**	7.95***
45	1.025**	0.07
60	0.075	− 3.80**
75	0.361	− 0.00
90	− 1.448***	− 5.46***
120	− 1.418***	− 5.32***
Types		
Control	2.329***	7.078***
Non-blanched	− 0.634**	3.226***
Blanched	− 1.695***	− 10.304***
Time-types	–	–
R^2	77.22%	91.10%
R^2 (Adj)	72.83%	86.86%
Model (Linear)	Significant***	Significant***

**p ≤ 0.01, ***p ≤ 0.001

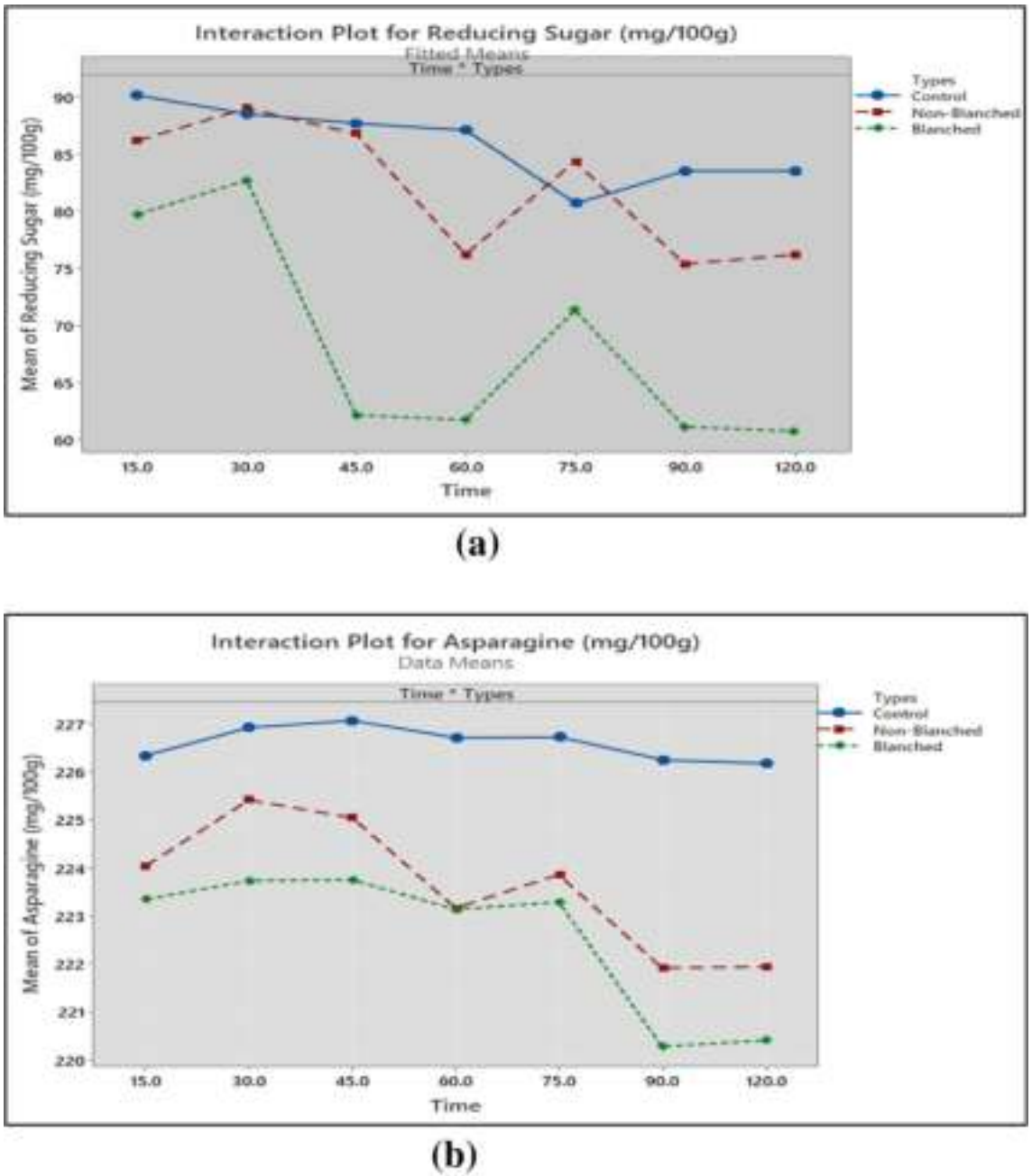

Fig. 1 Effect of fermentation time on (**a**) reducing sugar and (**b**) asparagine content in potato strips at different conditions

Fig. 1, there was an overall decline in reducing sugar content with an increase in the time duration of fermentation. However, the reducing sugar content increased at an interval of 30 min and 75 min due to the endogenous invertase activity hydrolyzing the sucrose of potato strips before the frying process. Baardseth et al. [12] found that fermentation for 5 h at 37 °C with *Lactobacillus plantarum* at an inoculum level of 10^9 CFU/mL reduced the level of total sugar content in potato strips of variety *Beate* by 72–96%. In the present study, a significant decrease in reducing sugar after 120 min of fermentation was observed (98.43 to 76.24 mg/100 g), and blanching after fermentation decreased the level of reducing sugar in potato strips at a sharp rate (98.43 to 59.27 mg/100 g) (Table 3).

Levels of asparagine in the potato strips before deep-frying

The proposed model was linear and significant (< 0.01) with the coefficient determination (R^2) i.e., 77.22% (Table 2). The

Table 3 Effects of lactic acid fermentation on pH, fat, moisture, reducing sugars, asparagine content, color value, browning index, and texture in raw and fried potato strips

Treatments	Control-NB	Control-B	LAB 37 °C 120 min-NB	LAB 37 °C 120 min-B
pH	6.87	6.86	4.3	4.3
Fat (%)	15.94 ± 1.13^{a}	16.03 ± 1.44^{a}	16.40 ± 1.89^{a}	12.16 ± 0.78^{b}
Moisture (%)	57.01 ± 2.04^{a}	56.67 ± 4.41^{a}	60.25 ± 1.44^{a}	63.78 ± 6.87^{a}
HMF (mg/kg)	12.93 ± 0.08^{a}	8.43 ± 0.16^{b}	1.87 ± 0.04^{c}	1.15 ± 0.10^{d}
Acrylamide (ug/kg)	1153.19 ± 19.93^{a}	766.66 ± 16.41^{b}	530.84 ± 3.03^{c}	490.11 ± 18.34^{d}
Asparagine (raw) (mg/100 g)	225.65 ± 0.87^{a}	225.50 ± 0.59^{a}	222.55 ± 1.06^{a}	186.74 ± 0.63^{a}
Reducing sugar (raw) (mg/100 g)	98.43 ± 1.75^{a}	86.81 ± 1.90^{b}	76.24 ± 2.02^{c}	59.27 ± 1.69^{d}
L*	53.39 ± 2.73^{c}	51.98 ± 0.48^{d}	54.39 ± 0.62^{b}	65.17 ± 1.09^{a}
a*	5.37 ± 0.05^{b}	6.56 ± 0.09^{a}	4.39 ± 0.17^{c}	3.08 ± 0.02^{d}
b*	37.77 ± 0.55^{a}	34.45 ± 0.22^{b}	23.66 ± 2.33^{c}	24.54 ± 0.72^{c}
BI	118.83 ± 4.53^{a}	110.26 ± 1.58^{b}	61.60 ± 6.02^{c}	49.59 ± 0.96^{d}
ΔE	65.62 ± 2.39^{b}	62.72 ± 0.39^{c}	59.49 ± 1.48^{d}	69.70 ± 1.24^{a}
Taste	7.97 ± 0.20^{a}	7.87 ± 0.15^{a}	6.00 ± 0.20^{b}	6.40 ± 0.26^{b}
Texture	7.37 ± 0.20^{ab}	6.63 ± 0.12^{bc}	6.40 ± 0.30^{c}	7.67 ± 0.12^{a}
Appearance	7.13 ± 0.01^{ab}	7.57 ± 0.15^{bc}	6.70 ± 0.20^{c}	7.30 ± 0.10^{b}
Colour	6.93 ± 0.15^{bc}	8.13 ± 0.12^{a}	6.40 ± 0.30^{c}	7.23 ± 0.31^{b}
Overall acceptability	7.40 ± 0.06^{a}	7.67 ± 0.04^{c}	6.29 ± 0.08^{d}	7.10 ± 0.11^{b}
Fructurability (N)	8.30 ± 0.22^{a}	6.87 ± 2.92^{a}	9.22 ± 0.52^{a}	8.38 ± 4.37^{a}

All values shown are means ± SD and superscript with different alphabets in row were significantly different from each other

NB non-blanched, *B* blanched

lactic acid fermentation did not show significant changes in the level of asparagine in potato strips at the initial time interval (Fig. 1) showing a little decline in the asparagine content after 30 min of fermentation ($P < 0.05$). This could be due to endogenous protease activity in potato strips or lysis of bacterial cells added at the beginning of the incubation. On the other hand, samples collected at a later stage of the fermentation process (after 120 min) showed a more significant decrease in the amount of asparagine content compared to control (225.65 to 222.55 mg/100 g) (Table 1). Blanching after fermentation decline the rate of reducing sugar degradation, i.e., from 225.65 to 186.74 mg/100 g (Table 3). Several findings also favored our study conducted by Amrein et al. [21] and Baardseth et al. [12].

Optimization

Optimization of the fermentation process was done based on the minimum concentration of asparagine and reducing sugar in potato strips. The optimized conditions for independent variables as predicted by the model were found to be 120 min of fermentation time followed by blanching (desirability 0.7588). The predicted values for responses were 60.73 and 220.58 mg/100 g for reducing sugar and asparagine content respectively, whereas the experimental values for reducing sugar and asparagine content of optimized potato strips were found to be 59.27 and 186.74 mg/100 g respectively. Therefore, a fermentation time of 120 min was selected for the preparation of french fries, and further experiments are presented below.

Multiple response prediction	
Variable	Setting
Time	120
Types	Blanched

Response	Fit	SE Fit	95% CI	95% PI	Composite desirability
Reducing sugar (mg/100 g)	60.73	2.97	(54.72, 66.74)	(48.71, 72.75)	0.758814
Asparagine (mg/100 g)	220.58	1.37	(217.81, 223.35)	(215.04, 226.12)	

Effect of fermentation on the level of AA and HMF content of french fries

Before deep-frying potato strips, both blanching and lactic acid fermentation significantly reduced the formation of HMF and AA during the frying. Fermentation without blanching reduced the amount of HMF and AA in french

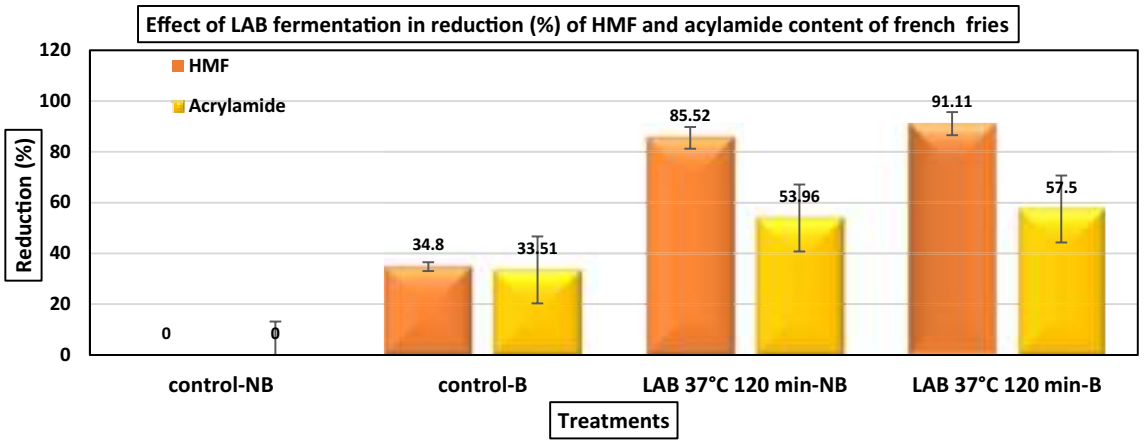

Fig. 2 Effect of fermentation in reduction (%) of AA and HMF content of french fries

fries by about 85.52 and 53.96%, respectively. The combined effects of fermentation and blanching amounted to a 91.11 and 57.50% decline in HMF and AA formation after 120 min of fermentation (Fig. 2). The AA level in (1153.19 µg/kg) control french fries (without any treatments), exceeded the range of benchmark level (EFSA, 500 µg/kg) whereas fermentation with blanching showed an AA level (490.11 µg/kg) within the range of benchmark value of EFSA as well as HMF (40 mg/kg) (Table 3). Similarly, Lingnert et al. [22] determined the AA value in french fries within the range of 300–700 µg/kg and 3500 µg/kg as the upper limit in control, while Jung et al. [23] reported about 1500 µg/kg and Friedman et al. [24] reported values between 200 and 12,000 µg/kg. Previously they have also reported, that the blanched potato strips also reduced the formation of AA in french fries. Grob et al. [25] reported a 50% reduction in the AA content of french fries after the blanching of potato strips. A similar finding was reported by Pedreschi et al. [26] when potato slices were blanched before deep frying of potato strips. Additionally, reduction in pH after fermentation was another important factor because it resulted in a decreased rate of Maillard browning [27–29]. The use of optical sorting to eliminate dark products [30] and changing processing conditions of potatoes [31, 32] have also been advocated to reduce the processing toxicants.

Color analysis of the fried sample

The color change caused by the fermentation process was demonstrated in this study using instrumental color analysis (L*a*b* color system) and visual judgments. The fermentation process had a significant effect on the color of the French fries, as the color turned lighter when the potato strips were fermented before frying (Table 3). The fermentation process increased the lightness (L*) of fried potato strips and decreased the redness (a*) and browning index (BI) values of fried potato strips. The control slices were darker and more uniform in color than the fermented slices (Fig. 3). Blanching was also effective for producing lighter-colored french fries. Additionally, the color of the french fries was improved when the potatoes were blanched following the fermentation process. Pedreschi et al. [26] reported that blanched, deep-fried potato slices had a lighter color than unblanched slices. It has previously been demonstrated that lactic acid fermentation of potato slices increases the lightness of deep-fried potato chips [33].

Sensory evaluation and textural properties of the fried sample

Sensory analysis of the French fries was also carried out in the present study. Significant differences in taste, texture, appearance, color, and overall quality were observed in fermented and control samples ($p < 0.05$) (Table 3). Although fermented potatoes resulted in a sour taste, the taste of fermented potatoes followed by blanching improved the taste, and the score for sensory parameters were similar to the control sample, this result is supported by Kiani et al. [42]. The color and appearance of blanched and fermented samples were also excellent. Fermentation has also a significant ($p < 0.05$) impact on the texture of French fries. The texture of fermented french fries was crispy and blanching after fermentation softened the texture of french fries. In contrast to our result, previous studies demonstrated that fermented carrots imparted a slightly sour flavor to carrot chips [29]. According to Troncoso et al. [33], significant correlations between sensory and instrumental responses indicated that both instrumental and visual methods were suitable for the measurement of color and texture parameters.

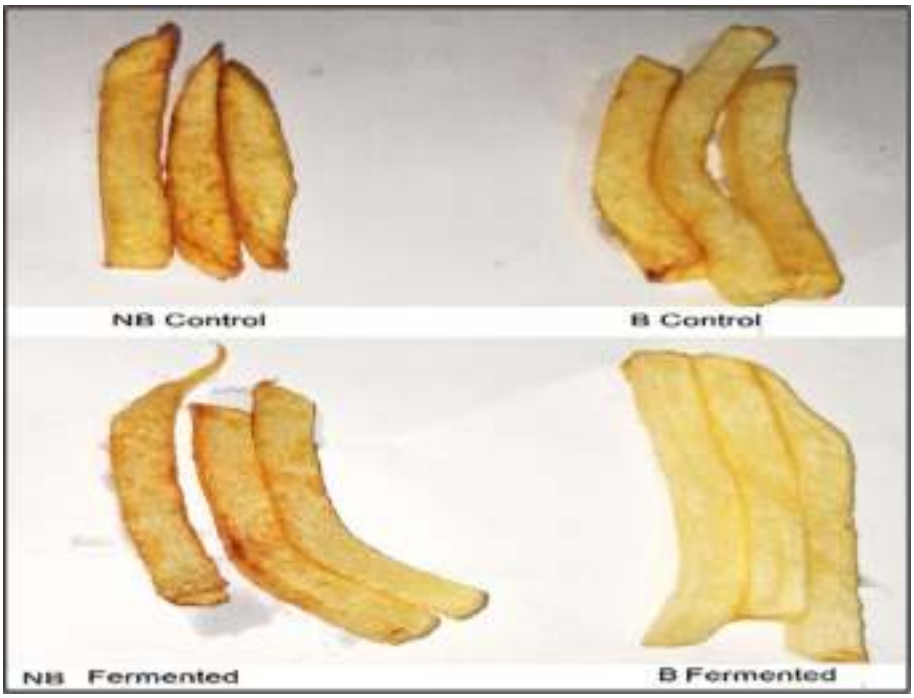

Fig. 3 Images of non-blanched (NB) and blanched (B) samples of control and fermentation treatment

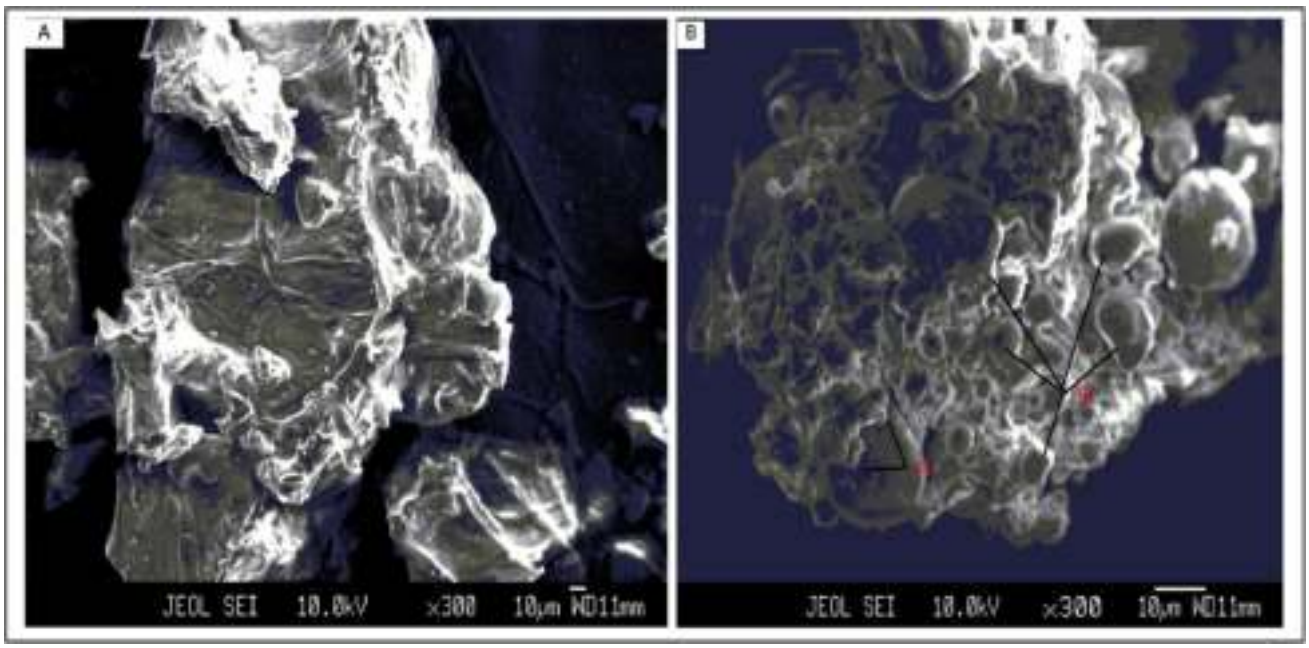

Fig. 4 Scanning electron microscopic images of the surface structure of french fries: **A** Control french fries and **B** fermented and blanched french fries (where A showed a small capsule-like structure of exopolysaccharides and B showed porous surface)

Microstructure of fried sample

Figure 4A, B are the results of the microstructure of the control sample (without any treatment) and fermented sample (fermentation with *Lactobacillus Plantarum* strain LP20 for 120 min followed by a blanching process was carried) respectively. The notable difference between the sample is caused by fermentation and blanching treatment. In control sample (Fig. 4A) had a compact smooth surface with some sharp points whereas in a fermented sample (Fig. 4B), the cell walls of the potatoes are broken, and many starch granules are released. There are also a few small oval-shaped

cells, which suggests that LAB bacteria are producing exopolysaccharides (EPS). The fermented sample was porous and had a rough surface, which helped the volume of water loss during the frying process. Thus, french fries were crisper if pore was generated on the surface of potatoes, this study is favored by Gouyo et al. [34]. Furthermore, small oval structures with filaments were seen in different parts of a sample. These structures were always caused by probiotic and amylolytic bacteria [13].

Correlation between the level of AA, HMF with reducing sugar, asparagine content, and color value

The color of deep-fried potato products was developed by the non-enzymatic Maillard browning reaction, which involves sugars and amino acids on the surface of the potato [35, 36]. In this study, AA and HMF content were significantly correlated with the lightness (L*), redness (a*), and browning index (BI) value of french fries (Table 4). AA is formed by the Maillard reaction between asparagine and reducing sugars, such as at elevated temperatures [37–39]. In our fermentation studies, it can be inferred that the reducing sugar could be more reactive with AA ($R^2 = 99.5\%$, $r = 0.905$) and HMF ($R^2 = 86.8$, $r = 0.927$) than asparagine ($R^2 = 77.22\%$, $r = 0.333$) (Fig. 5). A similar study was reported by Becalski et al. [40]. The conversion of a Schiff base to AA and the kinetics of the reaction between carbonyl and asparagine were not completely explained by Taeymans et al. [30].

In this study, we found that LAB fermentation before deep-frying significantly ($p < 0.05$) cut down on the amount of AA and HMF that formed in fried potato strips. This could be because the *Lactobacillus plantarum* strain NCDC LP 20 is capable of hydrolyzing asparagine to aspartic acid and adjusted to the abnormally low pH values, or it could be due to increased hydrolysis of peptides/proteins in the sample. However, the pH of the potato strips decreases (as a result of fermentation and the release of lactic acid) by which the asparagine becomes protonated. During fermentation, the concentration of reducing sugar decreased rapidly, whereas the asparagine content remained largely unchanged during the 60 min of fermentation time. Additionally, fermentation for 120 min duration resulted in a significant ($p < 0.001$) decrease in the amount of both asparagine and reducing sugar in potato strips, which confirms that the fermentation process significantly ($p < 0.05$) reduced the level of AA and HMF. This result agrees with recent studies by Baardseth et al. [12], which revealed that AA formation in potato tubers was primarily determined by the reducing sugar, rather than the asparagine content. On the other hand, Zyzak et al. [39] and Becalski et al. [40] discovered that the amount of asparagine in certain potato products influenced the amount of AA. *Lactobacillus plantarum* NC_8 possesses no asparaginase activity, even though other *Lactobacillus sp.* are capable of hydrolyzing asparagine to aspartic acid [41].

Table 4 Correlation and regression analysis between the L*, a*, BI value, reducing sugar, asparagine content, and acrylamide

Variables		Asparagine (mg/100 g)	Reducing sugar (mg/100 g)	HMF (mg/kg)	L*	a*	BI
Acrylamide (ug/kg)	r	0.333	**0.905**	**0.977**	− 0.586	0.592	**0.893**
	R^2 (%)	68	99.5	99.7	36	49	55.75
	p	0.006	< 0.001	0.001	0.045	0.042	< 0.001
Asparagine (mg/100 g)	r		0.456	0.359	− 0.561	0.472	0.413
	R^2 (%)		23.2	16.1	32.2	31.3	24
	p		0.004	< 0.001	0.001	< 0.001	< 0.001
Reducing sugar (mg/100 g)	r			**0.927**	− 0.868	0.804	**0.933**
	R^2 (%)			86.8	75.5	86	88
	p			< 0.001	< 0.001	< 0.001	< 0.001
HMF (mg/kg)	r				− 0.666	0.733	**0.964**
	R^2 (%)				52.8	59.3	97.9
	p				0.018	0.007	< 0.001
L*	r					**− 0.899**	− 0.777
	R^2 (%)					97.6	86.7
	p					0.001	0.001
a*	r						0.872
	R^2 (%)						88.7
	p						< 0.001

Bold font indicated the level of significance difference at 99.99% with r value ≥ 0.9

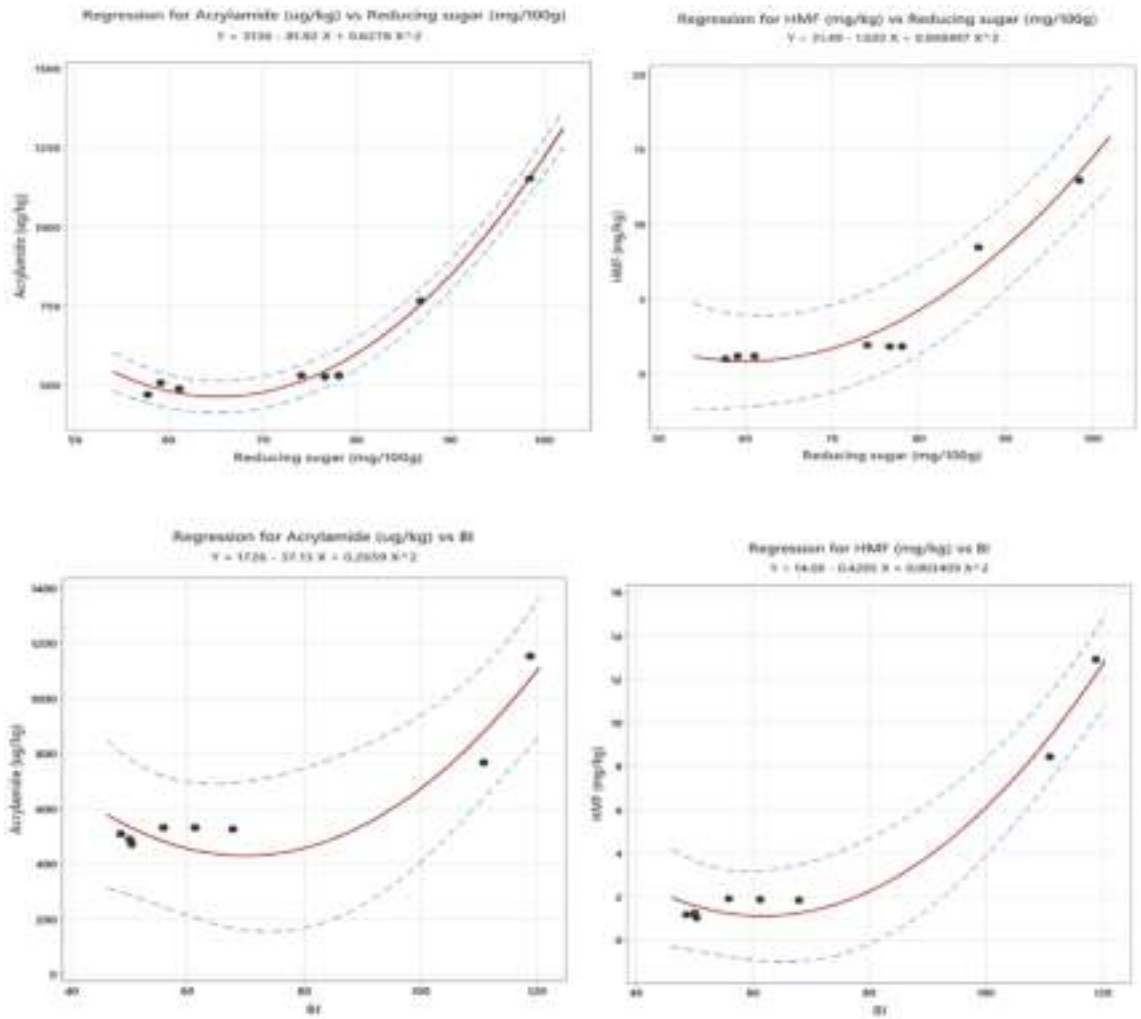

Fig. 5 A strong relationship between browning index (BI), reducing sugar with AA and HMF

Conclusion

The fact that acrylamide and 5-hydroxymethylfurfural were formed during the deep-frying of french fries resulted in a carcinogenic effect on the human body, so treatment with lactic acid fermentation before deep frying can be used as the best mitigation strategy. *Lactobacillus plantarum* is added to potato strips before they are deep-fried, which stops the formation of acrylamide. This can be because there is less reducing sugar and asparagine in the potato strips. Lactic acid fermentation also benefited in reducing the formation of HMF. In addition, the reduction in the browning index of the french fries can be seen as a result of the fermentation process. A combination of fermentation and blanching could be an effective method of reducing heat-induced toxicants and improving the overall acceptability of french fries. Based on microstructure images of the surface of fermented french fries we can say that a porous surface gives a crispy texture and the production of EPS can play an important role in the reduction of the level of processing toxicants mostly acrylamide and 5-hydroxymethylfurfural due to antioxidant activity of EPS and production of lactic acid at the end of LAB fermentation. Hence fermentation model can be implemented in the processing of other starch-based food products to reduce the level of processing toxicants for the development of safe food products.

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Effect of Uncertainty in Optimal Inventory Policy for Manufacturing Products

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Abstract: To provide the best storage facilities for an items is one of the main part for any inventory management system. There are many categories for perishable items which deteriorates at various rates due to temperature and some other environment conditions. This research study developed a fuzzy inventory model by considering the time varying demand. The model incorporates the linear decreasing demand with signed distance method. In inventory system the reliability of any procedure is the significant property in research work in which some parameters are very difficult to assign the values or nearly unreal. Fuzzy inventory models are quite useful in practice in such cases. The effectiveness of this system is shown through the consequence of fuzzy parameters on total inventory cost were considered, and a new improved model was modified and also for demonstrated the relationship between crisp and fuzzy environment.

Keywords: *Inventory system, Fuzzy, Signed distance method, variable demand.*

1. Introduction

Perishable products decay in various situations and manners; according to types of items and available storage facilities in a way of rate of deterioration and starting point. Many products of food, vegetable, cosmetic, pharmaceutical, blood bank etc., are fail to maintain their freshness of a long time due to environment, humidity, temperature and some other places problems. Therefore the smart and best storage facilities for items are the most important part for inventory management. Deterioration is one of the most important factors which is considerable when we analysing the inventory models. Holding cost also play an important roles for inventory system because of product storing time increase the total inventory cost. The first inventory model investigated was Economic Order Quantity (EOQ) inventory model by Harris (1915). Hadley and Whitin (1963) studied the theory of inventory systems with deterministic and probabilistic parameters, types of inventory models and inventory costs etc.

One of the key factors in attains the optimum profit is managing the inventory management is minimize the total inventory cost for any business organization. Some recent contributions in the field of inventory modelling are (Singh and Malik (2008, 2009, 2010, 2011); Sharma et al. (2013); Kumar et al. (2016, 2017 & 2019); Malik et al. (2016, 2017, 2019); Vashisth et al. (2015, 2016); Malik and Sharma (2011); Tyagi et al. (2022a); Tyagi et al. (2022b); Yadav and Malik (2014); Singh et al. (2011, 2014)). The research article written by Malik et al. (2018) suggests an inventory model with variable cost coefficients. The article of Gupta et al. (2013) provides a

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closed form solution for optimal ordering policies. Some other related research work can be found in Malik et al. (2008) proposes that the inventory model with time dependent demand. Malik et al. (2010) claims that most attempts in the literature try to clarify the importance of supply chain management in decision making.

In realistic conditions, for new products the probability of quality, price, demand, costs are not known or say fixed due to suitable information or deficiency of previous data. So these parameters and variables are considered as fuzzy parameters due to their uncertain behavior. In last three decades, the fuzzy theory especially has been magnificently applied and generated important methods and applications in the various engineering, science, medical and industrial problems. In inventory control and management, the fuzzy theory is a ground-breaking solution method to transform the optimal outcomes. Many inventory models were developed based on the crisp environment because of its general practice phenomena. If some inventory constraints are in fuzzy form then the resultant objective cost function are also in fuzzy form. Zadeh (1965) introduce the concept of fuzzy theory, which is a road map for the topic of uncertainty. Due to handling the uncertainty in inventory costs and demand rate in the inventory system applied the fuzzy set theory. Guiffrida (2010) examined the fuzzy inventory model in which EOQ models and Economic Production Quantity (EPQ) models, joint Economic Lot Sizing (ELS) models, Single period models, multi-items and multi-period inventory models discussed in detail.

Bellman and Zadeh (1970) investigate the relevance of fuzzy goals constraints which discuss the concepts decision making with fuzzy environment in which maximization decision is compact for functional equation is obtained. Kao and Hsu (2002) work on the study of inventory system considered fuzzy based demand which is a trapezoidal fuzzy number and applied Yager's ranking method to obtain the optimal fuzzy based objective cost function. Chang et al. (2006) investigate the fuzzy optimal objective cost function for order quantity, lead time in fuzzy demand using centroid method of defuzzification. Among these techniques/methods based on fuzzy environment such as costs, demand, objective function with Chang et al. (2004); Zimmermann (1985); Vujosevic and Petrovic (1996); Yao and Lee (1999); Halim et al. (2010); Yung et al. (2007); Yong et al. (2010), De (2021) etc., have drawn more and more attention in fuzzy theory.

Yao and Chiang (2003) work to find out using signed distance and centroid method to determine the optimal order quantity by defuzzifying the objective cost function and also compare the final results with these two methods. Chou (2009) performed a fuzzy EOQ model using Graded mean integration, function principal and Kuhn Tucker conditions in which parameters are in trapezoidal fuzzy number form. Liu and Iwamura (1998) reviewed most recently work on a new approach, through fuzzy objective function is optimized. Dutta et al. (2007) reviewed most recently research work on improved fuzzy inventory model where fuzziness and randomness environment using probabilistic mean values of parameters. Over the years, some research work has examined in the literature that the delicacy fuzzy based inventory model with different conditions such as Malik and Singh (2011 & 2013), Malik et al. (2012). Singh et al. (2014) studied theoretically the literature survey about soft computing methods with inventory control techniques.

Daniel et al. (2016) analysis the decision making policies in dynamic models using fuzzy theory. Shekarian et al. (2017) studied theoretically the systematic review on fuzzy inventory model with a sample of large data is considered. Priyan and Manivannan (2017) based their research work on a modelling of supply chain model for optimal inventory policies in fuzzy environment. Sarkar and Mahapatra (2017) focused on fuzzy inventory model in which fuzzy demand and variable lead time is proposed. Malik et al. (2018) proposed a new solution for inventory control model with time varying demand for useful in the manufacturing system. Hollah and Fergany (2019) focused on the inventory system in which stochastic deterioration rate with Pareto distribution function of demand. Recently, Malik and Garg (2021) investigate the relevant inventory model with fuzzy constraints for getting the optimum objective cost function.

In this research work a fuzzy inventory system for a deteriorating product (especially seasonal products) with linear decreasing demand is examined in rough environment (including fuzzy and crisp constraints). The resultant inventory ordering cost, holding cost and deteriorating costs are considered as fuzzy forms. A signed distance method is applied to obtain the optimal inventory decision and total costs. Finally, a crisp as well as fuzzy based sensitivity analysis is proposed and used for minimize the total inventory cost to obtain the optimal result.

2. Model

2.1 Assumptions and Notations

Formulating an appropriate inventory system is one of the most important anxieties for any business organization. This research work examined a fuzzy inventory model for decaying products in which coefficients of inventory costs and objective cost function are in fuzzy in nature which is solved by signed distance technique. The demand rate in this model follows time varying (decreasing function of time).

Shortages are not considered in this research work. This work study the fuzzy inventory model with succeeding assumptions and notations {~ sign used for the fuzzy constraints}:

(i) The demand of the product is $d(t) = (d_1 - d_2 t)$.

(iii) Shortage is not allowed to occur in this research work.

(iii) The replenishment rate is instantaneous i.e., lead time is assumed to be zero.

(iv) Let $\tilde{P}$ and $\tilde{Q}$ be any two fuzzy numbers: $\tilde{P} \oplus \tilde{Q} = (p_1 q_1,\ p_2 q_2, p_3 q_3, p_4 q_4)$, where $\tilde{P} = (p_1,\ p_2, p_3, p_4)$ and $\tilde{Q} = (q_1, q_2, q_3, q_4)$.

(vi) Triangular fuzzy number $\phi = (\phi_1, \phi_2, \phi_3)$, where $\phi_1 = \phi - \Delta_1, \phi_2 = \phi, \phi_3 = \phi + \Delta_2$.

The membership function of ϕ is

$$\mu_\phi(\tilde{\phi}) = \begin{cases} \dfrac{\phi - \phi_1}{\phi_2 - \phi_1} & \phi_1 \le \phi \le \phi_2 \\ \dfrac{\phi_3 - \phi}{\phi_3 - \phi_2} & \phi_2 \le \phi \le \phi_3. \\ 0 & \text{otherwise} \end{cases}$$

C_O	The order cost per unit product
C_h	The holding cost per unit product
$N_1(t)$	The inventory level in the time interval $(0, t_0)$
$N_2(t)$	The inventory level in the time interval (t_0, T)
N_0	The initial inventory level
χ	Deterioration rate
C_d	The Deterioration cost per unit product
F_{TC}	The inventory cost function
$\tilde{F}_{TC}$	The inventory cost function in fuzzy model

2.2 Mathematical Analysis

In this research, we worked on a new approached fuzzy based inventory system with variable demand. This research work on a demand and supply base system. Here we discuss two models: Crisp and Fuzzy model. In the time interval (0, T), inventory level slowly-slowly decreases to meet demands of the products. The proposed system under consideration the stock level in which decreases by a unit rate, over the cycle as shown in the below figure.1.

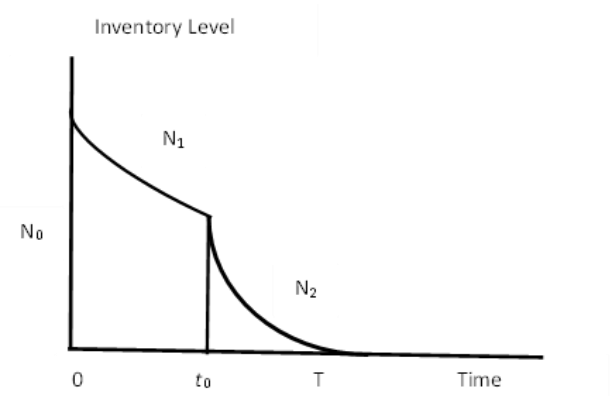

Figure 1- Graphical representation of Inventory system

2.2.1 Crisp Model

For manufacturing system, one of the most important issues is controlling and managing inventory. In this article, an improved inventory system is designed for manufacturing system. In the proposed system, we consider that there is no deterioration in the time interval $(0, t_0)$ and inventory level is depleted due to only demand rate. Therefore, the inventory level $N_1(t)$ describing in the following differential equation:

$$\frac{dN_1(t)}{dt} = -(d_1 - d_2 t), \qquad 0 \le t \le t_0 \qquad \ldots(1)$$

with the boundary condition

$$N_1(0) = N_0 \qquad \ldots(2)$$

The result of the above differential equation (1) is

$$N_1(t) = N_0 - \left(d_1 t - d_2 \frac{t^2}{2}\right), \qquad 0 \le t \le t_0 \qquad \ldots(3)$$

During the time interval (t_0, T) the inventory system depleted due to demand and deterioration rate. Therefore the inventory level $N_2(t)$ describing in the following differential equation:

$$\frac{dN_2(t)}{dt} + \chi N_2(t) = -(d_1 - d_2 t), \qquad t_0 \le t \le T \qquad \ldots(4)$$

with the boundary condition

$$N_2(T) = 0 \qquad \ldots(5)$$

The result of the above differential equation (4) is

$$N_2(t) = -\left[\frac{d_1 - d_2 t}{\chi} + \frac{d_2}{\chi^2}\right] + \left[\frac{d_1 - d_2 T}{\chi} + \frac{d_2}{\chi^2}\right] e^{\chi(T-t)} \qquad \ldots(6)$$

In the inventory system, the inventory levels $N_1(t)$ and $N_2(t)$ at the time t_0 are equal due to continuity. From equation (3) and (6), we have

$$N_1(t_0) = N_2(t_0)$$

or

$$N_0 = \left(\left(d_1 t_0 - d_2 \frac{t_0^2}{2} \right) - \left[\frac{d_1 - d_2 t_0}{\chi} + \frac{d_2}{\chi^2} \right] + \left[\frac{d_1 - d_2 T}{\chi} + \frac{d_2}{\chi^2} \right] . e^{\chi (T - t_0)} \right) \quad \ldots(7)$$

Present value of Inventory Ordering Cost

$$OC = C_O \quad \ldots (8)$$

Present value of Inventory Holding Cost

$$IH_C = C_h \left(\int_0^{t_0} N_1(t) dt + \int_{t_0}^{t_0 + t_1} N_2(t) dt \right)$$

$$= C_h \left[\left\{ N_0 . t_0 - \left(d_1 \frac{t_0^2}{2} - d_2 \frac{t_0^3}{6} \right) \right\} - \frac{d_1}{\chi^2} (1 + \chi t_1) \right.$$

$$\left. + \frac{d_2}{\chi} \left(\frac{t_1^2}{2} + t_1 t_0 + \frac{t_0}{\chi} - \frac{1}{\chi^2} \right) + \frac{1}{\chi} \left(\frac{d_1 - d_2 T}{\chi} + \frac{d_2}{\chi^2} \right) . e^{\chi t_1} \right] \quad \ldots(9)$$

Present value of Inventory Deteriorating Cost

$$ID_C = C_d \left(\int_{t_0}^{t_0 + t_1} \chi \, N_2(t) dt \right)$$

$$= \chi . C_d \left[- \frac{d_1}{\chi^2} (1 + \chi t_1) + \frac{d_2}{\chi} \left(\frac{t_1^2}{2} + t_1 t_0 + \frac{t_0}{\chi} - \frac{1}{\chi^2} \right) \right.$$

$$\left. + \frac{1}{\chi} \left(\frac{d_1 - d_2 T}{\chi} + \frac{d_2}{\chi^2} \right) . e^{\chi t_1} \right] \quad \ldots(10)$$

Total Inventory cost function is

$$F_{TC}(t_0, t_1) = \frac{1}{T} \left(OC + IH_C + ID_C \right)$$

$$= \frac{1}{T} \left[C_O + C_h \left\{ N_0 . t_0 - \left(d_1 \frac{t_0^2}{2} - d_2 \frac{t_0^3}{6} \right) \right\} + (C_h + \chi . C_d) \left\{ - \frac{d_1}{\chi^2} (1 + \chi t_1) \right. \right.$$

$$\left. \left. + \frac{d_2}{\chi} \left(\frac{t_1^2}{2} + t_1 t_0 + \frac{t_0}{\chi} - \frac{1}{\chi^2} \right) + \frac{1}{\chi} \left(\frac{d_1 - d_2 T}{\chi} + \frac{d_2}{\chi^2} \right) . e^{\chi t_1} \right\} \right] \quad \ldots(11)$$

2.2.2 Optimum Solution Method

For obtain the optimum solution, we obtain the values of t_0, T, N_0, F_{TC} for this inventory system. For minimize the total inventory cost F_{TC}, we have

$$\frac{\partial F_{TC}}{\partial t_0} = 0, \ \frac{\partial F_{TC}}{\partial t_1} = 0,$$

$$\left(\frac{\partial^2 F_{TC}}{\partial t_0^2} \right) \left(\frac{\partial^2 F_{TC}}{\partial t_1^2} \right) - \left(\frac{\partial^2 F_{TC}}{\partial t_0 \partial t_1} \right)^2 > 0$$

and $\left(\frac{\partial^2 F_{TC}}{\partial t_0^2} \right) > 0.$

2.2.3 Fuzzy Model

Most of the researchers proposed their models for forecasting the optimal solution and optimal ordering quantity assumed by constant demand and deterioration rate. Generally, the inventory system with deteriorating products, such as Vegetable, fruits, packing food products contains the rough constraints, like inaccurate inventory costs, fuzzy holding costs, ordering costs etc. In this research work we consider the inventory ordering cost ($\widetilde{C}_O$), inventory holding cost ($\widetilde{C}_h$) and inventory deteriorating costs ($\widetilde{C}_d$) are in fuzzy form. Therefore, due to our consideration, the objective function (F_{TC}) becomes $(\widetilde{F}_{TC})$.

2.2.4 Signed Distance Method

Signed distance method is a well-known method and applied in many uncertainty domain of the study. The fuzzy constraints of the proposed inventory model: inventory ordering cost ($\widetilde{C}_O$), inventory holding cost ($\widetilde{C}_h$) and inventory deteriorating costs ($\widetilde{C}_d$) are defined as

(i)
$C_h \in [C_h - \Delta_1, \ C_h - \Delta_2]$, where $0 < \Delta_1 < C_h$ and $0 < \Delta_1 \Delta_2$.

(ii)
$C_O \in [C_O - \Delta_3, \ C_O - \Delta_4]$, where $0 < \Delta_3 < C_O$ and $0 < \Delta_3 \Delta_4$.

(iii)
$C_d \in [C_d - \Delta_5, \ C_d - \Delta_6]$, where $0 < \Delta_5 < C_d$ and $0 < \Delta_5 \Delta_6$.

Using the signed distance method, the defuzzification of inventory ordering cost ($\widetilde{C}_O$), inventory holding cost ($\widetilde{C}_h$) and inventory deteriorating costs ($\widetilde{C}_d$) are defined as

(i) $d(\widetilde{C}_h, 0) = C_h + \frac{1}{4}(\Delta_2 - \Delta_1)$.

(ii) $d(\widetilde{C}_O, 0) = C_O + \frac{1}{4}(\Delta_4 - \Delta_3)$.

(iii) $d(\widetilde{C}_d, 0) = C_d + \frac{1}{4}(\Delta_6 - \Delta_5)$.

Fuzziness can be related to objective cost functions with constrained involved. Zimmermann (1976) proposed the fuzzy based both objective function and constraints. Here the fuzzy objective cost function $(\widetilde{F}_{TC})$ can be written as in form

$$\widetilde{F}_{TC}(t_0, t_1) = (F_{TC1} + F_{TC2} + F_{TC3})$$

$$F_{TC1}(t_0, t_1) = \frac{1}{T} \left[(C_O - \Delta_3) + (C_h - \Delta_1) \left\{ N_0 . t_0 - \left(d_1 \frac{t_0^2}{2} - d_2 \frac{t_0^3}{6} \right) \right\} \right.$$

$$+\left((C_h-\Delta_1)+\chi.(C_d-\Delta_5)\right)\left\{-\frac{d_1}{\chi^2}(1+\chi t_1)\right.$$

$$\left.+\frac{d_2}{\chi}\left(\frac{t_1^2}{2}+t_1t_0+\frac{t_0}{\chi}-\frac{1}{\chi^2}\right)+\frac{1}{\chi}\left(\frac{d_1-d_2T}{\chi}+\frac{d_2}{\chi^2}\right)e^{\chi t_1}\right\}\Bigg] \quad \ldots(12)$$

$$F_{TC2}(t_0,t_1)=F_{TC}(t_0,t_1)$$

$$F_{TC3}(t_0,t_1)=\frac{1}{T}\Bigg[(C_O-\Delta_4)+(C_h-\Delta_2)\left\{N_0.t_0-\left(d_1\frac{t_0^2}{2}-d_2\frac{t_0^3}{6}\right)\right\}$$

$$+\left((C_h-\Delta_2)+\chi.(C_d-\Delta_6)\right)\left\{-\frac{d_1}{\chi^2}(1+\chi t_1)\right.$$

$$\left.+\frac{d_2}{\chi}\left(\frac{t_1^2}{2}+t_1t_0+\frac{t_0}{\chi}-\frac{1}{\chi^2}\right)+\frac{1}{\chi}\left(\frac{d_1-d_2T}{\chi}+\frac{d_2}{\chi^2}\right)e^{\chi t_1}\right\}\Bigg] \quad \ldots(13)$$

Speciously, the fuzzy method examined in this paper can be applied to inventory system to get the optimum inventory policies. The defuzzification of the objective cost function is

$$\tilde{d}(F_{TC})=F_{TC}(t_0,t_1)+\frac{1}{T}\Bigg[\frac{1}{4}(\Delta_4-\Delta_3)+\frac{1}{4}(\Delta_2-\Delta_1)\left\{N_0.t_0-\left(d_1\frac{t_0^2}{2}-d_2\frac{t_0^3}{6}\right)\right\}$$

$$+\left(\frac{1}{4}(\Delta_2-\Delta_1)+\chi.\frac{1}{4}(\Delta_6-\Delta_5)\right)\left\{-\frac{d_1}{\chi^2}(1+\chi t_1)\right.$$

$$\left.+\frac{d_2}{\chi}\left(\frac{t_1^2}{2}+t_1t_0+\frac{t_0}{\chi}-\frac{1}{\chi^2}\right)+\frac{1}{\chi}\left(\frac{d_1-d_2T}{\chi}+\frac{d_2}{\chi^2}\right)e^{\chi t_1}\right\}\Bigg] \quad \ldots(14)$$

3. Numerical Analysis

For the importance of demand and supply based inventory system, this research work investigates the fuzzy based inventory model for non-instantaneous decaying products with time varying demand under fuzzy constraints. To demonstrate the validity and relevancy of this work, first we consider the numerical examples and discuss the sensitivity analysis of constraints used in this system with objective optimal total cost function. The solution procedure of the inventory system for the objective optimum cost function and order quantity illustrated through the following examples:

Example.1. Here we assumed the following constraints values for the developed model: Demand rate d_1=600 and d_2=4 units per annum; Inventory ordering cost (O_C) =1200; Deterioration rate (χ) =0.8; Inventory holding cost (C_h) =0.4; Inventory deteriorating cost (C_d) =0.05. Using these constraints values, the proposed inventory system have been solved by non-linear optimization techniques with various parameters values, and the sensitivity analysis with resultant are presented in table 1. The optimum solution is obtained with the MATLAB software after some iterations, t_0^*=112.411, $T^*(=t_0+t_1)$ =116.118, N_0^*=42174.129 and F_{TC}^*=6760.671. It can be decided that the output of this analyses (Table 1) and discusses the obtained result is acceptable and can be used in business industries for decision making. The below sensitivity analysis and graphical results demonstrate the efficiency of our developed system.

Table 1 Results for crisp model

Changes in		t_0	t_1	N_0	F_{TC}
d_1	-10%	101.140	4.133	34157.004	5479.358
	600	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	123.676	9.559	51034.729	8177.200
d_2	-10%	124.920	2.905	46862.973	7509.603
	4	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	102.175	1.496	38337.557	6148.103
χ	-10%	112.411	1.742	42174.130	6760.661
	0.8	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	112.411	1.381	42.174.130	6760.677
C_d	-10%	112.411	1.925	42174.128	6760.670
	0.05	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	112.411	6.677	42174.130	6760.672
O_C	-10%	112.402	3.507	42172.789	6751.738
	1200	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	112.420	3.916	42175.470	6769.603
C_h	-10%	112.401	6.713	42172.640	6085.671
	0.4	**112.411**	**3.707**	**42174.129**	**6760.671**
	+10%	112.419	2.162	42175.348	7435.671

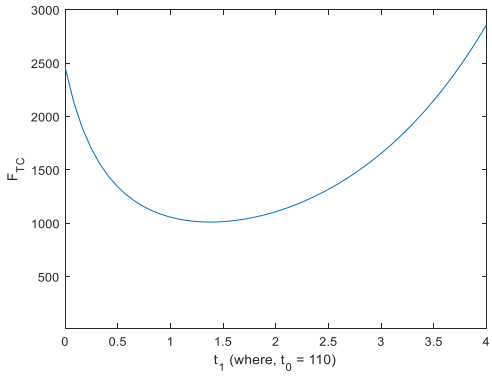

Figure 2- Optimum inventory cost function (Crisp model) vs. t_1

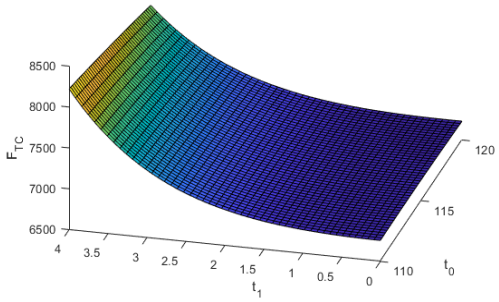

Figure 3- Optimum inventory cost function (Crisp model) vs. t_0 and t_1

Example.2. This example analyses the fuzzy model and discusses the obtained result and its implication to achieved the optimum objective cost function and ordering policies. Using the above record and interchange the objective cost functions and explain again with the same set of explanations determined in the first example. The sensitivity analysis, use of numerical results and concept of fuzzy model discussed in table 2. The optimum solution is obtained with the MATLAB software after some iterations: t_0^*=112.410, $T^*(=t_0+t_1)$ =115.202, N_0^*=42174.045 and F_{TC}^*=6718.483. From a real world study, data are collected from the business industries and corresponding fuzzy numbers are designed. From these fuzzy numbers and signed distance method, the optimum cost function is calculated.

Table 2 Results for fuzzy model

Changes in		t_0^*	t_1^*	N_0^*	dF_{Tc}
d_1	-10%	101.139	3.095	34156.910	5445.186
	600	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	123.676	3.955	51034.652	8126.153
d_2	-10%	124.919	9.056	46862.897	7462.728
	4	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	102.174	9.424	38337.464	6109.750
χ	-10%	112.410	1.512	42174.045	6718.480
	0.8	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	112.410	0.000	42174.045	6718.484
C_d	-10%	112.410	1.397	42174.045	6718.481
	0.05	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	112.410	5.195	42174.045	6718.485
O_C	-10%	112.401	2.635	42172.696	6719.551
	1200	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	112.419	2.958	42175.394	6719.416
C_h	-10%	112.400	5.081	42172.535	6043.484
	0.4	**112.410**	**2.792**	**42174.045**	**6718.483**
	+10%	**112.419**	**1.627**	**42175.279**	**7393.483**

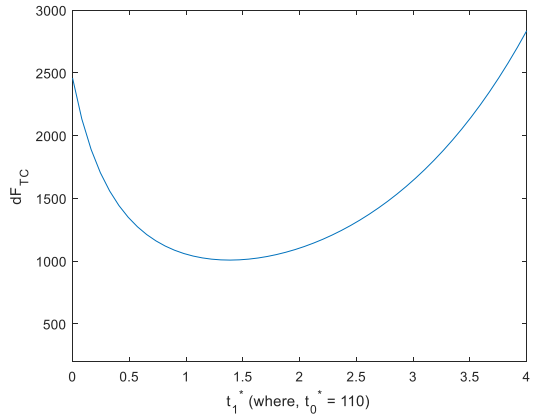

Figure 4- Optimum inventory cost function (Fuzzy model) vs. t_1

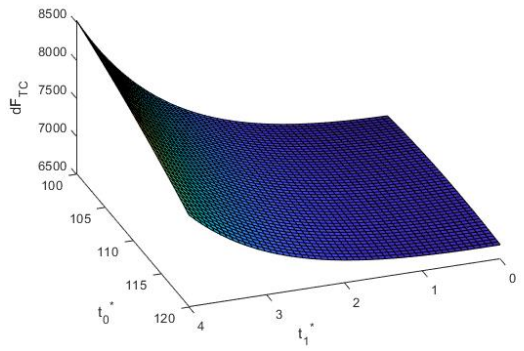

Figure 5- Optimum inventory cost function (Fuzzy model) vs. t_0 and t_1

4. Sensitivity Analysis

A numerical solution for finding the optimum values of initial inventory level and total inventory cost which provided to demonstrate adequately that the proposed system is feasible and efficient. However, the new improved model which we examined does not guarantee to obtain the optimal solution but after the sensitivity analysis of the objective function with constraints demonstrate the relevancy and validity of this model. Here the sensitivity analysis is implemented with the changing the values (+10%, 0%, -10%) of the constraints taking one constraints unchanged. The following observations are noted on the basis of the sensitivity analysis:

(i) From the above table 1 and 2, we see that the cost objective function obtained in fuzzy model is minimum compare to crisp model.

(ii) From the above table 1 and 2, we see that if the cycle time increases than the objective cost function F_{TC} as well as $\widetilde{F}_{TC}$ are also increases.

(iii) From the above table 1 and 2, we see that if the demand parameter d_1 is increases than the objective cost function F_{TC} as well as $\widetilde{F}_{TC}$ are also increases but if demand parameter d_1 is increases than the objective cost function F_{TC} as well as $\widetilde{F}_{TC}$ are also decreases due to linear decreasing demand.

(iv) From the above table 1 and 2, we see that the increases the cost of C_h, C_O and C_d also increases the objective cost function F_{TC} as well as $\widetilde{F}_{TC}$.

Conclusion

The effect of constraints involved in this inventory system with total inventory cost and sensitivity analysis is illustrated to demonstrate the optimal output. In this study a fuzzy inventory system with time varying (linearly decreasing demand) is formulated. This research work has been solved in both cases crisp and fuzzy environment. For crisp system, the optimal inventory cost is minimize with optimization techniques and in fuzzy system, the optimal inventory cost is minimize with signed distance method. This study will help the experts of seasonal items such as fruits, vegetable, packed food, medicine, cosmetic items etc. Finally numerical analysis and sensitivity analysis of total inventory cost with various constraints are illustrated to obtain the optimum result and, finally the fuzzy environment is better in comparison of crisp environment for optimizing (minimize) the total inventory cost of the system. This analysis and formulation examined are in general framework and can be protracted to contain some other fuzzy based method and fuzzy logic relations with various constraints of demand, deterioration, advertisement, price, backlogging, profit, production, trade credit and inflation etc.

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