

## SECURITY LABEL FOR ARONIA JUICE SCANNED IN NEAR INFRARED SPECTRUM BLOCKADE

### SIGURNOSNA ETIKETA SOKA OD ARONIJE SKANIRANA U BLOKADAMA U BLISKOM INFRACRVENOM SPEKTRU

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#### Abstract

We have developed new procedures in order to secure family agricultural production (FAP-OPG). As organic aronia juice has considerably high prices and a big competition, we have applied Infrared Design® (IRD) protection on the juice label which is liable to forgery. The developed CMYKIR color separation for two different spectra widens the application of graphic protection for various products through all printing techniques and technologies. Visible and infrared colors are being prepared according to the new and hereby suggested recipes. The new graphic protection, which has the information about product, manufacturer and designer, has been secured thus protecting the final consumer. The separated NIR (near infrared) information has been created, which is detected in NIR area of wave length from 750 to 1000 nm. Designer determines the procedure of the process IRD through the individualized choice of colors as well as the forming of the visual near infrared image. The suggested forensic solution of the aronia juice label is scanned in blockades of two light areas as multilayer specimen which contains hidden and visual information.

**Keywords:** *CMYKIR separation, graphic label protection, packaging forensics, near infrared blockade, twins VZ colors and colorants*

#### Sažetak

Razvili smo nove postupke u osiguranju proizvoda obiteljskih poljoprivrednih gospodarstva (OPG). Zbog velike konkurencije i iznimno visoke cijene eko soka od aronije primijenili smo InfraredDesign® (IRD) – zaštitu na etiketi soka koji je sklon krivotvorenju.

Razvijena CMYKIR separacija boja za dva različita spektra proširuje primjenu grafičke zaštite na različite proizvode kroz sve tehnike i tehnologije tiska. Vidljive i infracrvene boje pripremaju se prema novim, ovdje predloženim recepturama. Osigurana je nova grafička zaštita koja nosi informaciju o proizvodu, proizvođaču i dizajneru, štiteći krajnjeg potrošača. Kreirana je izdvojena informacija NIR (near infrared) koja se detektira u području valnih duljina NIR od 750 do 1000 nm. Dizajner određuje proceduru postupka IRD kroz individualiziran izbor boja i oblikovanje vizualne blisko infracrvene slike. Predloženo je forenzičko rješenje etikete aronijeva soka skenirano u blokadama dvaju svjetlosnih prostora kao višeslojni specimen koji sadržava sakrivene i vizualne informacije.

**Cljučne riječi:** *CMYKIR separacija, grafička zaštita etiketa, forenzika ambalaže, near infrared blokada, blizanci VZ boja i bojila*

## 1. Introduction

### 1. Uvod

The future of food products packaging insists on new graphic technologies and techniques in the domain of authentication. Formerly, the printing type of protection from forgery was applied exclusively on banknotes (1). Near infrared security print is applied to the fashion dress making, the production of shirts, ties and many other luxury products (2). The recipes of the colorant twins have been defined for each material according to the material on which they are printed (3). The first applications of the security design in VZ (visual and near infrared) technology were suggested for military uniforms (4). The quality of colorant duality which occurs in our environment is simulated. The photographs of nature taken in two spectra are joined.

The reproductions, which have two conditions for separated observation in two different spectra, are created (5). The archives of near spectrograph colorants for processed printing are used (6). Our solution is based on the algorithm for flexography, transparent packaging printing on polypropylenes (7). The motivation and interest for the introduction of food products protection by IRD method have resulted from the works which cover different areas of application and different mathematical models of VZ separation (8). The recipes for VZ twins' colorants have been elaborated by the authors for concrete application (9). The new way of colorant management for digital print on self-adhesive label with scan control in light blockade has been set up. The forgery detection is executed by means of forensic instrument - Projektina (10).

Graphic industry is based on visual colors that can be seen by naked eye. All the survey instruments and gadgets are subordinated to the above mentioned. The tints of color on the print are identified with the recipe of V and NIR colors (6). Only the visual elements will be reproduced by scanning of the image with commercially available scanners. Infrared quality cannot be scanned or reproduced by commercial scanners. The image hidden in infrared area is disclosed by optical NIR reader. Competent information of spectral measures of each of the used color are scanned from the print by spectrophotometer.

The label of aronia juice, produced by family farm (OPG) "Car Stjepan" from Vrbovec, is designed by the infrared design® procedure. Aronia plant is a very strong antioxidant which prevents the formation of free radicals and the degeneration of healthy cells in human tissue and blood plasma.



Figure 1 Croatian trade mark for eco-product and label design

Slika 1 Hrvatski znak za eko proizvod i dizajn etikete

The process of organism aging has been slowed down because of the quantity of tannin and flavonoids where anthocyanin, vitamins C and E have the main role. Aronia helps in lowering of the blood pressure and enables fast recovery after heart and brain strokes, stops the development of atherosclerosis and creates strong protection against dementia and Alzheimer's disease. It helps to cure headaches and migraines because it improves the blood circulation in blood vessels of the head; regenerates muscles and improves the blood supply of the myocardial as well as creates the complete protection of blood vessels blockade. The original aronia juice is produced from ecologically grown sort of aronia. The ecological and sanitary control is applied in the production of the juice as well as the strict measures of ecological control when breeding aronia fruits. The original 100% ECO (ecological) aronia juices are at disposal. Forged juices have the same name but they are different in quality and contents. Besides juices and syrups of aronia in different packaging, there are also eco original juices mixed with other fruit, fruit spreads of aronia, jam, marmelade, aronia powder as a food supplement or beverage supplement, dried berries, organic fruit spread, aronia juice with cranberry, bio-tablets, capsules and various aronia teas.

## 2. Security label with NIR characteristic

### 2. Sigurnosna etiketa s NIR obilježjima

All food products are marked according to the EU regulations. The way of packaging, appearance and the content of declaration have been prescribed. The informational system on packaging is based on two opposite variables which lead to the need of optimization. On the one side, those are legal rules which have to be respected by the producer in the sense of necessary information (for example, harm or danger from the product, bar code). On the other side, it is necessary to conform graphical, designer and protective elements in order to realize the exact and recognizable solution of the packed product. (OPG-s) family farms protect their eco products by certificates which guarantee the production congruent to all the regulations of ecological production. Trade-mark "Eco Product" (figure 1) is given only for the duration of one year or of one year's vegetation. That's why the design of graphically protected label will be different for each year or vegetation or the production serial. The security protection in print will follow such requirements.

The security label has the elements of protection, in the content, which are hidden but revealed with optical reader. The separation of achromatic area, with the aim of hiding the image in NIR area, is set by the processed colorants cyan, magenta, yellow and black.

Such label protects the product from copying. We got a picture by IR separation with dual content and image appearance where the first one is clearly visible on the print, while the other is hidden in near infrared region. The design of double graphics is developed by the twin colorants whose recipes can be observed through VZ models for each tint of colors (11). Two colorants of different matters, which have equal visual experience (V) and different response (Z) in infrared spectrum, are produced for each tint (12).

The label for aronia juice will contain two images. The first image will be seen on the print and the second will be hidden in the content of the first. The text which carries the name of the juice and the producer is chosen for the hidden image. The photograph of aronia plant is situated in the middle of the label and is easily recognizable by human eye. A glass bottle is used as a packaging for aronia juice. A label which contains colors absorbing the light out of the visual range of human eye is glued to the glass bottle. Colorant recipes with infrared effect have the characteristics easily detected by NIR camera. Three bottles are placed on the table cloth designed with hidden infrared image of a horse galloping. The description of the product and the producer is on the left side of the label and the juice contents and the manner of preservation are described on the right side of the label. The visible picture contains aronia berries in dark purple color with stems and green leaves. The linking of two images is performed in graphic preparation using established recipes for twin colors. "Twin colors" are chosen by testing which helps data base to be



*Figure 2 Label in visual spectrum on glass bottles*

*Slika 2 Etiketa u vizualnom spektru na staklenim bocama*



*Figure 3 Label in near infrared (1000 nm) spectrum on glass bottles*

*Slika 3 Etiketa u bliskom infracrvenom (1000 nm) spektru na staklenim bocama*

thoroughly worked out for typical colors placed in the design of the label. Twin colors ensure the programmed linking of the two images into one. Human eye sees in the same color tint the places on the label, where the hidden image of the text and the visible image of aronia, are duplicated.

The label with the image of aronia, which dominates on the label, is created, while the hidden text is revealed instrumentally. The real values of absorption range of the each of the printed colors are detected by spectrophotometer. The hidden image and its spectral values are revealed by professional scanning in light blockades. The specimen, that will be sample copies for all future printing editions, are prepared. Detailed instructions, for the elaboration of the secured aronia juice label with defined twin colors spectral values as well as the spectral values of printed colors, are written together with specimen.

### **3. Label design for visual and near infrared spectrum**









#### **3. Dizajn etiketa za vizualni i blisko infracrveni spektar**

The twin colors, on the print, will have the same emission of reflected light and the human eye will see them as the same color tint. Twin color pairs are tested on unvarnished, self-adhesive

and thermos stable paper and on self-adhesive, transparent and thermo stable foil in digital printing technique. If it is not possible to see the tint difference between the twin colors, than the difference is detected by spectrophotometer. Only those pairs of twin colors, whose color difference is less than three ( $\Delta E < 3$ ), are taken. The image, which will be dominant on the label of aronia juice, and the hidden NIR image are chosen only after the pairs of twin colors have been selected out of the following tints: green, ochre, purple, blue, brown, dark brown, red and other less represented colors.

**Table 1.** Recipes of twin colors in V and Z spectrum

**Tablica 1.** Recepture blizanaca boja u V i Z spektru

boja	X <sub>0</sub> =C,M,Y	X <sub>40</sub> =C, M,Y,	L*a*b
	78, 42, 85	56, 0, 41	44, -32, 24
	47, 35, 58	19, 0, 21	61, -7, 20
	72, 50, 40	54, 13, 0	45, -4, -13
	77, 66, 48	57, 33, 12	35, 4, -14
	68, 45, 40	49, 8, 0	49, -6, -10
	42, 38, 53	12, 6, 18	62, 0, 17
	39, 47, 39	9, 20, 9	59, 12, 6
	39, 78, 61	0, 63, 44	43, 39, 15

Colors with X<sub>0</sub> mark are "zero colors" without any portion of carbon black component. Colorants with X<sub>40</sub> mark are colorants that have given value of 40% carbon black component coverage. The twin colorants X<sub>0</sub> and X<sub>40</sub> have equal L\*a\*b values for digital print.

Human eye cannot distinguish the content with black component, on the printed image, from the content which does not contain black component. An observer cannot see this dual quality of an image by naked eye. The first image visible on the print can be unchangeable while the other hidden image can be changeable. The discussion on the management of dual image conditions is based on the twin colorants theory (13) and CMYKIR separation theory (14). CMYKIR color separation is based on the fact that carbon black component K has infrared response which can be controlled in any color tint. The real colors, in Table 1, recede from the conventional GCR method of color mixture determination with black component. CMYKIR colorant mixing includes the reciprocal influence of the process component characteristics: raster coverage, transparency and the quality of toner on paper. The values in Table 1 are related to the digital toner ES5431 and to the glossy paper for labels.

The label, 21x7,5 cm from the left side, contains the information about the producer while the right side contains the juice contents and the mode of preservation.

The photography reproduction of aronia dominates the middle part of the label while the name of the juice in purple - blue color is situated at the bottom. The trade - mark of eco product is placed in upper left part of the central image, while the EU eco trade - mark is on the right side. The image, which will be hidden in NIR area, consists of two separated words in the image. The hidden text contains the name of the juice producer "Car". The other hidden word is the name of the juice "Aronia" (Figure 3). The CMYKIR separation is performed according to the requirements of the hidden text (IR image) and visible image (V image). It has been established, by infrared camera that the colorants pigment of cyan, magenta and yellow do not have the response in NIR area. The maximum of K component blackness in CMYKIR separation is definite and amounts to 40%.

## 4. CMYKIR separation management

### 4. Upravljanje CMYKIR separacijom

The image visible on the print, transfers from RGB system into CMYK. This transfer from RGB system into CMYK is prepared according to the print technology and technique for each set of the process colorants. The value of the component K is zero when image V transfers from RGB into CMYK system. The V image is treated only with CMY colors. After that, the image transfers from CMY system into CMYK with targeted - given value of component K. The retractions of C, M, Y components are performed according to the rules of GCR (grey component replacement) procedure. The difference between the GCR separation and VZ (CMYKIR) separation is the approach towards the setting of the K component. Only with the combining V and Z images, the parts, where the V image is duplicated with hidden Z image, are treated with CMYK colors. The planning of double image is accomplished with CMYKIR separation which recedes from the conventional color separation (15). The values of C, M, Y and K components, for the certain tint of twin colors pairs, will be different in the area from K=0 to K=40 as the maximum values according to the principles of VZ separation. The maximum value of 40% is used for the hidden text. Chosen images are joined into one by CMYKIR separation. The symmetry of the twin colors pairs is set up by theoretical color mixture where the equal color tint in visible spectrum is achieved by different shares of C, M, Y and K. It is very difficult to achieve, in practice, the equal color tint by proportional retraction of C, M, and Y as well as adding black. Big differences in colorants, raw materials for printing and printing techniques are the reason for that. CMYKIR separation requires preliminary testing of real colorants in real printing conditions.

This is the way to optimize the contrast of incoming image with infrared effect. Algorithm of CMYKIR separation controls hidden image response in NIR spectrum.

Duality of solution of VZ label print is observed in forensic way. Scanning is performed with light blockades in the range of 245 to 1000 nm. Visual range from 400 to 750 nm is shown in Figure 1. Blockade at 850 nm, in the first part of near infrared spectrum, is given in Figure 4d. The images in blockades: 560, 660, 715 and 850 nm are shown in Figure 4 (4a, 4b, 4c and 4d).

Scanning by blockade at 570 nm shows the absence of yellow colorant (6). As one of the process component in missing, the perturbation of reciprocal relationships has occurred in VZ separation, so the black component started appearing a little from the initial design.



Figure 4a Blockade at 570 nm

Slika 4a Blokada na 570 nm



Figure 4b Blockade at 665 nm

Slika 4b Blokada na 665 nm

There is no yellow component in the trade - mark "HR-EKO 08" so it became cyanic. There is also no process colorant magenta at 665 nm. The planned NIR security graphic is already well visible by naked eye in the scanned snapshot by forensic instrument (10). The influence of cyan colorant has remained at 715 nm. There are no yellow nor magenta or cyan process components by 850 nm blockade. The planned graphic, for NIR spectrum in K cannal, cannot be visible by naked eye because the designed graphics with V twin colors and colorants are in its surrounding. These scanning are the data base for forensic checking of the authenticity and originality of the label.

Hidden text is placed all over the graphic of the whole visible design of the initial image except for text with big letters "Aronia". The grey scale range is usual from 0 to 40% for various motifs of hidden NIR image.

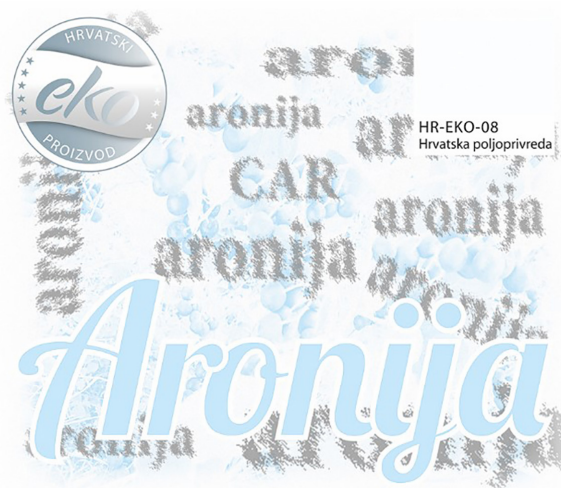


Figure 4c Blockade at 715 nm

Slika 4c Blokada na 715 nm



Figure 4d Light blockade at 850 nm

Slika 4d Blokada na 850 nm

In this case, hidden text has given value of 40% coverage of the grey scale. IR image with the texts "Aronia" and "Car" is instrumentally discernible. The intensity of letters appearance depends on the visual image. Some colors from V spectrum are impossible to exchange with planned value of 40% carbon black coverage. In those places the value in Z image is lowered according to the maximal GCR (grey component replacement) method.

## 5. Conclusion

### 5. Zaključak

IRD protection of food products is an innovative graphical design. The applied method raises the level of label security protection in food industry. The new field has been opened concerning the graphical procedure in label print production, with process colorants cyan, magenta, yellow and black. NIR light provokes Infra Red protective quality of packaging in this procedure of IRD® colorants conformance. The filtering of information by NIR camera will arouse consumer's feeling of security and confidence in product as well as in producer. The security labels for varied products are being developed by the new graphical method described in this paper. The solution of recipe for twin colors and colorants is cataloged together with the usage instruction for each type of label base in digital technology or in conventional offset print. The intellectual property, of food product producer, has been protected, in order to ensure the quality of original product for the consumer.

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