ORIGINAL INVESTIGATION

The Role of Cocoa as a Cigarette Additive: Opportunities for Product Regulation

Natasha A. Sokol MPH[1], **Ryan David Kennedy** PhD[2,3], **Gregory N. Connolly** DMD, MPH[1]

[1]*Center for Global Tobacco Control, Department of Social and Behavioral Sciences, Harvard School of Public Health, Boston, MA;* [2]*Propel Centre for Population Health Impact, University of Waterloo, Waterloo, Ontario, Canada;* [3]*Institute for Global Tobacco Control, Department of Health, Behavior and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD*

Corresponding Author: Natasha A. Sokol, MPH, Department of Social and Behavioral Sciences, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02155, USA. Telephone: 617-384-8542; Fax: 617-495-8543; E-mail: nsokol@hsph.harvard.edu

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ABSTRACT

Introduction: The 2009 Family Smoking Prevention and Tobacco Control Act prohibited the use of characterizing flavors in cigarettes; however, some of these flavors are still used in cigarettes at varying levels. We reviewed tobacco industry internal documents to investigate the role of one of these flavors, cocoa, with the objective of understanding its relationship to sensory and risk perception, promotion of dependence, and enhancement of attractiveness and acceptability.

Methods: We used the Legacy Tobacco Documents Library to identify documents relevant to our research questions. Initial search terms were generated following an examination of published literature on cocoa, other cigarette additives, and sensory and risk perception. Further research questions and search terms were generated based on review of documents generated from the initial search terms.

Results: Cocoa is widely applied to cigarettes and has been used by the tobacco industry as an additive since the early 20th century. Cocoa can alter the sensory properties of cigarette smoke, including by providing a more appealing taste and decreasing its harshness. The tobacco industry has experimented with manipulating cocoa levels as a means of achieving sensory properties that appeal to women and youth.

Conclusions: Although cocoa is identified as a flavor on tobacco industry Web sites, it may serve other sensory purposes in cigarettes as well. Eliminating cocoa as an additive from tobacco products may affect tobacco product abuse liability by altering smokers' perceptions of product risk, and decreasing product appeal, especially among vulnerable populations.

INTRODUCTION

Cigarettes are highly engineered products that allow smokers to optimize their delivered dose of nicotine, the primary addictive agent in tobacco (Henningfield & Fant, 1999). In the United States, an estimated 45 million people smoke cigarettes, and 3,000 young people try smoking every day (Centers for Disease Control and Prevention [CDC], 2011; Substance Abuse and Mental Health Services Administration [SAMHSA], 2011). As the primary cause of preventable morbidity and mortality, cigarette smoking causes more than 440,000 deaths each year in the United States (CDC, 2008). In 2009, Congress passed the Family Smoking Prevention and Tobacco Control Act (FSPTCA), providing the U.S. Food and Drug Administration (FDA) with the unprecedented authority to regulate tobacco products (U.S. FDA, 2009). The law empowers the FDA to set standards for tobacco products in the interest of public health, defined in terms of likelihood of initiation, maintenance of use, and harm to nonusers (U.S. FDA, 2009). As a provision of the law, all cigarettes with "characterizing flavors" have been removed from the market in the United States (U.S. FDA, 2009).

Published reviews of internal tobacco industry documents have revealed that the tobacco industry altered cigarette design and additives to target groups such as young new smokers, women, racial/ethnic minorities, and health concerned smokers (Carpenter, Wayne, & Connolly, 2005; Ferris Wayne & Connolly, 2002; Kreslake, Wayne, & Connolly, 2008). Manufacturers modify additives, design features, and tobacco blends to attract target groups (Carpenter et al., 2005; Ferris Wayne & Connolly, 2002). One example is the development of brands that targeted young women using specific design features that increased smoke mildness and reduced tobacco taste (Carpenter et al., 2005). Some tobacco additives have been shown to increase tobacco products' attractiveness by ameliorating or masking the natural harshness of tobacco, thereby easing use (Kreslake

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et al., 2008). A clear understanding of product design and constituents associated with enhancing attractiveness and appeal is needed to establish a science base for regulation. Product design features and additives that are not pharmacologically active may still play a role in stimulating and facilitating trial and experimentation (Henningfield, Hatsukami, Zeller, & Peters, 2011; Scientific Committee on Emerging and Newly Identified Health Risks, 2010). Regulation of tobacco products that affects their attractiveness and appeal could reduce the public health impact of tobacco (McNeill, Hammond, & Gartner, 2012). Research is needed to determine how cigarette design increases appeal and attractiveness in order to inform product regulation.

American cigarettes are a blend of Virginia, Burley, Oriental, and reconstituted tobaccos (Abdallah, 2004). Tobaccos are blended to achieve specific sensory characteristics, which smokers experience as a combination of gustatory (taste), olfactory (smell), and tactile (feel) effects (Carpenter, Wayne, & Connolly, 2007). These effects arise from the physiological responses from the stimulation of the olfactory and trigeminal nerves and collectively make up the sensory perception of tobacco smoke flavor, according to Philip Morris (PM) (Philip Morris, 1999; Tobacco Products Scientific Advisory Committee [TPSAC], 2011). Flavorings are added to casings (the additive solution applied to tobacco blends), which are added both during leaf processing, and often to reconstituted tobacco sheets (Browne, 1990). In American blended cigarettes, additives represent up to 10% of cigarette weight (Scientific Committee on Emerging and Newly Identified Health Risks, 2010). The tobacco industry uses hundreds of different additives, some of which have effects at very low levels (Rabinoff, Caskey, Rissling, & Park, 2007). Internal tobacco industry documents show that flavors are commonly added to cigarettes to mask the harshness of smoke and increase product acceptability or attractiveness (Rabinoff et al., 2007). One common flavor additive in American blended cigarettes is cocoa.

Chocolate flavor may make cigarettes more palatable to younger, first time users and may indirectly facilitate dependence by providing enhanced flavor and mouth sensations, potentially serving as a cue for drug reward (Bates, Connolly, & Jarvis, 1999; Rambali et al., 2002; Scientific Committee on Emerging and Newly Identified Health Risks, 2010; World Health Organization [WHO], 2007). Cocoa includes a range of psychoactive constituents including caffeine and theobromine, which is part of a group of chemical compounds called xanthines (Rambali et al., 2002). Xanthines are characterized by their central nervous system (CNS) effects and their ability to relax smooth muscle and bronchodilate (Rambali et al., 2002). Unlike other xanthines, theobromine is not typically used in asthma medications, as a result of its comparatively weaker bronchodilatory effects (Rambali et al., 2002). Previous research has indicated that the amount of theobromine present in cigarettes (an estimated 0.19 mg per cigarette) is likely not sufficient to produce these effects (Rambali et al., 2002). Theobromine also tends to have substantially weaker CNS action than other xanthines (Rambali et al., 2002).

The FDA's Tobacco Products Scientific Advisory Committee (TPSAC) has not yet defined how the term "characterizing" applies to cigarette flavors. In the absence of a definition, tobacco manufacturers continue to add flavors at levels that may elicit a detectible difference in cigarette flavor that may not be recognizably attributable to a known and identifiable flavor. Although chocolate and cocoa flavored cigarettes are specifically banned in the FSPTCA, the PM (www.philipmorrisusa.com) Web site lists cocoa and cocoa products as flavors in its cigarettes (Philip Morris USA, 2012), and the RJ Reynolds (RJR) (www.rjrt.com) and Lorillard (www.lorillard.com) Web sites list cocoa and cocoa products as cigarette ingredients (Lorillard, 2011; RJ Reynolds, 2010).

The current study examined tobacco industry internal documents as a means of understanding the tobacco industry's historical use of cocoa in cigarettes, including cocoa's function, and if and how its chemosensory effects may serve to attract or retain nonsmokers, smokers, or specific target groups.

METHODS

Data Sources

As a result of the 1999 Master Settlement Agreement, millions of formerly secret internal tobacco industry documents have been made available to the public online. Relevant internal documents were identified using the Legacy Tobacco Documents Library (http://legacy.library.ucsf.edu/), a searchable online database. Additionally, the current Web sites of major U.S. tobacco manufacturers were reviewed for reports regarding cigarette constituents.

Data Extraction

A snowball sampling design was used, beginning with the search phrase "(Chocolate OR cocoa) AND cigarette AND additive." This phrase was intentionally broad to avoid the exclusion of any relevant documents or themes. Results were examined, and more specific search terms were generated from emerging themes. The initial search phrase yielded 12,026 documents, and 50 search terms, yielding 34,032 results. Documents were included for analysis if they answered one or both of the research questions (how and for what purpose is cocoa used in cigarettes, and what if any target markets for cocoa exist). Exclusion criteria for documents were as follows: (a) The document or a longer version of the document had previously appeared in search results; (b) Chocolate or cocoa was mentioned, but with no further information given; (c) Chocolate or cocoa is mentioned, but not as a tobacco additive (i.e., in describing differences in the diets of smokers vs. nonsmokers); (d) The document was written by parties outside of the tobacco industry, includes no relevant commentary from the industry, and is available for viewing either publicly or through scientific literature databases; and (e) The document was confidential or privileged and therefore publically inaccessible. After reviewing documents appearing under the secondary terms, additional search terms were added to further investigate specific unanswered questions. A final set of 179 documents that met the inclusion criteria was analyzed. Review was completed by a single researcher.

RESULTS

Historical Use of Cocoa in Cigarettes

Cocoa beans are derived from pods on a cocoa tree (*Theobroma cacao* L.) that are fermented, split open, dried, and roasted (Harllee & Leffingwell, 1979a). The fermentation process of the cocoa bean converts starches to reducing sugars, and proteins to free amino acid (Harllee & Leffingwell, 1979a). The process of heating cocoa helps develop cocoa flavor, and the

roasting process reduces free amino acid and reducing sugars as a result of Maillard and Strecker Browning reactions (Harllee & Leffingwell, 1979a). These reactions produce compounds that contribute to cocoa aroma (Harllee & Leffingwell, 1979a). After they are roasted, the shell of the cocoa bean is opened, and the nib is sometimes alkali processed (Dutched) before it is ground and pressed, producing cocoa powder and butter (Harllee & Leffingwell, 1979a). For most products, cocoa powder (which retains between 11% and 23% cocoa butter) is reserved (Harllee & Leffingwell, 1979a). Cocoa powder is composed of crude protein, amino acids, polyhydroxy phenols, starch, sugars, theobromine, and caffeine (Leffingwell & Associates, 1991). Cocoa butter is nearly entirely composed of fatty acid triglycerides (Leffingwell & Associates, 1991).

Cocoa is one of the oldest tobacco additives and has been used in cigarettes since at least as early as 1932, when Souza Cruz (a Brazilian tobacco manufacturer and exporter owned by British American Tobacco) began adding cocoa powder with 10%–14% cocoa butter to its cigarettes (Pedreira, n.d.). Cocoa is generally incorporated into tobacco casing (Browne, 1990). Casings are typically applied to the air-cured portions of a cigarette's tobacco blend, as air-cured tobacco is generally lower in naturally occurring sugars and more absorbent than flue-cured tobacco (Browne, 1990). With sugars and humectants, cocoa is the most common casing ingredient (Browne, 1990).

Today, although cocoa is not used in every cigarette, it is widely applied, particularly in American blended cigarettes (Lorillard, 2011; Philip Morris USA, 2012; Reasor, 2000a, 2000b, 2000c; RJ Reynolds, 2010). A set of three Brown & Williamson Tobacco Company (B&W) documents, released in 2000, show the results of reverse engineering the company did to examine the design of the cigarette brands of their competitors (PM, RJR, and Lorillard) during 1998 and 1999 (Reasor, 2000a, 2000b, 2000c). Of the 107 cigarettes B&W tested for its presence in 1998, 80.4% contained cocoa (Reasor, 2000a, 2000b, 2000c). In 1999, cocoa was present in 81.2% of 138 cigarettes B&W tested (Reasor, 2000a, 2000b, 2000c). A 1991 B&W document identified that cocoa is generally applied to cigarettes at between 0.5% and 1.5% of tobacco weight (Leffingwell & Associates, 1991) (Table 1).

Chemosensory Properties of Cocoa in Cigarette Smoke

Enhancing or Improving Flavor or Aroma

Adding cocoa to cigarettes enhances and improves their taste and odor (e.g., Carmines, 1997; Lorillard, 1982; Pedreira, n.d.; Perfetti & Reynolds, 1996; RJ Reynolds, 1989). Cocoa powder contributes to a chocolate-like flavor in cigarette smoke, while its inherent sugars sweeten smoke (Bernasek & Woods, 1984; Brown & Williamson, n.d.-a; Harllee & Leffingwell, 1979b). Many cocoa volatiles (byproducts of burning cocoa) are identical to the volatiles produced by burning tobacco (Brown & Williamson, n.d.-b; Harlee & Leffingwell, 1979b). Therefore, when cocoa is added to cigarettes, it enhances what smokers perceive to be the tobacco flavor (U.S. Smokeless Tobacco, n.d.). One tobacco industry researcher hypothesized that the cocoa butter present in the cocoa used in cigarettes may enhance tobacco flavor by trapping tobacco volatiles in its aerosol droplets (Harllee & Leffingwell, 1979a).

> Cocoa has gained wide application in the tobacco industry since earliest times both as a sweetener and to add its own characteristic flavor. In recent years it has commonly been added to the burley tobacco of cigarette blends to enhance the cocoa-like aroma inherent in burley and, at the same time, suppress undesirable odors, thereby improving the smoking quality (Lorillard, 1982).

Increasing Smoothness or Decreasing Harshness

Cocoa affects tactile senses to reduce harshness and irritation caused by tobacco smoke. In one deposition, a former tobacco industry executive disclosed that the tobacco industry uses casing materials such as cocoa to produce acids in the smoke, which lowers smoke pH and reduces harshness (Rodgman, 1997). Tobacco smoke irritation is derived from the combustion or pyrolysis of cigarette constituents and is described as a sensation felt on the lips, tongue, mouth and back of the throat, and, rarely, in the chest, due to trigeminal nerve stimulation (Creighton, n.d.). Different cigarettes produce different levels of irritation, which are desirable to different smokers, and affect smoking topography and product satisfaction (Creighton, n.d.). Impact is another type of tactile sensation from tobacco smoke, similar to irritation, but much more immediately perceived and shortly lived, and directly related to the proportion of free nicotine available in the smoke, acting as a cue for nicotine reward (Creighton, n.d.). When sugars are heated, they become acids, which, when combined with nicotine, create nicotine salts that reduce impact and irritation (Brown & Williamson, n.d.-c). The triglycerides in cocoa also turn to acids when heated and combined with water, and in combination with nicotine also create nicotine salts to the same effect (Brown & Williamson, n.d.-c).

Table 1. Cocoa and Chocolate Ingredients in Cigarettes by the Top 3 American Manufacturers: 1998, 1999, and 2012

	Maximum level of use in any cigarette brand (%)			
Company	1998[b]	1999[b]	2012[a]	Stated function[a]
RJ Reynolds	1.13 (RJ Reynolds, 2010)	1.11 (RJ Reynolds, 2010)	1.84 (Reasor, 2000b)	Casing, flavor (Reasor, 2000b)
Philip Morris USA	0.81 (Philip Morris USA, 2012)	0.60 (Philip Morris USA, 2012)	0.50 (Reasor, 2000a)	Flavor (Reasor, 2000a)
Lorillard	0.00 (Lorillard, 2011)	1.04 (Lorillard, 2011)	[not given] (Reasor, 2000c)	[not given] (Reasor, 2000c)

[a]As reported on public company Web sites.
[b]Numbers obtained from reverse engineering done by Brown and Williamson in 2000. Cocoa levels are not available for all brands.

> Natural cocoa has traditionally been used as a tobacco additive to enhance flavor and reduce the harshness of nicotine (Day, 1985).

When cocoa is not alkalized, cocoa with higher butterfat content reduces smoke harshness more significantly than cocoa with lower butterfat content (Frank, 1976). Dutched cocoas are less harsh than cocoas that are not Dutched; however, Dutching does not appear to be as effective in reducing harshness or increasing smoothness as increased butterfat (Frank, 1976). Internal documents also explain though that in Dutched cocoa, higher levels of butterfat actually decrease smoothness (Frank, 1976).

> Cocoa reduces harshness resulting in a smoother, fuller smoke. With normal processed cocoas, butterfat is the major factor: i.e. high butterfat cocoa is a more effective ameliorant than low butterfat cocoa. Dutch processed cocoas, while offering some amelioration, are not as effective as normal processed cocoas. They also do not follow the butterfat trend found with normal processed cocoas; high butterfat Dutch cocoa gives less amelioration than low butterfat Dutch cocoa (Frank, 1976).
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> The new casing incorporated higher levels of cocoa (approximately 100% greater than current CAMEL Lt), high fructose corn syrup at levels to achieve sugar/nicotine balance, and removed licorice. This casing had a very significant effect on smoothness and acceptance (Smith, 1992).

Cocoa in Light Cigarettes

Tobacco manufacturers may have used cocoa to offset harshness from the lowered tar/nicotine (T/N) ratios in light cigarettes that resulted from filter ventilation. The cigarette T/N ratio is a crucial element of cigarette design because of tar's smoothing effect on the harshness and irritation caused by nicotine (Day, 1985). If nicotine is increased with decreased or maintained tar, a cigarette can become harsh (Day, 1985).

Some tobacco manufacturers who maintained nicotine levels in their products altered nicotine/sugar ratios in their products to increase smoothness (e.g., RJ Reynolds, 1994; Smith, 1992; Wolfe, 1983). One RJR project attempted to solve the problem of poor taste and low impact in light cigarettes by adding cocoa and sucrose to Burley, and heat treating the Burley (RJ Reynolds, 1994). This provided a lower T/N ratio (less tar compared to nicotine) but altered the sugar/nicotine ratio and produced better flavor (RJ Reynolds, 1994). RJR hypothesized that such products would have better taste, smoothness, and harshness compared to other low-tar products and could have lasting consumer appeal (RJ Reynolds, 1994). Another RJR document details 11 unique design features associated with a smooth tasting, low T/N cigarette, including increased sucrose, and the addition of cocoa at 0.78% of tobacco weight (Casey, 1994).

RJR's research of T/N ratios and sugar levels on cigarettes showed that certain T/N ratios require certain levels of sugar to maintain an acceptable level of smoothness (Wolfe, 1983). This research concluded that a relationship exists between the T/N ratio and sugar, having found that for a moderate level of harshness, a cigarette with a T/N ratio of 12 required 6.8% sugar, but an increase in nicotine for a T/N ratio of 11 required 8% sugar to achieve the same level of harshness (Wolfe, 1983). Blends with lower T/N ratios require more sugar for smoothness than blends with higher T/N ratios (RJ Reynolds, 1994; Smith, 1992; Wolfe, 1983).

Pharmacological and Physiological Activity

A 1969 document lists physiological activities of xanthines, including "central nervous system and respiratory stimulation, smooth muscle relaxation, skeletal muscle stimulation, coronary artery dilation, cardiac stimulation (including more efficient heart pumping), and diuresis" (Travers & Edmonds, 1968). The author of the document suggests determining the feasibility of engineering a product capable delivering xanthines in smoke for therapeutic effect, explaining that "coffee and/or cocoa may be used to balance or augment the flavor… …and afford additional Xanthine delivery" (Travers & Edmonds, 1968).

Although in one deposition, a former PM Vice President for Science and Technology agreed that PM used cocoa as a source of theobromine for bronchodilation, to increase the absorption of cigarette smoke constituents, in the lungs (Osdene, n.d.), internal documents examined did not reveal evidence that PM or other companies actually used cocoa explicitly for the pharmacological or physiological effect of theobromines. A number of industry documents investigated theobromine and determined that the levels present in cigarettes were not sufficient to produce physiological effects (e.g., British American Tobacco, 1999; Carchman, 1997; Philip Morris, 2001). Industry documents state that even at its maximum level in cigarettes, the amount of cocoa is not sufficient to produce a clinically effective dose of theobromine (e.g., British American Tobacco, 1999; Carchman, 1997; Carmines, 1997; Philip Morris, 2001).

Human Hedonic Research (Consumer Product Testing)

> A unique but subtle taste difference may be the key to broad acceptance of flavored cigarettes. Ideally, smokers would be able to recognize these cigarettes as delivering unique attributes and tastes but would not be able to specifically identify the flavor (Weber, 1983).

Results from hedonic research showed that although higher levels of cocoa in cigarettes increased acceptability (a global measure of consumer liking of and preference for a product), there was an "upper limit," with very high levels of cocoa actually decreasing product acceptability (Frank, 1976). One 1976 B&W study observed smoke quality improvements (in smoothness, irritation, and smoke character) after doubling levels of high-butterfat cocoa in one of their products but that these improvements dropped off after a 200% increase, with a 300% increase offering little or no improvement (Frank, 1976). The same study found that a 300% increase in low-butterfat cocoa resulted in decreased smoke quality, creating a cigarette that was less acceptable than the control (Frank, 1976). Researchers concluded, "there is an upper limit of the nonbutterfat material that is acceptable on tobacco unless accompanied by a proportionately greater increase in butterfat" (Frank, 1976).

RJR conducted a series of consumer testing initiatives in the 1980s to determine the feasibility of marketing cigarettes with varying levels and types of cocoa, including ones with discernible chocolate flavor (e.g., Carol Bernstein Research, 1983a, 1983b; Marco, 1993; Smith, 1992). Results from the testing

of one of these products (a chocolate-mint-flavored cigarette) revealed that consumers enjoyed the chocolate mint flavor, but preferred cigarettes with lower levels of this flavor, finding them more satisfying; however, the majority of smokers did not believe that they could smoke chocolate-mint-flavored cigarettes all the time, finding them to have too much or too sweet a taste for regular use (Carol Bernstein Research, 1983b; Cohen, 1983). It appears that this is an established pattern, not only for chocolate, but for other nonmenthol flavors as well. In a letter to an RJR executive in response to a suggestion of experimenting with flavored cigarettes, one RJR scientist wrote that although the company used some flavors at subliminal levels, RJR's experience had shown that with the exception of menthol, smokers did not want cigarettes with flavors that overpower tobacco taste and that brands that had experimented with flavored cigarettes (including chocolate flavor) had been marketplace failures (Brown & Williamson, 1992). Similarly, a PM document on low-tar cigarette flavor explains that flavors are added to tobacco to enhance tobacco smoke flavor and notes that "If the added flavors yield predominating nontobacco notes and become distinctive, they are not desirable for American cigarettes. The only exception is mentholated cigarettes" (Hale, Kroustatis, Lin, & Wynn, 1990).

> We do, in fact, use a couple of the ingredients you suggested in our current formulations. However, their contribution to the overall flavor is at a subliminal level rather than the high level that would be needed to effect the response your suggestion includes. Our experience has shown that the smoker does not want a flavor which overpowers the tobacco taste in a cigarette (with the exception of menthol). A number of brands have been introduced by cigarette manufacturers over the years which have such a design, and all of them have been failures in the marketplace. Examples are Lyme (lime), Spring (lemon), and Chelsea (chocolate) (Brown & Williamson, 1992).

Target Markets

Documents reviewed showed that at least one tobacco company used cocoa as part of efforts to achieve product attributes that increased product appeal among young women and youth. RJR experimented with increasing cocoa as part of a project designed to increase their share of the young female market (Marco, 1993; Smith, 1992). This project, "Camel RU" (a product marketed as Camel Special Lights), aimed to develop a cigarette that was less strong, more smooth, and better tasting than a Camel Light, but stronger than a Camel Ultra-Light, to increase Camel's market share among young women and older smokers, while continuing to attract male smokers (Marco, 1993; RJ Reynolds, 1992a). Camel RU used increased sugar, high fructose corn syrup, and increased cocoa for improved casing and smoothness (RJ Reynolds, 1992b). Consumer research from this project showed that this casing composition had a major impact on perceptions of smoothness (Smith, 1992). Consumers preferred cigarettes cased with double the cocoa used in other Camel brands, finding them to taste better and be smoother, more satisfying, and more acceptable (Smith, 1992). Consumers further preferred high fat or Dutched cocoa over "F1" (the standard cocoa used in Camel brands at the time), perceiving products that contained either of these to be smoother than products containing F1 (Dube, Lloyd, & Burger, 1992).

> RJR is underrepresented among this smoker target group [18–34 year old women], especially among the 18–24 younger adult female smoker target subsegment… … priority aroma candidates have been identified on basis of smoker preference and perceived compatibility with cigarettes. Vanillin, toffee, coconut, chocolate, marshmallow… …vanillin and chocolate are currently most viable candidate. These two flavors' ability to impact a distinctive smoothness benefit may be large. However, their ability to impact pleasant aftertaste or crisp, refreshing taste is less assured (RJ Reynolds, 1986).
>
> Project RU (CAMEL Special Lights) is a lights proposition strategically focused toward broadening CAMEL's appeal beyond the current prime prospect smoker group (21–24 males) to include female and older smokers. RU is a milder, smoother, lighter tasting CAMEL that will feature a white tipping (Marco, 1993).

Another RJR project ("Project XG") sought to update Camel Filters 85s to "replace Marlboro as the key brand among younger adult smokers" based on the understanding that "product benefit" (taste, smoothness, and satisfaction) is necessary to attract younger smokers, regardless of product imagery, and increased cocoa in a number of prototypes (e.g., Alber, 1985; RJ Reynolds, n.d., 1984, 1985).

DISCUSSION

Cocoa has been widely used in American cigarettes. At least two tobacco companies continue to use cocoa as a cigarette additive at levels similar to those recorded in their internal documents. Documents revealed that cocoa has been used in cigarettes for its influence on sensory qualities. The tobacco industry has used cocoa to impact gustatory and olfactory perceptions by enhancing and sweetening tobacco flavor and aroma, and tactile perceptions by reducing smoke irritation. Documents showed the importance of cocoa in improving light cigarettes' acceptability by enhancing smoke flavor lost through ventilation, and smoothing smoke made harsh through lowered T/N ratios. Results from hedonic research indicated that cigarettes with higher levels of cocoa in their casing are more appealing and acceptable to smokers; however, studies also showed that consumers and researchers felt that when present at a level that would create a recognizable gustatory chocolate/cocoa flavor, the cigarette was no longer appealing for regular use. Although one document suggested that cocoa be investigated for use for physiological effects in future products (Yates-Evans, 1986), documents showed no indication that this project was carried out or that cocoa has any physiological effects at levels used in cigarettes. A report by Rijksinstituut voor Volksgezondheid en Milieu (RIVM) confirms this finding, and further finds the levels of all psychoactive compounds in cocoa found in cigarettes are insufficient to produce pharmacological effects (Rambali et al., 2002). RIVM does suggest, however, that one compound found in cocoa, phenylethylamine, could potentially serve as a cue for drug reward in cigarettes (Rambali et al., 2002).

Despite its other sensory properties, cocoa is identified only as a flavor on the Web sites of the three major U.S. tobacco companies (Lorillard, 2011; Philip Morris USA, 2012; RJ Reynolds, 2010). Although it is not the only product feature or

additive with these functions (e.g., Carpenter et al., 2005, 2007; Ferris Wayne & Connolly, 2002; Ferris Wayne, Connolly, & Henningfield, 2006; Pritchard, Robinson, Guy, Davis, & Stiles, 1996), cocoa decreases sensory perceptions of cigarette smoke harshness, which ease or improve smoking, and prevent short-term adverse reactions to smoke inhalation. In particular, cocoa's smoothing properties may enhance product acceptability and attract certain subgroups of smokers such as women and young people (Henningfield et al., 2011; Scientific Committee on Emerging and Newly Identified Health Risks, 2010). Although research has shown that the compounds in cocoa with potential physiological activity likely have no effect on the development or maintenance of tobacco addiction (Rambali et al., 2002), one previous investigation of cocoa as a tobacco additive has indicated that cocoa, in addition to other similarly functioning additives, may play a role in dependence and addiction because of its sensory effects (WHO, 2007). Research has also shown that following the establishment of drug self-administration, sensory effects can function as reinforcing stimuli (e.g., Panlilio et al., 2005; TPSAC, 2011).

The FDA has defined "characterizing flavors" in food as those that are marketed in the labeling or advertising (U.S. FDA, 2011). Products so far affected by the ban on characterizing flavors in cigarettes have been ones that had a nontobacco, nonmenthol flavor designated in their marketing and recognizably attributable to a specific product flavor. This review presented tobacco industry research on cigarette flavoring from at least as early as 1976 showing that the consumers are not attracted to cigarettes with nonmenthol flavors at levels that are high enough to have been so far regulated as "characterizing." Further, sales data show that prior to the September 2009 ban, sales of flavored cigarettes made up less than 1% of the cigarette market (AC Nielsen, 2009), although it has been shown that cigarettes containing characterizing flavors were more popular among youth compared to adult smokers (Klein et al., 2008). Despite not imparting a characterizing "chocolate" flavor, at levels currently used in cigarettes, cocoa can alter cigarette flavor substantially and affect product acceptability. Cocoa plays a role in altering sensory perceptions of cigarette smoke, including by decreasing harshness and improving flavor. These altered sensory perceptions may impact smoker risk perceptions, particularly in regards to light cigarettes. Cocoa, at the low levels at which it is used in cigarettes, is of concern regardless of whether or not that level is considered to be characterizing.

Limitations

Due to the nature and quantity of available tobacco industry documents, and the inaccessibility of privileged and confidential documents, contents of this and any review of internal tobacco industry documents cannot be considered comprehensive. Further, because the documents reviewed were generally at least a decade old, findings from this review do not necessarily represent the current practices. However, according to the Web sites of two major tobacco manufacturers that list current maximum levels of cigarette ingredients by brand, current cocoa application appears to remain fairly consistent with historical standards cited in the older documents.

Section 904 of the FSPTCA requires tobacco manufacturers to disclose all cigarette additives (U.S. FDA, 2009). The FDA may also consider requiring manufacturers to disclose all intended and unintended functions of each cigarette ingredient to help better determine their appropriateness for continued use in cigarettes, given their impact on use behaviors. However, given the tobacco industry's history of a failure to fully disclose information about their products (USDCDC, 2006), independent internal documents investigation remains essential as a means of gaining a more holistic understanding of the intended purposes and functions of cigarette ingredients and components. Investigations of the tobacco industry documents may serve as an important means of identifying constituents for further regulatory research and action. In order to regulate cigarettes in the interest of public health, research is needed to investigate the relationships between noncharacterizing cigarette additives, perceptions of risk, and smoking behaviors.

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DECLARATION OF INTERESTS

None declared.

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