Improving the new product development using big data: A case study of a food company

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ABSTRACT

Recently, the concept of Big Data (BD) has evolved and started to play an essential role in the advancement of new product development (NPD) in various sectors contributing to value creation, idea generation and competitive advantage. However, limited research has been done on how the food industry can exploit BD to improve the processes involved in NPD. This research aims at understanding the use of BD in New Food Product Development (NFPD). It helps to find relevant information and integrate sustainability to the early stages of the NPD process in the food industry. This research illustrates a case study of a beverage company wherein they used BD analytics to support their NPD team to launch a 2-litre lemonade drink in the market for their retailer with less than 5g sugar per 100 ml in the shortest possible time. The use of BD helps to reduce NPD costs and time without affecting the taste and on par with competitor's products. The research can support NPD professionals through the application of BD analytics to bring products at lower costs to the market as quickly as possible.

Keywords: New food product development, big data analytics, Food Supply Chain, Food & Drink, Beverages, Sustainability

1. Introduction

An effective new product development (NPD) is widely considered as a way for food companies to gain competitive advantages, in the cutthroat business environment (Santoro et al., 2017). The frequent changes in technologies, specifications and market patterns force them to invest in new food product development (NFPD) activities to either gain profits or survive (Lascom, 2018). However, the NFPD process is complicated because of uncertainties such as in raw materials' prices and quality, operational costs, customers' demand (Cousins et al., 2011), or legislations (Driessen & Hillebrand, 2013). Developing a new food product or reformulating a current product can be a painful process; various factors must be considered such as factory size, capacity, layout, its hygiene design, supply chain flow and the equipment specifications (Costa & Jongen, 2006). In this context, to ensure profitability and gain market share, food companies could accelerate the NFPD process and take the lead by being the first in launching the product. However, it is highlighted in the literature that the NFPD process is time-consuming and needs significant investments (Ryynänen & Hakatie, 2014). It also requires NFPD professionals to have expertise in a wide range of areas such as ingredients, product safety, process validation, legislation and packaging (Campbell, 2016).

This situation is emphasised by the era of big data (BD) (IBM, 2017) with the increasing amount of data available to the business. According to IBM (2017), 90% of the data in today business was generated in the last 2 years. Gantz and Reinsel (2012) estimated that amount of the data collected in the world will reach 35 zettabytes by 2020. IBM (2017) defines BD as "*data sets whose size or type is beyond the ability of traditional relational databases to capture, manage, and process the data with low-latency."* BD is generated in real-time and in large volume through sensors, devices, video/audio, networks, log files, transactional applications, web and social media. Subsequently, companies collect a massive amount of data to derive real-time business awareness related to consumers, risk, return, efficiency and output (Gartner,

2017). Mazzei and Noble (2017) suggested that an increase in levels of data and technological competencies is transforming innovation, competition, and productivity. Companies that successfully harvest BD and extract value from their data have a distinct advantage over their peers and are changing the way they compete and operate (Ernst & Young, 2014; Motamarri et al., 2017). For example, Tan and Zhan (2016) identified and analysed three Chinese firms (i.e., Xiaomi Inc., Lenovo Group Ltd and Dididache Inc.) that successfully incorporated BD in supporting their new product development (NPD) activities to reduce the product development lead times and costs. Paulson (2014) showed how BD was used to inform the better vaccine design through an example of a yellow fever vaccine analysis. Johnson et al. (2017) addressed how BD is transforming NPD activities through operationalising and analysing the three dimensions of big data, "3Vs" – volume, velocity and variety – in an NPD model. Organisations have gathered unstructured data from both internal (e.g., sensor data) and external sources (e.g., social media). With the assistance of data management and analytics technologies, organisations can exploit the data for improving their business performance (Gandomi & Haider, 2015).

Recently, Edwards (2017) highlighted that BD supports the food supply chain (FSC) with pricing, product promotion, product development and demand forecasting. In the food industry, NFPD is one of the best ways to increase sales, product values, gain market share and customer satisfaction (Lascom, 2018). With the application of BD, substantial opportunities are available for businesses such as its usage in new product design, actionable consumer insights, and developing new products and improving existing products (Zhan et al., 2018). The food industry can make use of BD to collect reliable, global-, national-, and local-level information (Lascom, 2018). BD can be used to identify consumer needs and the type of products that need to be developed. Such information is also essential as it supports the integration of sustainability to the early stages of the NFPD process (Etzion & Aragon-Correa, 2016).

Yet, a little research study on how food companies effectively use BD to enhance their NFPD practices. Researchers suggest that big data could be used to enable customers to express their demand (Zhan et al., 2018) or to increase the speed of decision-making processes (GalbRaith, 2014). However, the mechanisms implicit in using BD for NFPD has not been explicitly exploited. This research, in response, aims at answering the question: *how food companies can use BD to improve the NFPD activities*. Understanding this mechanism is crucial because in the competitive environment with fast changing customers' needs and tastes, food companies need to develop and commercialise products more quickly and effectively (Santoro et al., 2017).

In addressing this gap, we apply a case study method as this approach has the abilities to study a phenomenon in its own natural setting where existing knowledge is limited (Yin, 2017). It can also generate in-depth contextual information while complex links and underlying meanings can be explored. As such, the case study method is suitable for this research.

The paper is organised as follows. Section 2 reviews the relevant literature relating to big data and new product development in the food industry. While, Section 3 illustrates a case study of a food beverage industry, which successfully exploited the BD to reduce sugar level in one of their product in no time and achieved benefits of reduced NPD and operational costs. Finally, Section 4 concludes the research and provides research implications.

2. New Food Product Development in the Era of Big Data

The food industry is under tremendous pressure to meet rapidly-changing consumer tastes and demands (Rudder et al., 2001). Addressing these changes with new products is a key factor in maintaining and gaining market shares of a food company. In the era of BD (IBM, 2017), the huge amount of data, the relentless rapidity, and the diverse richness of data generated transforms the NFPD process. Big data provides companies with ideas that can lead to new concepts, solutions, and engines for growth (Zhan et al., 2018). By studying the literature, we

have identified fundamental principles of big data, its benefits and challenges in the context of NFPD.

2.1. Fundamental Principles of Big Data

BD holds numerous insights that can be leveraged to develop a new product for evolving and continuously changing food markets. However, the useful application of harnessing BD for NFPD requires four fundamental principles: Business insights, Actionable insights, Agility and Real-time.

Business Insights. Companies are collecting data, but very few of them have invested in big data solutions to gain awareness of their business environment (Talbolt, 2017). Information sources for business insights could be classified into four streams: technology, manufacturing, market and customer as shown in Figure 1. Technology powers efforts and abilities of a company to extract and analyse data. Companies should take a realistic approach to technological investments and gaining as much value possible from the system (Aggarwal & Manuel, 2016). According to a review work of Wamba et al. (2015), the majority of research papers are dealing with technology issues in the big data, especially concerns in storage, computation, visualisation, and integration. Companies have used cutting-edge tools such as enterprise resource planning (ERP) or spatial systems to improve operations performance. However, many systems deliver data in batches, so they do not support real-time decisions (Wamba et al., 2015). Thus, "firms need to upgrade IT architecture and infrastructure for easy merging of data" (Barton & Court, 2012, p. 6).

A successful campaign for launching a new product also depends on the manufacturing. Companies constantly find new approaches and methods to improve manufacturing performance. In the past, the improvement process can take months to examine, test, re-test, and implement any change in the manufacturing (Blitz, 2018). By using existing information systems with powerful analytics tool, companies can gain real-time insight on the performance

at their manufacturing site, such as how different configurations improve overall efficiency (Blitz, 2018). Such information allows companies to analyse real-time improvements and reduce time of launching new products.

The initial phase of product development cycle is centred on the recognition and creation of new ideas or concepts (Cooper, 2014). BD can support this phase through collection of external information of customers' requirements or market trends. This information can be integrated into the NFPD process (Davenport, 2009). For example, the processed data source will span from food business news, scientific and academic food-related research papers, social media, or e-commerce. These collected data from various sources indicate the next generation technologies or developments. Business insights data inform in advance about the future disruptions and gives an opportunity for the NFPD team to create a product, which would be appropriate to future market needs. It provides stakeholders with the chance to be more proactive rather than reactive to market developments.

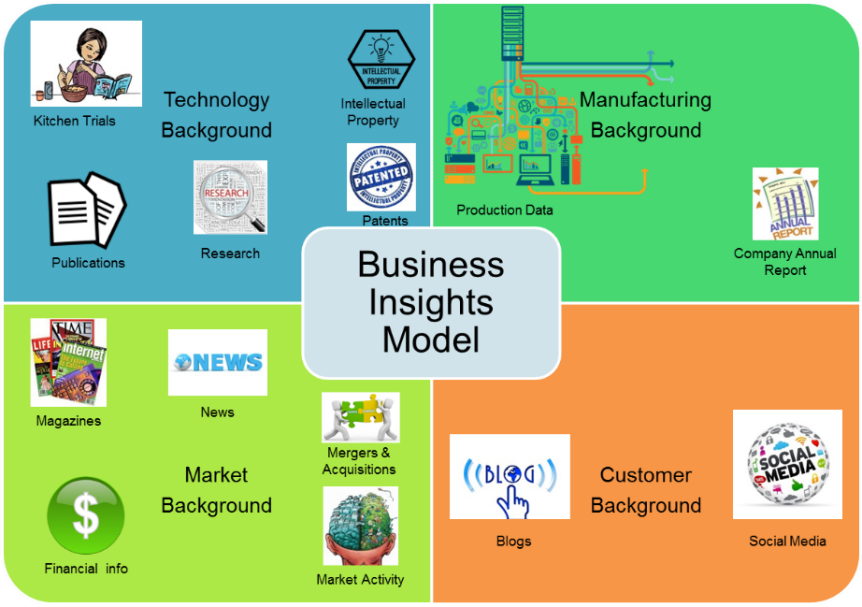

Figure 1 Big data sources for Innovation Process and NPD

Actionable insights. BD can only support or improve the NPD activities if it results in executable plans. However, actionable insights remain as a missing link for companies to drive business from their data. Hopkins (2016) reported that 74% of firms aim to be "data-driven,"

but only 29% of them are successful at connecting analytics to their business plans. Actionable insights are valuable outputs of collecting, preparing, and analysing data (Hopkins, 2016). In the food industry context, it helps to identify the insights needed at critical stages to develop appropriate NPD solutions. Information from multiple channels supports the decisions such as selecting the most efficient technology, best commercial strategy or tracking of a new product opportunity. Combining all the information gathered from these channels and making sense of it reveals crucial business insights (Dykes, 2016). Once the decision is agreed, the NPD team can act on modelling the decision and ensuing data inputs. The structuring and incorporating diverse data sources are challenging for BD analytics, but new technologies and solutions are making efforts to integrate the data thereby creating decision models (Dykes, 2016).

Agility. Agility is recognised as one of the most important capabilities of modern management (Agarwal et al., 2008). A prerequisite for the development of agility is the development of a collaboration mechanism between partners (e.g., suppliers and manufacturers, or departments with departments) (Agarwal et al., 2008). This mechanism requires a system that can share information rapidly and transparently (Dubey et al., 2018). With BD, companies by processing the data into meaningful information can share, analyse market trends in real-time and make appropriate decisions to their product development process. It influences the traditional ideas of research, strategy and competitive intelligence. It helps the NPD team to quickly identify the vulnerabilities and disruptions such as competitors' actions and market demands and adapt to the continuous changes.

Real-time. There is a continuous competition to maximise the market share, and NPD team must rely on business insights, actionable insights and agility, which is updated frequently, and develop new products based on the data received. A BD system allows companies to access data from multiple sources (e.g., smartphones) to fulfil requirements for making real-time decisions (Soroor et al., 2009). The real-time perception of a company can lead to process

integration, facilitate decision-making processes, and develop trust. Consequently, collaboration amongst partners and ability to generate knowledge from BD could be enhanced.

2.2. Big Data Benefits in New Product Development

The impact of BD on the food sector is growing, and through the advanced analytics, it offers an enormous opportunity for most actors in the FSC. It is discussed widely in the literature that the BD has helped the stakeholders with improvement in decision making, production optimisation, consumer-centric products, personalised diets, food safety and quality and fraud detection. Following are some of the opportunities offered by BD:

Production optimisation. This term stands for an approach where NPD team investigates a range of product formulas and manufacturing conditions. In the food-manufacturing context with multicomponent (e.g., ingredients) mixtures, BD allows visualisation for the NPD team to investigate if their product is in synchronisation with current production facilities. It is vital for them to be aware of changes needed regarding design, development and engineering before it is launched in the market (Khan et al., 2014).

Time and cost reduction. Implementation of BD applications in NPD would lead to latency reduction, less supervision and therefore the minimum amount of resources required (Sathi, 2012). BD allows companies to shift from product-focused innovation and turn their efforts to customer-centred focus (Zhan et al., 2018).

New product and service offerings. BD can support NPD professionals by developing food products, which are customer-centric and satisfy consumer needs and enhances the already existing product lines (Xie et al., 2016). BD allows customers to involve in the NPD process. According to Zhan et al. (2018) BD not only allows customers "to embrace inventive products to suggest novel ideas, via trial and error" (p. 589), but also "enables customers to fiddle around with novel products and new features, which enables them not only to share their tacit knowledge, but also to articulate their explicit needs" (p. 589).

Decision-making. BD offers greater transparency and visibility throughout the FSC and facilitates stakeholders with more actionable information (Scuotto et al., 2017). BD shows generic patterns, which is not always available for individual scenario. Right decisions can be made through the analysis of BD rather than relying on employee's experience (Poleto et al., 2015). McAfee et al. (2012, p. 6) shown that "companies in the top third of their industry in the use of data-driven decision making were, on average, 5% more productive and 6% more profitable than their competitors."

Food safety. Analysing BD can help to recognise potential food product quality and safety issues during product development stages. For example, tracking and tracing is mandatory in food manufacturing. The use of a sensor-based technology can collect real-time data on location or food attributes. When something is amiss, companies can quickly identify, locate, and recall the affected food. Hence, the early and efficient application of BD leverages food businesses to minimise the risks and losses (Infiniti Research, 2007), and improve the efficiency and quality of the NPD process.

2.3. Big Data Challenges in New Product Development

Although there are numerous benefits of BD applications for food businesses, there are also various challenges, which need to be resolved.

Security. One of the critical challenges for BD is privacy and security of individuals personal data especially related to their health, finances, location, buying habits and online actions (McNeely & Hahm, 2014). There are significant concerns about BD when it comes to business confidentiality, and as this data is stored in the cloud or local server, they are often vulnerable to security breaches and cyber-attacks (PwC, 2014). One of the key security issues in BD is that companies collect and process a huge amount of information regarding customers and employees, trade secrets, intellectual property and financial information. As companies aim to get value from such information, they are increasingly centralising information in one

place (Tankard, 2012). Then, the system becomes a valuable target for attackers, which can lead to high risks of information leaking out and damage companies' reputation. This calls for proper controlled and protected solutions for BD.

Data accessibility and standardisation. FSC consists of many actors, and some of these actors share data among themselves, but still, the majority of them are fragmented and do not share data since they fear to lose their profits or sensitive business information. Sometimes, data is stored in formats that are not compatible to other applications or technologies resulting in lack of standardisation and causing other issues such as data transfer or collection (Government Office for Science, 2015).

Data storage and transfer. Due to the nature of BD, the amount of information is large and complex that it is difficult to process by using traditional data management applications (Leeflang et al., 2014). The cost associated with data generation is cheaper than managing it, i.e. its storage, transfer and analysis. Structured data are easy to analyse, but unstructured data are difficult to manipulate (Khan et al., 2014). As the data is large, it takes long time to transmit data from a collection point to the processing point (Kaisler et al., 2013). Thus, companies need to investigate whether to transmit critical data only or to invest in methods to analyse as much data as possible at the collection point.

Skills. The lack of skills to analyse the enormous volume of BD to extract meaningful insights, which could add value to the business, is another challenging issue (Sivarajah et al., 2017). According to the survey of Leeflang et al. (2014), only 4% of respondents stated that they have the required capabilities to manage their business effectively. Highly skilled analysts are asset to companies. Even with highly skilled analysts, there is another challenge that these analysts may not have strong knowledge in the new product development. Thus, companies need to focus on not only training but also working closely with consultants or appropriate partners.

3. Methodology

Although there are many discussions on the use of BD, it is still unclear which specificities of NFPD ensure the success of applying BD. Given the advantages and challenges of BD applications in the food industry, it is interesting to understand the effects of BD in NFPD. To understand these effects, this research conducts a case study at the UK based food factory to understand the benefits of BD in NFPD.

A case study method was chosen as the research strategy for answering the research question. Case studies consist of detailed investigations with data collection, analysis of the context and processes involved in the study (Yin, 2017). A case study allows researchers to study a whole process in its own natural setting where complex links can be explored (Yin, 2017). This method is appropriate where current knowledge is limited, as such the use of a case study method is considered suitable in this research.

3.1. Background

Year 2018 was an important year for sugar with the introduction of the Soft Drinks Industry Levy (SDIL) targeting childhood obesity, which garnered huge media attention in April. SDIL led many companies to reformulate their drinks; in 2018, over 50% of manufacturers reducing the sugar content of drinks (HM Treasury, 2018). This in-time action by drink manufacturers steered them to a lower 'tax take' but resulted in higher amount of calorie and sugar reduction. The levy was estimated to generate £520 million annually, but due to manufacturers' timely actions; it was down to only £240m (HM Treasury, 2018). The case company is one of the top five drink manufacturers in the UK with turnover of approximately £750 million for the year 2018. The company is a juice manufacturer, and employs over 1,000 people and very much commits to innovation and NFPD. They supply to leading retailers, food outlets, service providers and manufacturers and continuously striving for quality and technological development.

3.2. Data Collection

Data were collected through visits to the NPD team at the company. Interviews were held with eight senior staffs at the NPD team. Additionally, to complete the interview and clarify some answers, in some cases follow-up telephone conversations were held. Interviews were carried out between January and April 2016. For the interview validity, interviews were transcribed and verified by the informants.

3.3. Case Project

In March 2016, the UK government announced that a tax on sugary drinks would be introduced from April 2018 to tackle rising rates of obesity and Type 2 diabetes among the population. The levy will tax the drinks industry for any product they manufacture with total sugar content over 5gram per 100 ml (Triggle, 2016). Hence, the company strategy was to develop soft drinks with less sugar. As a contract manufacturer for one of the UK based retailer to whom they supply lemonade drink in 2-litre Polyethylene Terephthalate (PET) bottles, the primary goal of the NPD team was to reduce the sugar content to less than 5g per 100 ml. Thus, based on government policies and its proven potential, the NPD project was sanctioned so that they could stay in the competitive fizzy drinks sector to generate income and keep their market share. It was also entirely aligned with the company's strategy to make healthy and quality drinks. Table 1 summarise the background of the case study.

Table 1 Case study summary

Main Points	Explanation
Project Aims	To develop a new lemonade drink with less than 5g sugar per 100 ml Developing a recipe that can be replicated to different consumers (retailers, outlets, food services) To offer consumer with a product similar to original lemonade
Business Opportunities	Creation of new less sugar category and becoming an innovation leader in the key markets. Keeping a strong focus on innovations to shake up a juice drinks category
Product Category	Carbonated lemonade fizzy drinks (2 litre PET bottle)
Consumer Insights	The rising level of Type 2 diabetes and obesity among the UK population The consumer will not compromise on the taste of lemonade.

4. Discussion

In this section, we analyse what we learned from the case study and issues we should address. To do so, we adopt the conceptual framework of using BD for the operational sustainability practices (Raut et al., 2019). This framework highlights the important of customer satisfaction and states that it is one of the most important factors of sustainable practices. As this research aims at investigating BD for NPD to achieve a sustainable development, the use of this framework is suitable.

4.1. Lemonade Supply Chain

The lemonade supply chain of the case company is as shown in Figure 2. Ingredients and packaging are supplied to the company by an approved list of suppliers. The ingredients and packaging undergo quality testing before being released for production. All the main ingredients (i.e., water, sugar, citric acid, sodium citrates, potassium sorbate, and sucralose) are mixed in a blender and pumped to bottle filling stations. A bottle filling station performs two functions; it firstly washes the bottles, secondly, it fills bottles with CO_2 gas, lemonade solution and hermetically seals them with plastic caps. As bottles moves down on the line, labels are glued on to the bottles; a set of six bottles are shrink-wrapped and palletised. The pallets of lemonade drinks are transported to retailers' depots and from there transported to outlets until it finally reaches consumers.

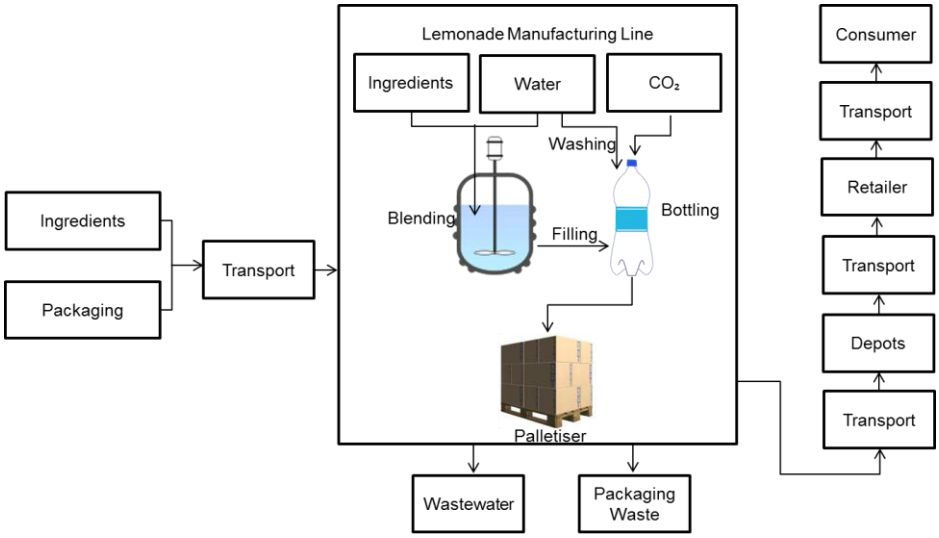

Figure 2 Lemonade Supply Chain

4.2. NPD management

The company is a market leader in fruit juice manufacturing. It has developed its NPD process model as in Figure 3. Since creating a new product or altering the existing line of products are a time and resource consuming process, the company follows a structured process to be cost-effective and achieve timely product launches. It consists of seven NPD steps before the product is commercially produced: concept generation, product concept, prototype, product approval, production process development, launch and post-launch review. The process is not straightforward or smooth, and some steps need to be repeated due to various reasons such as product formulation change, consumer demands or cost changes.

Figure 3 Fruit juice manufacturing NPD process model

4.3. Big Data Gathering, Synthesis and Use

The company aims to integrate sustainability during the product development phase, and they follow the model as shown in Figure 4. The model focuses on five principles which new food product needs to satisfy: Quality, Environmental impacts, Performance, Cost and Social Impacts. The company collected and synthesised BD to extract meaningful information from multiple sources.

Figure 4 Sustainable Product Development

4.3.1. Sugar Level - Seven brands (SM1, SM2, SM3, SM4, SM5, SM6, and SM7) of two litres lemonade PET bottles were analysed using data analytics. These seven brands are selected as they have been identified as top seven priority products to the NPD team. It is one of the most important responsibilities of the NPD to reformulate and make these brands become levy-liable. These seven brands are freely available in the top seven UK supermarket. Among these brands, the sugar level of six brands were levy-liable and one was discarded (SM5) since it had more than 5g/100ml of sugar (Figure 5).

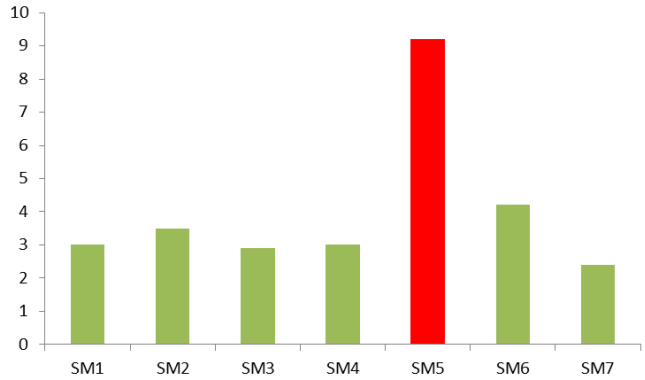

Figure 5 Number of grams of sugar per 100 ml

3.5.2. Product Pricing – The next step for the NPD team was to explore the product price. Since this product was produced for one of the major retailers in the UK, they wanted to place their product at the same price level as their competitors. Depending on this factor, they decided

to select products, which were equal to or below £1. Thus, SM7 was eliminated as its price is over £1 (Figure 6).

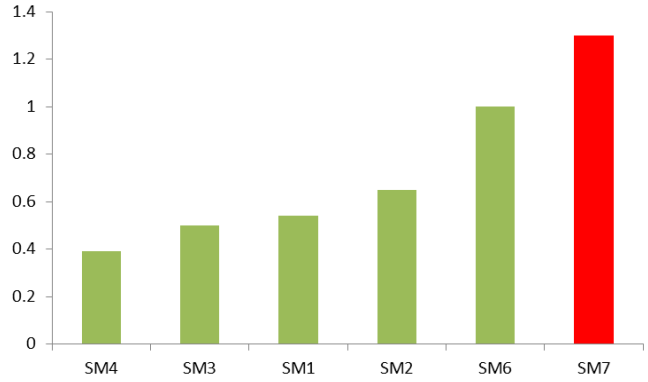

Figure 6 Prices equal or below £1

3.5.3. Quality – At this step, five brands (i.e., SM4, SM3, SM1, SM2 and SM6) remain to be analysed further. For the quality, we collected consumer feedback from company's product review platforms. We collected feedbacks generated from January 2016 to April 2016. In total, 578 feedbacks were collected. For each feedback, we extracted the content, the time, and the overall acceptance rate. Examples of product review are as follows:

*"Reviewer 1 - 21/12/2015 - Nice lemonade - I think this lemonade is a great value and tastes good. I like adding real lemons or limes for extra zing! Customer Rating - ****."*

*"Reviewer 2 - 07/07/2017 - Horrible sweeteners - Why did they change it and put sweetener in it. I hate the aftertaste of aspartame. Customer Rating - *."*

Boyd and Crawford (2012) suggested that big data analysis does not mean that more data is better. With this in mind, we focused on identifying brands with the highest acceptance rate. The acceptance rate on the feedback platform is recorded on a range from 0 to 100. The acceptance rate for each brand is calculated as its average value of all feedbacks. On that basis, we selected three brands that have the highest acceptance rate including SM1 (93.33%), SM3 (86.67%), and SM2 (70%). We eliminated SM4 and SM6 as their acceptance rate well below 70% (Figure 7).

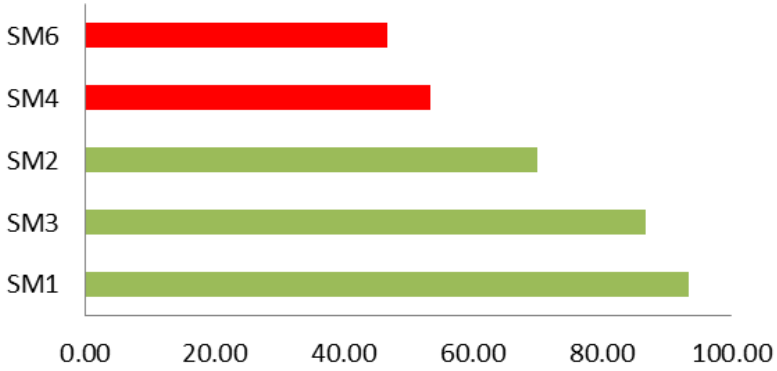

Figure 7. Acceptance percentage of consumers

3.5.4. Production Performance and Cost - To determine production cost, we investigate the type of artificial sweeteners that are used in SM1, SM3 and SM2 and whether it aligned with case company production facilities and strategy.

- SM1 – Used a mix of Acesulfame K, Sucralose
- SM2 and SM3 – Used only Sucralose

The studied company is using Sucralose for their current production processes; thus, it is preferred to keep using Sucralose based recipe (i.e., SM2 and SM3) as it is does not affect current processes and does not add any other overheads. In addition, another reason for selecting SM2 or SM3 based recipe is that they do not have to add another raw material (Acesulfame K) to their current inventory.

3.5.5. Environmental Impacts – In order to get an idea about the environmental impacts of producing lemonade drinks as per the new recipe, we followed the global warming potential report (Amienyo, 2012). According to this report, a 2-litre PET carbonated drink bottle in the UK is equivalent to 151 kg CO_2. Amienyo (2012) estimated that 1000 litres of unpacked drink during the manufacturing process is equivalent to 40.1 kg CO_2.

With the use of BD, the related annual costs at the NPD has been reduced by 33.43%. In detail, before using BD, the total annual expenditure for NPD including staff salaries, time and other consumables was £889,623. After using BD, the total annual expenditure dropped to £592,223. Moreover, the development time has been reduced from 30 weeks to 27 weeks,

which is better than the average development time of 28 weeks as mentioned in Rudder et al., (2001).

5. Conclusion

This research demonstrates the integration and application of BD in a food company. The results shows that using BD can accelerate the NPD process and expedite the launch of the product in relatively lesser time as supposed to a traditional NPD approach. It also supports stakeholders to identify any shortcomings of food products and address them earlier in the product development phase leading to massive saving on the cost involved in launching new products. Additionally, it helps businesses to develop food products, which are consumer centric and fulfil their needs.

The BD provides an enormous amount of business insights and valuable perspectives, which can benefit food businesses to perform more in-depth contextual analytics of structured, unstructured and multi-structured data during NPD procedure. However, BD also has some drawbacks such as security, privacy and confidentiality of sensitive business data. Furthermore, storing, analysing and integration of BD into the NPD process could be a tough task. However, novel technologies are continuously evolving to address this issue, and the benefits of BD applications still outweigh its limitations. Food businesses adopting BD to leverage their NPD cycle stays ahead over their competitors.

The case study illustrates that the food company successfully utilised BD for designing the lemonade recipe as per their consumer and market requirements fitting in well with their present production and operational activities. However, the case study was only limited to the selection of the best available recipe in the UK market. We also have not discussed other aspects relating to the use of BD such as security or privacy.

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